

**Characterization of Biomass Burning:
Fourier Transform Infrared Analysis of
Wood and Vegetation Combustion
Products**

By

Diomaris Padilla

**A dissertation submitted to the Graduate Faculty in Earth and Environmental Sciences
in partial fulfillment of the requirements for the degree of Doctor of Philosophy,
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THE CITY UNIVERSITY OF NEW YORK**Abstract****Characterization of Biomass Burning: Fourier Transform Infrared
Analysis of Wood and Vegetation Combustion Products**

By

Diomaris Padilla

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The Fourier transform infrared examination of the combustion products of a selection of forest materials has been undertaken in order to guide future detection of biomass burning using satellite remote sensing. Combustion of conifer *Pinus strobus* (white pine) and deciduous *Prunus serotina* (cherry), *Acer rubrum* (red maple), *Juglans nigra* (walnut), *Fraxinus americana* (ash), *Betula papyrifera* (birch), *Quercus alba* (white oak) and *Quercus rubra* (red oak) lumber, in a Meeker burner flame at temperatures of 400 to 900 degrees Fahrenheit produces a broad and relatively flat signal with a few distinct peaks throughout the wavelength spectra (400 to 4000 cm^{-1}). The distinct bands located near wavelengths of 400-700, 1500-1700, 2200-2400 and 3300-3600 cm^{-1} vary in intensity with an average difference between the highest and lowest absorbing species of 47 percent. Spectral band differences of 10 percent are within the range of modern satellite spectrometers, and support

the argument that band differences can be used to discriminate between various types of vegetation.

A similar examination of soot and smoke derived from the leaves and branches of the conifer *Pinus strobus* and deciduous *Quercus alba* (white oak), *Quercus rubra* (red oak), *Liquidambar styraciflua* (sweetgum), *Acer rubrum* (maple) and *Tilia americana* (American basswood) at combustion temperatures of 400 to 900 degrees Fahrenheit produce a similar broad spectrum with a shift in peak location occurring in peaks below the 1700 cm^{-1} wavelength. The new peaks occur near wavelengths of 1438-1444, 875 and 713 cm^{-1} . This noted shift in wavelength location may be indicative of a fingerprint region for green woods distinguishable from lumber through characteristic biomass suites.

Temperature variations during burning show that the spectra of low temperature smoldered aerosols, occurring near 400 to 450 degrees Fahrenheit, may be distinguished from higher temperature soot aerosols that occur above 600 degrees Fahrenheit. A heightened peak intensity of 50 percent is observed throughout the spectra of the lower temperature generated soot and smoke, with respect to the higher temperature generated soot and smoke. These observations suggest the possibility of establishing biomass reduction markers using a ratio method.

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-DP

Characterization of Biomass Burning: Fourier Transform Infrared Analysis of Wood and Vegetation Combustion Products

Diomaris Padilla, and Dr. Jeffrey Steiner, CCNY- Earth and Atmospheric Sciences

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List of Acronyms and Abbreviations

1. **FTIR: Fourier Transform Infrared Spectrometry**
2. **SEM/EDS: Scanning Electron Microscopy and Energy Dispersive Spectroscopy**
3. **XRF: X-ray Fluorescence**
4. **AIRS: Atmospheric Infrared Sounder**
5. **GOES: Geostationary Operational Environmental Satellite**
6. **MODIS: Moderate Resolution Imaging Spectroradiometer**
7. **S-HIS: Scanning High Resolution Infrared Spectrometer**
8. **AVIRIS: Airborne Visible/Infrared Imaging Spectrometer**
9. **NDVI: Normalized Difference Vegetative Index**

Chapter 1

Introduction

The effect of aerosols on solar radiation is perhaps the least understood of the major factors involved in models for climate prediction. Sulfate aerosols released during volcanic episodes are well known to contribute to severe down-swings in regional and global temperature [Stott, 2000], but the influence of aerosols released during industrial processes and the burning of fossil fuels has not been recognized. There is growing evidence that aerosols will play an increasingly pivotal role in climate predictions as the burning of forested areas, primitive cooking fires, and the burning of waste increases in third world countries [Andreae, 2004, Ackerman, 2000]. Natural forest fires can be traced using AIRS, GOES and MODIS satellite systems, but very little information is available as to the effect of small, but numerous, fires. Moreover, it is important to climate models to be better able to determine whether a fire is burning primarily through the canopy, involves the whole mass of the tree, or is in fact only smoldering.

Three main forms of instrumentation have been used to study the infrared response, elemental concentration and morphology of wood smoke from varying tree species and to distinguish lumber wood smoke from forest smoke. The instruments used are the Fourier Transform Infrared Spectrometer (FTIR), the X-ray Fluorescence spectrometer (XRF) and the Scanning Electron Microscope with Energy Dispersive Spectrometer (SEM/EDS).

The solid state FTIR records differences in the vibrational characteristics of the molecules comprising the solid. It therefore serves as a chemical detector for various smoke and soot species generated by a firing event. The potential major species remaining after decomposition include alkenes, alkynes, carbonyl sulfides, nitro aromatics, and various other

molecules. FTIR is unable to detect metals, and single elements such as carbon, nitrogen or potassium. The information gained through laboratory combustion experiments is intended for later use as a baseline reference for satellites that cover appropriate bands for detecting atmospheric composition.

The x-ray fluorescence spectrometer serves as an elemental analyzer. Analysis of metals such as iron (Fe), Potassium (K) and Titanium (Ti) are quickly and easily collected without sample destruction. Preservation of smoke samples is important since multiple sample analysis can be performed through out time.

The SEM/EDS system serves dual roles. First, it captures the morphological features present in soot, ash and smoke particles produced during firing events. Studies of this sort are needed as a reference for the morphology of pyrogenically emitted material. The EDS data complements the XRF analyses by helping to assess the source of a given elemental signal. Iron, for example, may be present as an oxide or as an agglomeration of carbon-iron molecules. Hence, SEM/EDS provide important information on particulate mixtures that cannot be seen either through FTIR or XRF analysis.

In this report we show that Fourier Transform Infrared Spectroscopy (FTIR) spectra highlight clear differences between deciduous and coniferous tree species. Spectral differences are highlighted at peak locations ranging from 400 to 4000 wavenumbers. Increases in spectral concentrations are indicative of higher particle abundances for molecules such as carbon monoxide (CO), carbonyl sulfide (SOC) and aromatics. By pinpointing these key features in smoke plumes we are able to increase the sensitivity of atmospheric models that use pyrogenic emissions in their data sets, thereby contributing to the formation of clearer climate predictions. Additional carbon potassium ratio (C/K)

information found through chemical analysis by Scanning Electron Microscopy and Energy Dispersive Spectroscopy (SEM/EDS) has found that lumber and forest products can be distinguished from one another.

I. Background and Motivation

There is a mounting interest in the assessment of biomass burning with respect to climate change modeling [Hansen, 1997, *Smith, 2000; Jacobson, 2004*]. Recent measurements have found that excesses of combustion products injected into the atmosphere contribute to a complex variety of climate interactions [Koren et al., 2004, Andreae, 2004, Ackerman, 2000]. The intermittent changes induced by cloud-smoke and/or smoke-atmosphere reactions have the potential to form micro-climate conditions with a seemingly globe spanning ability [Ramanathan, 2001, Kaufman, 2002, Rosenfeld, 2000]. These processes are further complicated by the increased amount of unregulated particulate matter dispersed into the atmosphere.

National air emission estimates of regulated pollutants such as carbon monoxide (CO), Nitrogen Dioxide (NO₂), Sulfur Dioxide (SO₂), Volatile Organics (VOCs), Lead and other particulate matter average over 205 million tons¹ per year in the US alone [EPA, 2007]. Further studies from the U.S. Department of Agriculture (USDA) and National Interagency Fire Center (NIFC) report an average of 88,000 forest fires per year² which consume an estimated 3 million acres³ of forest land and emit approximately 93 million tons of CO₂ per

¹ Fires and Dust excluded. Eight year average taken in five-year intervals 1975 to 2005 and 2006

² Forest Fires averaged over eight year period covering 1998 to 2006

³ Forest Fire Acreage averaged over eight year period covering 1998 to 2006

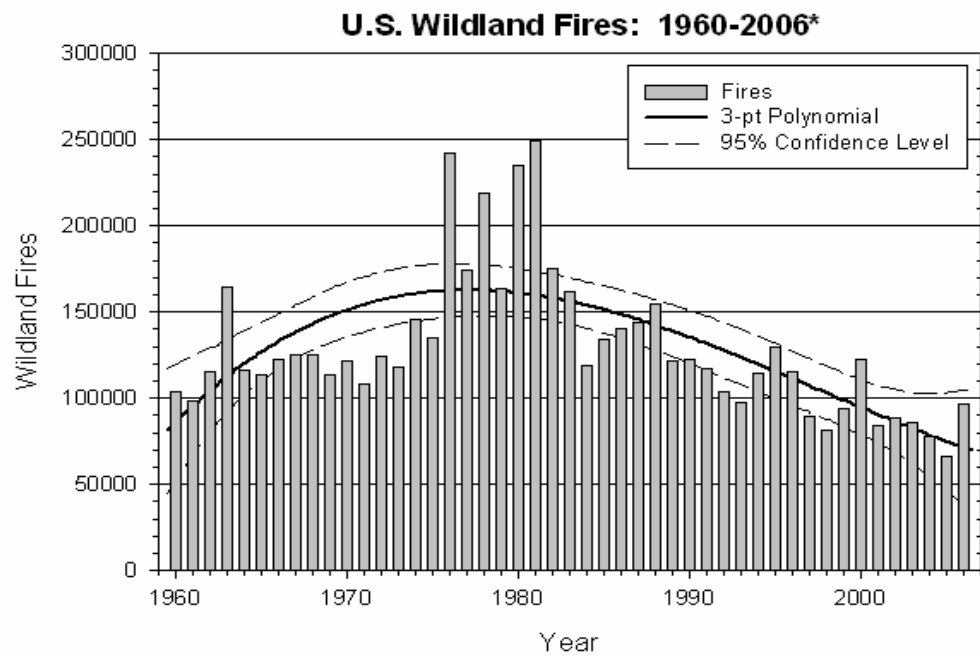
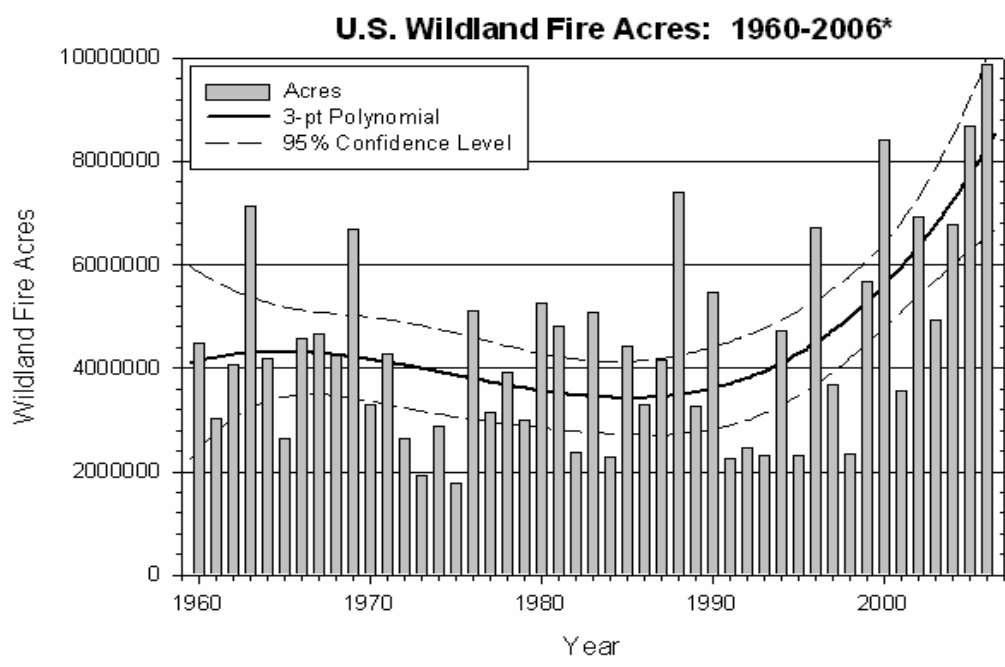
year⁴ (Figures 1 and 2 & Table 1). Trends in the same wildfire/prescribed fire study (Figures 1 and 2) show a decrease in fire instances but an increase in acreage burned during firing events, which suggests the importance of controlling fire size in order to lessen the release of combustion related gases. Additional projections indicate that the use of primitive cooking fires, burning of waste products, and land clearings will escalate, forcing increased amounts of pollutants into the atmosphere [Crutzen, 1990; Mathews, 2000]. Consequently, the chemical characterization, reflectance and absorption properties of these combustion aerosols provide important basic information for climate prediction.

The classification of carbon dioxide and other atmospheric compounds by Fourier Transform Infrared Spectroscopy (FTIR) has seen an increased application in the field of remote sensing [Russwurm, 1995; Mattu, 2000]. Previous studies use an open path FTIR system to monitor a mixture of combustion products, yielding information on aerosols such as: carbon dioxide (CO₂), carbon monoxide (CO), methane (CH₄), propylene (C₃H₆), hydrogen cyanide (HCN), nitrogen oxides (NO_x), non-methane hydrocarbons, ammonia (NH₃), hydrogen cyanide and oxygenated volatile organic compounds (OVOCS) [Bertschi et al., 2003; Andreae, 1983, Yokelson, 1996] These studies focus on temperature variations and infrared thermal bands to suggest the possibility that remote sensing can differentiate intense combustion episodes, that consume substantial amounts of vegetative matter, from relatively quiescent ones [Prins 1994, Menzel, 2004; Fuller, 2000] .

Chemical species determination through FTIR-CP engages a methodology employed for decades to identify key characteristic properties of organic and inorganic matter [Smith, 1999]. Kaufman (1997) and Koren (2004) suggest that characterization of aerosol chemistry

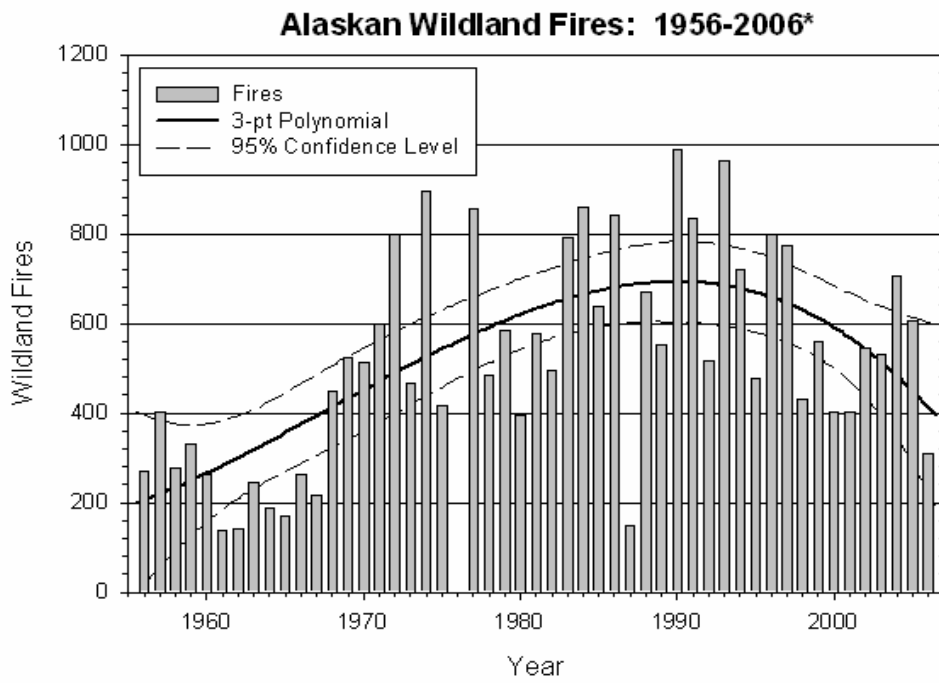
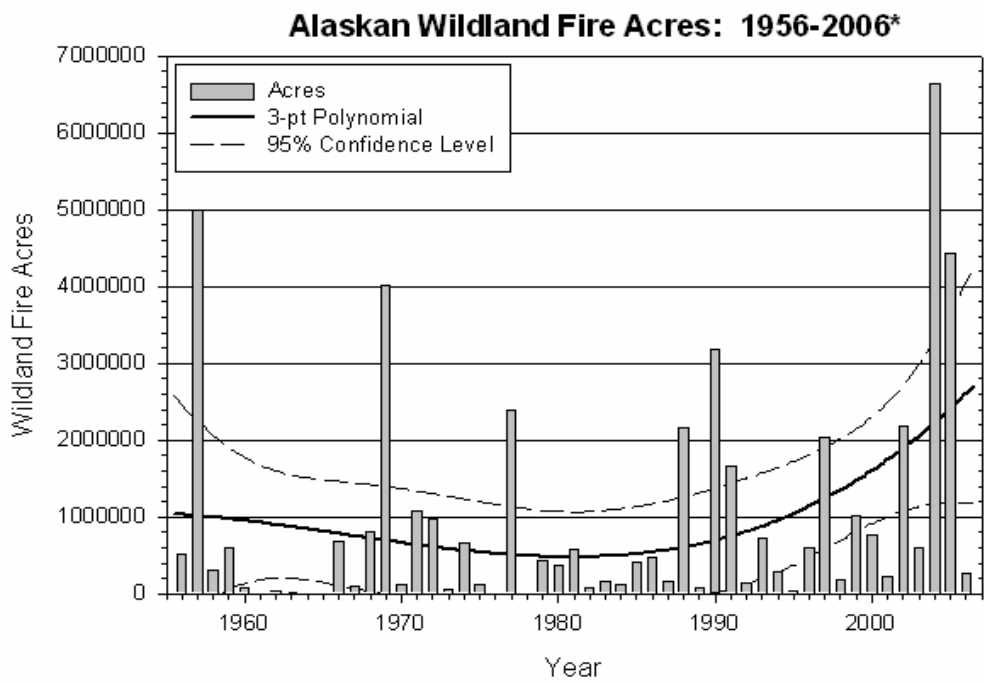
⁴ Emissions from forest fires in the 48 lower states and Alaska covering 1990,'95, 2000-2006

serves as an indicator of climate reaction to individual groups of pollutants as they enter the atmosphere. The present study uses a new laboratory FTIR closed path method (FTIR-CP) to determine whether the FTIR-CP signal is influenced strongly by combustion temperature, plant species, and vegetative morphology.



*2006 wildfire activity includes preliminary data through December 29th.

Figure 1: (Source: NOAA Satellite and Information Services) US wildfire chart shows an increase of approximately 60% of acres burned from the 1960's to present day (top chart). Increased emissions warrant an investigation into chemicals released. (Alaskan fire statistics not included.)



*2006 wildfire activity includes preliminary data through December 29th.
Figure 2 (Source: NOAA Satellite and Information Services) Alaskan wildfire shows an increase of approximately 40% of acres burned from the 1960's to present day (top chart). Increased emissions warrant an investigation into chemicals released.

Table 1: Estimates of CO₂ (Tg/yr) emissions for the lower 48 states and Alaska (Source: EPA 2007, table 7-8)

Year	CO ₂ emitted in the Lower 48 States (Tg/yr)	CO ₂ emitted in Alaska (Tg/yr)	Total CO ₂ emitted (Tg/yr)
1990	42.7	34.5	77.2
1995	42.9	0.5	43.3
2000	144.6	8.2	152.8
2001	63.0	2.4	65.3
2002	89.7	23.6	113.3
2003	81.4	6.5	87.9
2004	5.0	70.6	75.6
2005	75.9	50.5	126.4

II. Overview of Fourier Transform Infrared Spectroscopy

Infrared spectroscopy studies the interaction of infrared radiation with matter by utilizing electromagnetic radiation ranging from 0.78 to 1000 μm [Jensen, 2000]. The technique is limited to analyzing compounds with molecular bonds thereby excluding analysis of elements (C, N), monatomic ions (Fe^{2+}), homonuclear diatomic molecules (C_2 , N_2) and noble gases [Smith, 1996]. The Fourier Transform Infrared Spectrometer (FTIR) works by sending an infrared beam through a sample. The resultant beam is split by a grate to form two beams. The first beam is sent to a stationary mirror while the second beam is sent to a moving mirror, both beams are rejoined and travel to the detector. Intermolecular vibrations are recorded creating an interferogram and an infrared spectrum calculated by means of Fourier transform.

Chemical characteristics of compounds can be identified using the infrared signature of a known sample since functional groups within chemical structures are identical. In other words, a carbonyl which exhibits a stretch at 1700 cm^{-1} , will exhibit the same stretch in a ketone, aldehyde or carboxylic acid at the same wavenumber. FTIR can be applied to solids, liquids and gases which have been mounted onto special cells or films suited for infrared analysis such as potassium bromide (KBr). Fourier transform infrared spectroscopy (FTIR) is widely used to classify compounds on the basis of their molecular vibration modes. Dipolar molecules, such as water (H_2O) and ammonia (NH_3), for example, vibrate both longitudinally and axially to produce a unique signature when subjected to Fourier transform optics [*Smith, 1996*].

In the present study, the FTIR spectra of smoke generated in a laboratory-hood experiment is used to classify and compare the wood products listed in Table 2. Infrared spectroscopy is a useful tool for chemical speciation because functional groups within chemical structures behave similarly despite the local environment of the molecule in the organic or inorganic structure [e.g. leaf product vs. heart wood, etc.; *Smith, 1999*].

Table 2 The listed products are wood species from the northeastern United States used as combustion samples for FTIR experiments.

Fuel Used			
<u>Wood Name</u>	<u>Common Name</u>	<u>Tree Classification</u>	<u>Wood Type</u>
<i>Pinus Strobus</i>	White Pine	Coniferous	Untreated Lumber & Green Wood
<i>Prunus Serotina</i>	Cherry	Deciduous	Untreated Lumber Only
<i>Acer Rubrum</i>	Red Maple	Deciduous	Untreated Lumber & Green Wood
<i>Friglans Nigra</i>	Eastern Black Walnut	Deciduous	Untreated Lumber Only
<i>Fraxinus Americana</i>	American Ash	Deciduous	Untreated Lumber Only
<i>Betula Papyrifera</i>	Birch	Deciduous	Untreated Lumber Only
<i>Querus Alba</i>	White Oak	Deciduous	Untreated Lumber & Green Wood
<i>Querus Rubra</i>	Red Oak	Deciduous	Untreated Lumber & Green Wood
<i>Liquidambar Styraciflua</i>	Sweetgum	Deciduous	Green Wood Only
<i>Tilea Americana</i>	American Basswood	Deciduous	Green Wood Only

III. Research Goals

FTIR is a spectroscopic approach that has been utilized for decades to determine material chemistry. Advantageous when used to analyze solids, problems arise when looking at gases or liquids. For this reason we have developed a suitable filter media composed of Potassium Bromide (KBr) that is invisible in the infrared region. By using KBr as a matrix for aerosol capture we reduce interferences by other components that would be introduced if we used the usual polycarbonate or quartz filter.

This thesis serves as a tool for developing a technique that will diminish interferences caused by strongly absorbing atmospheric gases, such as water and carbon dioxide. These types of discriminations have never been attempted and are of critical use in

climatology because they give a clearer interpretation of chemicals injected into the atmosphere after a firing event. Such interpretations are useful in climate modeling since chemical speciation is more precise. FTIR research is widely used for gas phase discriminations, but has not been applied to the problem of defining various types of solid residue materials on filters or other media.

The purpose of this research is to develop methods for distinguishing from among the important climate factors by achieving the following goals:

1. Develop a method in which soot and smoke can be collected without jeopardizing the integrity of the sample or minimizing sample loss.
2. Extract a viable signal in the mid infrared spectrum for soot and smoke that would yield chemistry other than carbon dioxide.
3. Distinguish the chemical signal of soot and smoke among lumber varieties
4. Distinguish the chemical signal of soot and smoke among branch and limb samples
5. Deduce the effects of combustion temperature on absorbance properties

These and other goals are based on being able to develop an analytical system that will be useful for obtaining these distinctions. The proposed use of the Fourier Transform Infrared method is useful because in theory:

- Carbon-carbon bonds in the smoke can be resolved from a suitable collection matrix.

- Carbon-ammonium bonds in the smoke can be distinguished from carbon-carbon and other bond types.
- Smoke products can be captured using filters or other collection procedures.

This proposed research is based on the following research questions:

- Can gaseous byproducts of biomass burning, soot and smoke be characterized by using Fourier Transform Infrared Spectroscopy (FTIR)?
- Since live trees produce a unique fingerprint in the infrared does the byproduct of their incineration should also produce a unique infrared signal?
- Can temperature differences between flaming and smoldering be distinguished by Fourier Transform Infrared Spectrometry?

The approach used to meet these research challenges consists of creating a collection chamber able to withstand the high temperatures of combustion while vacuuming particulates onto a filtering system. A unique filtering system has been devised to both create and hold the filter. Minimal contamination and loss of the filter media is achieved by forming potassium bromide (KBr) filters in the same container used to collect particulate matter. Collection periods are in a range of thirty to forty-five minutes per sample for adequate smoke removal from the chamber. Sample collection is followed by drying and humidity control and is kept in an oven at a constant temperature of 100 °C. Prior to insertion into the

FTIR analyzer, all samples are powdered and pressed into a KBr glass. Remaining sample material is further analyzed by SEM/EDS analysis, yielding qualitative information on elemental composition. Additional XRF analysis on smoke filled polycarbonate filters serve as an additional analysis technique used to verify the existence of heavier elements that may have been missed by FTIR. Raw untreated lumber material was obtained through the internet at the Woodworkers Source (<http://www.woodworkerssource.net/>). Tree branch samples were obtained from Little Alley Pond Park (Figure 3).

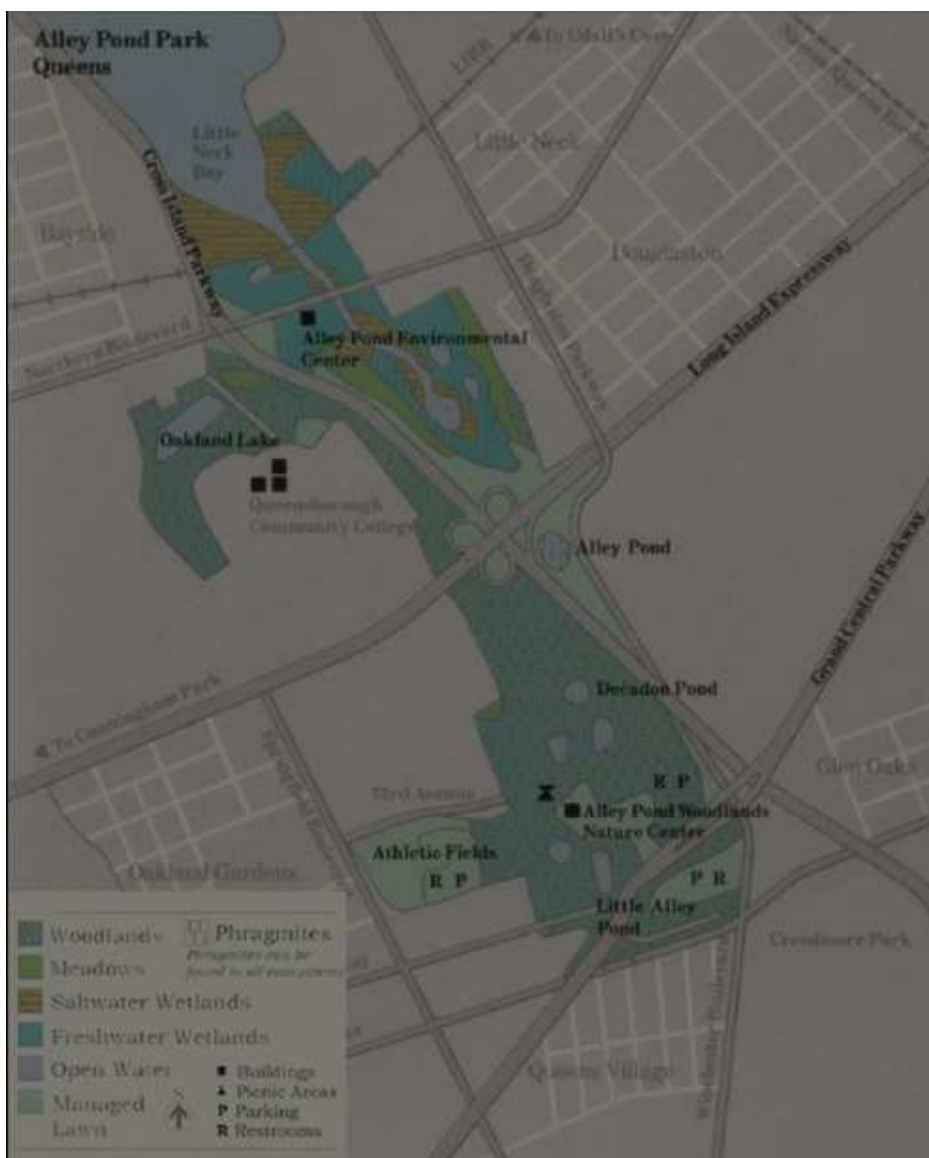


Figure 3 Map of area containing tree limb collection site in Alley Pond Park, Queens, NY.

IV. Thesis outline

This document consists of an introduction which examines the ideas that led up to the research of tree smoke and soot, as well as explains literature reviews, methods, analysis, statistics and results. The literature section focuses on health issues related to wood smoke and soot; climate responses pertaining to massive amounts of smoke and biomass particulates in the air as well as past tracking methods and how they can be improved with this approach.

Previous satellite research related to biomass burning is also reviewed. Statistical results will conclude the paper.

While statistical comparisons of smoke from lumber and greenwood indicate that greenwood and lumber spectra are very similar, individual analysis of pine, maple and white oak point toward significant differences between lumber and greenwood. Similar results were achieved during sample by sample analysis, for the exception of birch. Additionally, the FTIR spectra for the combustion products of lumber and green wood have been shown to be relatively unique for the woods displayed in Table 1. In particular, the green wood information forms a complex array of data that can be organized on the basis of the position of a given absorption band occupying a set of bands in the interval of 900 to 400 wavenumbers thereby giving evidence of spectral signatures per sample species. Furthermore, the differences exhibited between lumber and green wood absorbance's are an indication that much of the tree chemistry is retained in the inner and outer bark portions of the tree. The magnitude of the vibrational response suggests that the FTIR differences can be recorded by satellite platforms.

The SEM/EDS and XRF information demonstrates that the aerosol chemistry of the solid aerosol particulates can be used in combination with the FTIR to strengthen the definition of the combustion products. White Pine and White Oak have a distinctive feature, a lack of a carbon response, when associated with potassium. The SEM/EDS and XRF data are equally suggestive of the possibility that the chemistry of the smoke can be used to differentiate between deciduous and conifer forest combustion products.

Chapter 2

I. Literature Review

Aerosols⁵ exist in our atmosphere in a multitude of forms. From simple solids and liquids to more complex composites, aerosols persist as a permanent fixture in the environment. Although biogenic sources such as volcanic emission, sea spray and windborne dusts are copious anthropogenic sources from wildfires and everyday pollution are quickly threatening to become insurmountable [Houghton et al., 2001]. Recent research on the carbon dating of methane ($\delta^{13}\text{CH}_4$) levels in Antarctic ice cores suggests a global increase in pyrogenic aerosols over the past 2000 years [Ferretti, 2005]. As the world population increases the trend in fossil fuel use grows at an incredible rate with biomass⁶ burning being one of the most difficult to control [Hood, 2002].

Biomass burning produces many complex particles, the two most common being: smoke⁷ and soot⁸ [Seinfeld, 1998]. Numerous studies [Jacobson, 2004, Meehl, 2004, Tyson, 2001] and models [Ryu, 2004, Menon, 2002] have agreed that aerosols in the form of soot and smoke are creating atmospheric problems such as regional warming and cooling in areas near the Tropics, Africa, India and China. Pyrogenic pollution conditions affect rainfall by both increasing or decreasing cloud formation and varying the radiative budgets over tropical regions in which global climate are

⁵ “Small droplets or particles suspended in the atmosphere, typically containing sulfur. They are usually emitted naturally (e.g., in volcanic eruptions) and as the result of anthropogenic (human) activities such as burning fossil fuels.” (EPA, 2007)

⁶ “Total mass of living organisms present in an area, i.e. plant biomass.” (Clark, 2004)

⁷ “An aerosol, consisting of visible particles and gases, produced by the incomplete burning of carbon-based materials such as wood and fossil fuels” (EPA, 2007)

⁸ “Carbon dust formed by incomplete combustion” (EPA, 2007)

mostly dependent on. Consequently, regions surrounding the African Sahara are experiencing intensified periods of draught, while areas in the south of China are suffering through elevated amounts of flooding [Koren, 2004].

It is due to the far reaching effects of atmospheric particulates that the role of monitoring aerosol speciation comes into play. Distinguishing varying aerosol compositions remotely may make it viable to predict and possibly counter the negative influences of pyrogenic particulates in our atmosphere. The unique flexibility of the aerosol to affect both large scale systems, such as climatic changes, and small scale systems, human health, is seen in its size variations. An aerosol can range from 0.1 micrometers to slightly less than 100 micrometers [Pitts, 2000], easily affecting cloud formation or human lung tissue development.

A. Health Issues

At its smallest size, 0.1 micrometers, an aerosol can play a deadly role in the human respiratory system. Although scientists do not fully understand the role of the aerosol mechanism in the human lung or heart tissues, research has shown that aerosols such as soot, ozone, smog and dust are damaging and at times fatal [Journal of Environmental Health, 2004].

In the United States alone, lung and heart related deaths have increased by 17%, linking 60,000 deaths a year to over-exposure to smog and other aerosols [Journal of Environmental Health, 2004]. Ozone levels of up to 60ppm, below the Environmental Protection Agency's 80ppm standard for "good air" quality, has been found to increase the severity of symptoms for children suffering from asthma

[Journal of Environmental Health, 2004]. Additionally, asthma related incidences in the Caribbean have been linked to windborne dust, $D_p > 1\mu\text{m}$, traveling from Africa's Sahara desert [Schmidt, 2002]. Hence, smoke particles that range from a D_p of $0.1\mu\text{m}$ to greater than $2\mu\text{m}$, due to particulate coagulation, are capable of traveling for long distances within the atmosphere and may also serve an important role in the decrease of lung function [Snegirev, 2001, Radke, 1994, Ovadnevaite, 2006].

Increased incidences of chronic bronchitis, tuberculosis and acute respiratory infections are also being associated to harmful particulates, specifically byproducts of wood combustion [Hood, 2002, Mishra, 1999, Ibalid-Mulli, 2004]. In his study Hood links wood fuel use in kitchens to the decreased respiratory health of Indian women and children who are most likely closest to the combustion source throughout the cooking process. Similar research in Costa Rica found $\text{PM}_{2.5}$ concentrations of up to $8170\text{ ug}/\text{m}^3$ during cooking periods [Lee, 2003]. Infants are also being affected by the toxicity of pyrogenic particulates. In 2002 a study was published linking acute respiratory infections in infants with an increase in biomass burning aerosols in the environment [Etiler, 2002]. Findings from this study indicate that acute respiratory infections in infants increased by a factor of 2 for families using wood stoves, comparable to smoking eleven cigarettes a day. As of 1998, global wood fuel consumption equaled to 1.9 billion cubic meters of wood fuel used for cooking, heating and coal production [Mathews, 2000]. Seventy seven percent of wood fuel use for cooking, heating and coal making come from Africa and Asia, the world's largest continents.

B. Ecological Factors

Through direct or indirect means, certain aerosols such as soot and ozone have become detrimental to human and ecological systems. A 2002 study in the Caribbean by Schmidt shows the contribution of globally traveling dust to increased cases of respiratory diseases and ecological imbalances in the region. Researchers at the National Oceanic and Atmospheric Association (NOAA) have done studies linking African dust particles with disruptions in the marine environment of the Caribbean [Schmidt, 2002]. Higher incidences of coral mortality were noted during large spans of dust transport to the Caribbean helping scientists establish the theory that airborne bacteria and/or viruses may be traveling along with other particulates in the air. Some of these bacteria and viruses can lead to disease or death of a coral species once they have entered the marine environment [Schmidt, 2002].

Similar studies relating asthma in inner cities and poor economical regions have been linked to particulate matter; specifically smoke and vehicle exhaust [Brown, 2007, Gilmour, 2006, McConnell, 2006]. The global travel of organic and inorganic particulates has been proven detrimental to the delicate balance observed in the atmosphere. If heavier dust particles can leap from one continent to the next, then smaller particulates may be able to span the globe and remain in the atmosphere for years [Seinfeld, 1998]. Pyrogenic particles are produced through combustion and may have many different sources, wildfires, cooking fires and other fuel uses. Other less likely sources of pyrogenically emitted pollution may be from the burning of woods undergoing phytoremediation in highly polluted land areas. Phytoremediation is a

remediation method in which plants, trees or other vegetation are used to absorb toxic chemicals from the ground, water and air [Becker, 2000]. Typical vegetation types used in phytoremediation consist of cottonwood, pine, poplar and various grass species. Chemical varieties removed include metals, pesticides, PCBs, perchlorates, and other organic and inorganic compounds [EPA, 2000, Becker, 2000]. Once extracted contaminant pathways vary. Some contaminants are merely extracted and physically collected, while others go through an internal degradation process within the plant tissues and transformed to less toxic components. Contaminants like mercury are made less volatile by conversion from solid to gas through transpiration off of plant leaves [EPA, 2000]. Throughout the range of methods imposed in the natural treatment of contaminants one factor remains fixed, that is the length of time taken to treat a site. During the period of treatment it is very possible to have conditions that will incite a fire event. While studies have been done documenting the lengthy periods that contaminants remain in leaves, stems, and other vegetative appendages little research has been done on dispersion and travel of these chemicals during a firing event [Nzengung, 2004, EPA 2000].

Under normal conditions, natural wildfires are difficult to discover, contain and avoid. Incendiary conditions not only devastate the ecology of a region but change the chemical and physical structures of soils. Wildfire research indicates that soil changes due to natural firing events lead to changes in the watershed [Ice, 2004]. As organic matter and nutrients are consumed by fire, mineral deposits and ash replace them. Such transformation leads to changes in soil acidity and removes much needed nutrients. Physical changes in soils reduce infiltration of water into sediment

and affect stream flow by creating increased stream loads. Additionally, reductions in evapotranspiration and plant root strength have been found to increase the incidence of rockfall and erosion [Ice, 2004].

C. Climate Disruptions

1. Thunderstorms: Lightning & Ozone

As firing events persist in disrupting the global budget, scientists are extrapolating new evidence linking excessive biomass burning to various climate changes [Ferretti, 2005, Penner 1992]. Satellite images from varying sources, MODIS, AVHRR and GOES have measured fluctuations in the atmosphere that are consistently related to the firing events associated with biomass burning. Furthermore researches done by Notholt and Andreae have found increased amounts of carbonyl sulfides (COS) and potassium (K) in the troposphere linking them to biomass burning sources. Backward trajectories indicate that some of these biomass burning events originated in the tropics, where slash and burn clearings are common [Andreae, 1983]. In order to understand the mechanisms associated with biomass burning it is best to look at the most common aerosols emitted through combustion including smoke, soot, carbon black (C_{Black})⁹, carbon brown (C_{Brown})¹⁰ and elemental carbon (EC)¹¹ as well as climate interaction with pyrogenic materials [Andreae and Gelenscer, 2006] .

Atmospheric reactions to pollutants are partially dominated by particle size, aggregate optical properties, air temperature and relative humidity [Graf, 2004,

⁹ “An amorphous form of carbon” (EPA, 2007)

¹⁰ “Light-absorbing organic matter in atmospheric aerosols of various origins, e.g., soil humics, HULIS, tarry materials from combustion, bioaerosols, etc. (Andreae and Gelenscer, 2006)

¹¹ “Near-elemental soot-carbon like composition, and usually referring to the fraction of carbon that is oxidized above a certain threshold temperature, and only in the presence of an oxygen containing atmosphere” (Andreae and Gelenscer, 2006)

Hobbs, 1997]. Clean clouds produced over oceans that are nucleated with larger particles have an average droplet size of 14 μ m while smoke induced clouds have an average droplet size of 9 μ m [Andreae, 2004]. The immediate consequence of the above mentioned phenomenon is that arid areas prone to wildfires suffer stronger drought conditions due to rain cloud migration. Furthermore, while slowing the production of rain clouds, the introduction of submicron pyrogenic particles ranging from PM_{0.3} to PM_{0.7} has been linked to increased thunderstorm activity over the Northern Hemisphere, Australia and the Tropics where smaller particles assist in cloud nucleation [Perkins, 2003, Lyons, 1998].

The generation of excess heat through smoke-strengthened thunderstorms assists in pushing up combusted material to higher altitudes as convection currents are strengthened and lengthened [Perkins, 2003]. Pyrogenic aerosols that escape nucleation are propelled from the upper troposphere (8-15km above earth's surface) into the lower stratosphere through updrafts strengthened by temperature differences between colder cloud bases and warmer air emanating from wildfire events [Andreae, 2004]. Further rising of submicron particles increases the humidity within stratospheric layers and generates ice and intense electrical charges, lightning [Graf, 2004]. These effects are normally not localized to the outer edges of the system, but seen throughout the entire storm structure [Perkins, 1993]. Thunderstorms generated in this manner form uncommonly high amounts of positively polarized lightning, an occurrence typically observed in colder systems and normally leading to stronger storm cloud systems [Lyons, 1998]. Works by Zhou and Zhang found heightened

levels of NO_2 in the upper troposphere to be good indicators of stormy conditions associated with lightning strikes.

Wildfires caused by lightning strikes have increased by 13% during the 2001-2006 periods, destroying an estimated four million acres of forest lands in the US alone [NICC, 2007]. While any increase in biomass burning threatens to increase the tons of particulates entering the atmosphere, lightning does not solely threaten to burn down forest acreages. Studies have shown that lightning is a principle producer of nitrous oxides (NO_x), with global lightning activity producing an estimated 2.8 Tg[N]/year [Beirle, 2003, Zhou, 2004]. The increased amounts of nitrous oxide in the troposphere undergo natural photochemical processes which in turn convert nitrous oxide into ozone (O_3) [Bond, 2001].¹² When compared to nitrogen and nitrogen oxide emissions from domestic burning, 2.5 Tg NO-N/year, lightning produces 10% more ozone boosting particulates [Ludwig, 2003].

In the same means by which nitrous oxides can be converted into ozone, other biomass burning emissions can destroy much needed stratospheric ozone. Biomass burning produces methyl bromide (CH_3Br) the single source of atmospheric bromine with a two year lifetime [Cicerone, 1994]. Although other sources of methyl bromide exist, the ocean and pesticides, biomass burning emits approximately thirty percent more of the aerosol than any other means, at 50 gigagrams per year [Mano, 1994]. Methyl chloride (CH_3Cl) is an additional ozone destroying byproduct of biomass burning and is emitted at a rate of 1.8 Tg/year. Despite the fact that methyl chlorine degrades ozone, methyl bromide is forty percent more efficient in ozone destruction

¹² See appendix for associated photochemical reaction

[Mano, 1994]. Both chemicals are assisted through photochemical processes in the breakdown of ozone [Cicerone, 1994].¹³

2. Cloud Properties: Absorption & Reflection

While heightened levels of ozone in the troposphere are an obvious hazard to both plants and animals, cloud mechanics driven by pyrogenic aerosols create additional concern. Cloud formation due to biomass burning contains many complexities with particle size and chemistry being the dominating factors in determining if or when cloud formation occurs and whether the cloud will act as an absorbing or a reflecting medium.

As a byproduct of wood fuel combustion, carbon black serves as an atmospheric absorber of solar radiant energy. Work by Hobbs in 1997 attributes atmospheric cooling to the radiative forcing caused by biomass burning, estimated to be -0.3 W/m^2 compared to 2.45 W/m^2 contributed by the greenhouse effect. However, a 1998 study by Kirrkerag found that carbon black produced by polluted regions in North Africa, Antarctica and Europe had varying aerosol forcing results. Cooling was found to be -5 W/m^2 over Europe, but a warming effect was found in North Africa and Antarctica, at rates of 2 W/m^2 and 0.4 W/m^2 respectively. While Kirrkerag used a single column model, this warming effect over North Africa and Antarctica are seen to be due to the external mixing of carbon black and sulphates.

An Amazon study found the reduction of cloud coverage from 38% (clean) to 0% (smoke) because of biomass burning [Koren, 2004]. The same study revealed

¹³ See appendix for associated photochemical reaction

that heavy aerosol concentrations over the Indian Ocean and the Amazon basin formed absorbing aerosols that had a warming affect on tropospheric layers and reduced radiation to the ground by 15%. Stunted amounts of ground reaching radiation lowered evaporation off of vegetation and water surfaces. Subsequently less cloud formation results in drier more stable air which may benefit areas currently suffering from flooding, but dry air creates more problems for drought prone locales like the African Sahara desert. Drier air also suppresses convection currents that may otherwise bring pollutants to higher elevations [Koren, 2004]. Findings in the same paper by Koren, however, have found the more common occurrence of aerosol induced reflection occurring in China. In China great biomass burning has caused an uplifting of hot air which subsequently brings in cold wet air that increases precipitation leading to flooding. It seems that different areas are exhibiting different symptoms of the same problem, high amounts of smoke and soot in the atmosphere, with China having more floods and the Amazon and Sahara drying out [Koren, 2004].

Particulates from firing events are know to generate an abundance of submicron sized aerosols [Crutzen, 1990]. These particles assist in cloud nucleation by forming clouds composed of small droplets, 14 to 9 um [Kaufman, 1997]. Studies show that a cloud formed by these means produce less rain and reflect more sunlight, smoke-cloud forcing $2\text{W}/\text{m}^2$ [Kaufman, 1997, Crutzen, 1990].

D. Previous Biomass Burning Studies

Many studies have been done on biomass burning and the chemical outputs produced by firing events. The goal of this review is to familiarize the reader with previous studies and their conclusions.

Multiple atmospheric reactions to varying chemicals introduced by firing events have found a connection between wood types and chemical smoke species released. For instance, conifers and hardwoods were found to produce different types of smoke. Studies by both Kjallstrand and Simoneit found that conifers produced major molecular tracers such as methoxyphenols and diterpenoids, while hardwood smoke contained 2,6-dimethoxyphenols and methoxyphenols. The difference between the two wood types stems from conifers lacking a lignin with 2,6-dimethoxyphenol [Kjallstrand, 1999]. Aside from giving off the molecular tracers mentioned above, both wood smokes contained carbon monoxide, methane, nitrous oxides and other assorted aerosols. Smoke produced from barley and rice straw discharged similar chemicals with an average $PM_{2.5}$ concentration of 129.6 ± 24.6 ($\mu\text{g}/\text{m}^3$) and PM_{10} concentration of 24.2 ± 7.7 ($\mu\text{g}/\text{m}^3$) [Ryu, 2004]. A 1997 study by Lute incinerated wood, sticks, twigs, leaves and other organic materials to simulate land clearing practices. Lutes study utilized a GC-Mass spectrometer and found carbon monoxide as well as total hydrocarbon discharged.

Other researchers took very different approaches in examining smoke chemistry. Liodakis, Zheng, Kozinski, Olson and Wiinikka have looked at the effects of temperature variation on chemistry. All five studies agreed that emission chemistry is dependant on temperature. Liodakis' work focused more on woods found in clearing areas of the Greek countryside such as Aleppo pine, Olive, Italian Cypress and the Holly oak. This study found that lower burning temperatures, 600°C , produced concentrated amounts of ash, potassium, sodium, zinc, and chlorine. While higher temperatures, 1000°C , produced heightened concentrations of calcium,

magnesium, manganese, iron, silicon, titanium, phosphorous, sulfur and soluble alkalinity. Korinski's experiment pinpointed the growth and formation of soot particulates as owing to oxygen mixing within the aerosols. Additional determinations by Zheng focused on varying burning temperatures and concluded that biomass residue underwent changes in the methyl group. As temperatures increased in the biomass residue, the methyl group slowly disappeared until at 1300°C it completely vanished. Olson's study on softwood pellets from three Swedish manufacturers found that during flaming 2-methoxyphenol was formed, but during glowing benzene was produced. Wiinikka, 2006, also focused on the burning of wood pellets specifically 6mm pellets from Scottish pine and Norway spruce. The temperatures observed during this study ranged from 1450°C to 200°C. The particle sizes produced during and after combustion fell under PM_{2.5}. In this study higher temperatures produced lower concentrations of pyrogenic aerosols with smaller diameters. Meanwhile, lower temperatures produced larger particulates in higher concentrations due to the condensation of particulates [Wiinikka, 2006].

E. Previous Biomass Burning studies using FTIR

1. FTIR of Raw Wood

Recent work on the infrared spectrum of wood materials has observed that varying tree species interact with chemical treatments used for wood preservation [Upreti, 2006]. Upreti's study uses 50um shavings from the Indian kino tree (*Pterocarpus marsupium*) mixed with KBr to investigate changes within the wood structure and found that woods treated with a certain preservative degraded slower than other chemically treated woods. Work by Anderson also found that wood

preservatives change the infrared spectrum of various hardwoods. An additional FTIR study on raw wood material observed the wood cell walls of several softwood species in order to classify wood cells amongst those species [Hori, 2002]. Hori was successful and found that the infrared spectrum for wood cell walls from one tree differed from that of another tree. In 2001 a study performed by Hinterstoisser found that the vibrational nodes located at 1510 and 896 wavenumbers could be used to distinguish levels of lignification within a tree species. An assortment of fungi in woods has also been distinguished using FTIR by Naumann in 2005.

2. FTIR of Biomass Burning

Many studies have been done on biomass burning and the chemicals released during and after the combustion process. Most studies, however, have been operated using an open path Fourier transform infrared spectrometer (OP-FTIR), airborne FTIR, or Fourier transform near infrared spectrometry (FT-NIR).

At the forefront of such studies is Yokelson, who in 1996 produced two studies citing the chemical analysis of mixed wood products. In the first study pine needles, sagebrush and mixed fuels simulating forest fires are incinerated to determine fire temperatures, fuel mass loss and total mass flow. Yokelson's first study found that CO_2 , NO_x , SO_2 and water vapor were produced during flaming, while smoldering events yielded CO_2 , methane (CH_4), ammonia (NH_3) and ethane (C_2H_6). The secondary report by Yokelson reviewed the smoldering affects of a mixture of hardwoods, grasses and organic forest floor material, duff. Findings show that these types of combined materials produced tar and generate both white and black smoke. White smoke is associated with oxygenated organic molecules, while

black smoke is connected to oxidized compounds [Yokelson, 1996]. In 1999, Yokelson made use of an airborne FTIR with a “flow through” multi-pass cell (AF-FTIR). The study was done over a North Carolina firing event with emission ratios of $2.5 \pm 1\%$ for CO, formaldehyde (H_2CO), acetic acid (CH_3COOH) and methanol (CH_3OH).

Research by Goode, in 1999, also found similar ratios for the emissions of CO, H_2CO , CH_3COOH and CH_3OH in grass fires only. In this work, Goode used an OP-FTIR with an associated glass cell that held the smoke as it was being produced. In 2003 Bertsci used the same method to observe the thermal properties of a mixture of woods and organic materials. This study found that the chemicals released during smoldering differed depending on whether the material was right above the source (ground level) or higher above in the smoke column. Emissions at the ground level surpassed higher altitude measurements by a factor of 2.5 [Bertschi, 2003].

3. Particle Size & Temperature Dependence

Infrared spectrometry is a chemical analysis tool that can pinpoint characteristic absorption features in particulate matter. Temperature changes within substances, like wood, determine inner bond responses which can be detected using FTIR. A 2006 study by Idalgo found that particle size and nucleation were affected by temperature and the differences could be captured on infrared spectra. The temperatures observed in the study ranged from 274°C to 319°C , and was done on lithium oxide (Li_2O) and tellurium dioxide (TeO_2). Idalgo found differences in intensities over peak wavenumber regions. A similar study by Sharpless (1958) focused on particle size differences within chloranil ($\text{C}_6\text{Cl}_4\text{O}_2$) and its absorbance

responses. The sizes used for the experiment ranged from $12.2 \pm 0.1 \mu\text{m}$ to $158.8 \pm 6.2 \mu\text{m}$. Correlations between each spectrum were strong, with small differences being found in absorbance intensity, which concluded that the same chemical would absorb at the same frequency independent of particle size [Sharpless, 1958].

F. Scanning Electron Microscope & Energy Dispersive Spectroscopy (SEM/EDS) of Combusted Material

Scanning electron microscopy and energy dispersive spectroscopy have been utilized in material and chemical sciences since its inception in 1935. While some research has been applied to wood and wood cell structures, not many studies have been done using SEM/EDS on wood smoke or soot. In 2005 a study by Gwaze focused on using SEM/EDS to look at various wood smoke sizes: 200, 275, 350 and 450nm on filters. Gwaze found variously shaped matter with radiuses approximating $25.5 \pm 3.5 \text{nm}$. This study only focused on smoke material originating from *Fagus Sylvatica* (European Beech wood) produced through open furnace combustion.

In 2004 experiments by Baliga focused on combusted materials from tobacco products, cigarettes. Baliga's research looked at the morphological features of tobacco and the coal char from cigarettes. This work found a consistent rod shaped formation and vesicles within coal but no ash material. Other particles found within the combustion byproducts were inorganic crystals and oxidized particulates. Elemental analysis of the tobacco products found Sodium (Na), Potassium (K), Sulfur (S), Magnesium (Mg) and Potassium (P) in ash. Carbon, Nitrogen and Hydrogen concentrations were found to decrease in ash but not coal material.

G. X-Ray Fluorescence of Combusted Materials

X-Ray Fluorescence analyses on smoke products are few, but two such works were found. Al-Mutairi's research focused on oil based pollutants created by oil fires in Kuwaiti. The main focus of this work was to study the effects of biomass pollutants on building material strength. By using contaminated sand, gravel and concrete to produce building materials Al-Mutairi was able to find the effects of various elements on material strength. Surface elements found were lime (CaCO_3), Magnesia (MgO) and Sulfur trioxide (SO_3) at elevated amounts while alkalis (Na_2O & K_2O), Alumina (Al_2O_3) and Silica (SiO_2) were found at lower concentrations on surfaces, concentrations of weakening elements lessened at deeper sampling sites. Al-Mutairi surmised that building material strength was compromised by oil based pollutants.

Molnar looked at pollutants created by indoor wood burners using the XRF. This work concentrated on finding pollutant levels for personal and indoor pollution during the combustion of Scandinavian Birch and Spruce. Samples were collected by cyclones and impactors and analyzed via XRF. Elemental concentrations of K, Ca and Zinc (Zn) were found to be elevated for both indoor and personal exposure.

H. Satellites

For decades satellites have collected data over the earth for the purpose of giving scientists a broader view of the chemical and biological diversities that our planet has to offer. While there are many satellites that can be used to study the temperature variations associated to biomass burning, or follow the plumes of ozone

as they are created in the atmosphere, very few have the ability to chemically characterize pyrogenically emitted particulates.

The moderate resolution imaging spectroradiometer (MODIS) is one of the satellites used to observe pyrogenically produced aerosols as they are produced. By using thermal bands scientists can follow a plume and assume that its chemistry is close to what is found in a laboratory or in smaller in-situ experiments. As Watson noted in 2003 as he studied the plumes originating from active volcanoes, MODIS channels 31 and 32 works well in observing ash clouds of sulfur dioxide (SO_2) and the radical SO_4 . MODIS has also been used to detect smoke cloud concentrations, by looking at the optical thickness of smoke columns [Kaufman, 2003].

Other research, Prins 1994, has used information from the Geostationary Operational Environmental Satellite (GOES) satellite to look at pixel information and determine whether or not fires are taking place at certain locations. McCourt (2004), however has gone one step further by using a scanning high resolution interferometer sounder (S-HIS) to review spectra from local firing events. McCourt found that fire events correlated to a CO_2 band at 2400 wavenumbers, this peak was dubbed the “blue spike”.

NASA’s Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) has worked well in collecting chemical data over land, vegetation and fires as they occur. In 1997, Martin worked with AVIRIS data to determine forest canopy chemistry over Blackhawk Island in Wisconsin and Harvard forest in Massachusetts. Using data with a spatial resolution of 20m Martin was able to find nitrogen and lignin signatures. Moura, 2003, used AVIRIS information to determine the effects of smoke on the normalized difference vegetative index (NDVI). Differences in NDVI were

found to correlate with smoke column density over the Brazilian savannah region [Moura, 2003].

Chapter 3

I. Research Design and Methods

A. *Instruments*

1. Fourier Transform Infrared Spectroscopy (FTIR)

The Fourier Transform Infrared spectrometer (FTIR) works on the basic principles of infrared absorption spectroscopy. Infrared light is a type of electromagnetic radiation which covers a range in the spectrum of 0.78 to 1000 μm (Finlayson, 2000). The infrared spectrum is usually broken down into three main groups: The near infrared covering a range of 0.78 to 2.5 μm , the mid-infrared covering a range of 2.5 to 5.0 μm and the far-infrared which covers a range of 50 to 1000 μm (Pavia, 1979). However, the most commonly used range in infrared spectrometry falls between 2.5 to 42 μm (4000-670 cm^{-1}).

Infrared spectroscopy studies the interaction of infrared radiation with matter. In order for absorption of infrared radiation into the molecular bonds to occur, there must be bonds present in the substance. However, if intermolecular bonds are too rigid as with diatomic molecules of nitrogen or oxygen, vibration cannot occur since changes in dipole moment are nonexistent. The theory follows that when infrared radiation hits a molecule the radiation may be absorbed provided that the vibration within the molecule triggers a change in the entire dipole moment of the molecule, see Figure 4 (Smith, 1996). This triggered change then causes absorption of the infrared light into the molecule, thereby causing the molecular bonds to increase their vibrational states. Every molecule absorbs at a certain wavenumber or frequency. Hence, organic and inorganic molecules can be identified by using characteristic absorption frequencies for each molecular group.

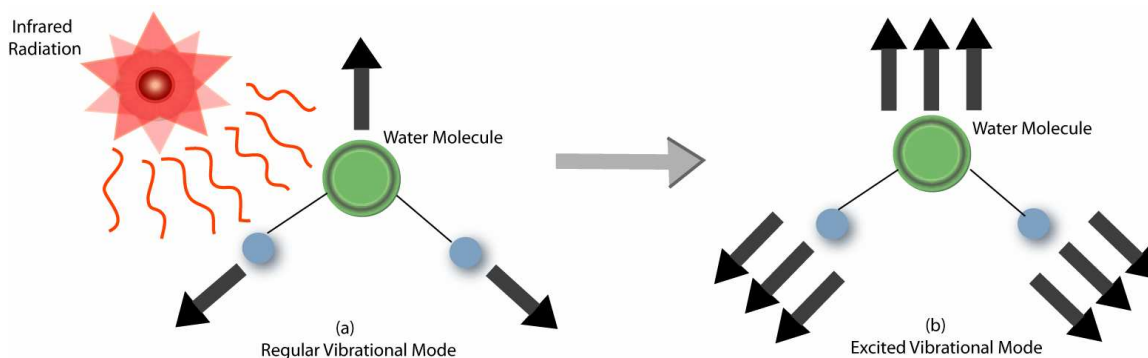


Figure 4 Scene (a) shows the interaction between infrared light and a water molecule. As the infrared energy is absorbed the normal vibrational mode increases. Scene (b) shows the increase in vibrational speed caused by infrared light absorption.

These groups are called functional groups and in the analysis of both inorganic and organic matter, functional groups aid in the identification process. Correlations of wavenumber or frequency are made using charts for known substances thereby linking absorbance intensities and the wavenumber at which they occur to cataloged chemistries. Infrared spectroscopy is a useful tool in chemical identification because functional groups within chemical structures are comparable. This means that a carbonyl which exhibits a stretch at 1700 cm^{-1} , will exhibit the same stretch in a ketone, aldehyde or carboxylic acid at the same wavenumber [Griffiths, 1986]. Since absorption is unique to the bonding found within a particular chemical structure, the spectrum generated then becomes unique to that chemical structure. For example, the spectrum of pure water in one lab will yield the same results in another lab. With each chemical species yielding an infrared fingerprint unique to its chemical structure will also be unique [Smith, 1979].

FTIR can be applied to solids, liquids and gases which have been mounted onto filter media, enclosed in special cells, smeared onto thin films, mixed into mineral oils or dispersed in KBr [Smith, 1979]. Each sampling technique is bound by limitations, KBr dispersal is limited because KBr is a hygroscopic material and must be handled specifically to decrease water absorption from the atmosphere. A limitation of the FTIR itself is its sensitivity to atmospheric gases such as carbon dioxide and water vapor which are strong infrared absorbers. Vacuum chambers have been fitted onto most FTIR instruments to decrease the effects of atmospheric gas absorbance for this purpose.

The Michelson interferometer was created in 1891 and is the basis by which present FTIR instruments are built [Smith, 1996]. The interferometer works by introducing an infrared light source into a chamber, see Figure 5. The infrared light travels to a grating beam splitter which divides the light and sends it to one stationary mirror and one moving mirror. A scan is produced by one cycle of back and forth motion of the moving mirror. During normal sampling analysis a minimum of 64 and a maximum of 256 scans are taken per sample. Scan numbers are user determined and it follows that the higher the number of scans the lower the signal to noise ratio (SNR) in the spectrum [Smith, 1996]. The path difference between the mirrors dictates the range of beam intensities received by the sample as well as instrumental resolution [Griffiths, 1986]. The beams are recombined at the beam-splitter where interferences occur and are then refocused onto a mounted sample, where interactions between infrared light and sample molecules take place. Most research grade FTIR instruments contain the sample within an evacuated vacuum sealed chamber to minimize atmospheric absorption interferences. An interferogram, a measurement of detector response versus path length, is collected and sent to a computer where a Fourier transform is applied to

produce infrared spectra. The two FTIR instruments used in the duration of this experiment were: the IFS 66v/S Vacuum FTIR (mid and near infrared spectral region of 400 to 8000 cm^{-1} (1-20 μm)) and the Thermo-Nicolet (TN) Closed-Path FTIR (mid-infrared at 400 to 4000 cm^{-1} (1-10 μm)).

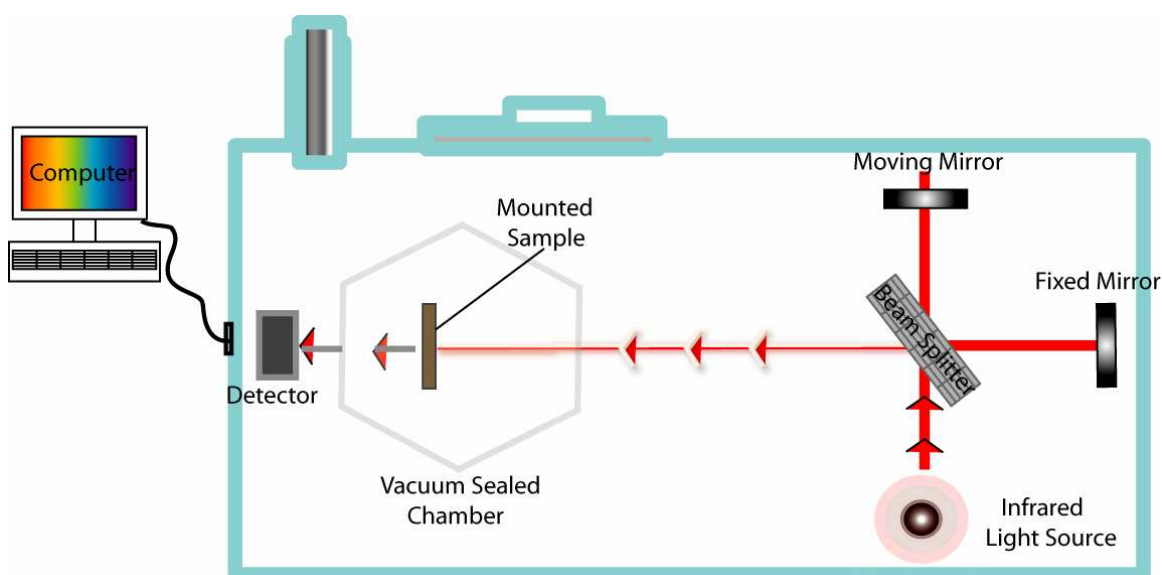


Figure 5 Schematic of Fourier Transform Infrared Spectrometer (FTIR). An infrared light is generated and sent through a beam splitter which sends one beam to a fixed mirror, the next to a moving mirror. Once recombined, the infrared light goes through the sample where atomic interactions take place. The resulting beam is sent to a detector where an interferogram is formed and a Fast Fourier transform applied.

2. Scanning Electron Microscope with Micro-Analysis (SEM/EDS)

The Scanning Electron Microscope (SEM) is an instrument capable of observing the topographic, morphologic, compositional and crystalline properties of materials at magnifications ranging from 10 to 200,000 times. By means of three dimensional images the

SEM is effective in particulate determinations for both organic and inorganic substances.

The first SEM was created by German scientists in 1935 and has been a standard analytical tool in biology, chemistry and engineering laboratories for decades (Clark, 2004).

Typical SEM systems use either tungsten or lanthanum hexaboride filaments to generate an electromagnetically focused electron beam. As the beam travels through condenser lenses and certain apertures the electron beam is transformed from stages of coarseness to a fine concentrated stream of electrons. Once the beam has reached scanning coils it has been shaped for an effective magnification, the sample is then bombarded by these electrons and secondary electrons are generated and released [Gabriel 1985]. The newly released secondary electrons are captured onto a grid pattern and simultaneously transmitted to a television screen where layer by layer an image is built (Figure 6). The SEM used in this research is the Zeiss DSM 940 model, with tungsten filament and a maximum resolution of 5nm at 15kv. By itself the SEM can be used to discover properties such as: pore size, surface roughness, fractures and other material weaknesses. However, in conjunction with the Energy Dispersive X-Ray Spectrometer system (EDS or EDX) it is also possible to determine which elements are in a sample.

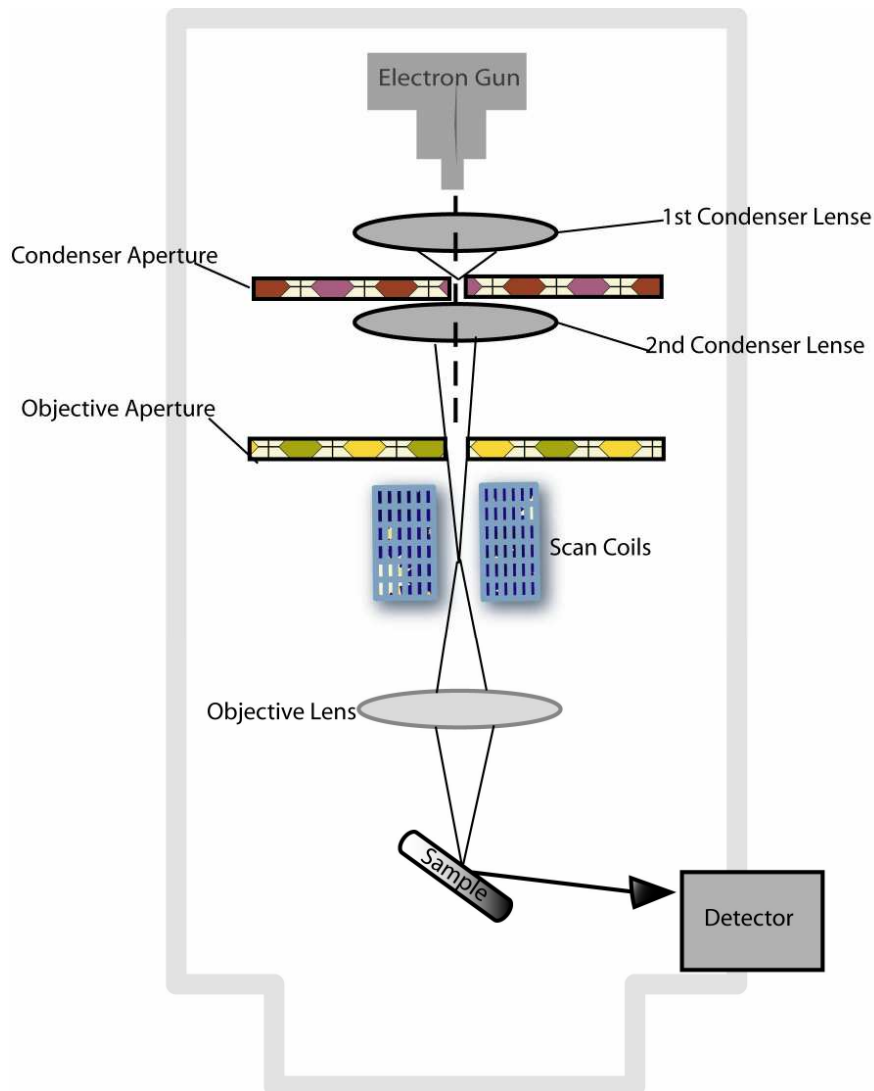


Figure 6: Schematic SEM process. Step1: An electron beam of monochromatic electrons is generated and focused by electromagnets and sent through the first condenser. Step2: The first condenser lens controls the initial current (coarseness) and removes high-angled electrons. Step 3: The condenser aperture continues to filter out high-angled electrons and further narrows the beam. Step 4: The second condenser lens compresses the electron beam into a finer electron stream. Step 5: More high-angled electrons are filtered out within the objective aperture. Step 6: The scan coils deflect the electron beam onto a sample in a grid pattern for an interval of time determined by the scan speed. The information is sent to the detector which simultaneously casts an image on a television screen.

Both the SEM and EDS system rely on proper sample coating, since differences in coating thicknesses can alter quantitative measurements. Therefore coating mediums are chosen according to the elements being looked for. If looking for carbon rich materials, the coating can either be gold or gold/palladium other wise coating with carbon is satisfactory. The EDS system works by pairing the functions of the SEM, electron bombardment, with the capabilities of an x-ray spectrometer. After the dislodgement of electrons, the secondary electrons return to transitional stages and emit radiation in the form of x-rays (Figure 7). EDS detects the emitted radiation and is able to give both qualitative and quantitative information on a specimen. The EDS system used in this research is the Princeton Gamma-Tech Prism 2000, with an energy resolution of 130eV.

Since soot and smoke are mostly composed of carbon, the SEM-EDS system is very useful in locating any other elemental properties included in the smoke and soot mixtures. By capturing the SEM-EDS images it becomes possible to study the structural features of smoke and soot captured onto KBr pellets and detects how much of the actual burn has produced any other elements other than carbon. SEM-EDS analysis also gives a comprehensive view of the pore sizes available on the KBr collection media used in the research.

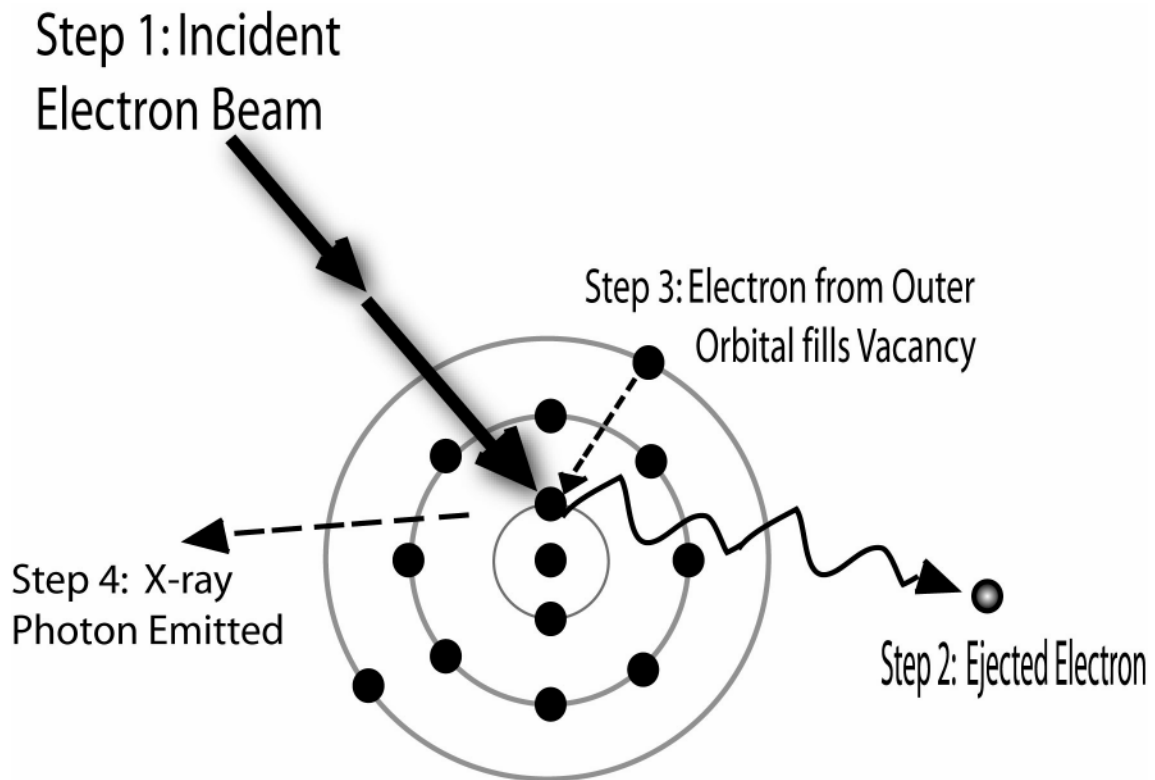


Figure 7: Electron bombardment dislodges K orbital electron, which is then replaced by an electron at a higher state (L orbital). The energy released is called an x-ray photon.

3. X-Ray Fluorescence (XRF)

X-ray fluorescence is a method used to detect metals and other various elements. X-ray fluorescence works by bombarding an elemental tube, like Au or Mo, with electrons thereby causing the tube to release x-rays (see Figure 7). These newly created x-rays then travel and hit the sample causing the sample to fluoresce. The wavelength of fluorescence of the sample is unique to a specific element. The resulting spectrum generated is used for both qualitative and quantitative analysis, usually being compared to standards for a means of identification.

X-ray fluorescence is a useful analytical addition to this research because it will be used as verification for the findings of the Fourier transform infrared spectrometer and the Scanning Electron Microscope and Energy Dispersive system. The XRF will assist in finding any other elements that the SEM/EDS system has missed both prior to burn and after incineration

4. Thermocouple

Temperature analysis of the combustion of biomass, coals and other vegetations will be collected by using a thermocouple. A thermocouple is a basic geological tool which works by using two different metals, called sensors, which when cooled or heated produce a unique voltage (Bayda, 2003). The sensors come in an array of different metal combinations. The sensor type that will be used in this research will be the type E sensor. The type E sensor consists of chromel and constantan, and can measure a temperature range of -70 to 1600 degrees Fahrenheit (-57 to 871 degrees Celsius). The type E sensor is a sensor which can be used in vacuums or highly oxidizing environments and has been chosen for its high temperature capabilities. The voltage generated can be correlated to a distinct temperature. The charts corresponding to the metals used give the converted temperature readings.

B. Methods

1. Collection Media: Potassium Bromide (KBr)

The Potassium bromide (KBr) mull, or pellet, is a commonly used pelletizing agent for dispersing samples in the FTIR method [Sterling, 1959; Tuddenham, 1960]. Potassium bromide, KBr, is a type of salt that is transparent in the infrared spectrum up to 400 cm⁻¹, 2.5 microns, (Pavia, 1979). A disadvantage with using KBr is that it is a hygroscopic material, which means that it can easily absorb water from the atmosphere (Smith, 1996).

Due to the uniqueness of the collection media it is necessary to keep potassium bromide as dry as possible at all times, either by keeping the powder in an oven at 100 degrees Celsius or by keeping samples in desiccators. Excess drying can cause brittleness after the potassium bromide has been pressed and so any pellets or filters made from potassium bromide are contained in small glass dishes.

The present study uses a novel design that causes smoke particles to become embedded in KBr powder. The impactor comprises a cylindrical cup with a network of holes in its base and an exit tube that holds KBr powder (KBr cup, Figure 8). Air is drawn through the compressed powder via the holes in the base of the cup causing a loading of particles onto the KBr plug. The cup is loaded by placing approximately two grams of loose, 60 micron KBr powder inside a central O-ring (Figure 8). A housing is placed over the cup and the cup-housing system is compressed using a hydraulic press at approximately 500psi. Test conditions that lead to the selection of a 500psi compression are in the “Pressure Tests for Potassium Bromide Section” Table 3 and Figure 10. The KBr pellet remains porous and can be used to scour aerosols by drawing air through the systems.

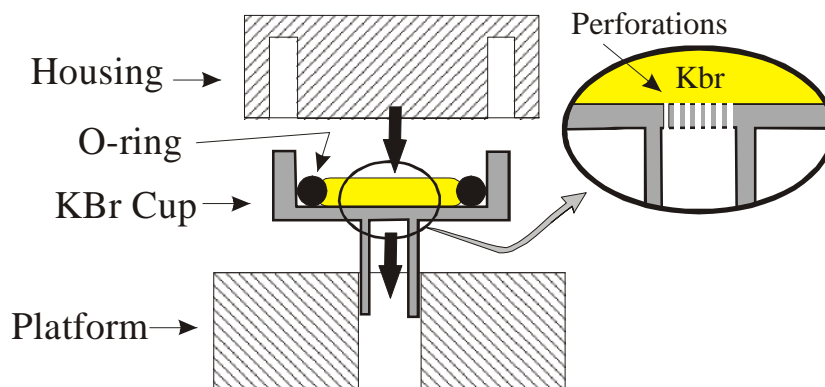


Figure 8 KBr aerosol filtration system: 2” diameter (O.D.) KBr pelletizing cup with 0.5” deep walls and a 1.5” stem powder; insert illustrates air passageways in the base of the cup.

The KBr-cup is centered in a rubber stopper and placed in a 250 ml Erlenmeyer flask (Figure 9). The exit port of the flask is connected to a Millipore High Output pump vacuum pump drawing air through the KBr matrix at a rate of 6 ± 0.2 liters per minute. The pressure applied to the KBr and the size of the pellet is sufficient to collect an FTIR sample in as little as 20 minutes. To carry out the analysis, the KBr pellet is removed from the cup, transferred to a drying oven maintained at 100 °C to prevent hydration for 24 hours, ground, and then re-pelletized at 500 psi using a standard KBr pelletizing method [Sterling, 1959; Tuddenham, 1960].

By directly collecting aerosols onto the potassium bromide media it is possible to directly analyze the aerosol samples from the collection via a solid state FTIR. Potassium bromide ‘soft’ pellet filters were created for this specific purpose. A ‘soft’ KBr pellet filter is a pellet pressed to any amount less than the 1100lbs it takes to pressurize powdered potassium bromide into glass. These pellets are produced on the “Steiner Press,” a steel press designed by Dr. Steiner (Figure 8.) The Steiner press was designed to allow for the potassium bromide to be pressed and held in the same container that is used for aerating. This method should minimize the loss of potassium bromide as the vacuuming, via the vacuum pump, takes place. In preparation for the experiment the vacuum pumps were calibrated for airflow consistency and the airflow rate through the vacuum pump was found to be 0.1 liters per second for 500lb of pressure.

2. Aerosol Collection Chamber

Testing of this capturing technique has been performed in a controlled experiment using soot and smoke aerosols generated by the low temperature, 300 to 450 degrees Fahrenheit, burning of various lumber. The lumber used was: conifer *Pinus strobus* (white

pine) and deciduous *Prunus serotina* (cherry), *Acer rubrum* (red maple), *Fraxinus nigra* (walnut), *Fraxinus Americana* (ash), *Betula papyrifera* (birch), *Quercus alba* (white oak) and *Quercus rubra* (red oak). The purpose of this phase of the experiment was: (1) To find a standardized method of collecting aerosols directly onto KBr; (2) To find the spectra generated by varying wood species and; (3) To be able to match the spectra of the direct (mixing of soot directly into the KBr to create a standard pellet) and indirect (using the soft pellet as an air filter to capture the soot aerosols as they are generated) soot sampling methods.

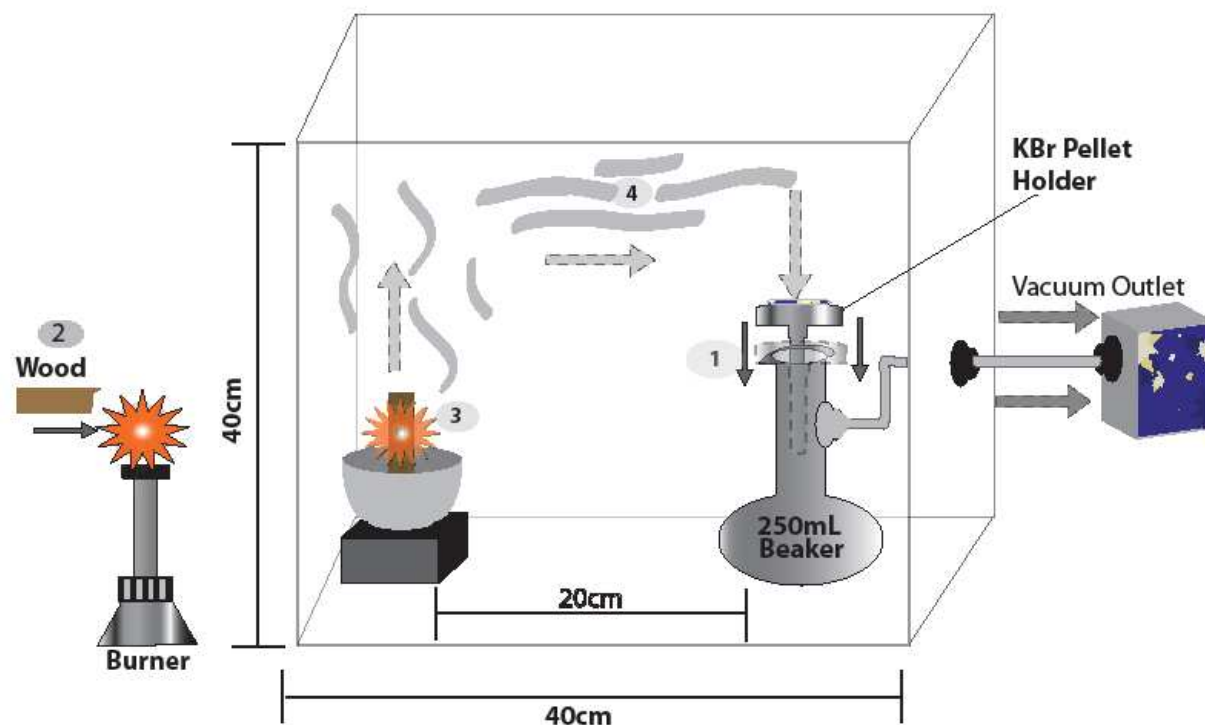


Figure 9 Aerosol collection procedure: (1) KBr Pellet Holder is fitted in the mouth of a 250mL beaker. (2-3) Wood is ignited and placed in a porcelain crucible in a sealed Lucite chamber. (4) smoke is filtered through the KBr pellet filter. (5) After thirty to forty minutes the KBr pellet is removed from the chamber and placed in a desiccator.

Soot is collected by burning woods of various types in an enclosed chamber (Figure 9.) Before initiating combustion a potassium bromide pellet is placed on the mouth of a 1000ml flask which is attached to a vacuum pump. The wood is then held with tongs over a flame in order to initiate combustion. For the burning of leaves and or grass ignition of the sample will be as follows: The leaves and or grass will be placed in a pile with a hollow center. An ignition pipe with a flame at the end will be held under the hollow pile of leaves and or grass until ignition has begun and quickly removed. At the onset of flames the vacuum pump is turned on and the wood allowed to burn in a porcelain crucible. The tube connecting the vacuum pump to the flask is fitted through a hole on the side of the box and sealed to minimize smoke escape. The smoke and soot created is subsequently vacuumed onto the pellet and through it. The vacuum pump works at a rate of 4 cm Hg throughout the proceedings.

3. Pressure Tests: Potassium Bromide Pellets

Test conditions that lead to the selection of a 500psi compression are in the Table 3 and Figure 10. Since Potassium Bromide has not been previously used as a filter medium for particulate collection, tests were initiated to infer the proper means of collecting and handling the samples. Hence, a method for aerosol collection onto KBr pellets was devised. Initial pressure tests were made in the laboratory to test for the best pressures to form the soft pellet potassium bromide filters. The manual press in the laboratory increases by steps of 500lbs and so pressure tests at intervals of 250lbs were generated and tested to see which pressure would form a better filter. Pressure comparisons of Potassium Bromide (KBr) soft pellets at: 250lbs, 500lbs and 750lbs clearly show that the highest concentration of materials is being

collected at pressures of 500lbs (seen in yellow in Figure 10.) Table 3 shows that absorbance in the 500psi were on average 75% higher than absorbance at 750psi. The average increase in absorbance was 79% when comparing 500psi to 250psi. The higher absorbance numbers in the 500psi pressed pellets indicate a heightened capturing ability at that pressure.

Wavenumber (cm-1)	Absorbance Intensity (250 psi)	Absorbance Intensity (500 psi)	Absorbance Intensity (750 psi)	% Increase (500 psi vs. 750psi)	% Increase (500 psi vs. 250 psi)
669	0.0088	0.051	0.0036	93%	83%
877	-0.0057	0.0212	-0.0059	128%	127%
1437	0.005	0.079	0.013	84%	94%
1458	0.0144	0.0902	0.022	76%	84%
1508	0.018	0.0524	0.0227	57%	66%
1541	0.012	0.0335	0.0143	57%	64%
1560	0.0254	0.0424	0.0275	35%	40%
1655	0.0252	0.0354	0.0282	20%	29%
2335	0.0029	0.0906	0.003	97%	97%
2345	0.0118	0.0998	0.0122	88%	88%
2362	0.0075	0.1401	0.0089	94%	95%
Average				75%	79%

Table 3 Comparison of CP-FTIR Purple Heartwood results for combustion experiments that involve increasing initial pelletization pressures (250 to 750 psi) showing greatest signal to noise increase (average 75-79 percent increase in signal to signal absorbance) is achieved using at 500psi of compaction pressure applied to the KBr cup of Figure 1.

Pressure Comparison of Potassium Bromide(KBr) soft pellets

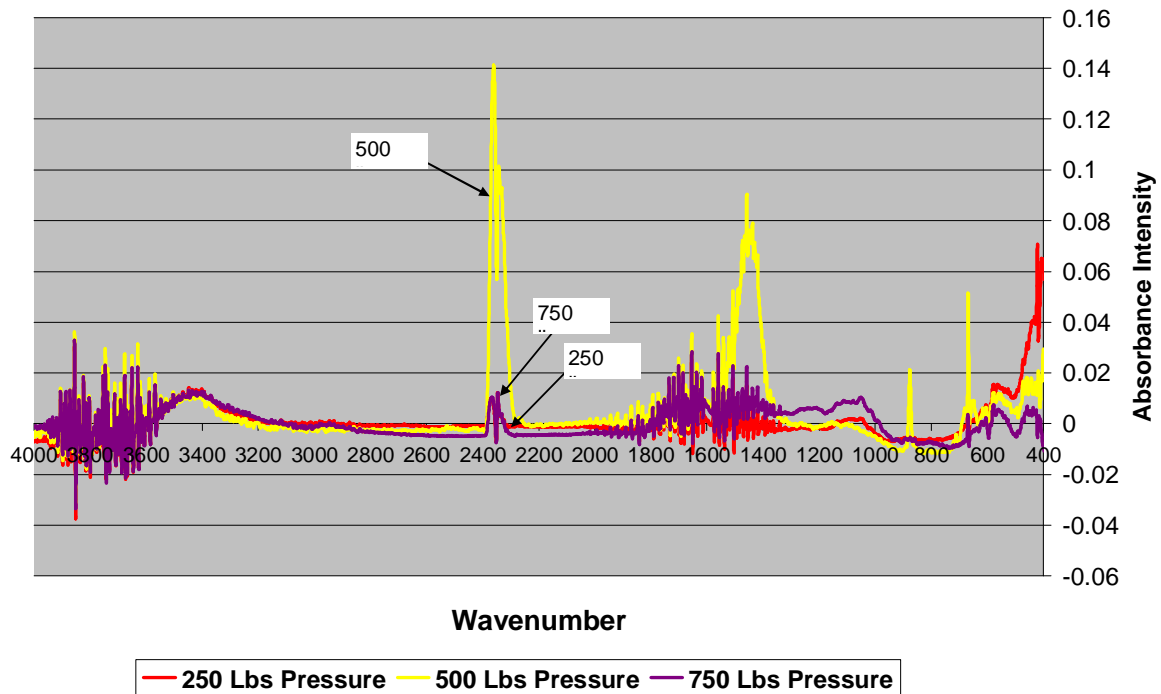


Figure 10. Pressure comparison of Potassium Bromide (KBr) soft pellets at: 250lbs, 500lbs and 750lbs. The comparison clearly shows that the highest concentration of materials is being collected at the 500lb pressure (seen in yellow.)

Possible reasons for low collection concentrations at 250lbs may be due to the lack of cohesion of the potassium bromide grains allowing for airflow to pass right through the media without properly capturing aerosol particles. At 750lbs, shown in purple, the reverse is true. The high pressure of the 750lbs, purple line, has brought the potassium bromide grains so close together that the tight weaving of the grains does not allow for easy airflow, thereby restricting aerosol capture within the soft pellet. At 500lbs of pressure, shown here in yellow, the grains are tightly enough woven to sustain an environment where aerosol capture is maximized. With this in mind flow rates for the two pressures falling under 750lbs, 250 and 500lbs, were taken. The 250lb press had a flow rate of 0.09 L/s (liters per

second) and the 500lb press had a flow rate of 0.106 L/s, and so 500lbs of pressure was chosen for future pressing.

4. Temperature Capture

Temperature readings were collected on a Fluke thermocouple, a geological tool used for measuring temperature. A thermocouple uses two different metals that when cooled or heated generate a specific voltage corresponding to a specific temperature. Charts are usually used to look up corresponding temperatures. A chromel/constantan type B sensor, capable of measuring temperatures ranging from -57 to 871 °C (-70 to 1600 °F), was used by placing the sensor tip directly into the flame produced by the combusting material. In order to avoid contamination from the sensor tips, a separate set of samples were used to measure temperature variations throughout the combustion process. By maintaining the thermocouple sensors in place during the combustion and flaming processes changing temperatures were recorded. The set consisted of the same woods used throughout the group experiments and were burned and handled identically to ensure experimental consistency.

After sample collection onto the KBr pellet, the holder and KBr pellet were reweighed and the pellet scraped off of the holder and placed into a glass dish. The soft pellet remained covered in an oven, maintained at a temperature of 100 degrees Celsius, for 24 hours and reground into powder for analysis. The new sample was dispersed in KBr and diluted to about 1%.

5. Reproducibility Test of Cherry Wood

Using a Nicolet Fourier Transform Infrared Spectrometer (FTIR) the infrared spectrum of plain potassium bromide and a soft pellet pressed to 500 pounds were obtained and compared to note any differences arising from applying pressure for pellet creation, Figures 11 and 12. The spectrum of the pressed potassium bromide, Figure 12, exhibited a significant difference in water and carbon dioxide levels when compared to a normal potassium bromide spectrum, Figure 11. These peaks are due to the use of a non-evacuatable FTIR collection chamber. Therefore any spectra analyzed by the Nicolet FTIR instrument will have the spectrum of the potassium bromide plus atmospheric gases used as a background to the smoke and soot spectrums.

Duplication of initial procedures on the lumber for the species *Prunus serotina* (cherry wood) yielded closely matching spectra for each of the four samples, original cherry and three duplications, with a variance calculated at 0.0013 (Figure 13). Variations arose in peak intensities, absorbance; however peak locations which are used in fingerprinting molecular structures were very similar. The differences in absorbance intensities may be due to the slight differences in burning temperature. Smaller yet highly concentrated particles generated at lower burning temperatures absorb more infrared light and would appear at higher absorbance intensities when compared to particles burned at hotter temperatures.

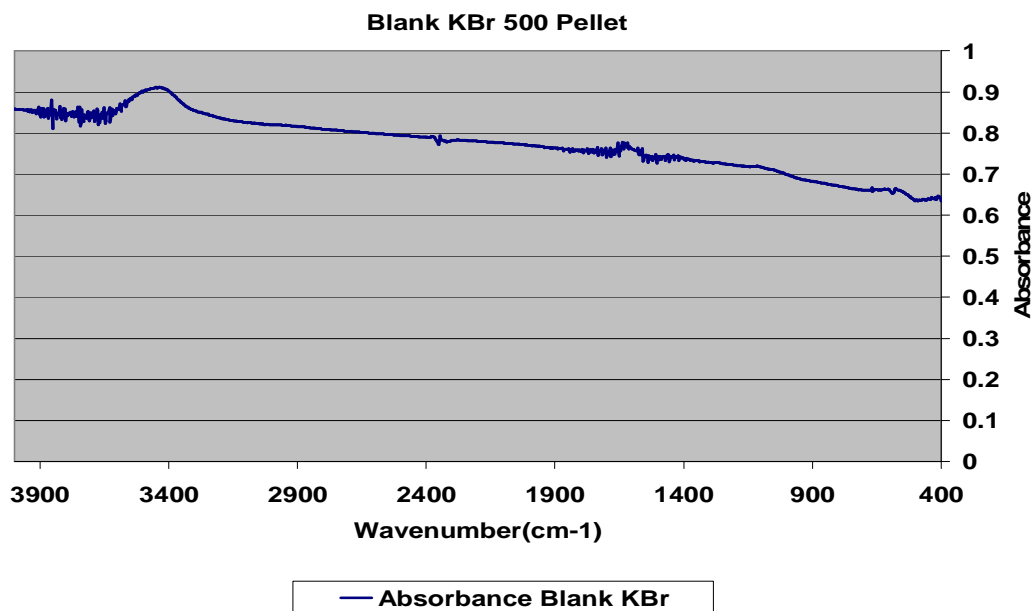


Figure 11 Infrared Spectrum of Potassium Bromide pressed to 500lbs in a laboratory press. Carbon dioxide and water peaks are due to use of un-evacuated press.

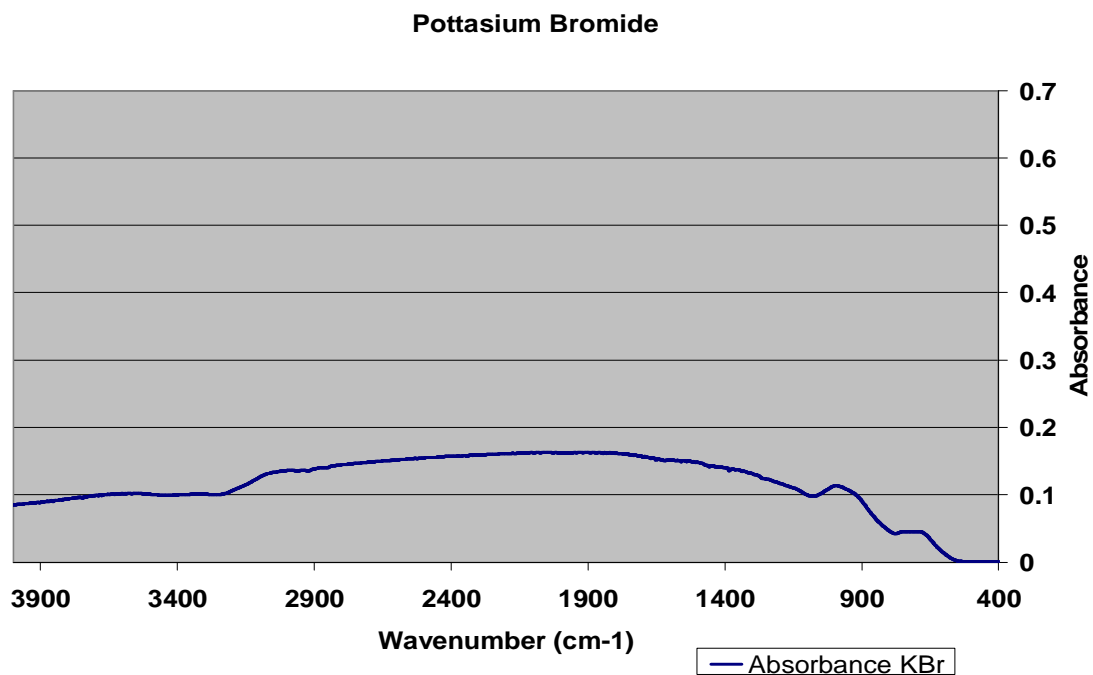


Figure 12 Infrared Spectra of plain Potassium Bromide (KBr).

Comparison Between Original Cherry Wood and Duplicate Samples 1,2 & 3

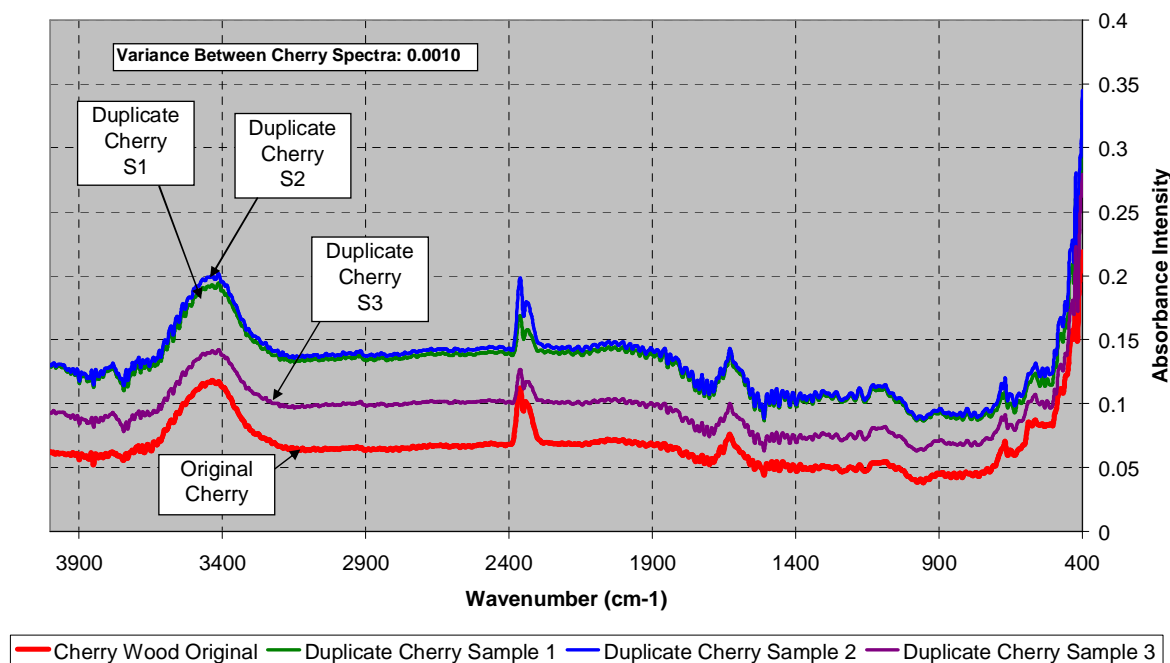


Figure 13 Comparison between cherry wood original spectra and duplicated spectra, samples 1, 2 and 3. The spectra only vary by 0.0013 showing a good indication that the original results can be duplicated.

C. Instrumental Analysis Methods

1. Fourier Transform Infrared Spectrometer (FTIR)

Analysis of the sample smoke and soot aerosols is as follows: Once the smoke and soot has been collected onto the potassium bromide soft pellet filter the filter is placed in an oven at 100 °C for at least 24 hours. Drying is appropriated for burning off any atmospheric water that may have collected onto the sample. After drying, the sample pellet is re-powdered in an agate mortar and pestle.

Mulling of the KBr is produced by using a “Quick Press KBr Pellet Kit” with a 7mm die (Figure 14). The powdered sample is placed into two thirds of the die, and capped with

the remaining part of the die. The die system is then placed within the collar of the stainless steel anvil. A knob on the top of the anvil adjusts pressing pressure and is maintained at 1100lbs throughout the KBr mulling event. By firmly holding one press handle and squeezing until both press handles meet enough pressure is applied to the KBr matrix to form a glass pellet. To insure even distribution of KBr and sample the die surfaces must remain mirror smooth at all times.



Figure 14 “Quick Press Die Kit” used for KBr mulling.

The glass pellet contains the aerosol sample in suspension, a necessary state making it possible for the infrared beam to travel through the sample. Once the glass pellet is ready to be placed into the FTIR chamber the instrument must be readied. For the IFS 66v/S Vacuum FTIR (mid and near infrared spectral region of 400 to 8000 cm^{-1} (1-20 μm)) the instrumental

analysis technique is as follows: Instrumental preparation is done at least two hours before samples are pressed. The FTIR is turned on and liquid nitrogen poured into a nitrogen tank. The liquid nitrogen is needed to maintain proper instrumental functions and decreases the amount of atmospheric interferences within the sample chamber. All excess atmospheric gases are removed during the vacuum process and a background taken before the sample is put into position. The ratio of the sample to background is taken by the instrument and a scan of 64 to 256 is used to decrease the signal to noise ratio. A single beam spectrum is produced and manually divided by the background to produce a transmission spectrum which is then converted to an absorbance spectrum (of infrared light by the molecules) for ease of use in qualitative analysis. A spectrum of absorbance versus wavenumber or transmittance versus wavenumber is generated. The absorbance spectrum will yield qualitative information, while the transmittance spectrum will yield quantitative data.

The secondary FTIR system used was the Thermo-Nicolet (TN) Closed-Path FTIR (mid-infrared at 400 to 4000 cm^{-1} (1-10 μm)). The Thermo-Nicolet system is similar to the IFS system but differs in that it does not contain a vacuum chamber that removes most atmospheric gases. Instead the Thermo-Nicolet FTIR has a desiccant which is changed on a weekly basis by a lab technician. Sample preparation is identical to the IFS FTIR, the sample is prepared, dried and milled into a KBr glass pellet. By using a pellet holder the die containing the glass KBr pellet is mounted into the instrument and enclosed within. A background of an empty holder was previously collected and is used as the background to diminish the effects of atmospheric gases. Sample analysis is done by measuring the instrumental response to the KBr glass and recorded within a computer in transmission spectra which is converted into absorbance spectra for qualitative analysis. The ratio of the

sample to background is taken by the instrument and a scan of 64 to 256 is used to decrease the signal to noise ratio.

Data analysis is done using infrared spectroscopy software called the ACD 7.0 UVIR processor. In handling the spectra the first procedure is to smooth any baseline anomalies and resave under a different file name in order to maintain an unaltered original copy of the spectra. Next, samples are referenced to a blank, pre-pressed KBr pellet to eliminate trace potassium bromide interference bands, Figure 11. The same procedure is followed for the removal of interferences caused by atmospheric carbon dioxide and water, Figures 15, 16 and 17. Subtraction of atmospheric CO₂ from a Maple wood smoke sample collected in un-evacuated chamber can be seen in Figure 18; Figure (a) is a CO₂ reference spectrum; Figure (b) is the original Maple wood spectrum and Figure (c) is the subtraction result. Note that the CO₂ associated peaks at 670, and 2358 have been removed from the final result. Once KBr and atmospheric gas interferences have been removed a peak analysis is generated and a peak table recorded for each sample. Sample spectra are then identified by using charts of characteristic absorbance frequencies for functional groups and by comparison of molecular spectra as seen for ozone (O₃), Figure 17. After identification spectra are labeled accordingly and prepared for statistical analysis.

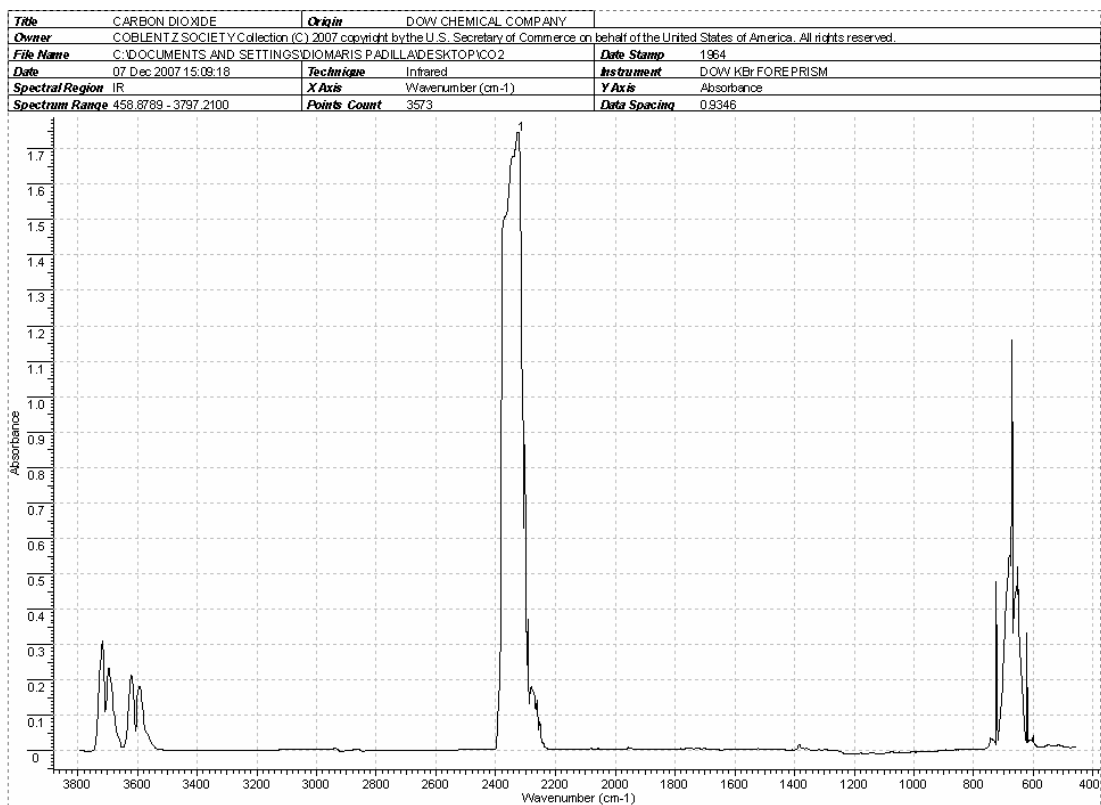
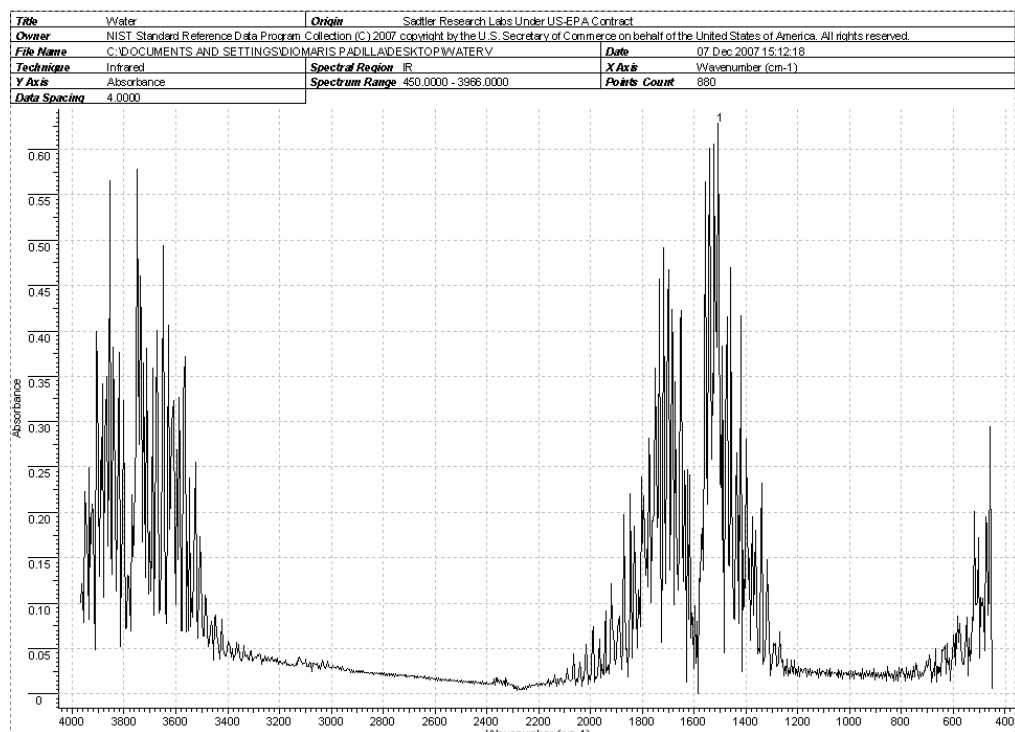


Figure 15 Absorbance Spectrum of Carbon Dioxide

Figure 16 Absorbance Spectrum for Water (H₂O)

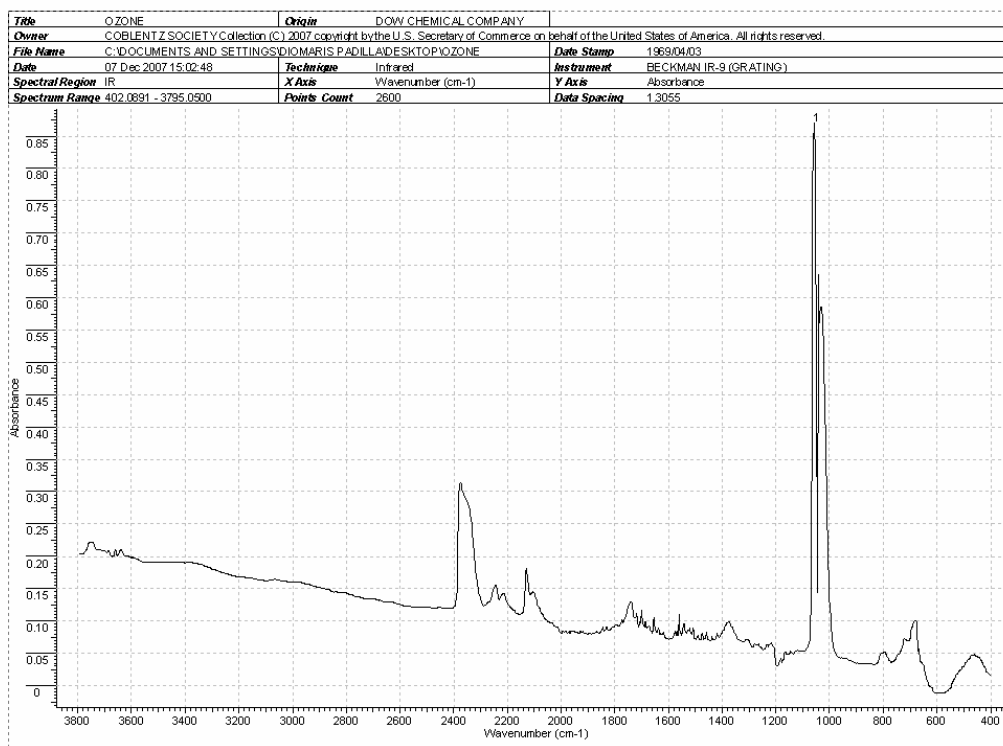


Figure 17 Absorbance spectrum for Ozone (O₃)

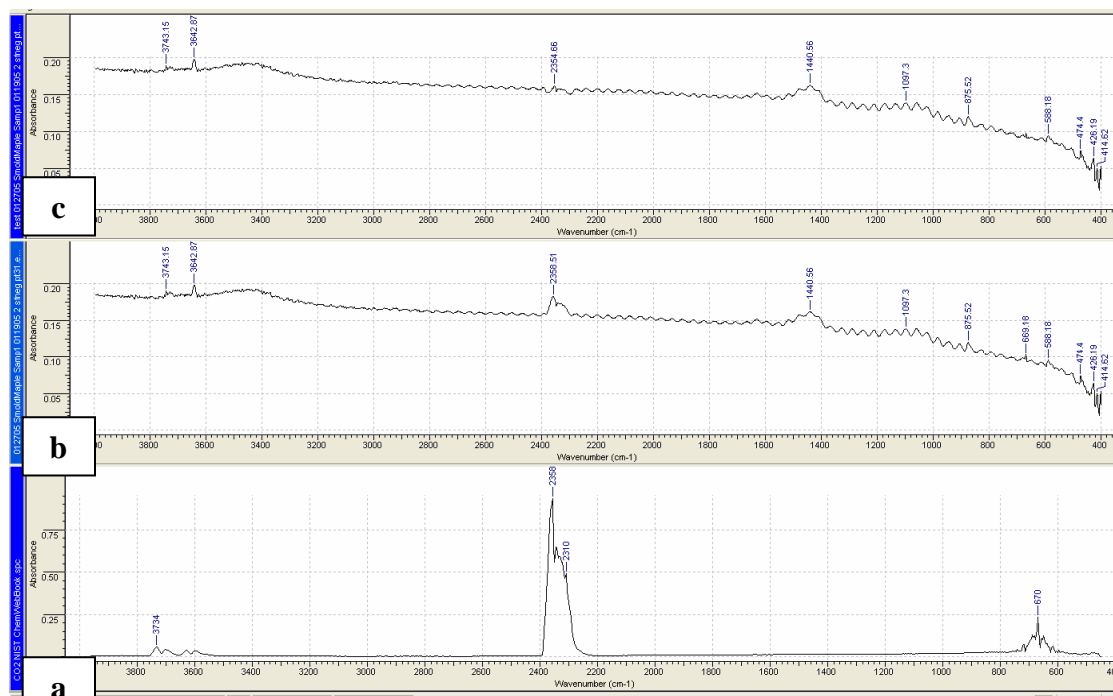


Figure 18 Example of subtraction of atmospheric CO₂ from Maple wood smoke sample collected in un-evacuated chamber. Figure (a) is a CO₂ reference spectrum; Figure (b) is the original Maple wood spectrum and Figure (c) is the subtraction result. Note that the CO₂ associated peaks at 670, and 2358 have been removed from the final result.

2. Successes and Failures of KBr Technique

Potassium Bromide (KBr) has served as a useful collection media for aerosols for several reasons; the first reason being that the material is pliable and can easily be formed into a large or small pellet. For use with FTIR, KBr serves as an excellent backdrop since it is invisible in the infrared region and requires very little sample amount for analysis. When using in conjunction with SEM analysis, KBr grains are easily discerned by their cubic nature. Since smoke and soot particles mainly exist either in chains or spheres, they can be easily identified by high magnification microscopy. Additionally when examining under EDS, KBr grains have a lower charging capacity and can withstand long periods of time under x-ray radiation.

However, problems do arise when using a hygroscopic material to collect aerosols that may contain molecular water or are captured in an environment with high water vapor concentrations. For this reason, before and after aerosol capture, the KBr whether pelletized or in powder form, must remain in either a desiccator or an oven. Another issue when dealing with KBr is that after pressing for collection of pyrogenic emissions onto the substrate, the pellet becomes very brittle and can easily break when being removed from the holder. For FTIR analysis this is not a problem since the sample must be ground and pressed into a glass. For SEM analysis the brittleness does present a problem since the pellets have a tendency to fall off of the adhesive holder. To get around this problem we have had to use both re-powdered and full pieces of the KBr pellet for SEM analysis.

3. Scanning Electron Microscope & Energy Dispersive System (SEM/EDS)

In preparation for analysis through SEM/EDS, smoke and soot collected onto the KBr pellet are not reground. Instead, the pellets are gently scraped off of the Steiner holder and placed onto a 9mm carbon conductive tab. The carbon conductive tabs are sticky therefore; by inverting the SEM specimen stubs onto the tabs they remain fixed onto the stub without danger of contamination. After the attaching the tabs onto the specimen stubs the sample KBr pellet can be pressed onto the exposed sticky surface of the tab by inverting the stub and placing it gently, but firmly, on top of the KBr pellet. Once the samples are loaded onto the stubs they are dried in an oven and kept below 50°F for 24 hours.

Prior to loading into the SEM, the mounted KBr pellet samples must be coated either with carbon or gold. Two sets of coated samples, one gold and one carbon, were generated in order to measure carbon and other elemental properties. A blank KBr pellet was coated with both carbon and gold for use as a background value. In order to sputter coat, samples of KBr pellets were placed in a chamber within a sputtering instrument where they were held in place by a stub holder. A small piece of carbon filament or a gold ring is inserted into a holder, after which the chamber is closed, evacuated and a current is turned on eroding the carbon filament, or gold, and coating the sample stubs with carbon/gold. Sputter coating is needed to produce a smooth and even conductive surface that resist particle charging or further damage to the sample.

Once samples have been coated with either carbon or gold they can be loaded into the SEM/EDS instrument. After the machine has been turned on and vented the samples can be inserted and screwed into stub holders. Samples must be fixed in place to reduce vibrations

that would yield a blurry image. After an appropriate vacuum has been achieved the SEM/EDS is ready to collect images. By adjusting the amount of energy hitting the sample, through coarse and fine voltage knobs, an image can be magnified up to 200,000 times. However, instrumental drift allowed for a maximum magnification of 10,000 times.

For each image recorded, an accompanying x-ray analysis was done. By documenting x, y and z coordinates it was possible to go back to spots of interest. Higher resolution images, of up to 4028, were also taken of spots of interest to achieve higher image quality. Elemental mapping was also taken in order to assist in locating the best spots to perform an x-ray analysis. Figure 19 shows the product of elemental mapping, and reveals that the spot of interest is approximately 4 μ m in width and 9 μ m in length, with a highly silicon makeup.

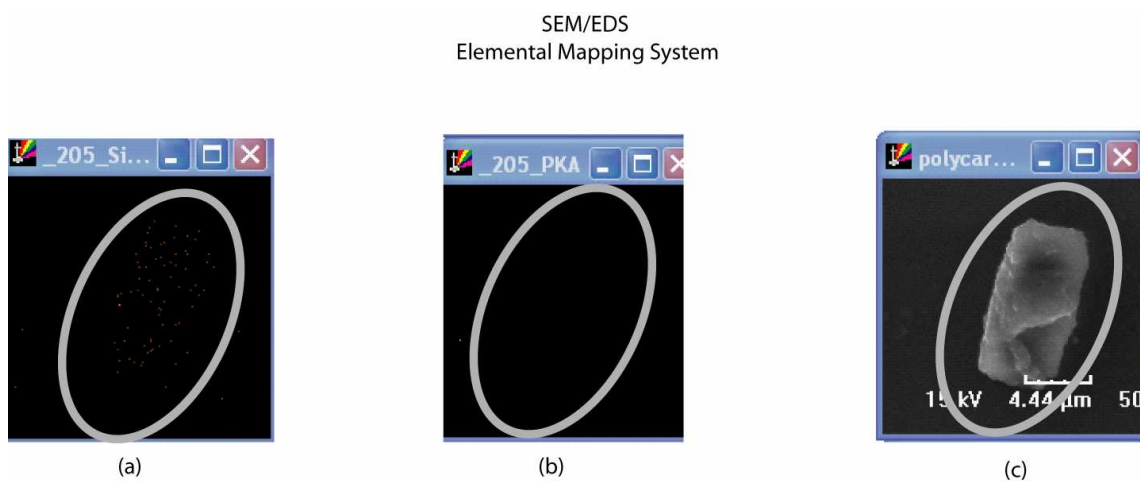


Figure 19 SEM image obtained for a spot of interest on the KBr pellet. Above image (a) shows the elemental mapping for silicon (Si), the saturation of orange dots is indicative of the presence of Si in high amounts. Elemental map for phosphorous (P) lacks dots from elemental mapping and indicates that there is no P present. Image (c) is the SEM image for the particulate taken at 15kV, at magnifications of 5,000 times. The particulate is approximately 4.44 μ m in width and 9 μ m in length.

4. X-Ray Fluorescence (XRF)

In preparation for x-ray fluorescence analysis (XRF) smoke and soot were collected onto Millipore 13mm polycarbonate filters with a 0.22um pore size. Sample collection was identical to KBr filter methods except for using a membrane filter instead of a KBr filter. After collection of smoke and soot sample filters were collected and put into Petri dishes where they were sealed to decrease contamination. The samples were then pressed in preparation for XRF loading. Pressing was done by the following methods: All equipment was sanitized using methanol and allowed to dry. An XRF sample cup was then filled with 2/3 lithium tetra-borate ($\text{Li}_2\text{B}_4\text{O}_7$) and one sample filter placed on top of the lithium tetra-borate matrix. A steel die was placed in the center of the collar and directly on top of the filter and lithium tetra-borate filled cup. The cup and filter were placed on an evacuated steel disk and a steel collar was placed over both enclosing them. The apparatus was then placed in the collar of an anvil and pressed to 2000lbs thereby fusing the filter to the lithium tetra-borate. Since neither Li nor Br was being tested for interferences due to both elements were null.

Once the sample was prepped for the instrument the XRF was turned on and allowed to warm up. After instrumental preparation the sample cup is loaded into the XRF and a preprogrammed analysis is begun. Peak locations and concentrations are recorded into the computer and removed on a floppy disk after all samples have been analyzed. All smoke and soot samples were analyzed twice to ensure accuracy of instrumental response. Additionally, between sample analysis USGS standards for rock material were also analyzed to ensure proper instrumental response. All subsequent data was inputted into Excel and SPSS for statistical and graphical analysis.

CHAPTER 4

I. Experimental Results

A. Lumber Combustion Experiments

The CP-FTIR results for the untreated lumber combustion products are given in Table 4 and Figures 20 and 21. An average of four separate Cherry-lumber combustion experiments (Figure 3) yields an average variance of 0.001. Prominent peaks appear in the ranges: 3500-3900, 3100-3300, 2300-2400, 1660, 1580-1630, 1060-1350, 500-700 and 400-500 cm^{-1} ; these are labeled in consecutive order A through H.

Using infrared correlation charts, regions A and A' represent nitrogen-hydrogen bonding resulting from the breakdown of proteins within wood cell walls. These proteins are utilized within catalytic enzymes and initially introduced to the wood system via nitrate or ammonium ions [Shigo, 2005]. The strong broad peak in region B is accompanied by a sharp peak in region B', both of which are associated with hydrogen-oxygen bonding. Bonding of this type is attributed by Shigo (2005) to the breakdown of naturally abundant water and carbohydrate rich tissues as well as some proteins and nucleic acids found throughout the tree anatomy and are therefore present in untreated lumber. Areas C, D and E contain a mixture of moderate to strong peaks consisting of carbon-oxygen bonds, carbon double bonds, and alkenes that are presumed byproducts of the breakdown of lignin and hemi cellulose. The peaks in sections F and G are consistent with the presence of aromatic and amine bonding, features also related to the breakdown of lipids, carbohydrates, proteins and nucleic acids. In

general, the Cherry wood spectrum for the combustion products is in agreement with the chemical features present in the tree species before combustion.

When compared to greenwood spectra, lumber was found to generate exclusive peaks at: 406.91, 433.91, 607.47, 620.97 and 671.11 wavenumbers. These results suggest that distinctions between smokes from building materials using lumber can be distinguished from fires associated to burning biomass. A comparison of soot collected via the KBr filter method with that of a direct method of soot analysis, produces nearly identical spectra with a resulting variance of only 0.0012 wavenumbers, an indication that the lumber ash and smoke from certain species retain their characteristic infrared signal as they are transformed from lumber into soot and ash by-products.

Table 4. FTIR peak maxima for lumber combustion experiments over the ‘fingerprint’ region (900-400 cm⁻¹). Deciduous trees include the same peak set (bold: 458.98; 563.11; 607.47; 620.97; 671.11; 875.52) whereas the evergreen sample includes only the 433.91, 563.11 and 588.18 peaks. These data appear to provide the basis for distinguishing deciduous from coniferous and one deciduous species from the other.

No	Birch	Birch	Cherry Wood	Cherry Wood	Maple	Maple	Pine	Pine
	cm-1	Absorbance	cm-1	Absorbance	cm-1	Absorbance	cm-1	Absorbance
1	406.91	0.045	406.91	0.018	414.62	0.012	404.98	0.173
2	412.69	0.046	422.33	0.031	422.33	0.025	422.33	0.147
3	420.41	0.043	430.05	0.022	433.91	0.014	433.91	0.122
4	430.05	0.035	487.9	0.006	576.61	0.015	457.05	0.093
5	441.62	0.031	538.04	0.008	669.18	0.012	476.33	0.084
6	447.4	0.029	561.18	0.011			495.62	0.071
7	482.12	0.022	588.18	0.017			522.61	0.064
8	574.68	0.012	624.82	0.003			538.04	0.067
9	619.04	0.008	669.18	0.011			563.11	0.071
10	667.25	0.009	875.52	0.007			588.18	0.077
11							649.89	0.053
12							680.75	0.054
13							732.82	0.043
14							800.31	0.044
15							892.88	0.044

Table 4 cont. FTIR peak maxima for lumber combustion experiments over the ‘fingerprint’ region (900-400 cm^{-1}). Deciduous trees include the same peak set (bold: 458.98; 563.11; 607.47; 620.97; 671.11; 875.52) whereas the evergreen sample includes only the 433.91, 563.11 and 588.18 peaks. These data appear to provide the basis for distinguishing deciduous from coniferous and one deciduous species from one another.

No	Walnut	Walnut	White Oak	White Oak	Red Oak	Red Oak	Ash	Ash
	cm-1	Absorbance	cm-1	Absorbance	cm-1	Absorbance	cm-1	Absorbance
1	410.76	0.013	412.69	0.008	406.91	0.086	406.91	0.025
2	424.26	0.011	426.19	0.013	422.33	0.082	424.26	0.016
3	458.98	0.004	441.62	0.01	433.91	0.072	433.91	0.014
4	476.33	0.002	458.98	0.01	457.05	0.063	458.98	0.008
5	487.9	0.003	489.83	0.002	476.33	0.061	563.11	0.011
6	563.11	0.014	509.12	0.003	482.12	0.063	586.25	0.015
7	588.18	0.021	563.11	0.012	495.62	0.058	607.47	0.007
8	607.47	0.008	588.18	0.019	541.9	0.06	620.97	0.006
9	620.97	0.006	607.47	0.009	565.04	0.062	671.11	0.006
10	671.11	0.007	620.97	0.008	592.04	0.062	738.6	0.003
11	744.39	0.001	636.39	0.008	667.25	0.062	806.1	0.004
12	757.89	0.001	659.54	0.006	678.82	0.062	840.81	0.005
13	875.52	0.007	671.11	0.007			875.52	0.006
14			711.6	0.004			919.88	0.006
15			723.18	0.004				
16			819.6	0.007				
17			850.45	0.007				
18			875.52	0.008				
19			904.45	0.007				
20			921.81	0.006				

Comparison of Six Different Wood Soots Collected onto Individual Potassium Bromide Pellets

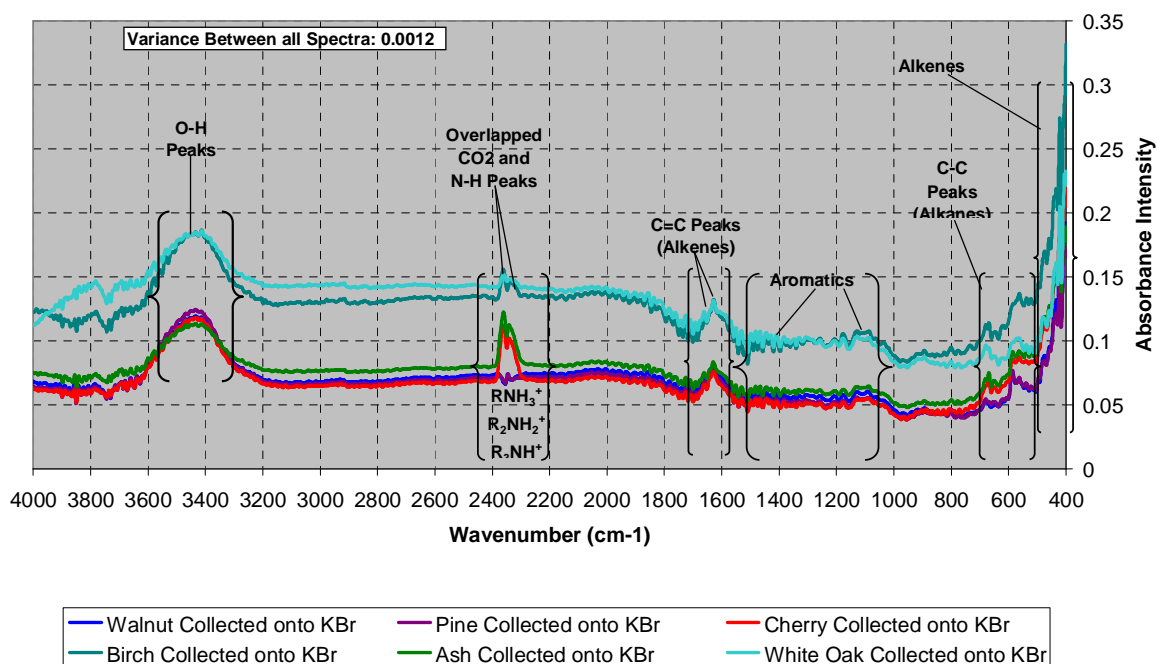


Figure 20a Comparison of 6 discrete scans of combusted lumber show similarities of the OH peaks near 3600 to 3400 wavenumbers, as well as similar NH, CO₂ and carbon to carbon peaks. These results indicate that lumber can be identified as a group and discerned from other combusted materials.

FTIR analysis of lumber material, Figure 20a, resulted in similar spectral outputs. Throughout the full peak spectrum, peaks located near 3600-3400, 2400-2200, 1600-1700 and 1100-1200 wavenumbers were very similar. Differences could mainly be seen in the absorbance changes of about 50%, indicating a change in particle size during the combustion process. Higher absorbencies occur at lower temperatures, since larger particles absorb more infrared radiation than smaller particles. These results show that the lumber family retains its peak signatures throughout a range of combustion temperatures.

Comparison Between Original Cherry Wood and Duplicate Samples 1,2 & 3

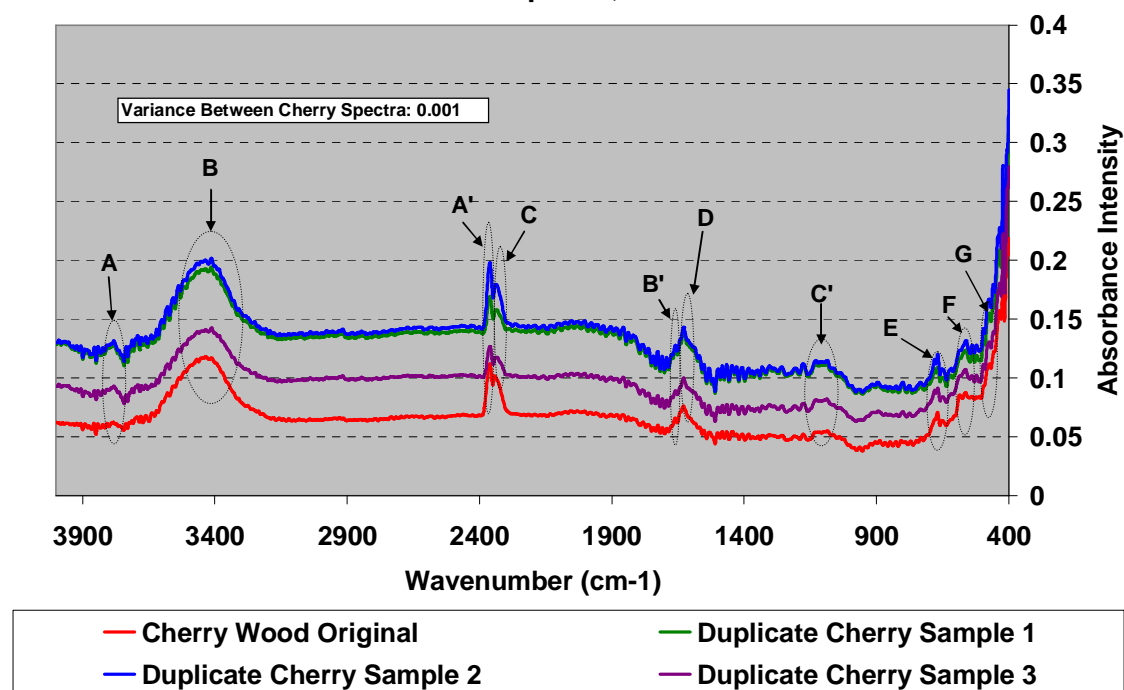


Figure 21b Comparison of 4 discrete scans of the combusted Cherry from four separate combustion experiments showing a high degree of intra-sample correspondence in wavenumber locations (variance of 0.001); differences in average absorbance is attributed to slight differences in the original amount of structural water and percentage of lipids in individual specimens. Vibrational definitions: A & A' = NH, B & B' = OH stretch (H-bonded), C & C' = CO stretch, D = CC double bonding stretch, E = Alkenes (C-H), F = Aromatics, G = Amines

The spectra at wavenumbers 1000-400 show both a decrease in relative absorbance intensity of the set of peaks from approximately 1000 to about 700 wavenumbers, and the development of two broad peaks at 700-500 and 500-400 (Figure 20, peaks e & f). The broad peaks comprise sets of absorbance maxima that are unique to each wood variety. A set of peaks is unique to the deciduous lumber (bold peaks 406.91; 607.47; 620.97; 669.18; 671.11; 875.52) whereas one peak, 563.11 is common to all combustion products but Birch

and Maple. The collection of these peaks in Table 4 shows that certain wavenumbers are present in some or all of the eight studied wood varieties. However, as a whole, the location of specific wavenumbers changes their positional ranking, varying from species to species. For example, the 458.98 peak is the third peak in the list of peaks for Eastern Black Walnut, the fourth peak for both White Oak and American Ash, but is absent altogether from the list for White Pine. Figure 21 shows slight varieties within the lumber fingerprint regions, each variety of wood therefore has a unique signature that should enable each variety to be indexed and mapped by a spectrometer with appropriate resolution and intensity gain.

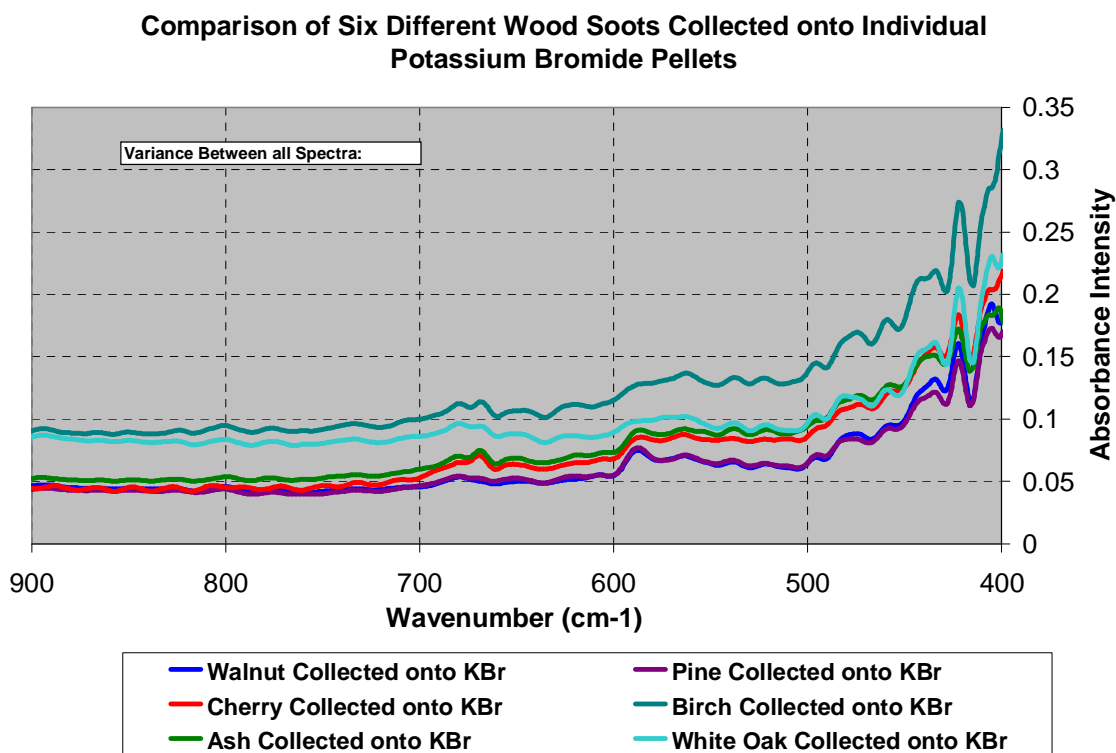


Figure 22 Comparison of Eastern Black Walnut (*genus, species*), White Oak and American Ash showing a slight variation in peak pattern under 900 wavenumbers, indicating a possible fingerprinting technique for wood species.

B. Greenwood Combustion Experiments

The FTIR spectra for leaf-and-branch¹⁴ combustion experiments (Table 5) are consistent with those for untreated lumber (pine, red oak, white oak and maple). Absorbance values generally exceed those for lumber, reflecting slight differences in the relative concentration of infrared-active molecules. For instance, the 406.91 wavenumber series set is absent in lumber but appears in nearly all greenwood spectra. Additionally, wavenumber series: 418.5 and 516.85 appear in greenwoods but not lumber. There are, however, notable spectral changes in the “fingerprint” range (900-400 wavenumber; Figures 22-25). Sweetgum, for example, has a seven-peak signature, with major peaks at 875, 713 and 418 wavenumbers and minor peaks at 804, 472, 457 and 445 (Table 5; Figure 22). White Oak (Table 5; Figure 23) shows peaks at 875, 848 and 713, and an absorbance that is approximately three times greater than that for Sweetgum. While the Red Maple (Table 5; Figure 24) exhibits strong peaks at 877 and 715, with weaker modes at the lower wavenumbers: 472, 458 and 424. In contrast, the White Pine (Table 5; Figure 25) exhibits only a single peak at 877 wavenumbers over a broad background peak (746 to 416 wavenumbers). These results strongly suggest that spectrometers with appropriate windows and resolutions can be discriminated and tracked based on present definitions for peak distributions, as proposed earlier by Christopher (2002).

¹⁴ Fresh branches are taken from live trees and dried at 100 C for one to three days before combustion.

Table 5 Represents peak frequencies and associated absorbance intensity.

No	Pin Oak	Pin Oak	White Oak	White Oak	Sweet gum	Sweet gum
	cm-1	Absorbance	cm-1	Absorbance	cm-1	Absorbance
1	418.5	0.03	410.76	0.461	418.5	0.377
2	435.85	0.002	426.19	0.454	439.71	0.293
3	443.57	0.005	439.69	0.449	457.07	0.295
4	457.07	0.011	464.76	0.446	472.5	0.283
5	472.5	0.009	561.18	0.443	713.57	0.234
6	484.07	0.003	588.18	0.448	875.57	0.26
7	501.43	0.004	669.18	0.43		
8	518.78	0.007	746.32	0.43		
9	526.5	0.006	875.52	0.454		
10	669.21	0.014				
11	873.64	0.017				

Table 5: Cont. Represents peak frequencies and associated absorbance intensity.

No	American Basswood	American Basswood	Maple	Maple	Pine	Pine
	cm-1	Absorbance	cm-1	Absorbance	cm-1	Absorbance
1	451.28	0.091	418.5	0.587	418.5	0.531
2	576.64	0.118	457.07	0.405	443.57	0.302
3	667.28	0.13	472.5	0.376	457.07	0.365
4	769.5	0.127	501.43	0.331	472.5	0.337
5	875.57	0.144	516.85	0.323	516.85	0.29
6			669.21	0.274		
7			713.57	0.277		
8			875.57	0.31		

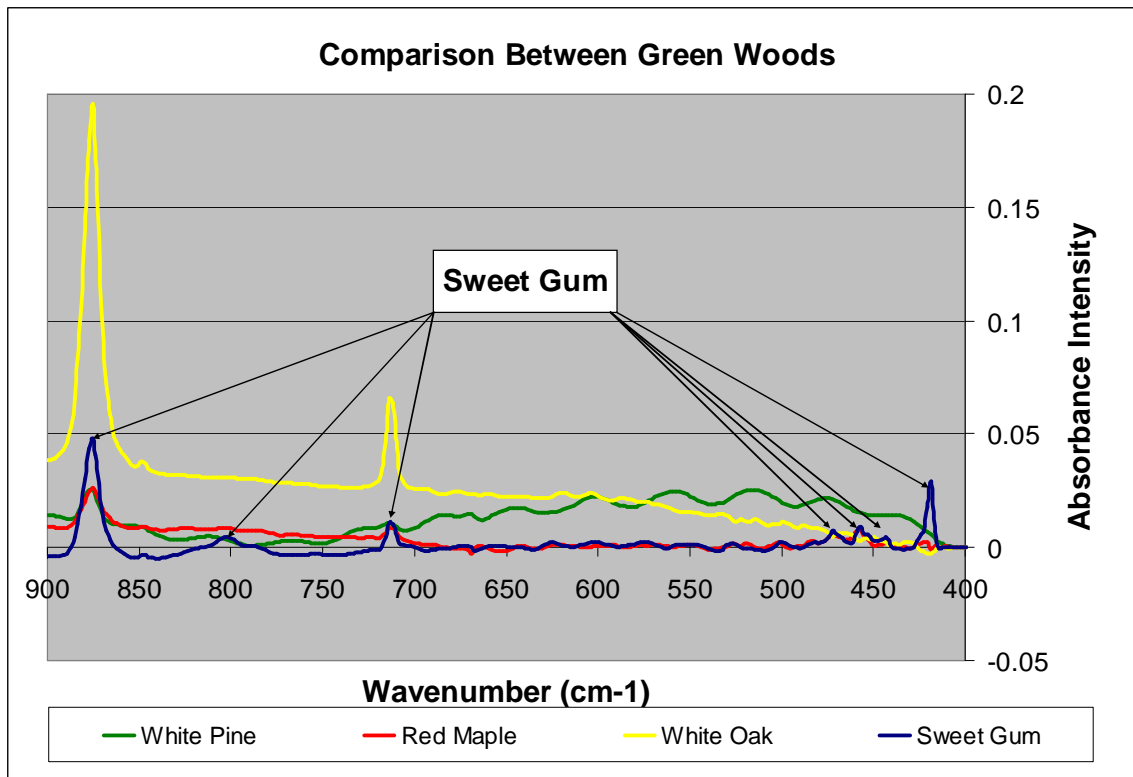


Figure 23 *Fingerprint region for Sweet Gum combustion products, highlighted in blue, showing four distinct peaks near 875, 800, 710 and 430 wavenumbers.*

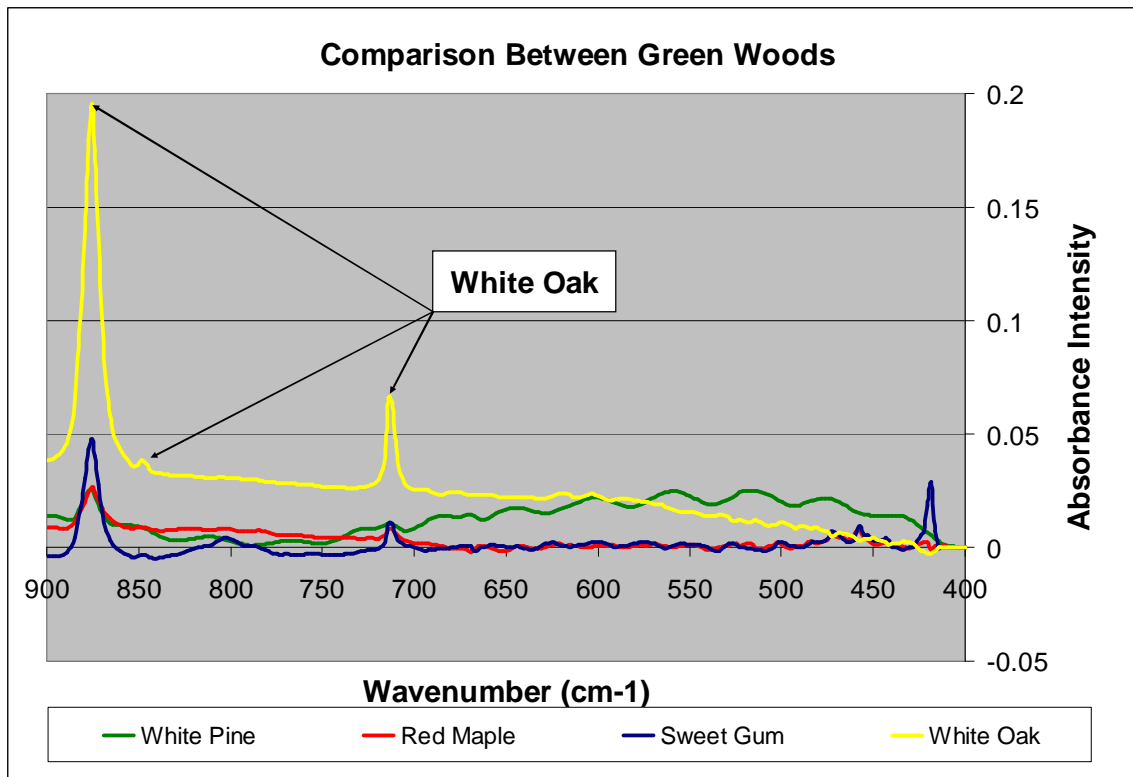


Figure 24 *Fingerprint region for White Oak combustion products, highlighted in yellow, showing two distinct peaks near 875 and 710 wavenumbers.*

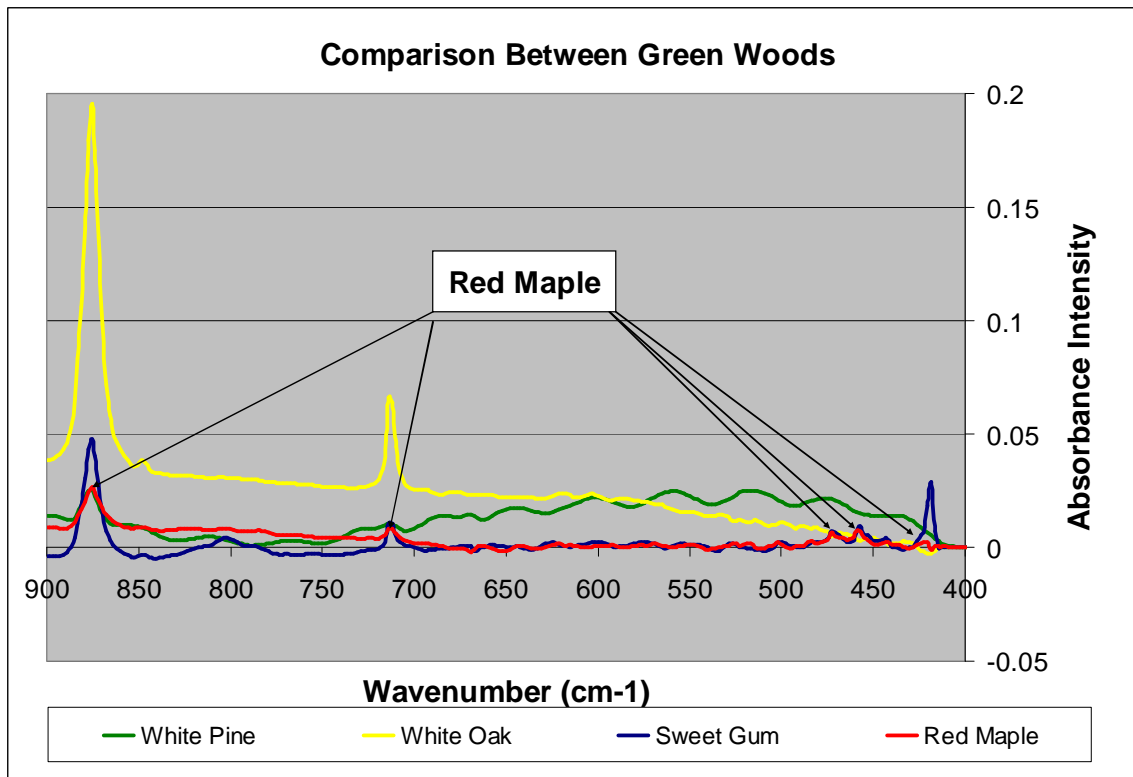


Figure 25 *Fingerprint region for Red Maple combustion products, highlighted in pink, showing two distinct peaks near 875 and 475 wavenumbers.*

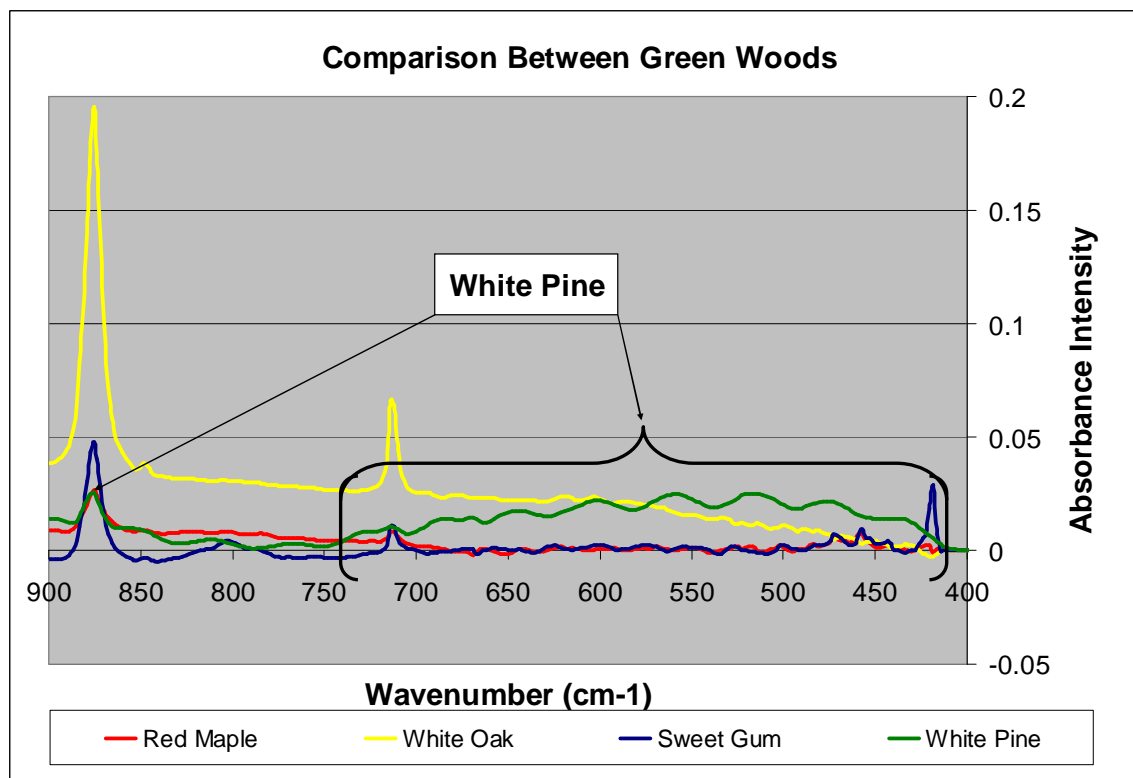


Figure 26 *Fingerprint region for White Pine combustion products, highlighted in teal, showing one distinct peaks near 875 wavenumbers.*

C. Combustion Temperature

In order to evaluate the effect of temperature on combustion, samples were ignited and thermal measurements recorded using a Fluke type E chromel-constantan thermocouple placed directly into the flame itself. When the temperature reaches approximately 700 C (Figure 26), the vacuum system is activated, drawing the smoke through the filtration system. The collection of smoke from the Red Maple experiment thus begins at 720 C after initial ignition; the temperature increase from 400 to 720 occurs in ten to fifteen minutes. The smoke-collection interval typically lasts 30-40 minutes and is accompanied by a slight drop

in temperature (best illustrated by downturn in the Red Maple curve solid curve at 21-24 minutes; Figure 26). Cooling to room temperature requires an additional 15 minutes.

The FTIR absorbance signal for woods and wood products combusted at 700 °C is markedly less than that obtained for both green woods and wood products when smoldered at 400-450 °C; a particularly substantial increase in peak height is found at approximately 1620 wavenumbers for low-temperature combustion. The absorbance differences appear to be due in part to greater relative concentrations of smoke produced by smoldering, although soot concentration does not appear to provide a complete explanation (Padilla, in preparation). Higher absorbance quantities found in smoldered smoke is also consistent with the production of greater amounts of aromatics and other carbon-hydrogen bearing bonds at lower temperatures.

Note also the change in polarity of the 2348-2372 peaks, Figure 27. The high temperature carbon-oxygen 2348 cm^{-1} mode develops a negative absorbance; it is the product of 5 individual combustion experiments, each of which is scanned 64 separate times and averaged, producing a negative response in all observed cases. This suggests that peak inversion of the carbon-oxygen may constitute a valuable tool in an effort to distinguish high- vs. low- energy combustion conditions.

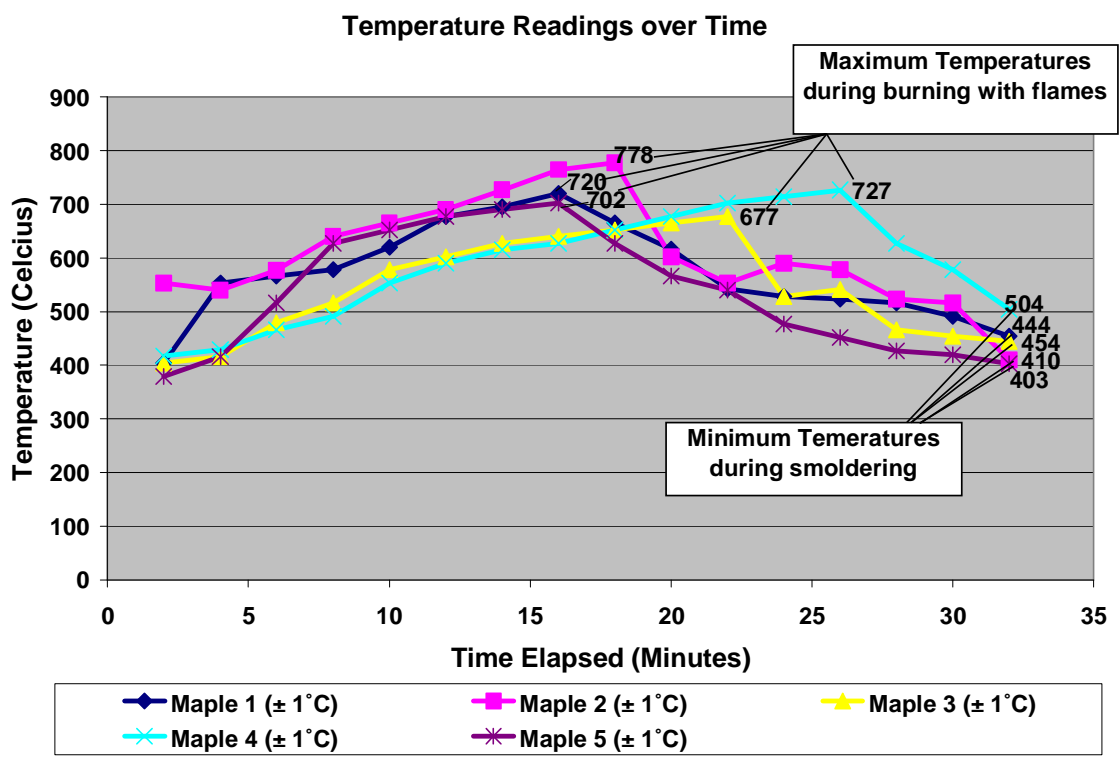


Figure 27 The heat- cool curve for Red Maple wood.

High vs Low Temperature Burning of Maple Wood

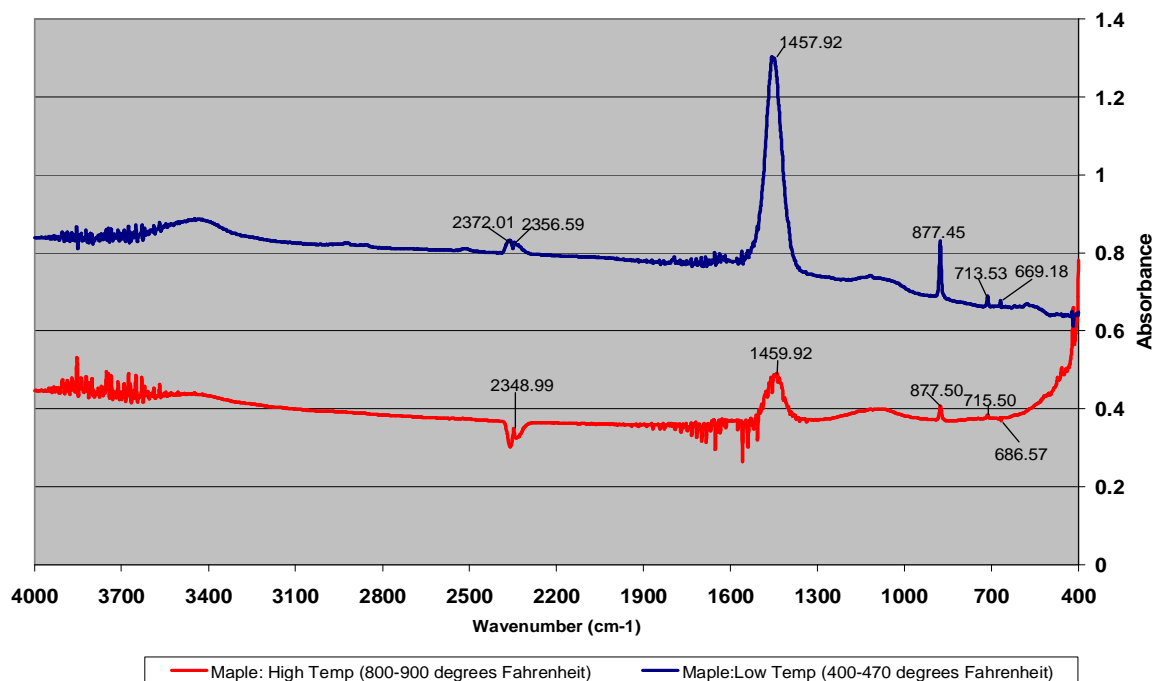


Figure 28 Temperature variation in spectra observed as a change in peak intensity. Higher temperature combustion produces inverted carbon dioxide peak near 2348 wavenumbers with a lowered absorbance indicating smaller sized particle production.

D. SEM Results

The composition of soot micro-particles is obtained by scanning electron microscope (SEM) and energy dispersive analysis (SEM/EDS). Results show significant differences between species (Padilla and Steiner, in preparation), but a broad general agreement in most of the major elements produced. SEM/EDS cannot produce an accurate quantitative analysis due to variability in the thickness of the gold or copper coatings, placement at different depths within the filter, failure to isolate the analyzed volume from neighbor-neighbor or background interference, It is capable of qualitative to semi-quantitative analysis depending on numerous factors, including the type of sample coat (Au, C, etc.); the application of coats

that are uniform in thickness and coverage; the elimination of element information from the substrate; adequate standard materials, and similar factors. Since one set of combustion experiments is impacted on potassium bromide, the absence of bromide in the analyzed product indicates a lack of background interference, and therefore the likelihood of achieving semi-quantitative results.

In view of the fact that carbon is among the key elements in this study, both carbon-coated and gold-coated samples are analyzed to determine the effect of the coating on carbon assessment. Parallel experiments are obtained from using a variable-pressure SEM with no coating show close agreement with present results (Padilla and others, in preparation). The SEM/EDS results for carbon-coated Eastern Black Walnut, White Pine and Pin Oak (Table 6) show that the aerosol products of combustion experiments comprise a complex array of carbon and metal-associated compounds. Sample selection is based on obtaining both backscatter and SEM images of the particles. The backscatter image settings cast the samples with elements of relatively high atomic number in white against a low atomic background set that appears dark. The present review searches primarily for the “heavy” atomic number set and are capable of distinguishing carbon-bearing from carbon-free particulates. The carbon-bearing soot will be described and discussed in a later paper (Padilla, et al, in preparation). However, it is interesting to note at this juncture that not all particulates comprise a significant fraction of carbon. On a first-pass basis, the July 2004 aerosol includes both carbon-enriched and relatively carbon free components for several species. The combustion products are relatively sulfur and nitrogen-free (Figure28; Table 6) as opposed to aerosols examined in prior SEM/EDS and surface scattered excitation studies

(see Niemi (2004) and Scarano (2004)) where metal cations are bonded principally to sulfur. Therefore the type of bonding that takes place in the present associations is uncertain.

In the present paper we compare particulates that are present on both the potassium bromide and polycarbonate filters in order to identify the most common type of particulate by doing a random search of particles that are easily resolved by SEM/EDS methods. We use these data to help to distinguish between aerosol-forming combustion results and primarily gas-producing combustion products for controlled experiments where combustion occurs at approximately the same temperatures.

The SEM/EDS analytical data for aerosols impacted on KBr crystals and used for the FTIR study (Figures 28) show that carbon is present in significant above-background levels only in the Eastern Black Walnut- and Cherry-combustion experiments. For the present, we assume a uniform coating of carbon or gold, and that the amount of carbon or gold calculated by the internal software for the coating can be simply subtracted from the sample result. This procedure produces a negative result for carbon in all samples except Eastern Black Walnut and Cherry. Therefore, the solid particulate aerosols from the White Pine and White Oak experiments are both carbon-poor and potassium- and tin-enriched in contrast to experiments on Eastern Black Walnut and Cherry that produces a carbon-enriched particulate associated with minor amounts of potassium and tin. Note that each of these cases represents a class of particulates, e.g. all the particulates show approximately the same elemental abundances and elemental strengths as opposed to the case where a class is represented by carbon-only, or potassium- and zinc-only particulates. Errors for each element are given at the upper-right of the element box at the element boundary.

Comparisons of carbon (C) and potassium (K) ratios were also established and results show that lumber has higher C/K ratios than greenwood, Figure 29. These types of ratios

have been used in the past to distinguish biomass burning fires from other anthropogenic sources of potassium and carbon, but never to distinguish wood sources [Park, 2007].

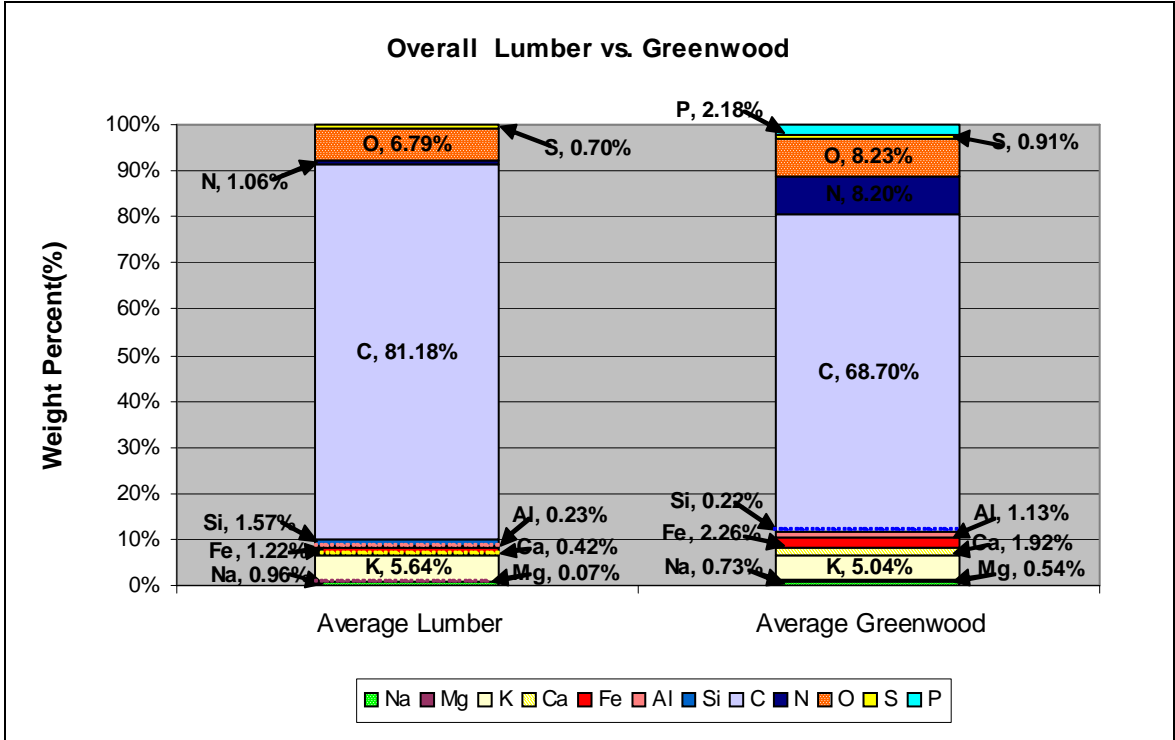


Figure 29 Average Lumber and Greenwood elemental concentration results from SEM

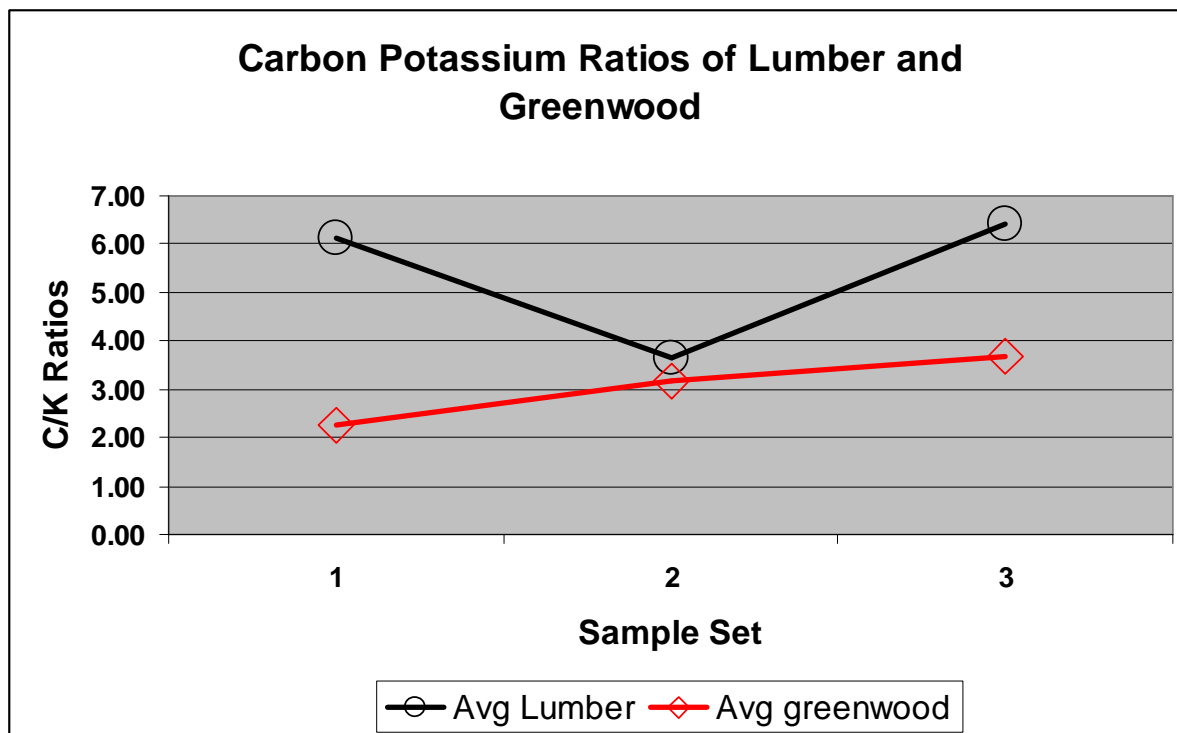


Figure 30 Comparison between carbon (C) and potassium (K) ratios for average lumber and average greenwood show a high C/K ratio in lumber generated smoke when compared to greenwood generated smoke.

Table 6 SEM/EDS results, in weight percentage, for carbon and gold coated soot samples mounted onto KBr pellets. Percentages represent “spot” analysis for regions of interest.

Element	Carbon Coated KBr Eastern Black Walnut	Carbon Coated KBr White Pine	Carbon Coated KBr Pin Oak	Gold Coated White Oak	Gold Coated Birch	Gold Coated Cherry
K	0.1046	0.8118	0.7734	-	8.85	-
Br	-	-	-	-	3.13	-
C	0.8507			-	-	20.58
O	0.0089	0.0209	0.2229	0.02	-	3.87
Na	0.0072	0.0244	0.0003	0.06	0.09	0.03
Fe	0.0286	0.0453	0.0008	0.19	0.15	0.12
Mg	-	-	0.0011	-	-	0.01
Ca	-	0.0139	0.0007	-	-	0.05
Al	-	-	0.0004	-	-	0.52
Cl	-	-	0.0005	-	-	-
P	-	0.0836	-	-	-	-
S	-	-	-	0.50	0.1	0.60
N	-	-	-	1.41	-	0.50
Si	-	-	-	-	-	0.11

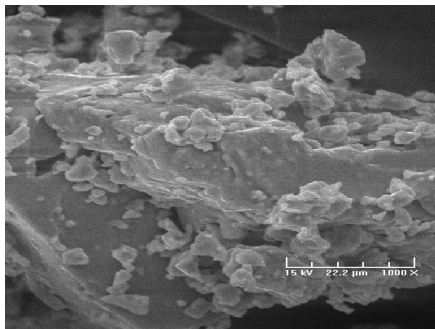


Figure 30: SEM image of KBr pellet with wood soot & smoke at a magnification of 1000x. Quantitative analysis reveals a mostly Potassium rich composition.

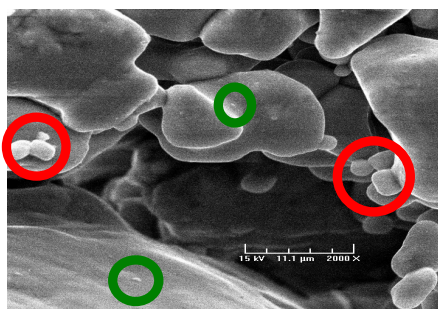


Figure 31: SEM image of wood soot & smoke trapped in a KBr matrix, at a magnification of 2000x. Red circles indicate carbon rich material, green circles, Aluminum.

A separate, gold-coated slice of each sample continues to show that carbon is restricted to the Eastern Black Walnut and Cherry samples (Figure 30 & 31). As reviewed above, the remaining samples are potassium and tin-enriched. White oak appears to represent an exception to the other woods by showing exceptional amounts of nitrogen. As stated earlier, each bar represents an average of approximately 25 separate SEM/EDS data points, but only a single combustion experiment.

In a few instances, the SEM/EDS images derived from smoke and a few added inhalants, such as methanol, show that the carbon and iron concentrations are not associated with carbon or oxygen. These very small (<0.1 micron) particles may represent an early stage in the evolution of the PM_{2.5} particles. Single particle mass spectrometry studies by

Schneider (2005), for example, show that diesel emission exhaust initially comprises nanometer-size molecular fragments that progressively combine with sulfur and oxygen.

E. XRF Results

X-Ray Fluorescence (XRF) samples of green wood materials were mounted onto polycarbonate filters to decreased interferences due to the potassium (K) contained in KBr pellets. To date XRF results for woods demonstrated that both raw woods and burned woods, labeled R and S in Figure 32, have high concentrations of K when comparing K, Ca, Ti and Fe weight percentages. Calcium (Ca), however, was found at its highest concentrations within the raw wood material only, Figures 32 through 34. Iron (Fe), was present in trace amounts throughout both burned and unburned wood material.

When comparing Ti, Ca and Fe, higher weight percentages for Titanium (Ti) were found only in burned maple and pin oak, Figure 35. Concentrations for Ca were found to be high in both burned and unburned wood material. Additionally, Fe was found in trace amounts for both unburned and burned material.

These results demonstrate that potassium and calcium are good trace elements for burned and unburned wood material. Figure 35 results find that when rationing elements of Ti, K and Fe with Calcium higher concentrations are found when rationing K/Ca. While the K/Ca ratio did not distinguish lumber from greenwood higher concentrations were found in maple and oak species. Hence, the ratios can be used as an atmospheric tracer of biomass produced particulate matter.

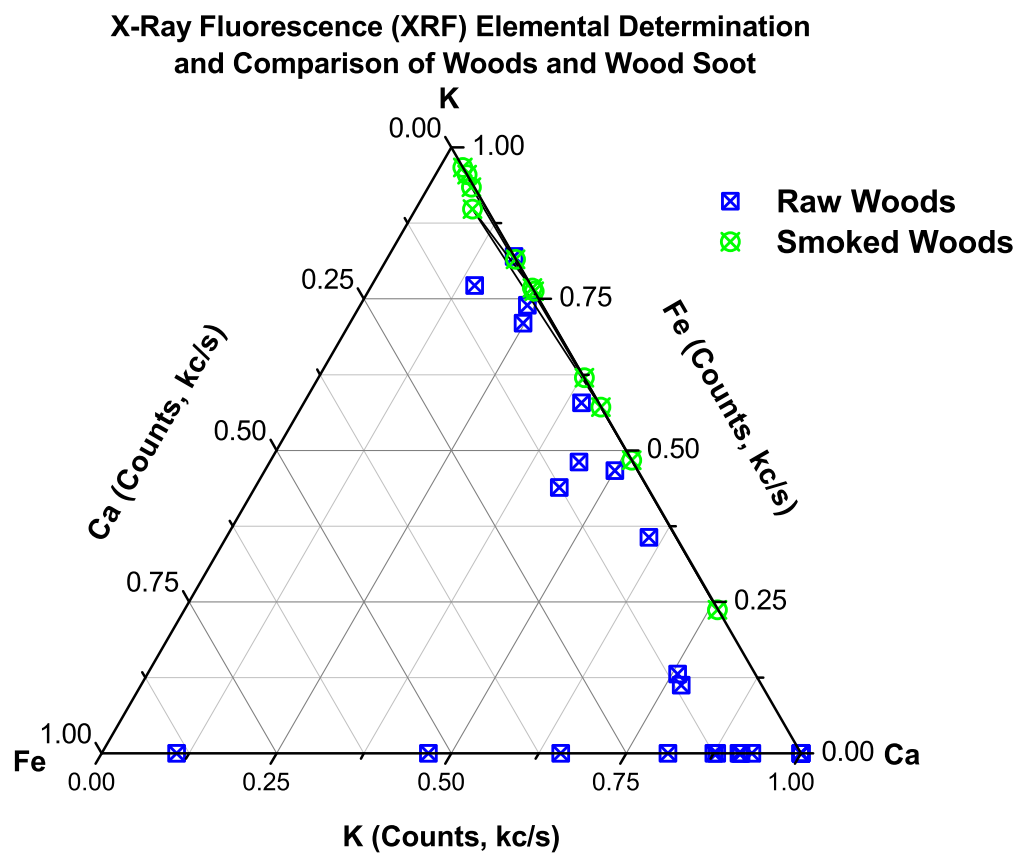


Figure 32 Triangular plots of XRF data on Unburned and Burned woods showing high concentrations of potassium (K) and calcium (Ca). Before being burned woods are high in calcium and have trace amounts of Iron. After combustion, wood smoke contains high concentrations of potassium and calcium, with barely any iron.

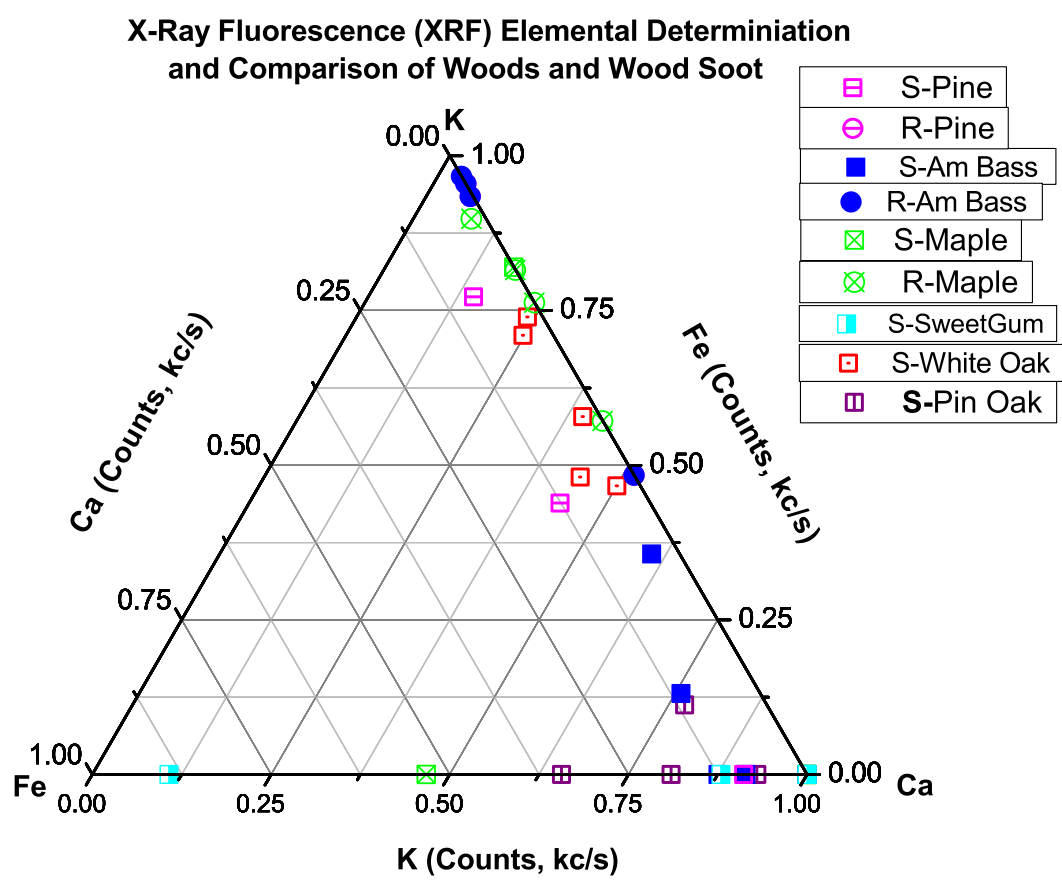


Figure 33 Triangular plot of XRF data for specific Unburned and Burned woods, with a focus on K, Ca, Fe. Here we have a distinction of elemental concentrations of K, Ca, and Fe by wood species. Most woods contain K concentrations higher than 75% after combustion.

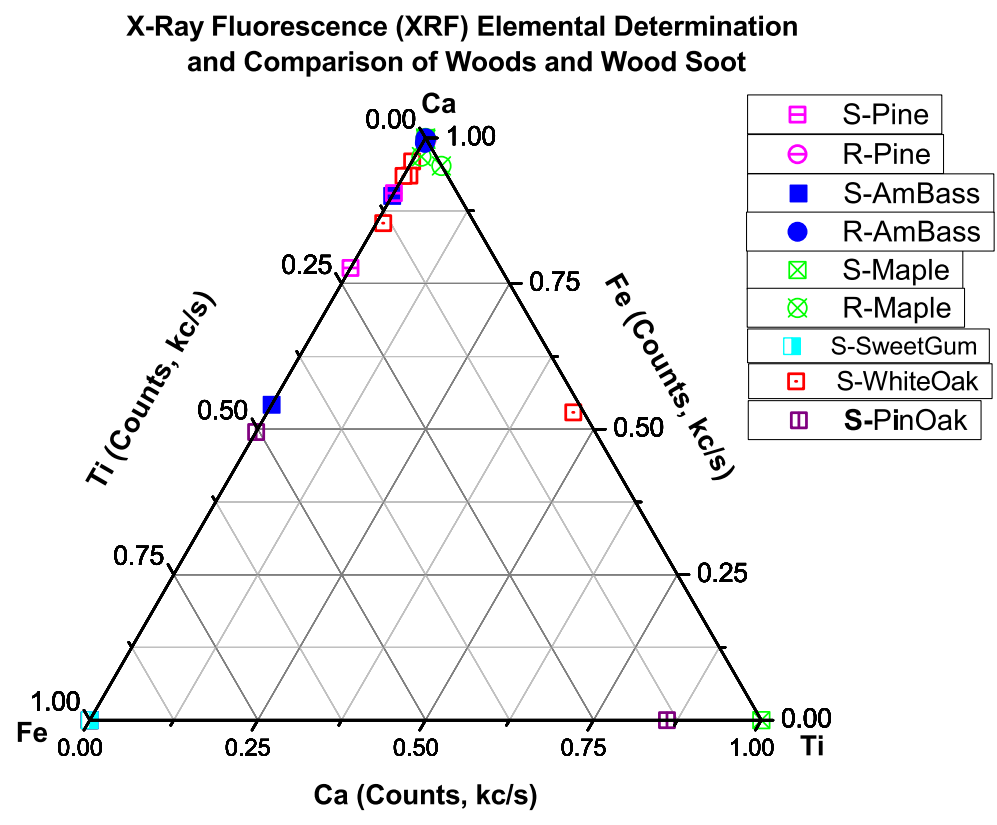


Figure 34 Triangular plot of XRF data for specific Unburned and Burned woods, with a focus on Ti, Ca, Fe. Here we have a distinction of elemental concentrations of Ti, Ca, and Fe by wood species. Concentrations of Ca seem to remain at a constant high throughout the combustion process.

Comparison of Elemental Ratios for XRF samples

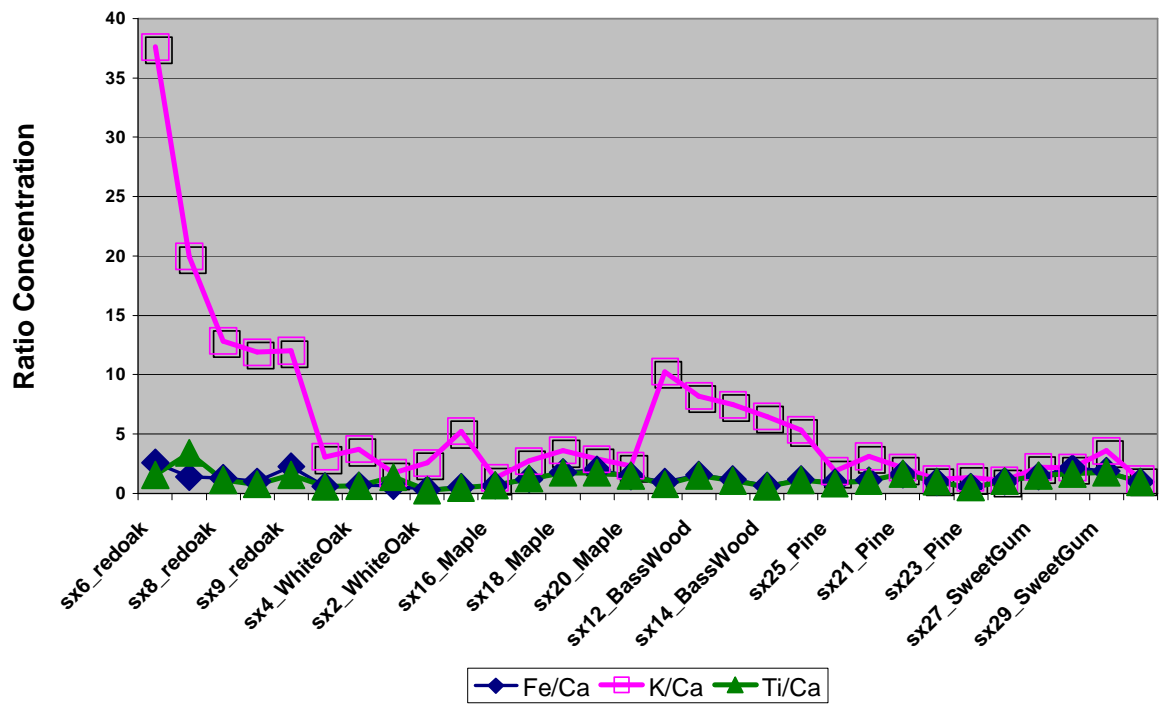


Figure 35 Comparison of elemental ratios for Fe/Ca, K/Ca and Ti/Ca find a higher K/Ca throughout the smoke samples indicating a possible tracer ratio for biomass burning events. The highest K/Ca ratios occur in Red Oak and American Basswoods, both deciduous tree species.

II. Statistical Results

Statistical analysis on FTIR, XRF and SEM/EDS data was performed with SPSS version 12 software. An analysis of variance (ANOVA) was performed on all test data, and results appear in tables 7 through 11.

Statistical results for FTIR spectra, Table 7-9, show that comparisons within individual sample sets of lumber and greenwood, maple sample 1, 2 and 3, do not vary significantly from sample to sample when viewed either in the fingerprint region (Table 7-A) or for the entire peak spectrum (Table 7-B). These results show that wood smoke spectra, whether from lumber or greenwood, are reproducible when captured onto KBr filter media. The only sample that was not shown to be reproducible was birch wood. The results for birch wood may be due to sampling error or instrumental drift.

In comparisons between samples sets of greenwood and lumber statistical results varied. When observing the fingerprint region, within 400 to 900 wavenumbers, there was no significant difference found between sample sets, maple versus white oak for example (Table 8-A). The same results were found for lumber when observing within the region of 400 to 900 wavenumbers, there was no significant difference between sample sets, walnut versus cherry lumber (Table 8-A). However, when taking into account the entire peak spectrum, 400 to 4000 wavenumbers it was found that lumber could significantly be differentiated with a 95% confidence interval, while greenwood could not (Table 8-B).

Additionally when comparing greenwood forest material with lumber statistical results also varied. In Table 9-A, results show that when greenwood and lumber peaks are compared in the fingerprint region, the peak sets do not significantly differ from one another. However, when featuring the entire peak spectrum, from 400 to 4000 wavenumbers, a

significant difference is found between lumber and greenwood material. These results indicate that lumber and greenwood material can be differentiated with a 95% confidence interval, by using their FTIR signals as long as the entire peak region is taken into consideration.

Deciduous and coniferous trees samples were also statistically compared to gauge whether or not they could be differentiated by their infrared spectrum. Statistical results, Table 9-B, show that the infrared spectrums for both types of wood are significantly different in the fingerprint region, 400 to 900 wavenumbers, and in the entire peak spectrum. These results show that there is a clear difference when comparing deciduous and coniferous wood species that can be readily picked up by FTIR.

SEM/EDS results, Table 10, for gold and carbon coated woods comparing results for various woods indicate that sample means are similar enough to accept the null hypothesis. Therefore when using SEM/EDS for smoke analysis, elemental on titanium and potassium content alone does not appear to be uniquely linked to a specific wood.

Statistics for XRF, Table 11, yield similar results to those of the SEM/EDS. These results indicate that both unburned and burned woods yield similar ratios of titanium and potassium that are not unique to wood smoke type. There was a slight decrease, however, when comparing burned and unburned material with a specific titanium target which may indicate that a more sensitive technique may yield different results.

Table 7 Statistical Results for the comparison within individual sample sets. Small significance levels (<0.5) indicate group differences, H_0 is rejected. Results show that sample duplicates are reproducible on the KBr filter media.

Statistical Results: FTIR						
(A) Comparison within individual sample sets						
For entire peak spectrum: 400-4000 wavenumbers (cm-1)						
Lumber	Sig	H(0) Null		Greenwood	Sig	H(0) Null
Maple	0.303	accepted		Pine	0.987	accepted
Pine	0.488	accepted		Maple	0.742	accepted
White Oak	0.389	accepted		White Oak	0.858	accepted
Ash	0.217	accepted		PinOak	0.859	accepted
Birch	0.004	rejected		AmBssWd	0.607	accepted
Walnut	0.974	accepted		SweetGum	0.872	accepted
Red Oak	0.083	accepted				
Cherry	0.426	accepted				
(B) Comparison within individual sample sets						
For Fingerprint Region Only: 400-900 wavenumbers (cm1)						
Lumber	Sig	H(0) Null		Greenwood	Sig	H(0) Null
Maple	0.932	accepted		Pine	0.745	accepted
Pine	0.99	accepted		Maple	0.999	accepted
White Oak	0.998	accepted		White Oak	0.998	accepted
Ash	0.999	accepted		PinOak	0.948	accepted
Birch	0.035	rejected		AmBssWd	0.996	accepted
Walnut	0.832	accepted		SweetGum	0.999	accepted
Red Oak	0.243	accepted				
Cherry	0.978	accepted				

Table 8 Statistical results for the comparison between sample sets show: **(A)** when comparing samples sets of greenwoods or lumber in the fingerprint region, there is no significant difference between the sets. **(B)** When comparing sample sets for the entire peak spectrum greenwoods still show no significant difference between the sample sets. However, lumber wood does show a significant difference between sets for the entire peak spectrum and can be differentiated with a 95% confidence interval.

Statistical Results:FTIR		
(A) Comparison between sample sets		
Within Groups Fingerprint Regions:400-900 wavenumbers (cm-1)		
	Sig	H(0) Null
Within Greenwoods	0.377	accepted
Within Lumber	0.181	accepted
(B) Comparison between sample sets		
Within Groups: 400-4000 wavenumbers (cm-1)		
	Sig	H(0) Null
Within Greenwoods	0.075	accepted
Within Lumber	0.000	rejected

Table 9 (A) Statistical results for the comparison of lumber and greenwood samples show that when viewed only in the fingerprint region, lumber and greenwood are not discernable.

However, when viewed throughout the entire peak spectrum, 400 to 4000, there is a significant difference between lumber and greenwood material. **(B)** Comparisons of deciduous and coniferous trees find significant differences between both types of wood in both the fingerprint region and entire peak spectrum.

Statistical Results:FTIR					
(A) Comparison between Lumber and Forest Wood					
400-900 cm-1			400-4000 cm-1		
Wood	Sig	H(0) Null	Wood	Sig	H(0) Null
All Greenwood vs. All Lumber	0.596	accepted	All Greenwood vs. All Lumber	0.022	rejected
(B) Comparison between Deciduous and Coniferous Wood					
400-900 cm-1			400-4000 cm-1		
All Deciduous vs. Coniferous	0.021	rejected	All Deciduous vs. Coniferous	0.000	rejected

Table 10 Statistical Results for SEM. Significance levels >0.5 indicate acceptance of H_0 .

SEM		Sig	H(0) Null
All Gold Coated Woods		1	accepted
All Carbon Coated Woods		1	accepted

Table 11 Statistical Results for XRF. Significance levels >0.5 indicate acceptance of H_0 .

XRF		Sig	H(0) Null
	Within Burned Green Woods (Ti)	0.946	accepted
	Within Burned Green Woods (K)	1	accepted
	Within Unburned Green Woods (Ti)	1	accepted
	Within Unburned Green Woods (K)	1	accepted
	Between Burned and Unburned (Ti)	0.52	accepted
	Between Burned and Unburned (K)	0.911	accepted

III. Conclusion

This work presents several findings: The first is a clear and concise method of capturing lumber and forest wood smoke onto KBr media filters. The second is distinguishing the smoke signals of lumber from forest material as well as deciduous from coniferous forest material. Additional distinctions between lumber sets, cherry distinguishable from walnut lumber for example, were also made. Lastly was the detection of a carbon peak inversion between high temperature smoke and low temperature smoke as well as the production of smaller particle size during high combustion temperatures versus larger particle size during lower temperature combustion.

Statistical results show that wood smoke spectra, whether from lumber or greenwood, are reproducible when captured onto KBr filter media. The only sample that was not shown to be reproducible was birch wood. The results for birch wood may be due to sampling error or instrumental drift. Additionally, when taking into account the entire peak spectrum, 400 to 4000 wavenumbers, it was found that one lumber set could significantly be differentiated from another lumber set with a 95% confidence interval (Table 8-B). Similar results found a significant difference between lumber and greenwood material, when distinguished throughout the entire peak spectrum. These results indicate that lumber and greenwood material can be differentiated with a 95% confidence interval, by using their FTIR signals as long as the entire peak region is taken into consideration.

Deciduous and coniferous trees samples were also statistically compared to gauge whether or not they could be differentiated by their infrared spectrum. These results show that there is a clear difference when comparing deciduous and coniferous wood species that

can be readily picked up by FTIR. Furthermore, the differences exhibited between lumber and green wood absorbance indicate that much of the tree chemistry is retained in the inner and outer bark portions of the tree. The magnitude of the vibrational response suggests that the FTIR differences can be recorded by satellite platforms.

The SEM/EDS and XRF information demonstrates that the aerosol chemistry of the solid aerosol particulates can be used in combination with the FTIR to strengthen the definition of the combustion products. Shown in the SEM/EDS data is that, White Pine and White Oak have a distinctive feature, a lack of a carbon response, when associated with potassium. While, comparisons of carbon (C) and potassium (K) ratios show that lumber smoke contains higher C/K ratios than greenwood smoke. These types of ratios have been used in the past to distinguish biomass burning fires from other anthropogenic sources of potassium and carbon, but never to distinguish wood sources from one another [Park, 2007]. The XRF data shows a transfer of high Calcium-Iron concentrations previous to burning, to a higher Potassium-Calcium concentration after burning. While the data from the SEM/EDS and XRF are not as clear at determining differences between the smoke of deciduous and conifer forest combustion products, they can be combined with spectral analysis by FTIR to strengthen key indexing features.

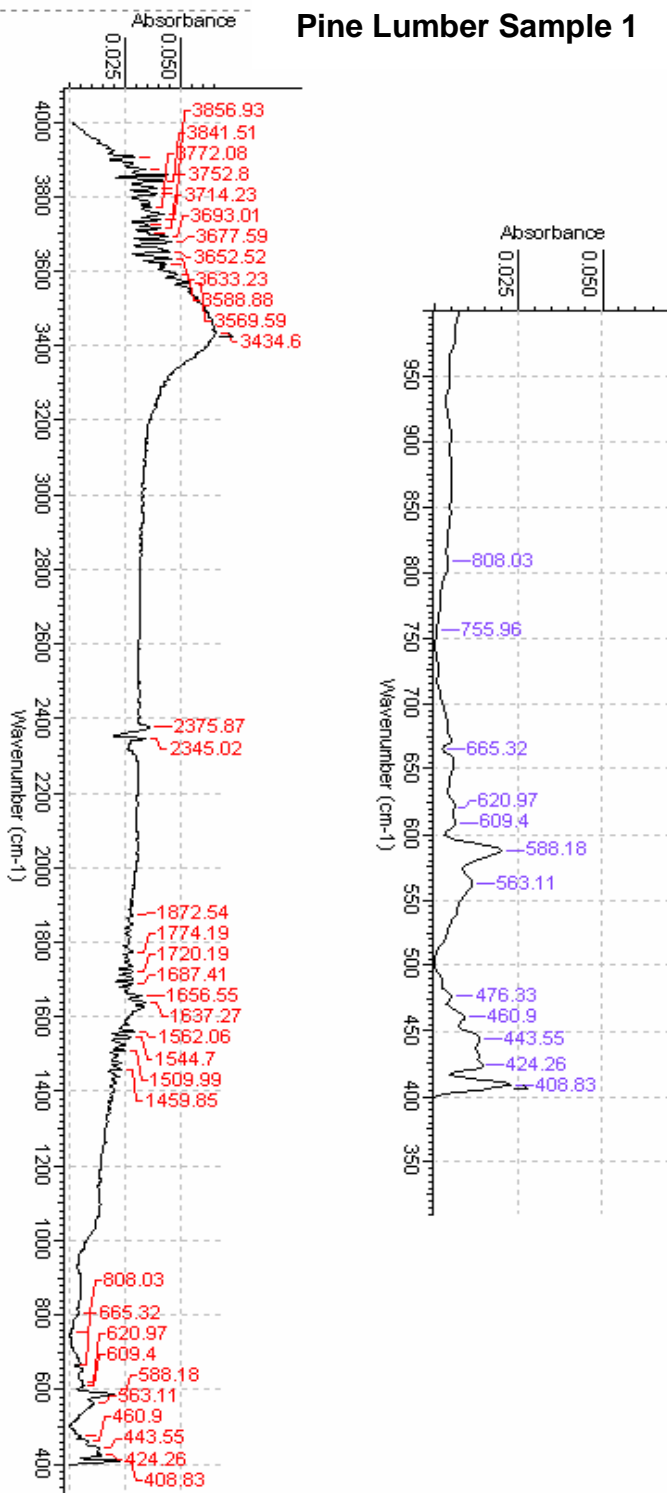
In this paper we have been able to show that Fourier Transform Infrared Spectroscopy (FTIR) spectra are capable of highlighting clear differences between deciduous and coniferous tree species as well as determine one lumber set from another. Spectral differences are highlighted at peak locations ranging from 400 to 4000 wavenumbers. Increases in spectral concentrations are indicative of higher particle abundances for molecules such as carbon monoxide (CO), carbonyl sulfide (SOC) and aromatics. By pinpointing these key features in smoke plumes we are able to increase the sensitivity of

atmospheric models that use pyrogenic emissions in their data sets, thereby contributing to the formation of clearer climate predictions. Additional carbon potassium ratio (C/K) information found through chemical analysis by Scanning Electron Microscopy and Energy Dispersive Spectroscopy (SEM/EDS) has found that lumber and forest products can be distinguished from one another.

Future work can now be done on correlating satellite imagery with sample FTIR instrumental response. By correlating satellite imagery with lab response it will be possible to pinpoint and track pyrogenically released materials and determine their effect on climate by issuing numerical concentrations and bulk chemical analysis for atmospheric modeling purposes. Future work can also be made on studying the carbon peak inversion related to the differences in smoke temperature, since this may be related to particle size. Particle size in the atmosphere determines whether a particulate will be an absorber of solar radiation or a reflector which is also important in generating climate models.

APPENDIX A SPECTRA

Pine Lumber Sample 1



Pine Lumber

Comment	031704 M83 Pine KBR8		
File Name	C:\DOCUMENTS AND SETTINGS\DJDMARIS PADILLAD\ESKTO\PMAR.CH 2004\031704 OTHER\031704 M83 PINE KBR8.SPC		
Date Stamp	17/03/2004 17:01:00	Date	17 Mar 2004 16:11:24
Spectral Region	IR	X Axis	Wavenumber (cm.⁻¹)
Spectrum Range	399.1928 - 3999.6399	Points Count	1988
		Y Axis	Absorbance
		Data Spacing	1.9286

Pine Lumber Sample 1

Comment	031704 M93 Pine KBR8	
File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS PADILLAUDESKTOP\MARCH 2004\031704 OTHER\031704 M93PINE KBR8.SPC	
Date Stamp	17/03/2004 17:01:00	Date 17 Mar 2004 16:11:24
Spectral Region	IR	X Axis Wavenumber (cm-1)
Spectrum Range	399.1926 - 3999.6399	Points Count 1668
		Y Axis Absorbance
		Technique Infrared
		Data Spacing 1.9285

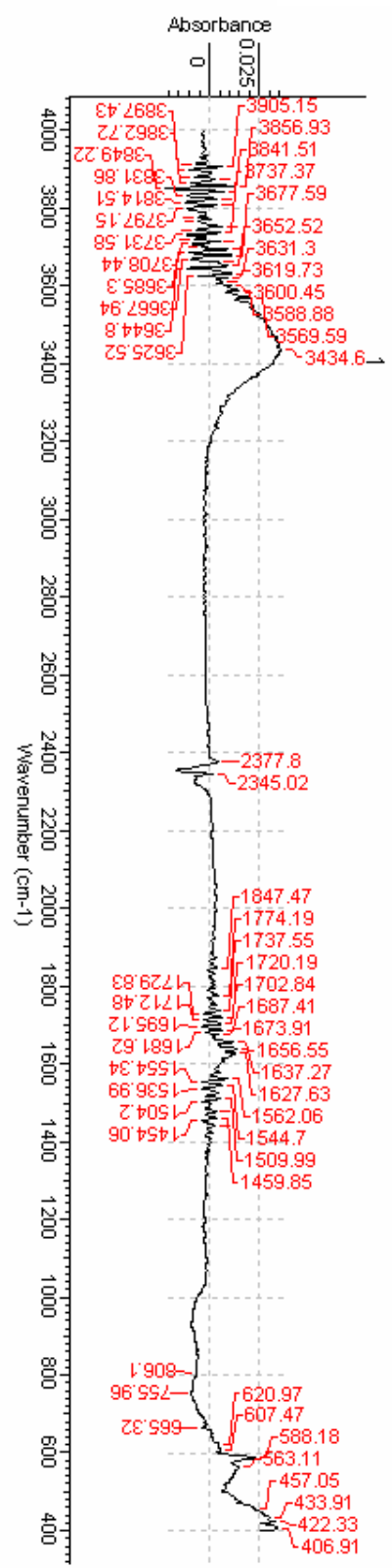
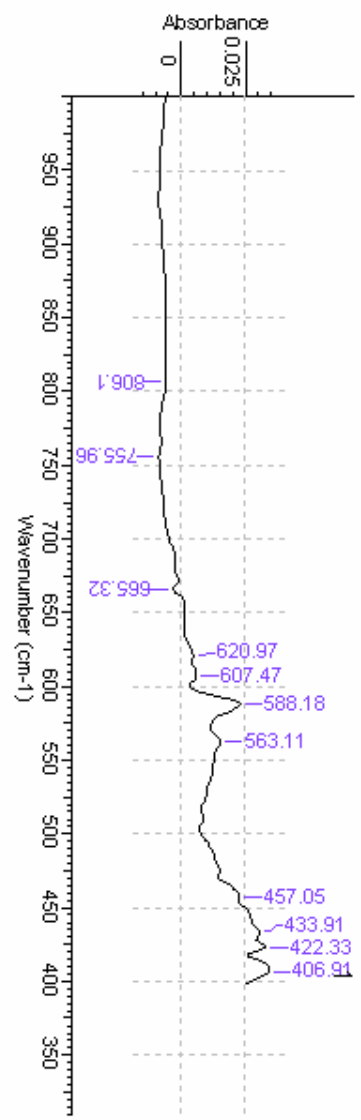
Pine Lumber

No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity
1	408.83	0.023	8.99	0.03	M	12	808.03	0.004	-	-	M	23	2346.02	0.034	-	-	M
2	424.26	0.014	-	-	W	13	1469.86	0.023	-	-	M	24	2376.87	0.036	-	-	M
3	443.66	0.014	-	-	W	14	1609.99	0.026	-	-	M	26	3434.60	0.066	-	-	VS
4	480.90	0.009	-	-	W	15	1644.70	0.027	-	-	M	26	3680.59	0.064	-	-	S
5	476.33	0.006	-	-	W	16	1662.06	0.029	-	-	M	27	3688.88	0.046	-	-	S
6	563.11	0.011	-	-	W	17	1637.27	0.034	-	-	M	28	3619.73	0.044	-	-	S
7	588.18	0.020	16.86	-0.77	M	18	1666.66	0.033	-	-	M	29	3633.23	0.046	-	-	S
8	609.40	0.006	-	-	W	19	1687.41	0.029	-	-	M	30	3662.52	0.046	-	-	S
9	620.97	0.006	-	-	W	20	1720.19	0.029	-	-	M	31	3677.69	0.046	-	-	S
10	666.32	0.002	-	-	W	21	1774.19	0.029	-	-	M	32	3693.01	0.044	-	-	S
11	756.96	0.001	-	-	W	22	1872.54	0.029	-	-	M	33	3702.66	0.036	-	-	M
												44	3905.15	0.029	-	-	M

Pine Lumber Sample 2

*031704 M93 Pine KBR8 2.25turn			
File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS PADILLADESKTO\SPEC TRACOPY OF 031704 SPC\CA 031704 M93 PINE KBR8 2.25TURN.SPC	Date	17 Mar 2004 17:14:54
Date Stamp	17/03/2004 17:05:00	Technique	Infrared
Spectral Region	IR	X Axis	Wavenumber (cm-1)
Spectrum Range	399.1926 - 3999.6399	Points Count	1868
		Y Axis	Absorbance
		Data Spacing	1.9285

Pine Lumber



Pine Lumber Sample 2

Comment	*031704 M93 Pine KBR8 2.25URN				
File Name	C:\DOCUMENTS AND SETTINGS\MARIUS P ADILL\DESKTOP\SPECTRACOPY\031704 SP CICA 031704 M93 PINE KBR8 2.25URN.SPC				
Date Stamp	17/03/2004 17:05:00	Date	17 Mar 2004 17:14:54	Technique	Infrared
Spectral Region	IR	X Axis	Wavenumber (cm-1)	Y Axis	Absorbance
Spectrum Range	399.1926 - 3999.6399	Points Count	1868	Data Spacing	1.9285

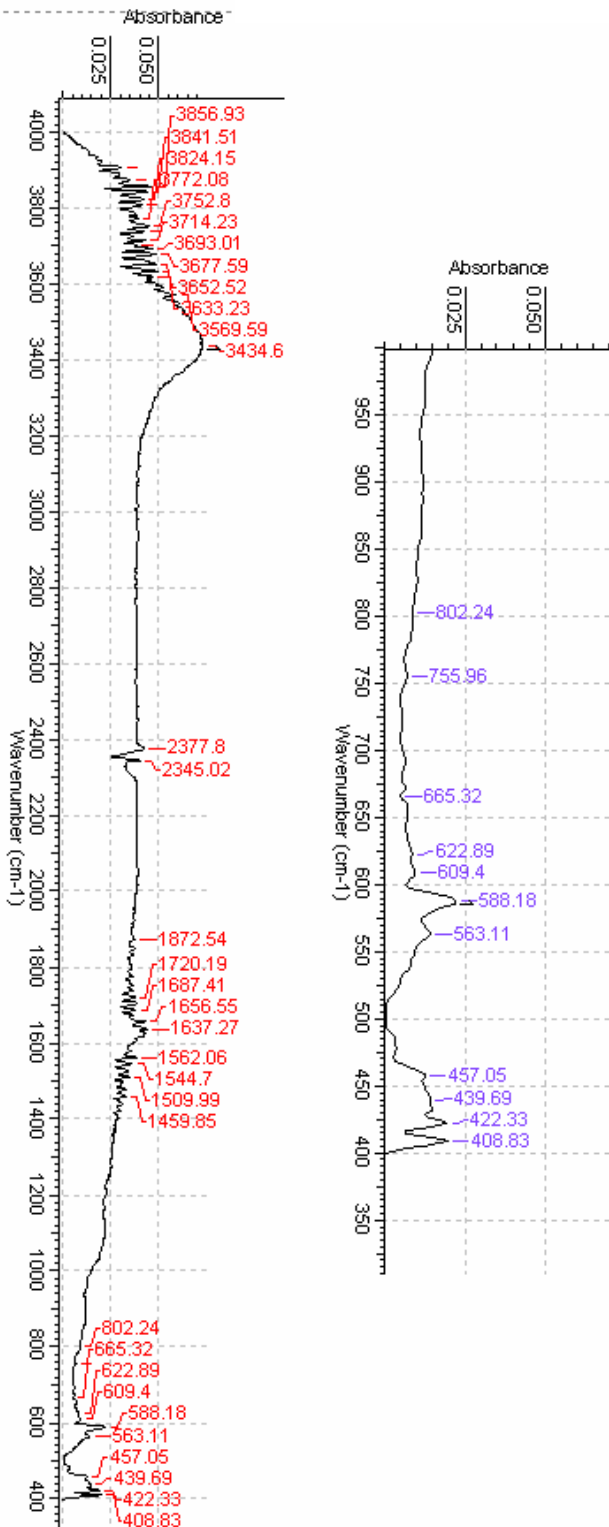
Pine Lumber

No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity
1	406.81	0.034	-	-	VS	20	1564.34	-0.004	3.89	0.28	M	39	3269.59	0.021	-	-	S	58	3737.37	0.005	3.26	-0.70	M
2	422.33	0.033	-	-	VS	21	1582.06	0.009	5.75	-0.12	M	40	3288.88	0.014	-	-	S	59	3743.15	-0.006	5.16	0.17	W
3	433.91	0.031	-	-	VS	22	1627.63	0.013	-	-	M	41	3200.46	0.011	-	-	M	60	3752.80	0.007	5.99	0.13	M
4	467.05	0.023	-	-	S	23	1637.27	0.014	-	-	S	42	3610.09	0.006	-	-	M	61	3766.30	-0.005	-	-	W
5	563.11	0.015	-	-	S	24	1666.55	0.012	8.33	-0.54	M	43	3619.73	0.009	5.79	-0.29	M	62	3777.87	-0.006	6.21	-0.29	W
6	588.18	0.023	-	-	S	25	1673.91	0.005	6.44	0.12	M	44	3625.52	-0.006	3.03	0.94	W	63	3797.15	-0.011	9.41	-0.26	W
7	607.47	0.006	-	-	M	26	1681.62	-0.002	-	-	M	45	3631.30	0.011	-	-	M	64	3806.79	0.004	3.85	-0.20	M
8	620.97	0.005	-	-	M	27	1687.41	0.007	5.24	-0.00	M	46	3644.80	-0.011	4.77	0.06	W	65	3814.51	-0.012	6.39	0.15	W
9	665.32	-0.003	6.30	0.52	M	28	1695.12	-0.004	4.10	-0.64	M	47	3652.52	0.010	6.12	0.14	M	66	3822.22	0.004	-	-	M
10	755.96	-0.009	-	-	W	29	1702.84	0.005	8.61	0.61	M	48	3660.23	0.005	-	-	M	67	3831.86	-0.011	7.75	0.50	W
11	806.10	-0.006	-	-	W	30	1712.48	-0.003	-	-	M	49	3667.94	-0.009	7.78	0.17	W	68	3841.51	0.007	4.38	0.75	M
12	1438.64	0.003	4.91	0.78	M	31	1720.19	0.006	6.39	0.48	M	50	3677.59	0.011	5.28	0.57	M	69	3849.22	-0.022	5.07	0.18	W
13	1464.06	-0.004	-	-	M	32	1729.83	-0.002	4.25	-0.33	M	51	3685.30	-0.011	4.41	0.10	W	70	3856.83	0.013	4.03	-0.84	M
14	1469.85	0.004	5.42	0.66	M	33	1737.55	0.005	7.00	0.18	M	52	3693.01	0.009	4.64	-0.96	M	71	3862.72	-0.009	-	-	W
15	1477.21	0.003	5.53	-0.13	M	34	1774.19	0.005	7.24	0.93	M	53	3698.80	-0.003	3.58	-0.42	M	72	3872.36	0.003	-	-	W
16	1504.20	-0.004	-	-	M	35	1847.47	0.004	7.68	0.48	M	54	3708.44	-0.008	-	-	W	73	3880.07	-0.007	5.76	-0.21	W
17	1509.99	0.006	4.79	0.19	M	36	2345.02	0.002	-	-	M	55	3714.23	0.005	3.46	-0.67	M	74	3897.43	-0.010	6.06	0.57	W
18	1536.99	-0.004	4.56	-0.18	M	37	2377.80	0.004	10.71	-0.04	M	56	3720.01	-0.008	5.17	0.36	W	75	3905.15	0.007	4.40	0.96	M
19	1544.70	0.007	6.87	0.21	M	38	3434.60	0.036	207.92	0.48	VS	57	3731.58	-0.011	-	-	W	76	3912.86	-0.007	-	-	W

Pine Lumber Sample 3

Comment	031704 M93 PineKBR8 1 2Sturn		
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Spectral Region	IR	X Axis	Wavenumber (cm-1)
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		Y Axis	Absorbance
		Data Spacing	1.9285

Pine Lumber



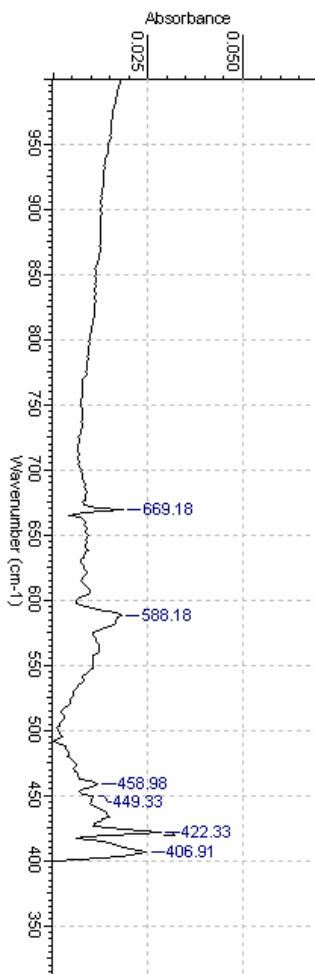
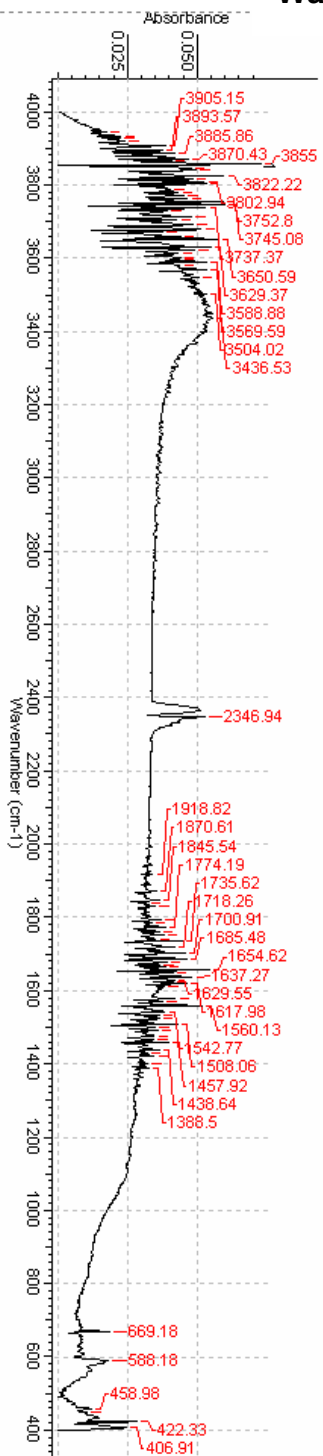
Pine Lumber Sample 3

Comment	031704 M93 Pine KBR8.1.25TUR		
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Spectral Region	IR	X Axis	Wavenumber (cm ⁻¹)
Spectrum Range	399.1926 - 3999.6399	Points Count	1868
		Y Axis	Absorbance
		Data Spacing	1.9285

Pine Lumber

No	cm-1	A	Fw/HH	Asym	Intensity	No	cm-1	A	Fw/HH	Asym	Intensity	No	cm-1	A	Fw/HH	Asym	Intensity	No	cm-1	A	Fw/HH	Asym	Intensity
1	408.83	0.020	9.12	-0.02	W	11	802.24	0.009	-	-	W	21	2346.02	0.040	-	-	M	31	3714.23	0.043	-	-	M
2	422.33	0.019	-	-	W	12	1469.85	0.033	-	-	M	22	2377.80	0.042	-	-	M	32	3737.37	0.043	-	-	M
3	439.69	0.014	-	-	W	13	1509.99	0.034	-	-	M	23	3434.60	0.073	-	-	V/S	33	3762.80	0.046	-	-	S
4	467.05	0.013	-	-	W	14	1544.70	0.036	-	-	M	24	3669.59	0.069	-	-	S	34	3772.08	0.039	-	-	M
5	563.11	0.014	-	-	W	15	1562.06	0.038	-	-	M	25	3619.73	0.047	-	-	S	35	3806.79	0.041	-	-	M
6	588.18	0.022	-	-	M	16	1637.27	0.044	-	-	S	26	3633.23	0.049	-	-	S	36	3824.15	0.042	-	-	M
7	609.40	0.009	-	-	W	17	1656.55	0.043	-	-	M	27	3652.52	0.048	-	-	S	37	3841.51	0.044	-	-	S
8	622.89	0.009	-	-	W	18	1687.41	0.038	-	-	M	28	3677.59	0.049	-	-	S	38	3866.93	0.047	-	-	S
9	665.32	0.005	-	-	VW	19	1720.19	0.038	-	-	M	29	3693.01	0.046	-	-	S	39	3872.36	0.035	-	-	M
10	755.96	0.007	-	-	VW	20	1872.54	0.038	-	-	M	30	3702.86	0.038	-	-	M	40	3905.15	0.031	-	-	M

Walnut Lumber Sample 1

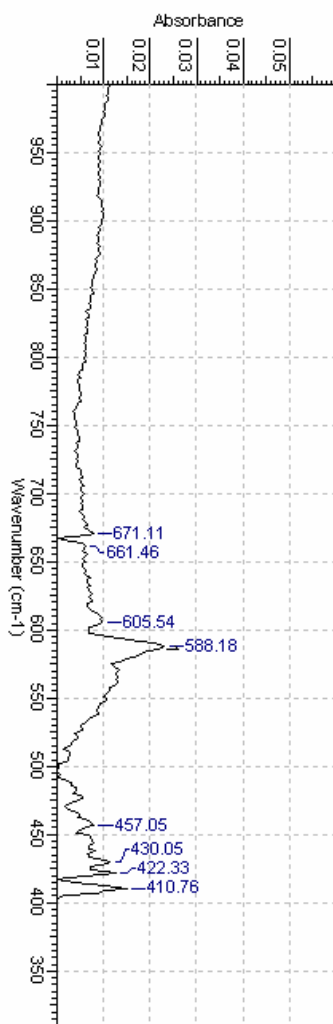
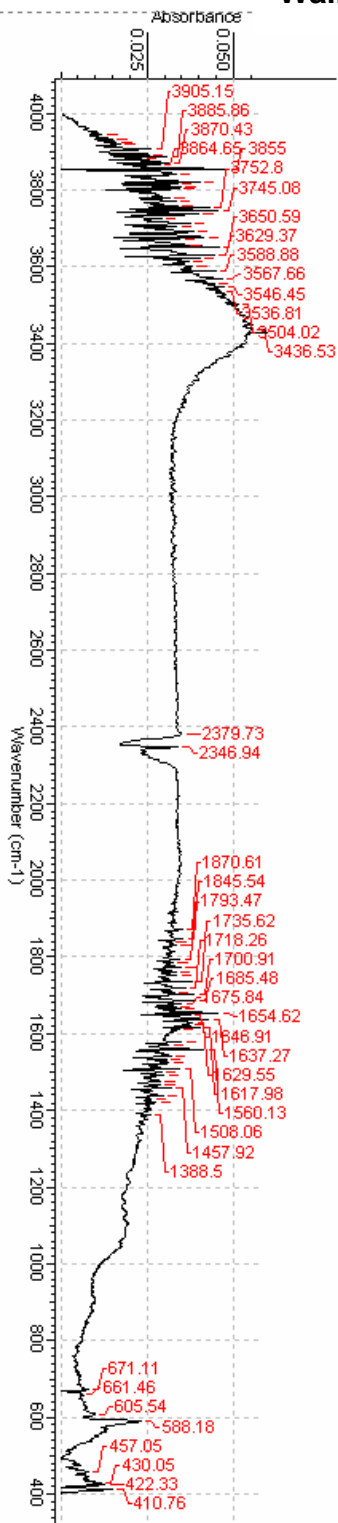


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Spectral Region	IR	X Axis	Wavenumber (cm-1)
Spectral Range	399.1926 - 3999.6399	Points Count	1868
		Y Axis	Absorbance
		Data Spacing	1.9285

Walnut Lumber Sample 1

0317D4.WS7.Ash.1.25turn																	
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Date Stamp	1703/2004 16:18:00				X Axis	Wavenumber (cm-1)											
Spectral Region	IR				Points Count	1898											
Spectrum Range	399.1926 - 3999.6399				Y Axis	Absorbance											
					Data Spacing	1.9285											
No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity
1	406.91	0.025	12.76	0.66	M	24	1610.27	0.038	-	-	M	47	1670.61	0.036	-	-	M
2	422.33	0.029	5.95	-0.03	M	25	1617.96	0.046	-	-	S	48	1618.82	0.034	-	-	M
3	449.33	0.011	-	-	W	26	1623.77	0.041	-	-	M	49	2346.94	0.063	-	-	S
4	458.98	0.012	-	-	W	27	1629.55	0.042	-	-	M	50	3436.53	0.065	-	-	S
5	468.18	0.018	-	-	W	28	1637.27	0.048	-	-	S	51	3504.02	0.063	-	-	S
6	669.18	0.018	4.86	0.87	W	29	1648.94	0.041	-	-	M	52	3546.46	0.060	-	-	S
7	1388.50	0.032	-	-	M	30	1654.62	0.054	-	-	S	53	3569.59	0.064	-	-	S
8	1400.07	0.032	-	-	M	31	1664.27	0.039	-	-	M	54	3581.16	0.044	-	-	M
9	1421.28	0.035	-	-	M	32	1670.05	0.037	-	-	M	55	3588.88	0.063	-	-	S
10	1430.92	0.032	-	-	M	33	1675.94	0.039	-	-	M	56	3596.59	0.044	-	-	M
11	1438.64	0.036	-	-	M	34	1685.48	0.046	-	-	S	57	3602.38	0.044	-	-	S
12	1467.92	0.040	-	-	M	35	1700.91	0.046	-	-	S	58	3613.95	0.043	-	-	M
13	1466.63	0.034	-	-	M	36	1718.26	0.042	-	-	M	59	3621.66	0.049	-	-	S
14	1473.35	0.035	-	-	M	37	1735.62	0.045	-	-	S	60	3629.37	0.065	-	-	S
15	1490.70	0.036	-	-	M	38	1741.41	0.035	-	-	M	61	3650.59	0.067	6.04	0.64	S
16	1498.42	0.035	-	-	M	39	1752.98	0.038	-	-	M	62	3658.30	0.044	-	-	S
17	1508.06	0.043	-	-	M	40	1762.62	0.036	-	-	M	63	3669.87	0.038	-	-	M
18	1523.49	0.036	-	-	M	41	1774.19	0.039	-	-	M	64	3677.59	0.061	-	-	S
19	1536.06	0.036	-	-	M	42	1785.76	0.034	-	-	M	65	3691.09	0.048	-	-	S
20	1542.77	0.038	-	-	M	43	1793.47	0.037	-	-	M	66	3702.66	0.043	-	-	M
21	1560.13	0.062	-	-	S	44	1832.04	0.035	-	-	M	67	3712.30	0.048	-	-	S
22	1571.70	0.038	-	-	M	45	1837.83	0.032	-	-	M	68	3727.73	0.039	-	-	M
23	1577.49	0.042	-	-	M	46	1846.54	0.036	-	-	M	69	3737.37	0.063	6.64	-0.11	S
						48	1846.54	0.036	-	-	M	91	3943.71	0.018	-	-	W

Walnut Lumber Sample 2



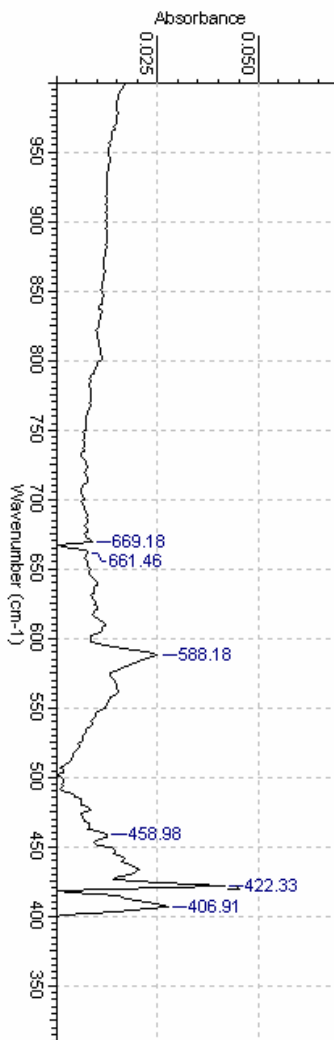
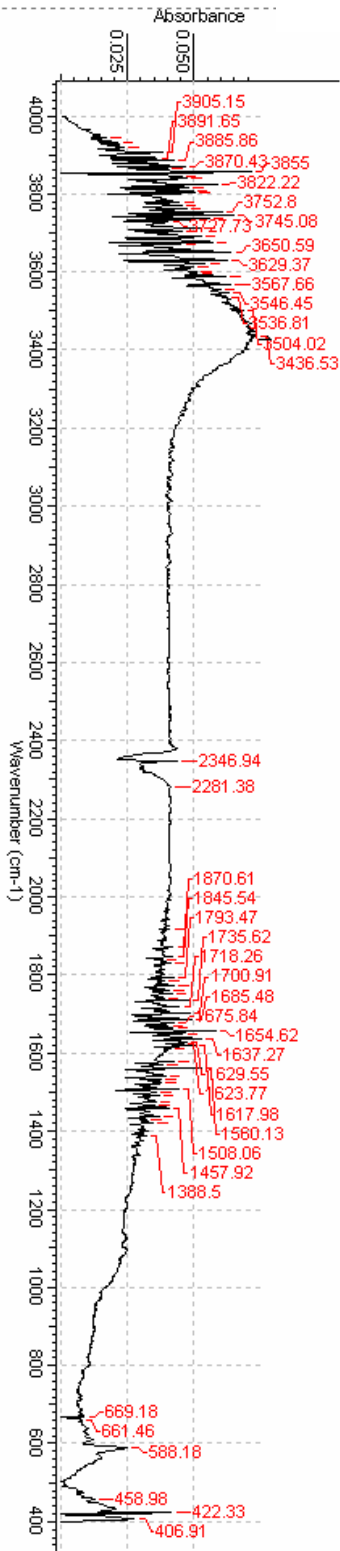
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Date Stamp	17/03/2004 17:20:00	Date	17 Mar 2004 17:33:32
Spectral Region	IR	Y Axis	Absorbance
Spectrum Range	399.1926 - 3999.6399	Points Count	1868
		Data Spacing	1.9286
		Technique	Infrared

Walnut Lumber Sample 2

Comment		03-1704 M92 W Walnut KBR1 1 25turn								
File Name		C:\NO DOCUMENTS AND SETTINGS\GSD\IGNARIS PADJILAUDESKTO\P\SPECTRA\MALL SPEC TRAMARCH 2004\031704 OTHER\031704 M92 W ALNUT KBR1 1 25TURN.SPC								
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Spectral Region		X Axis	Wavenumber (cm ⁻¹)							
Spectrum Range		IR	399.1926 - 3999.6399							
		Points Count	1898							
		Y Axis	Absorbance							
		Data Spacing	1.9285							
No	1	410.76	0.016	A	FWHH	6.93	Asym	-0.51	Intensity	W
No	2	422.33	0.013	-	-	-	-	-	-	W
No	3	430.06	0.012	-	-	-	-	-	-	W
No	4	467.06	0.008	-	-	-	-	-	-	W
No	5	588.18	0.023	-	-	-	-	-	-	M
No	6	606.64	0.010	-	-	-	-	-	-	W
No	7	661.46	0.006	-	-	-	-	-	-	W
No	8	671.11	0.008	-	-	-	-	-	-	W
No	9	1388.60	0.026	-	-	-	-	-	-	M
No	10	1421.28	0.028	-	-	-	-	-	-	M
No	11	1430.62	0.026	-	-	-	-	-	-	M
No	12	1438.84	0.030	-	-	-	-	-	-	M
No	13	1467.92	0.032	-	-	-	-	-	-	M
No	14	1486.63	0.029	-	-	-	-	-	-	M
No	15	1473.96	0.029	-	-	-	-	-	-	M
No	16	1490.70	0.030	-	-	-	-	-	-	M
No	17	1498.42	0.029	-	-	-	-	-	-	M
No	18	1608.06	0.036	-	-	-	-	-	-	S
No	19	1623.49	0.031	-	-	-	-	-	-	M
No	20	1636.06	0.030	-	-	-	-	-	-	M
No	21	1640.84	0.032	-	-	-	-	-	-	M
No	22	1660.13	0.041	-	-	-	-	-	-	S
No	23	1671.70	0.031	-	-	-	-	-	-	M
No	24	1677.49	0.036	-	-	-	-	-	-	S
No	25	1670.27	0.034	-	-	-	-	-	-	S
No	26	1617.98	0.040	-	-	-	-	-	-	S
No	27	1628.77	0.037	-	-	-	-	-	-	S
No	28	1629.66	0.038	-	-	-	-	-	-	S
No	29	1637.27	0.043	-	-	-	-	-	-	S
No	30	1646.91	0.037	-	-	-	-	-	-	S
No	31	1664.62	0.046	-	-	-	-	-	-	S
No	32	1664.27	0.036	-	-	-	-	-	-	S
No	33	1670.06	0.033	-	-	-	-	-	-	S
No	34	1676.84	0.036	-	-	-	-	-	-	S
No	35	1686.48	0.039	-	-	-	-	-	-	S
No	36	1700.91	0.039	-	-	-	-	-	-	S
No	37	1706.69	0.033	-	-	-	-	-	-	M
No	38	1718.26	0.036	-	-	-	-	-	-	S
No	39	1736.62	0.038	-	-	-	-	-	-	S
No	40	1762.98	0.034	-	-	-	-	-	-	S
No	41	1762.62	0.033	-	-	-	-	-	-	M
No	42	1774.19	0.036	-	-	-	-	-	-	S
No	43	1796.76	0.032	-	-	-	-	-	-	M
No	44	1788.47	0.036	-	-	-	-	-	-	S
No	45	1832.04	0.034	-	-	-	-	-	-	S
No	46	1832.04	0.034	-	-	-	-	-	-	S
No	47	1846.54	0.036	-	-	-	-	-	-	S
No	48	1870.61	0.036	-	-	-	-	-	-	S
No	49	2346.94	0.034	-	-	-	-	-	-	S
No	50	2379.73	0.036	-	-	-	-	-	-	S
No	51	3486.53	0.036	-	-	-	-	-	-	VS
No	52	3604.02	0.061	-	-	-	-	-	-	VS
No	53	3606.81	0.046	-	-	-	-	-	-	S
No	54	3646.46	0.047	-	-	-	-	-	-	S
No	55	3664.16	0.044	-	-	-	-	-	-	S
No	56	3667.66	0.047	-	-	-	-	-	-	S
No	57	3668.88	0.046	-	-	-	-	-	-	S
No	58	3662.38	0.038	-	-	-	-	-	-	S
No	59	3613.96	0.037	-	-	-	-	-	-	S
No	60	3619.73	0.040	-	-	-	-	-	-	S
No	61	3629.37	0.044	-	-	-	-	-	-	S
No	62	3660.69	0.046	-	-	-	-	-	-	S
No	63	3669.37	0.036	-	-	-	-	-	-	S
No	64	3669.87	0.034	-	-	-	-	-	-	S
No	65	3676.66	0.041	-	-	-	-	-	-	S
No	66	3661.09	0.038	-	-	-	-	-	-	S
No	67	3702.66	0.034	-	-	-	-	-	-	S
No	68	3712.30	0.038	-	-	-	-	-	-	S
No	69	3727.73	0.029	-	-	-	-	-	-	M
No	70	3737.37	0.040	A	FWHH	9.22	Asym	-0.70	Intensity	S
No	71	3746.08	0.046	-	-	-	-	-	-	S
No	72	3762.80	0.043	-	-	-	-	-	-	S
No	73	3780.61	0.034	-	-	-	-	-	-	S
No	74	3770.16	0.033	-	-	-	-	-	-	M
No	75	3779.79	0.031	-	-	-	-	-	-	M
No	76	3802.94	0.034	-	-	-	-	-	-	S
No	77	3808.72	0.036	-	-	-	-	-	-	S
No	78	3816.44	0.034	-	-	-	-	-	-	S
No	79	3822.22	0.040	-	-	-	-	-	-	S
No	80	3839.68	0.033	-	-	-	-	-	-	M
No	81	3866.00	0.048	-	-	-	-	-	-	M
No	82	3864.66	0.029	-	-	-	-	-	-	M
No	83	3870.43	0.032	-	-	-	-	-	-	M
No	84	3880.07	0.023	-	-	-	-	-	-	M
No	85	3886.86	0.031	-	-	-	-	-	-	M
No	86	3891.66	0.026	-	-	-	-	-	-	M
No	87	3906.16	0.026	-	-	-	-	-	-	M
No	88	3918.64	0.017	-	-	-	-	-	-	M
No	89	3924.43	0.016	-	-	-	-	-	-	W
No	90	3934.07	0.016	-	-	-	-	-	-	W
No	91	3943.71	0.012	-	-	-	-	-	-	W

Walnut Lumber Sample 3

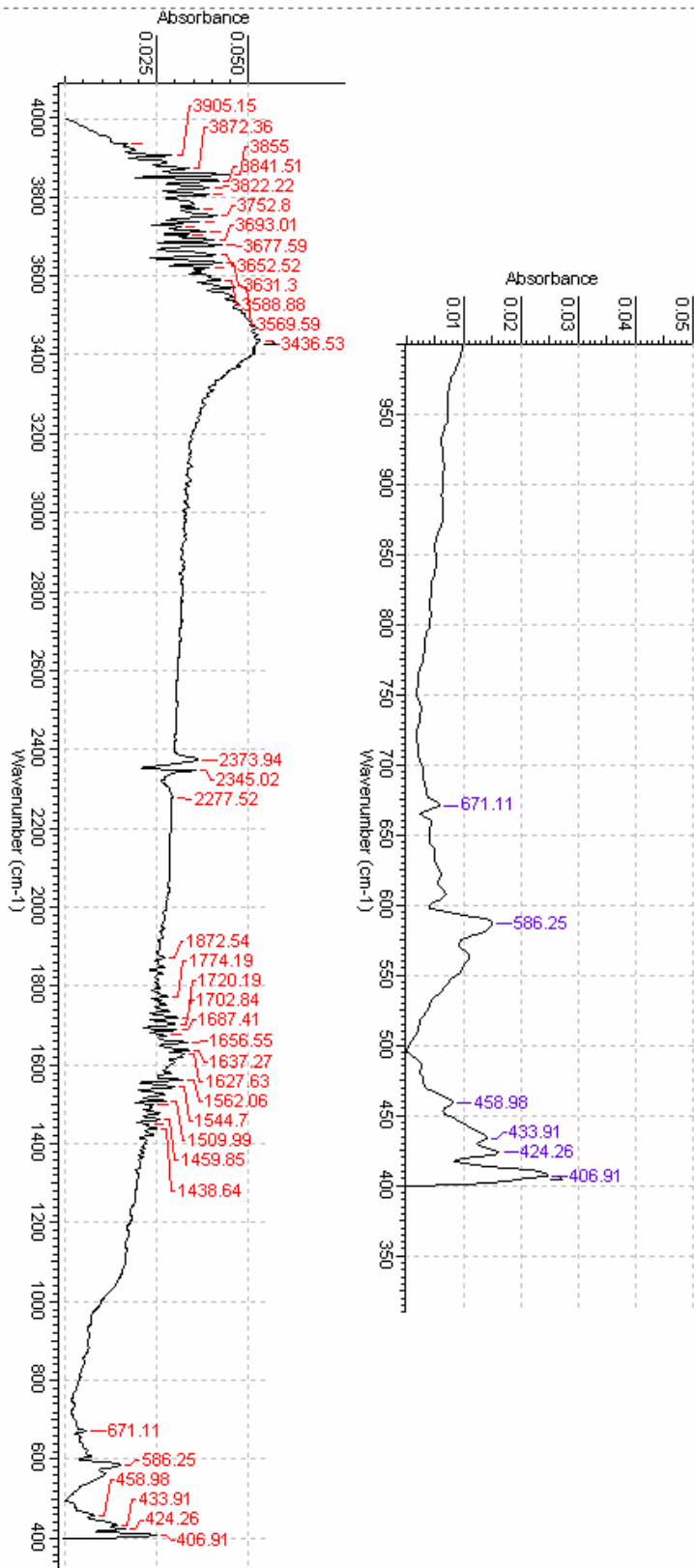
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Date Stamp	17/03/2004 17:22:00	Date	17 Mar 2004 17:33:50
Spectral Region	IR	X Axis	Wavenumber (cm-1)
Spectral Range	399 - 1926 - 399 6399	Points Count	1868
		Y Axis	Absorbance
		Data Spacing	1.9265



Walnut Lumber Sample 3

Comment		031704.M92.W.alnut.KBR1.2.25turn															
File Name		C:\DOCUMENTS AND SETTINGS\JOSID\IOMARIS PADILLAW\DESKTOP\SPC.TRAVALL.SPECTRA\MAR\CH.2004\031704.OTHER\031704.M92.WALNUT.KBR1.2.25TURN.SPC															
Date Stamp		1703/2004 17:22:00		Date		17 Mar 2004 17:33:50		Technique		Infrared							
Spectral Region		IR		X Axis		Wavenumber (cm-1)		Y Axis		Absorbance							
Spectral Range		399.1926 - 3999.6399		Points Count		1898		Data Spacing		1.9285							
No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity
1	4069.1	0.027	12.00	0.99	M	24	1617.98	0.090	-	-	S	47	1918.82	0.041	-	-	M
2	4223.3	0.041	5.14	0.14	M	25	1623.77	0.045	-	-	S	48	2281.38	0.041	-	-	M
3	4689.8	0.013	-	-	W	26	1629.55	0.047	-	-	S	49	2348.94	0.044	-	-	M
4	6681.8	0.025	-	-	M	27	1637.27	0.063	-	-	S	50	3436.63	0.073	-	-	VS
5	6614.6	0.008	-	-	W	28	1648.84	0.046	-	-	S	51	3504.02	0.068	-	-	VS
6	6691.8	0.009	-	-	W	29	1654.62	0.068	-	-	S	52	3536.81	0.063	-	-	S
7	1388.50	0.032	-	-	M	30	1654.27	0.042	-	-	M	53	3546.46	0.063	-	-	S
8	1421.28	0.035	-	-	M	31	1670.05	0.040	-	-	M	54	3554.16	0.060	-	-	S
9	1490.92	0.032	-	-	M	32	1675.84	0.048	-	-	M	55	3567.66	0.064	-	-	S
10	1488.64	0.037	-	-	M	33	1685.48	0.049	-	-	S	56	3588.88	0.062	-	-	S
11	1467.92	0.040	-	-	M	34	1700.91	0.048	-	-	S	57	3596.59	0.051	-	-	S
12	1485.63	0.035	-	-	M	35	1718.26	0.044	-	-	S	58	3602.38	0.051	-	-	S
13	1473.35	0.036	-	-	M	36	1735.62	0.048	-	-	S	59	3613.95	0.050	-	-	S
14	1490.70	0.037	-	-	M	37	1741.41	0.039	-	-	M	60	3619.73	0.054	-	-	S
15	1488.42	0.036	-	-	M	38	1752.98	0.041	-	-	M	61	3629.37	0.063	-	-	S
16	1508.06	0.044	-	-	S	39	1762.62	0.041	-	-	M	62	3650.89	0.064	-	-	S
17	1523.49	0.038	-	-	M	40	1774.19	0.043	-	-	M	63	3669.87	0.045	5.33	0.89	S
18	1535.06	0.038	-	-	M	41	1785.76	0.039	-	-	M	64	3675.66	0.057	-	-	S
19	1540.94	0.039	-	-	M	42	1793.47	0.043	-	-	M	65	3691.09	0.052	-	-	S
20	1590.13	0.052	-	-	S	43	1833.04	0.041	-	-	M	66	3702.66	0.045	-	-	S
21	1571.70	0.038	-	-	M	44	1837.83	0.038	-	-	M	67	3712.30	0.052	-	-	S
22	1577.49	0.043	-	-	M	45	1845.54	0.042	-	-	M	68	3727.73	0.040	-	-	M
23	1610.27	0.041	-	-	M	46	1870.61	0.042	-	-	M	69	3737.37	0.055	7.08	-0.19	S
70	3745.08	0.065	3.23	-	S	71	3752.80	0.061	-	-	S	72	3780.51	0.047	-	-	S
73	3770.15	0.046	-	-	S	74	3779.79	0.044	-	-	S	75	3802.94	0.060	-	-	S
76	3808.72	0.060	-	-	S	77	3816.44	0.048	-	-	S	78	3822.22	0.059	-	-	S
79	3839.88	0.047	-	-	S	80	3845.36	0.045	-	-	S	81	3855.00	0.071	5.79	0.57	VS
82	3864.65	0.040	-	-	M	83	3870.43	0.048	-	-	S	84	3885.86	0.048	5.22	0.94	M
85	3891.65	0.036	-	-	M	86	3905.15	0.038	14.07	0.28	M	87	3918.64	0.024	-	-	M
88	3934.07	0.021	-	-	W	89	3948.71	0.017	-	-	W						

Ash Lumber Sample 1



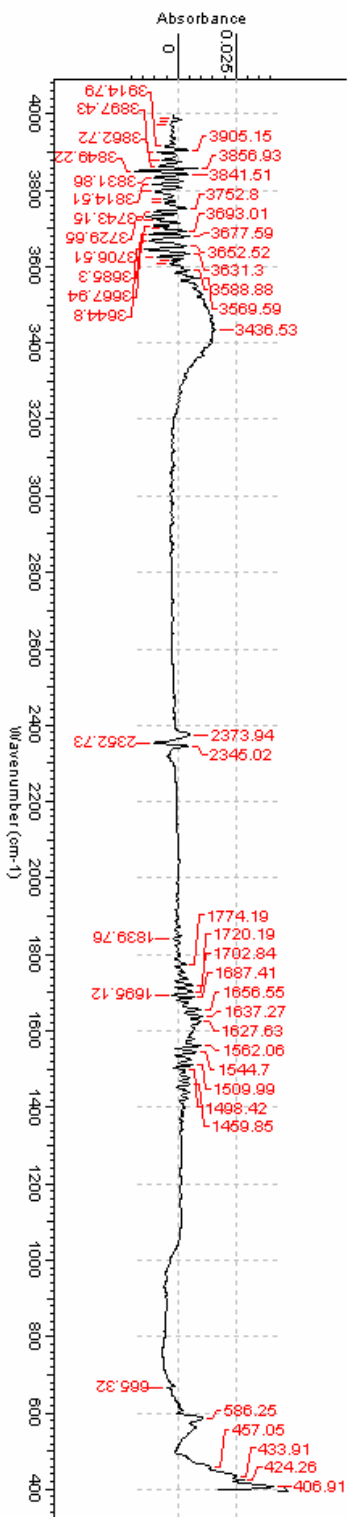
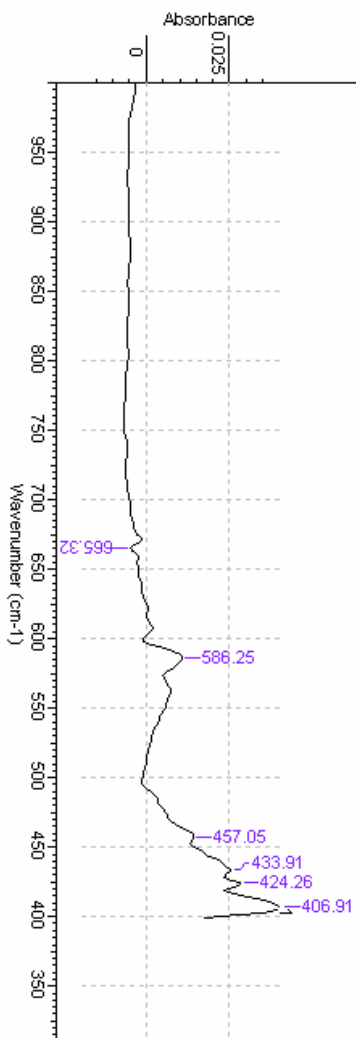
Title	Ash Lumber	Y Axis	Absorbance	Spectral Region	IR
File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS P ADILLAM\Y\DOCUMENTS\DISSERTATION\WORK\RESULTS\WALNUT WHITE OAK ASH PINE LUMBER\YASH.TXT	X Axis	Wavenumber (cm-1)	Spectrum Range	399.1926 - 3999.6399
Date	03 Jan 2006 00:33:30	Technique	Infrared		
Points Count	1868	Data Spacing	1.9285		

Ash Lumber Sample 1

Title		Ash Lumber															
File Name		C:\DOCUMENTS AND SETTINGS\SIDDIQI\MARIS PADILLAMY\DOCUMENTS\DISSERTATION\WORKRESULTS\WALNUT\WHITEOAK ASH PINE LUMBER\ASH.TXT															
Date		03 Jan 2006 00:33:30															
X Axis		Wavenumber (cm-1)															
Points Count		1898															
Technique		Infrared															
Y Axis		Absorbance															
Data Spacing		1.9285															
Spectral Region		IR															
Spectral Range		399.1926 - 3999.6399															
No	cm-1	A	FW/HH	Asym	Intensity	No	cm-1	A	FW/HH	Asym	Intensity	No	cm-1	A	FW/HH	Asym	Intensity
1	406.91	0.025	12.81	0.44	M	13	1562.06	0.032	-	-	S	25	2373.94	0.036	-	-	S
2	424.26	0.016	-	-	M	14	1627.63	0.032	-	-	S	26	3486.53	0.053	-	-	VS
3	433.91	0.014	-	-	W	15	1637.27	0.034	-	-	S	27	3599.59	0.046	-	-	S
4	458.98	0.008	-	-	W	16	1656.56	0.033	-	-	S	28	3688.88	0.042	-	-	S
5	586.25	0.015	-	-	W	17	1675.84	0.028	-	-	M	29	3619.73	0.039	-	-	S
6	671.11	0.006	-	-	W	18	1687.41	0.030	-	-	M	30	3631.30	0.043	-	-	S
7	1438.64	0.025	-	-	M	19	1702.84	0.030	-	-	M	31	3662.52	0.041	-	-	S
8	1448.28	0.023	-	-	M	20	1720.19	0.031	-	-	M	32	3677.59	0.048	-	-	S
9	1469.85	0.026	-	-	M	21	1774.19	0.028	-	-	M	33	3693.01	0.041	-	-	S
10	1498.42	0.024	-	-	M	22	1872.54	0.027	-	-	M	34	3702.86	0.033	-	-	S
11	1509.99	0.027	-	-	M	23	2277.52	0.029	-	-	M	35	3714.23	0.038	-	-	S
12	1544.70	0.030	-	-	M	24	2346.02	0.035	-	-	S	36	3723.87	0.032	-	-	M
												No	cm-1	A	FW/HH	Asym	Intensity
												37	3737.37	0.037	-	-	S
												38	3752.80	0.041	-	-	S
												39	3772.08	0.036	-	-	S
												40	3806.79	0.039	-	-	S
												41	3822.22	0.039	-	-	S
												42	3941.51	0.042	-	-	S
												43	3865.00	0.045	-	-	S
												44	3872.36	0.034	-	-	S
												45	3905.15	0.029	-	-	M
												46	3934.07	0.017	-	-	M

Ash Lumber Sample 2

Comment	*031704 W/S7 Ash		File Name	Z:\031704 SPC\CT_031704 W/S7 ASH.SPC	Date Stamp	17032004 16:14:00
Date	17 Mar 2004 16:22:02		Technique	Infrared	Spectral Region	IR
Y Axis	Absorbance		Spectrum Range	399.1926 - 3999.6399	Points Count	1868
					X Axis	Wavenumber (cm-1)
					Data Spacing	1.9285

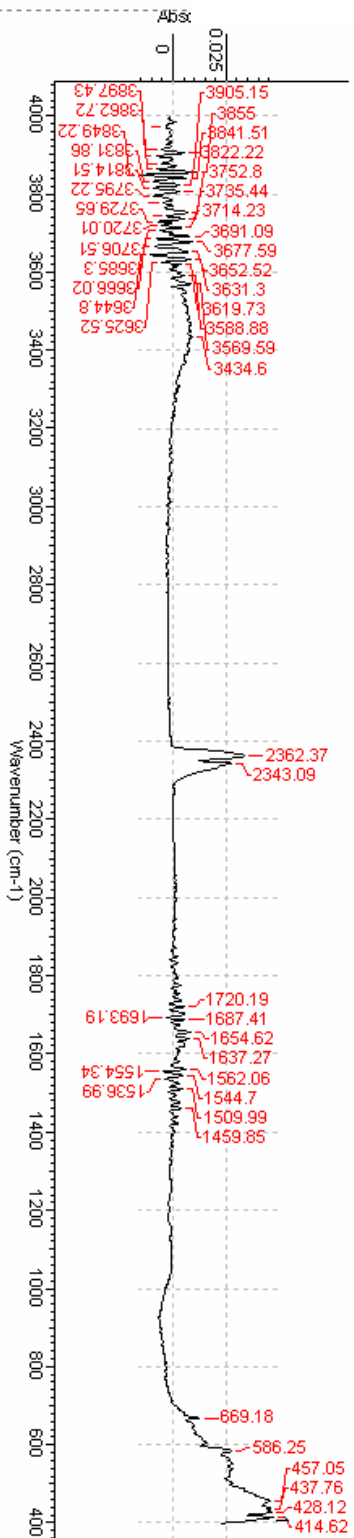
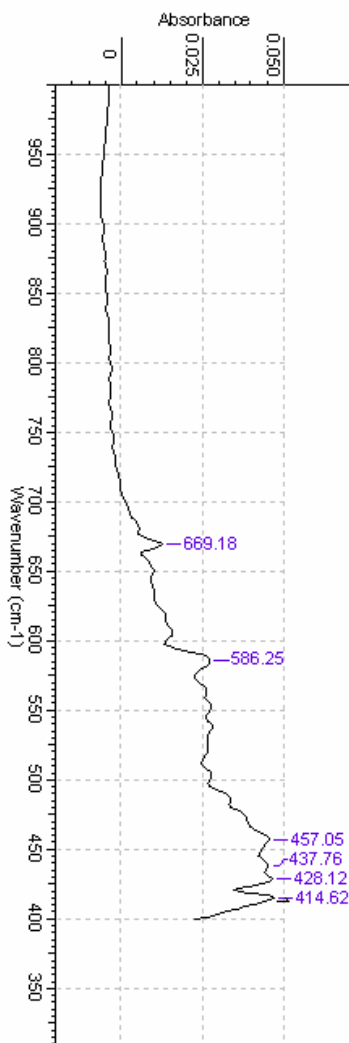


Ash Lumber Sample 2

Comment		*031704 WVST Ash | Fire Name		Z:\031704 SPC\CT 031704 WVST ASH SPC		Date Stamp		1703/2004 16:14:00		X Axis							
Date		17 Mar 2004 16:22:02		Technique		Spectral Region		IR		Wavenumber (cm-1)							
Y Axis		Absorbance		Spectrum Range		Points Count		1888		Data Spacing							
		399.1926 - 3999.6399								1.9285							
No	sm-1	A	FWHH	Asym	Intensity	No	sm-1	A	FWHH	Asym	Intensity	No	sm-1	A	FWHH	Asym	Intensity
1	406.91	0.041	-	-	V/S	16	1696.12	-0.002	3.50	-0.99	W	31	3644.80	-0.014	6.36	-0.07	VW
2	424.26	0.028	-	-	S	17	1702.84	0.006	9.36	0.62	M	32	3662.62	0.004	3.71	-0.25	M
3	433.91	0.025	-	-	S	18	1720.19	0.006	7.12	0.48	M	33	3667.94	-0.012	9.76	0.01	W
4	467.05	0.014	-	-	M	19	1774.19	0.003	5.90	0.74	M	34	3677.69	0.005	-	-	M
5	586.25	0.011	19.74	-0.90	M	20	1839.78	-0.002	6.10	0.70	W	35	3685.30	-0.012	5.54	0.05	W
6	665.32	-0.005	-	-	W	21	2346.02	0.004	4.42	-0.16	M	36	3693.01	0.003	-	-	M
7	1469.86	0.005	7.86	0.83	M	22	2362.73	-0.010	8.48	0.97	W	37	3698.80	0.006	-	-	W
8	1498.42	0.003	-	-	M	23	2373.94	0.005	13.31	0.15	M	38	3706.61	-0.011	7.32	0.30	W
9	1509.99	0.006	5.60	0.20	M	24	3486.63	0.016	17.25	0.33	M	39	3720.01	-0.009	-	-	W
10	1544.70	0.008	8.33	0.32	M	25	3588.88	0.009	8.21	0.42	M	40	3729.66	-0.014	7.67	0.27	VW
11	1562.06	0.010	6.98	0.06	M	26	3588.88	0.005	-	-	M	41	3743.15	-0.010	7.52	-0.03	W
12	1627.63	0.009	-	-	M	27	3606.23	-0.004	5.07	-0.03	W	42	3752.80	0.003	4.22	0.61	M
13	1637.27	0.010	-	-	M	28	3615.88	-0.002	-	-	W	43	3766.30	-0.006	-	-	W
14	1656.55	0.010	8.03	-0.34	M	29	3626.62	-0.009	4.77	0.12	W	44	3775.94	-0.006	-	-	W
15	1687.41	0.007	5.71	-0.07	M	30	3631.30	0.005	-	-	M	45	3797.15	-0.010	10.61	-0.60	W
												46	3814.51	-0.011	7.15	0.00	W
												47	3831.86	-0.010	8.38	0.34	W
												48	3841.51	0.004	3.74	0.70	M
												49	3849.22	-0.019	5.41	0.08	VW
												50	3856.93	0.008	-	-	M
												51	3862.72	-0.008	-	-	W
												52	3880.07	-0.007	6.92	-0.11	W
												53	3897.43	-0.009	6.58	0.42	W
												54	3905.15	0.004	-	-	M
												55	3914.79	-0.006	8.01	-0.15	W
												56	3970.71	-0.004	-	-	W
												57	3978.43	-0.003	-	-	W
												58	3988.07	-0.002	-	-	W

Ash Lumber Sample 3

Comment	*031704 M9.4 ASH PLUS KER 500		
Date Stamp	1703200416:32:00	Date	17 Mar 2004 17:10:10
X Axis	Wavenumber (cm-1)	Y Axis	Absorbance
Data Spacing	1.9285	Spectrum Range	399.1925 - 3999.6399
		File Name	Z:\031704 SPC\CT 031704 M9.4 ASH PLUS KER 500.SPC
		Technique	Infrared
		Spectral Region	IR
		Points Count	1988



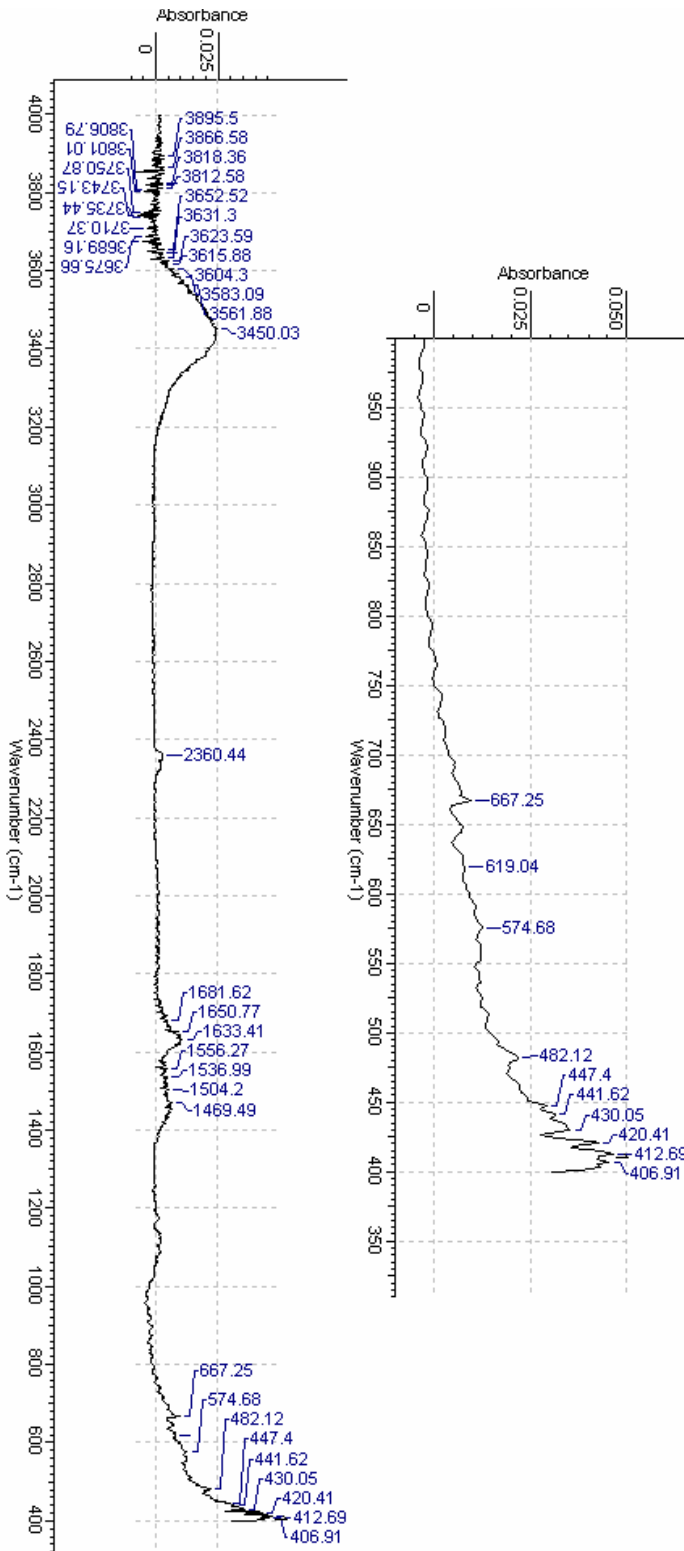
Ash Lumber Sample 3

Comment	*031704 M9.4 Ash plus KER 500	Date	17 Mar 2004 17:10:10	File Name	Z:\031704 SPC\CT 031704 M9.4 ASH PLUS KER 500 SPC
Date Stamp	1703/2004 16:32:00	Y Axis	Absorbance	Technique	Infrared
X Axis	Wavenumber (cm-1)	Y Axis		Spectrum Range	399 1926 - 3999 6399
Data Spacing	1 9285			Points Count	1868

No	cm-1	A	FW/HH	Asym	Intensity	No	cm-1	A	FW/HH	Asym	Intensity	No	cm-1	A	FW/HH	Asym	Intensity
1	41462	0.047	-	-	VS	16	1687.41	0.005	5.56	-0.47	M	29	3677.69	0.009	5.36	-0.20	M
2	428.12	0.047	-	-	VS	16	1683.19	-0.003	-	-	M	30	3685.30	-0.008	4.42	-0.66	W
3	437.76	0.046	-	-	VS	17	1720.19	0.005	6.55	0.04	M	31	3691.09	0.008	4.86	0.68	M
4	467.05	0.046	-	-	VS	18	2343.09	0.027	-	-	S	32	3706.51	-0.006	5.10	0.20	W
5	666.26	0.027	-	-	S	19	2362.37	0.033	23.13	0.61	S	33	3714.23	0.004	-	-	M
6	669.18	0.013	11.44	-0.01	M	20	3434.60	0.009	175.08	0.43	M	34	3720.01	-0.005	4.92	-0.16	W
7	1469.65	0.004	6.24	0.41	M	21	3698.69	0.008	7.68	0.03	M	35	3729.65	-0.007	4.96	-0.05	W
8	1509.99	0.005	4.99	-0.07	M	22	3688.88	0.005	-	-	M	36	3735.44	0.005	-	-	M
9	1536.99	-0.004	5.71	-0.98	W	23	3619.73	0.004	3.95	-0.81	M	37	3743.16	-0.003	3.78	-0.48	W
10	1544.70	0.005	5.89	-0.26	M	24	3625.52	-0.005	3.66	-0.62	W	38	3752.80	0.007	7.44	-0.68	M
11	1554.34	-0.005	5.27	-0.47	W	25	3631.30	0.008	5.68	0.72	M	39	3759.94	-0.005	6.30	0.72	W
12	1562.06	0.006	5.41	-0.35	M	26	3644.80	-0.010	5.68	-0.60	VW	40	3765.22	-0.009	9.69	-0.06	W
13	1637.27	0.007	8.09	0.30	M	27	3662.52	0.007	6.33	0.06	M	41	3804.96	0.003	-	-	W
14	1654.62	0.008	7.81	0.52	M	28	3666.02	-0.009	7.62	0.60	W	42	3814.51	-0.009	6.59	-0.39	W
												43	3822.22	0.003	4.22	0.07	M
												44	3831.86	-0.009	7.91	-0.03	W
												45	3841.51	0.006	4.38	-0.17	M
												46	3848.22	-0.016	5.18	-0.53	VW
												47	3855.00	0.011	-	-	M
												48	3862.72	-0.007	6.08	0.48	W
												49	3878.16	-0.005	5.71	0.79	W
												50	3897.48	-0.008	5.91	-0.11	W
												51	3905.16	0.006	4.64	0.07	M
												52	3912.86	-0.005	6.97	0.70	W
												53	3970.71	-0.003	-	-	W

Birch Lumber Sample 1

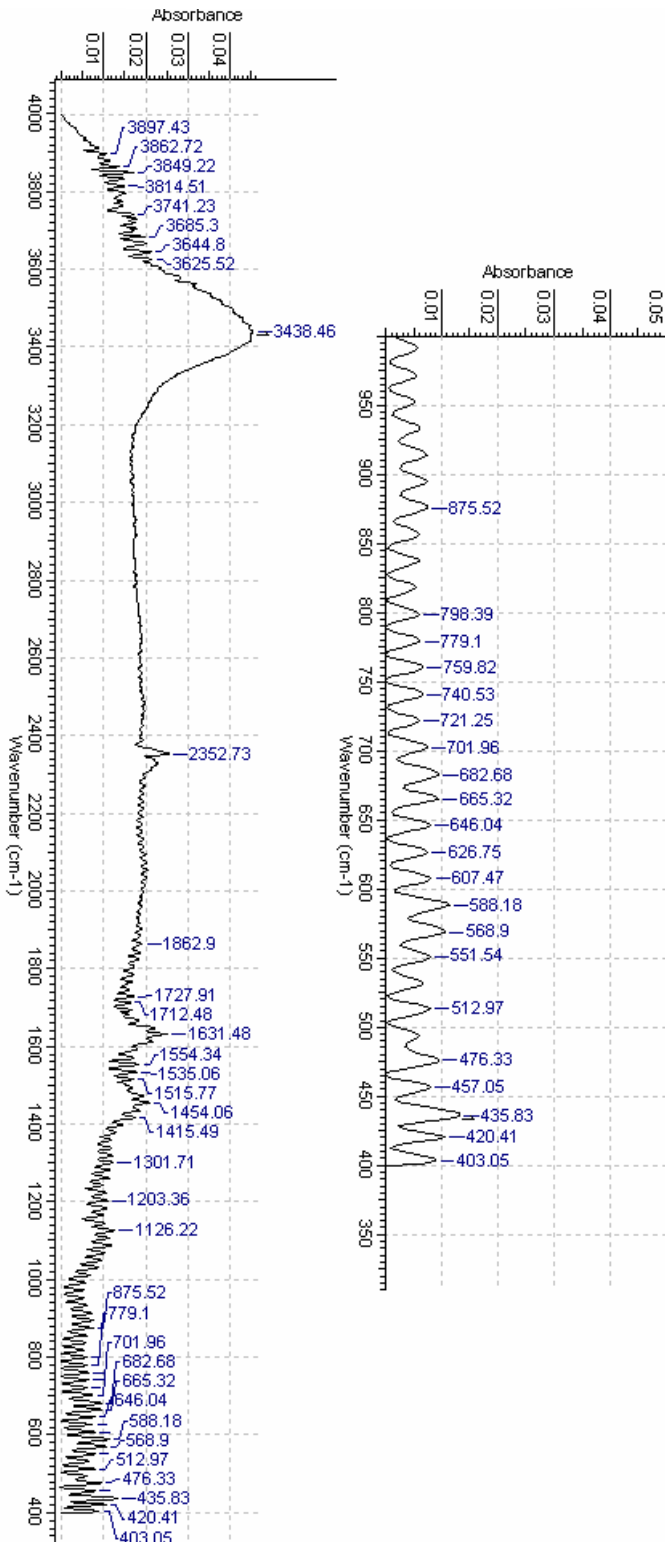
Comment	*031704 W/S4 Birch1.25	File Name	Z:\031704 SP C\CT 031704 W/S4 BIRCH 1.25.SP.C
Date Stamp	17.03.2004 15:35:00	Date	17 Mar 2004 15:39:50
Spectral Region	IR	X Axis	Wavenumber (cm-1)
Points Count	1868	Data Spacing	1.9285
		Y Axis	Absorbance
		Technique	Infrared
		Spectrum Range	399.1926 - 3999.6399



No	cm-1	A	FWHM	Asym	Intensity	No	cm-1	A	FWHM	Asym	Intensity	No	cm-1	A	FWHM	Asym	Intensity
1	4069.1	0.045	-	-	VS	11	1469.49	0.007	-	-	W	21	3583.09	0.010	-	-	M
2	4126.9	0.046	-	-	VS	12	1504.20	0.005	-	-	W	22	3604.30	0.007	-	-	W
3	4204.1	0.043	-	-	VS	13	1536.99	0.005	-	-	W	23	3615.88	0.005	-	-	W
4	4300.5	0.035	-	-	S	14	1556.27	0.004	-	-	W	24	3623.59	0.005	5.95	-0.22	W
5	4416.2	0.031	-	-	S	15	1633.41	0.011	-	-	M	25	3631.30	0.003	-	-	W
6	4474.0	0.029	-	-	S	16	1650.77	0.009	-	-	M	26	3644.80	0.002	-	-	W
7	4821.2	0.022	-	-	M	17	1681.62	0.005	-	-	W	27	3652.52	0.003	-	-	W
8	5746.8	0.012	-	-	M	18	2360.44	0.003	21.55	-0.95	W	28	3675.66	-0.005	-	-	W
9	6190.4	0.008	-	-	M	19	3450.03	0.024	-	-	M	29	3689.16	-0.004	3.93	-0.67	W
10	6672.5	0.009	-	-	M	20	3561.88	0.013	-	-	M	30	3710.37	-0.003	3.99	0.78	W
												31	3735.44	-0.005	-	-	W
												32	3743.15	-0.007	-	-	W
												33	3750.87	-0.005	-	-	W
												34	3801.01	-0.004	1.59	-0.09	W
												35	3806.79	-0.004	1.60	0.03	W
												36	3812.58	0.002	-	-	W
												37	3818.36	0.003	1.11	-0.89	W
												38	3824.15	0.002	1.70	0.14	W
												39	3866.58	0.003	1.70	-0.55	W
												40	3895.50	0.003	3.81	-0.67	W

Birch Lumber Sample 2

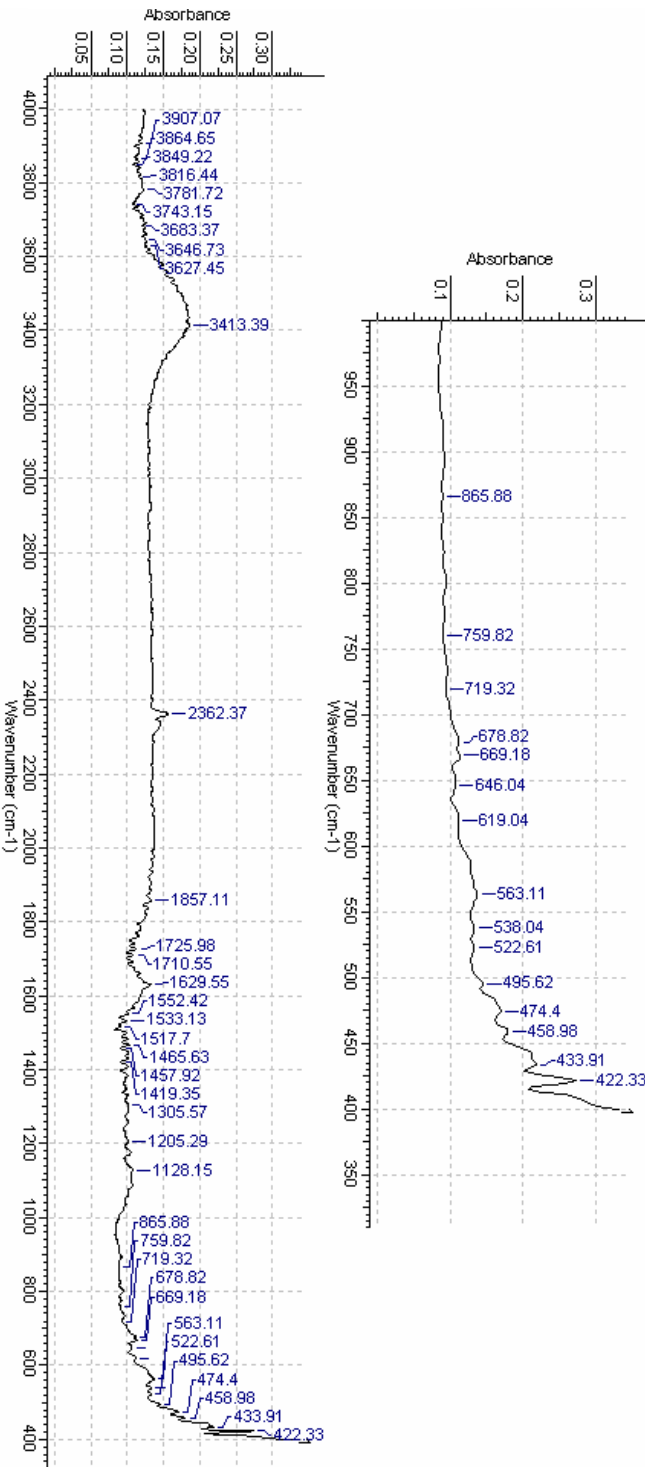
Comment	031704 W54 Birch 4.25 lum		
File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS.PADILLA\DESKTOP\SPECTRACOPY\031704.SP\031704.W54.BIRCH.4.25.TURN.SP.C		
Date Stamp	17/03/2004 15:31:00	Date	17 Mar 2004 15:40:34
Spectral Region	IR	X Axis	Wavenumber (cm-1)
Spectrum Range	399.1926 - 3999.6399	Points Count	1869
		Y Axis	Absorbance
		Data Spacing	1.9285



No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity
1	4030.5	0.009	-	-	W	12	646.04	0.008	9.99	0.04	W	23	1203.36	0.011	-	-	W
2	4204.1	0.011	8.32	0.15	W	13	665.32	0.009	10.39	0.20	W	24	1301.71	0.012	-	-	W
3	4358.3	0.013	11.56	0.53	W	14	682.68	0.009	12.43	0.14	W	25	1415.49	0.017	-	-	M
4	4570.5	0.008	9.46	-0.41	W	15	701.96	0.007	11.00	0.20	W	26	1454.06	0.021	-	-	M
5	4763.3	0.009	11.81	0.08	W	16	721.25	0.006	9.69	0.26	W	27	1515.77	0.017	-	-	M
6	5129.7	0.008	9.90	-0.02	W	17	740.53	0.007	9.85	0.21	W	28	1535.06	0.018	-	-	M
7	5515.4	0.008	11.09	-0.21	W	18	759.82	0.007	9.49	0.27	W	29	1554.34	0.018	-	-	M
8	5689.0	0.010	12.55	0.34	W	19	779.10	0.006	9.54	0.26	W	30	1631.48	0.025	-	-	M
9	5881.8	0.011	12.47	-0.03	W	20	798.39	0.006	9.76	0.33	W	31	1712.48	0.016	-	-	M
10	6074.7	0.008	10.26	0.05	W	21	875.52	0.008	12.03	0.30	W	32	1727.91	0.017	-	-	M
11	6267.5	0.007	9.75	-0.01	W	22	1126.22	0.012	-	-	W	33	1862.90	0.019	-	-	M
												34	2352.73	0.025	-	-	M
												35	3438.46	0.045	314.36	0.16	VS
												36	3625.52	0.022	-	-	M
												37	3644.80	0.021	-	-	M
												38	3685.30	0.020	-	-	M
												39	3741.23	0.017	-	-	M
												40	3814.51	0.015	-	-	M
												41	3849.22	0.017	-	-	M
												42	3862.72	0.014	-	-	M
												43	3897.43	0.011	-	-	W

Birch Lumber Sample 3

Comment	*061104 M9.9BIRCH 2	File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS P ADILL\ADESKTOP\SPECTR\AD061104\M9.9BIRCH 2.SPC
Date Stamp	11/06/2004 13:34:00	Date	11 Jun 2004 13:41:38
X Axis	Wavenumber (cm-1)	Y Axis	Absorbance
Data Spacing	1.9285	Spectrum Range	399.1925 - 3999.6399
		Points Count	1868

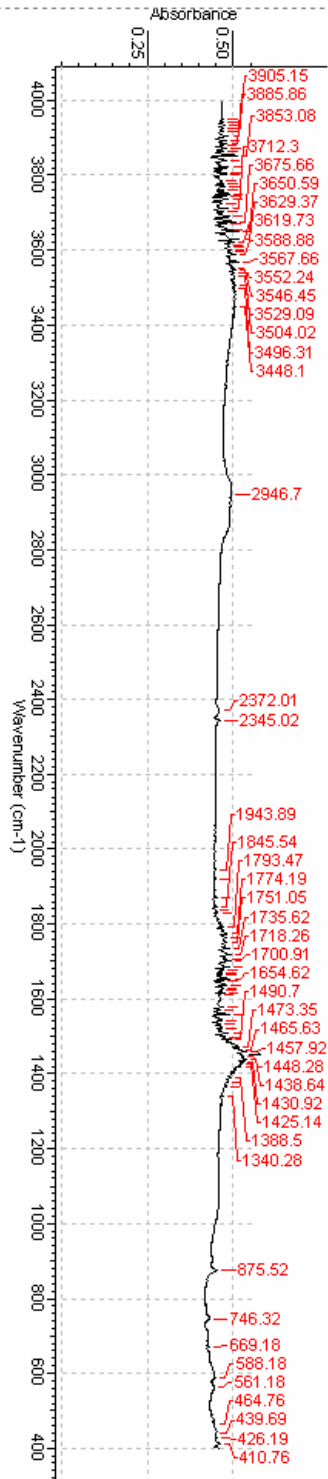
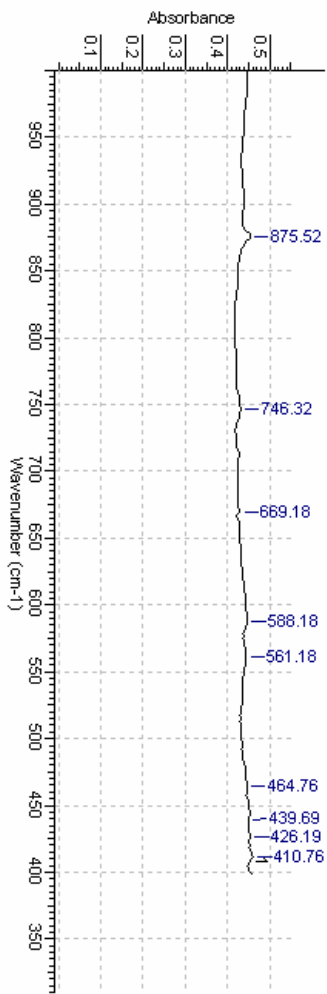


No	cm-1	A	Intensity	No	cm-1	A	Intensity	No	cm-1	A	Intensity
1	4223.3	0.273	S	14	759.82	0.091	VW	27	1725.98	0.113	W
2	4339.1	0.219	M	15	865.88	0.089	VW	28	1857.11	0.133	W
3	4589.8	0.180	M	16	1128.15	0.108	W	29	2362.37	0.156	W
4	4744.0	0.170	M	17	1205.29	0.101	VW	30	3413.39	0.186	M
5	4956.2	0.145	W	18	1305.57	0.102	VW	31	3627.45	0.126	W
6	5226.1	0.133	W	19	1419.35	0.092	VW	32	3646.73	0.125	W
7	5380.4	0.133	W	20	1457.92	0.092	VW	33	3683.37	0.119	W
8	5631.1	0.137	W	21	1465.63	0.103	VW	34	3743.15	0.107	W
9	6190.4	0.112	W	22	1517.70	0.091	VW	35	3781.72	0.123	W
10	6460.4	0.107	W	23	1533.13	0.099	VW	36	3816.44	0.116	W
11	6691.8	0.114	W	24	1552.42	0.102	VW	37	3849.22	0.108	W
12	6788.2	0.112	W	25	1629.55	0.132	W	38	3864.65	0.113	W
13	7193.2	0.093	VW	26	1710.55	0.109	W	39	3907.07	0.120	W

C:\Documents and Settings\Diomaris P adilla\Desktop\Ina Work\Dissemination Index\BIRCH_ORIG_SF1_OP_T03_SF2_4P_T07_F.aso

White Oak Lumber Sample 1

Comment	090104 White Oak Soot		
File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS PADI\LADESKTOP\SPECTRA\SPECTRA2\2004\09\01\04\090104\WHITE OAK SOOT GREEN.SPC		
Date Stamp	Date	Technique	Y Axis
01/09/2004 15:26:00	01 Sep 2004 15:27:58	IR	Absorbance
Spectral/Region	X Axis	Wavenumber (cm-1)	Points Count
IR			1888
Spectrum Range	399.1926 - 3999.6399		



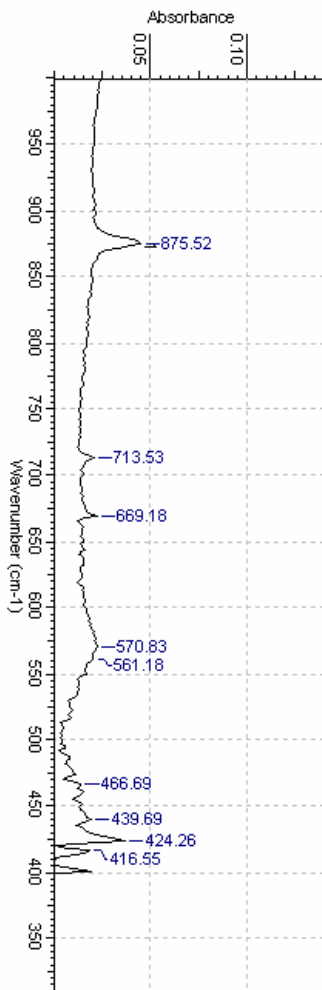
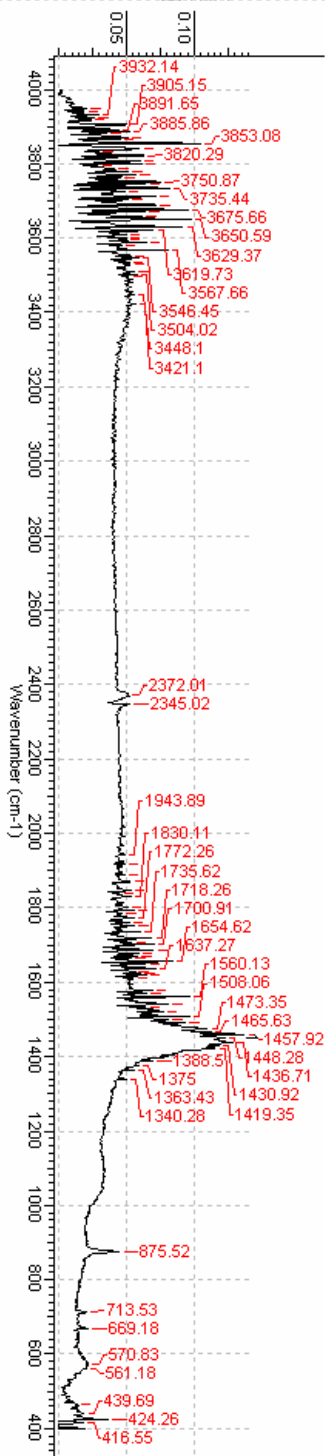
White Oak Lumber Sample 1

Comment	090104 White Oak Soot	
File Name	C:\DOCUMENTS\AND SETTINGS\DIOMARIS PADILLAS\ESKTOP\SPECTRA\SPECTRA\2004090104\090104 WHITE OAK SOOT GREEN.SPC	
Date Stamp	01/09/2004 15:26:00	Date 01 Sep 2004 15:27:58
Spectral Region	IR	Y Axis Technique Infrared
Spectrum Range	399.1928 - 3999.6399	X Axis Points Count 1998 Wavenumber (cm-1)
		Y Axis Data Spacing 1.9285 Absorbance

No	cm-1	A	Intensity	No	cm-1	A	Intensity	No	cm-1	A	Intensity
1	410.76	0.461	M	27	1540.84	0.469	M	53	1870.61	0.452	WV
2	426.19	0.454	M	28	1560.13	0.488	M	54	1918.82	0.449	WV
3	439.89	0.449	WV	29	1569.77	0.462	M	55	1943.89	0.449	WV
4	464.76	0.446	WV	30	1577.49	0.473	M	56	2345.02	0.461	M
5	561.18	0.443	WV	31	1610.27	0.461	M	57	2372.01	0.459	M
6	588.18	0.448	WV	32	1617.98	0.473	M	58	2946.70	0.494	S
7	669.18	0.430	WV	33	1623.77	0.468	M	59	3448.10	0.507	S
8	746.32	0.430	WV	34	1629.55	0.469	M	60	3496.31	0.503	S
9	875.52	0.454	WV	35	1637.27	0.481	M	61	3504.02	0.508	S
10	1340.28	0.469	M	36	1646.91	0.471	M	62	3529.09	0.504	S
11	1363.43	0.480	M	37	1654.62	0.492	S	63	3536.81	0.502	S
12	1375.00	0.484	M	38	1664.27	0.468	M	64	3546.45	0.507	S
13	1388.50	0.493	S	39	1670.05	0.469	M	65	3552.24	0.502	S
14	1419.35	0.523	S	40	1675.84	0.473	M	66	3567.66	0.517	S
15	1425.14	0.525	S	41	1685.48	0.488	M	67	3568.88	0.505	S
16	1430.92	0.528	VS	42	1700.91	0.493	S	68	3594.66	0.491	S
17	1438.64	0.536	VS	43	1706.69	0.482	M	69	3600.45	0.492	S
18	1448.28	0.530	VS	44	1718.26	0.493	S	70	3608.16	0.490	M
19	1457.92	0.539	VS	45	1735.62	0.489	M	71	3613.95	0.487	M
20	1465.63	0.523	S	46	1751.05	0.483	M	72	3619.73	0.503	S
21	1473.35	0.514	S	47	1762.62	0.481	M	73	3629.37	0.518	S
22	1490.70	0.492	S	48	1774.19	0.482	M	74	3650.59	0.517	S
23	1498.42	0.477	M	49	1793.47	0.473	M	75	3656.37	0.487	M
24	1508.06	0.486	M	50	1830.11	0.455	M	76	3669.87	0.482	M
25	1521.95	0.468	M	51	1837.83	0.449	WV	77	3675.66	0.505	S
26	1535.06	0.463	M	52	1845.54	0.454	WV	78	3691.09	0.488	M

No	cm-1	A	Intensity
79	3702.66	0.471	M
80	3712.30	0.487	M
81	3725.80	0.467	M
82	3735.44	0.487	M
83	3745.08	0.480	M
84	3750.87	0.489	M
85	3760.51	0.471	M
86	3770.15	0.476	M
87	3779.79	0.473	M
88	3785.58	0.466	M
89	3801.01	0.479	M
90	3806.79	0.480	M
91	3822.22	0.487	M
92	3839.58	0.478	M
93	3853.08	0.509	S
94	3864.65	0.471	M
95	3870.43	0.481	M
96	3880.07	0.469	M
97	3885.86	0.482	M
98	3891.65	0.478	M
99	3905.15	0.485	M
100	3918.64	0.470	M

White Oak Lumber Sample 2



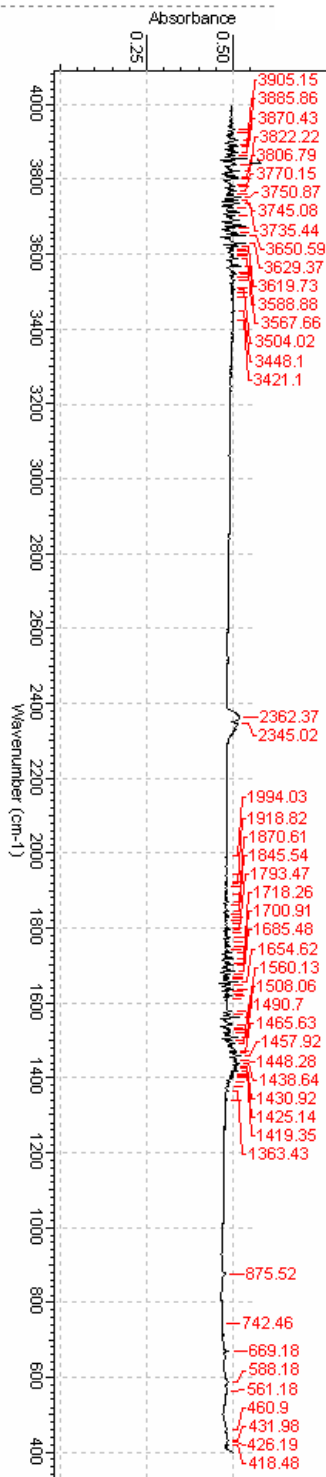
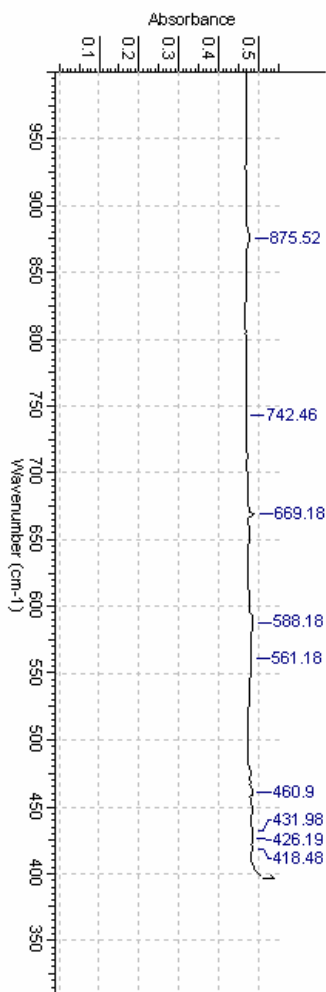
Comment	090104 White Oak Sampl 2 4 green		
File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS.PADILLA\DESKTOP\SPECTRA\SPECTRA\A2\2004\090104\090104\WHITE OAK_SAMP 2 4 GREEN.SPC		
Date Stamp	Date	Technique	Y Axis
01/09/2004 16:45:00	01 Sep 2004 16:56:34	Infrared	Absorbance
Spectral/Region	X Axis	Points Count	Data Spacing
IR	Wavenumber (cm-1)	1668	1.9285
Spectrum Range	399.1926 - 3999.6399		

White Oak Lumber Sample 2

Comment										080104 WhiteOak_Samp 2.4 green													
File Name										C:\DOCUMENTS AND SETTINGS\DIOMARIS PADILLA\DESKTOP\SPECTR\ASPECTR\22\2004\09\01\04\090104\WHITE OAK_SAMP 2.4 GREEN.SPC													
Date Stamp										Date													
01/09/2004 16:45:00										01 Sep 2004 16:56:34													
Spectral Region										X Axis													
IR										Wavenumber (cm-1)													
Spectral Range										Points Count													
389.1926 - 3999.6399										1868													
Data Spacing										1.9285													
Technique										Infrared													
Y Axis										Absorbance													
No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity
1	416.56	0.018	-	-	W	27	1660.13	0.097	-	-	S	53	1846.54	0.053	-	-	M	79	3669.87	0.094	3.11	0.06	M
2	424.26	0.037	-	-	W	28	1668.77	0.065	-	-	M	54	1870.61	0.053	-	-	M	80	3675.66	0.095	-	-	S
3	439.89	0.019	-	-	W	29	1677.49	0.069	-	-	M	55	1889.90	0.049	-	-	M	81	3689.16	0.072	-	-	M
4	461.89	0.014	-	-	W	30	1610.27	0.065	-	-	M	56	1918.82	0.048	-	-	M	82	3702.86	0.052	-	-	M
5	561.18	0.020	-	-	W	31	1617.96	0.065	-	-	M	57	1943.99	0.049	-	-	M	83	3712.90	0.072	6.22	0.20	M
6	570.83	0.022	-	-	W	32	1623.77	0.060	-	-	M	58	2346.02	0.053	-	-	M	84	3725.80	0.049	-	-	M
7	689.18	0.022	-	-	W	33	1629.65	0.066	-	-	M	59	2372.01	0.051	-	-	M	85	3735.44	0.082	5.20	0.88	S
8	713.63	0.020	-	-	W	34	1637.27	0.072	-	-	M	60	3421.10	0.057	-	-	M	86	3746.08	0.094	3.42	-0.79	M
9	875.62	0.046	21.33	0.14	M	35	1648.91	0.064	-	-	M	61	3448.10	0.056	-	-	M	87	3750.87	0.076	-	-	M
10	1340.28	0.060	-	-	M	36	1654.62	0.064	8.92	0.78	S	62	3466.31	0.052	-	-	M	88	3760.61	0.045	-	-	M
11	1363.48	0.066	-	-	M	37	1664.27	0.064	-	-	M	63	3504.02	0.058	-	-	M	89	3770.16	0.057	10.49	-0.88	M
12	1375.00	0.069	-	-	M	38	1670.05	0.068	-	-	M	64	3509.61	0.056	-	-	M	90	3779.79	0.052	-	-	M
13	1388.50	0.070	-	-	M	39	1675.84	0.059	-	-	M	65	3529.08	0.053	-	-	M	91	3785.88	0.041	-	-	M
14	1419.35	0.115	-	-	S	40	1685.48	0.070	-	-	M	66	3536.61	0.052	-	-	M	92	3795.22	0.029	-	-	W
15	1430.92	0.119	-	-	S	41	1700.91	0.070	-	-	M	67	3546.45	0.059	-	-	M	93	3801.01	0.061	-	-	M
16	1436.71	0.129	-	-	VS	42	1706.89	0.064	-	-	M	68	3552.24	0.053	-	-	M	94	3806.79	0.060	5.08	0.99	M
17	1448.28	0.122	-	-	S	43	1718.26	0.069	-	-	M	69	3567.66	0.080	-	-	M	95	3820.29	0.063	-	-	M
18	1457.92	0.137	-	-	VS	44	1736.62	0.061	-	-	M	70	3579.23	0.046	-	-	M	96	3831.86	0.030	-	-	W
19	1466.63	0.113	-	-	S	45	1751.05	0.066	-	-	M	71	3588.88	0.066	-	-	M	97	3839.68	0.060	9.65	0.78	M
20	1473.35	0.110	-	-	S	46	1762.62	0.062	-	-	M	72	3594.96	0.050	-	-	M	98	3853.08	0.105	-	-	S
21	1490.70	0.093	-	-	S	47	1772.26	0.066	-	-	M	73	3600.46	0.050	-	-	M	99	3864.65	0.046	-	-	M
22	1488.42	0.081	-	-	M	48	1786.76	0.047	-	-	M	74	3608.16	0.050	-	-	M	100	3870.43	0.051	-	-	M
23	1508.06	0.097	-	-	S	49	1793.47	0.056	-	-	M	75	3619.73	0.070	6.33	-0.05	S	...	...	...	...	...	...
24	1521.68	0.077	-	-	M	50	1801.18	0.051	-	-	M	76	3629.37	0.092	4.80	-0.74	S	...	...	...	...	...	...
25	1533.13	0.064	-	-	M	51	1830.11	0.053	-	-	M	77	3650.59	0.098	-	-	M	...	...	...	...	...	...
26	1540.84	0.081	-	-	M	52	1837.83	0.046	-	-	M	78	3666.37	0.062	-	-	M	...	...	...	...	...	...

White Oak Lumber Sample 3

Comment	090104 White Oak Sample2 Green		
File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS.PADILLA\DESKTOP\SPECTRA\SPECTRA\A2\2004\090104\090104 WHITE OAK SOOT_SAMP2 GREEN.SPC		
Date Stamp	01/09/2004 15:52:00	Date	01 Sep 2004 15:58:24
Spectral/Region	IR	X Axis	Wavenumber (cm-1)
Spectrum Range	399.1926 - 3999.6399	Points Count	1668
		Y Axis	Absorbance
		Data Spacing	1.9285

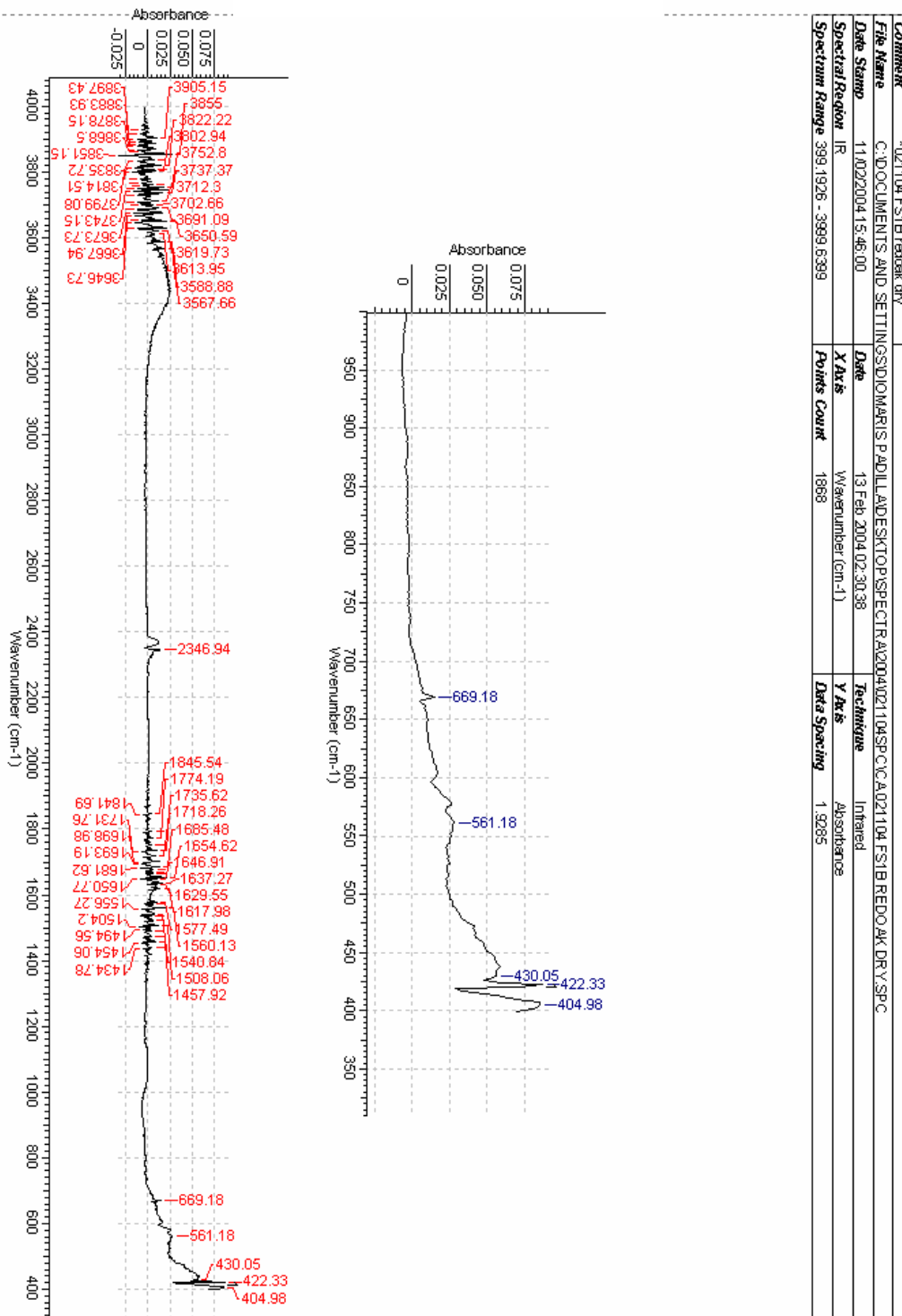


White Oak Lumber Sample 3

Comment	090104 White Oak Sample2 Green		
File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS PADILLA\DESKTOP\SPECTRA\SPECTRA\SPCTR A2\0004090104\090104\WHITE OAK SOOT_SAMP2.GREEN.SPC		
Date Stamp	01/09/2004 15:52:00	Date	01 Sep 2004 15:58:24
Spectral Region	IR	X Axis	Wavenumber (cm-1)
Spectral Range	399.1926 - 3999.6399	Points Count	1868
		Y Axis	Absorbance
		Data Spaving	1.9285

No	1	cm-1	418.48	A	0.486	Intensity	M
No	2	cm-1	426.19	A	0.484	Intensity	WV
No	3	cm-1	431.98	A	0.486	Intensity	M
No	4	cm-1	460.90	A	0.484	Intensity	M
No	5	cm-1	561.18	A	0.482	Intensity	WV
No	6	cm-1	588.18	A	0.486	Intensity	M
No	7	cm-1	669.18	A	0.489	Intensity	M
No	8	cm-1	742.46	A	0.468	Intensity	WV
No	9	cm-1	875.52	A	0.479	Intensity	WV
No	10	cm-1	1340.28	A	0.483	Intensity	WV
No	11	cm-1	1363.43	A	0.486	Intensity	M
No	12	cm-1	1375.00	A	0.488	Intensity	M
No	13	cm-1	1388.50	A	0.493	Intensity	M
No	14	cm-1	1400.07	A	0.499	Intensity	M
No	15	cm-1	1405.86	A	0.499	Intensity	M
No	16	cm-1	1411.64	A	0.500	Intensity	M
No	17	cm-1	1419.36	A	0.512	Intensity	S
No	18	cm-1	1425.14	A	0.510	Intensity	S
No	19	cm-1	1430.92	A	0.510	Intensity	S
No	20	cm-1	1438.64	A	0.517	Intensity	S
No	21	cm-1	1448.28	A	0.511	Intensity	S
No	22	cm-1	1457.92	A	0.523	Intensity	S
No	23	cm-1	1465.63	A	0.509	Intensity	S
No	24	cm-1	1473.36	A	0.507	Intensity	M
No	25	cm-1	1490.70	A	0.504	Intensity	M
No	26	cm-1	1498.42	A	0.495	Intensity	M
No	27	cm-1	1508.06	A	0.511	Intensity	S
No	28	cm-1	1521.56	A	0.493	Intensity	M
No	29	cm-1	1527.35	A	0.491	Intensity	M
No	30	cm-1	1535.06	A	0.489	Intensity	M
No	31	cm-1	1540.94	A	0.497	Intensity	M
No	32	cm-1	1560.13	A	0.519	Intensity	S
No	33	cm-1	1569.77	A	0.489	Intensity	M
No	34	cm-1	1577.49	A	0.497	Intensity	M
No	35	cm-1	1610.27	A	0.484	Intensity	M
No	36	cm-1	1623.77	A	0.495	Intensity	M
No	37	cm-1	1629.55	A	0.487	Intensity	M
No	38	cm-1	1629.55	A	0.487	Intensity	M
No	39	cm-1	1637.27	A	0.500	Intensity	M
No	40	cm-1	1646.91	A	0.490	Intensity	M
No	41	cm-1	1654.62	A	0.512	Intensity	S
No	42	cm-1	1664.27	A	0.487	Intensity	M
No	43	cm-1	1670.05	A	0.488	Intensity	M
No	44	cm-1	1675.84	A	0.490	Intensity	M
No	45	cm-1	1685.48	A	0.503	Intensity	M
No	46	cm-1	1700.91	A	0.502	Intensity	M
No	47	cm-1	1706.69	A	0.490	Intensity	M
No	48	cm-1	1718.26	A	0.501	Intensity	M
No	49	cm-1	1735.62	A	0.497	Intensity	M
No	50	cm-1	1741.41	A	0.482	Intensity	WV
No	51	cm-1	1751.05	A	0.491	Intensity	M
No	52	cm-1	1762.62	A	0.489	Intensity	M
No	53	cm-1	1774.19	A	0.491	Intensity	M
No	54	cm-1	1785.76	A	0.484	Intensity	M
No	55	cm-1	1793.47	A	0.491	Intensity	M
No	56	cm-1	1801.19	A	0.486	Intensity	M
No	57	cm-1	1812.76	A	0.485	Intensity	M
No	58	cm-1	1818.54	A	0.481	Intensity	WV
No	59	cm-1	1830.11	A	0.487	Intensity	M
No	60	cm-1	1837.83	A	0.481	Intensity	WV
No	61	cm-1	1845.54	A	0.488	Intensity	M
No	62	cm-1	1860.97	A	0.481	Intensity	WV
No	63	cm-1	1870.61	A	0.488	Intensity	M
No	64	cm-1	1889.90	A	0.484	Intensity	M
No	65	cm-1	1911.11	A	0.483	Intensity	WV
No	66	cm-1	1918.82	A	0.485	Intensity	M
No	67	cm-1	1924.61	A	0.484	Intensity	M
No	68	cm-1	1943.89	A	0.485	Intensity	M
No	69	cm-1	1994.03	A	0.484	Intensity	M
No	70	cm-1	2345.02	A	0.515	Intensity	S
No	71	cm-1	2362.37	A	0.519	Intensity	S
No	72	cm-1	3421.10	A	0.502	Intensity	M
No	73	cm-1	3448.10	A	0.504	Intensity	M
No	74	cm-1	3482.81	A	0.502	Intensity	M
No	75	cm-1	3496.31	A	0.500	Intensity	M
No	76	cm-1	3504.02	A	0.505	Intensity	M
No	77	cm-1	3509.81	A	0.502	Intensity	M
No	78	cm-1	3529.09	A	0.502	Intensity	M
No	79	cm-1	3536.81	A	0.502	Intensity	M
No	80	cm-1	3546.45	A	0.508	Intensity	M
No	81	cm-1	3552.24	A	0.502	Intensity	M
No	82	cm-1	3567.66	A	0.521	Intensity	S
No	83	cm-1	3586.88	A	0.513	Intensity	S
No	84	cm-1	3594.66	A	0.499	Intensity	M
No	85	cm-1	3600.45	A	0.501	Intensity	M
No	86	cm-1	3608.16	A	0.500	Intensity	M
No	87	cm-1	3613.95	A	0.498	Intensity	M
No	88	cm-1	3619.73	A	0.515	Intensity	S
No	89	cm-1	3629.37	A	0.534	Intensity	VS
No	90	cm-1	3650.59	A	0.537	Intensity	VS
No	91	cm-1	3656.37	A	0.507	Intensity	M
No	92	cm-1	3669.87	A	0.506	Intensity	M
No	93	cm-1	3702.66	A	0.503	Intensity	M
No	94	cm-1	3725.80	A	0.499	Intensity	M
No	95	cm-1	3735.44	A	0.520	Intensity	S
No	96	cm-1	3745.08	A	0.513	Intensity	S
No	97	cm-1	3750.87	A	0.521	Intensity	S
No	98	cm-1	3760.51	A	0.502	Intensity	M
No	99	cm-1	3770.15	A	0.508	Intensity	M
No	100	cm-1	3779.79	A	0.504	Intensity	M

Red Oak Lumber Sample 1



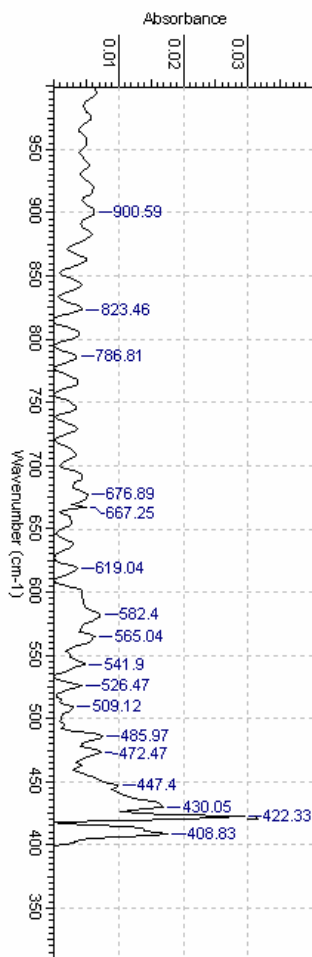
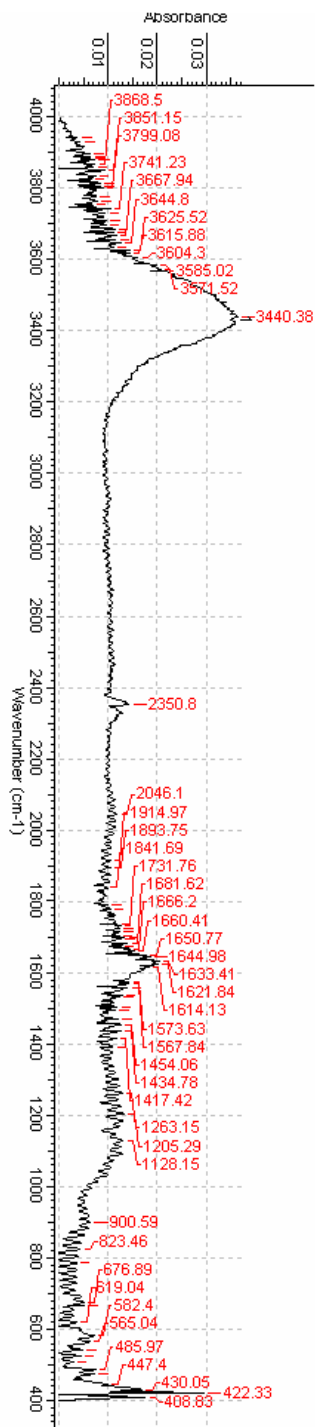
Comment	*021104 FS1B red oak dry		
File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS.PADILLA\DESKTOP\SPECTRA\AD004\021104 FS1B RED OAK DRY.VSPC		
Date Stamp	11/02/2004 15:46:00	Date	13 Feb 2004 02:30:38
Spectral Region	IR	X Axis	Wavenumber (cm-1)
Spectral Range	3991.1926 - 3999.6399	Points Count	1868
		Y Axis	Absorbance
		Data Spacing	1.92885

Red Oak Lumber Sample 1

File Name		C:\DOCUMENTS AND SETTINGS\DIOMARIS PAOLILAND\DESKTOP\SPECTRA\2004\021104SPCCA.021104.FS1BREDQAK.DRY.SPC	
Date Stamp	11/02/2004 15:46:00	Date	13 Feb 2004 02:30:38
Spectral Region	IR	X Axis	Wavenumber (cm-1)
Spectral Range	399.1926 - 3999.6399	Points Count	1899
		Y Axis	Absorbance
		Data Spacing	1.9285

No	cm-1	A	FW/HH	Asym	Intensity	No	cm-1	A	FW/HH	Asym	Intensity	No	cm-1	A	FW/HH	Asym	Intensity	No	cm-1	A	FW/HH	Asym	Intensity
1	40498	0.085	-	-	VS	23	1629.55	0.011	-	-	M	46	3968.88	0.018	4.45	0.10	M	67	3769.22	-0.006	-	-	W
2	422.33	0.087	-	-	VS	24	1637.27	0.017	5.00	0.51	M	48	3813.95	0.008	-	-	M	68	3777.87	-0.007	-	-	W
3	430.05	0.096	-	-	S	25	1649.91	0.010	-	-	M	47	3819.73	0.012	-	-	M	69	3799.08	-0.017	2.04	-0.27	W
4	561.18	0.028	-	-	M	26	1650.77	-0.008	1.08	0.48	W	48	3827.46	-0.011	-	-	W	70	3802.94	0.009	-	-	M
5	669.18	0.015	5.42	0.95	M	27	1654.62	0.021	2.84	0.41	M	49	3846.73	-0.013	-	-	W	71	3808.72	0.008	-	-	M
6	1484.78	-0.005	1.58	-0.82	W	28	1659.27	0.006	-	-	M	50	3850.59	0.021	2.74	0.82	M	72	3814.51	-0.014	-	-	W
7	1488.64	0.005	-	-	M	29	1670.05	0.006	-	-	M	51	3864.44	-0.006	0.77	0.11	W	73	3822.22	0.015	1.66	0.25	W
8	1454.06	-0.006	3.23	0.99	W	30	1675.84	0.007	-	-	M	52	3867.94	-0.013	-	-	W	74	3836.72	-0.012	-	-	W
9	1457.92	0.010	-	-	M	31	1681.62	-0.007	2.38	0.24	W	53	3873.73	-0.016	1.29	-0.74	W	75	3839.58	0.007	2.47	0.22	M
10	1473.35	0.005	-	-	M	32	1686.48	0.013	2.23	0.66	M	54	3887.23	-0.011	-	-	W	76	3851.15	-0.032	-	-	VW
11	1490.70	0.005	2.08	0.51	W	33	1693.19	-0.006	-	-	W	55	3891.09	0.012	4.47	0.08	M	77	3865.00	0.027	2.55	0.29	M
12	1494.56	-0.005	1.79	0.27	W	34	1698.98	-0.005	-	-	W	56	3898.80	-0.006	2.26	0.89	W	78	3880.79	-0.007	4.25	0.43	W
13	1504.20	-0.010	2.27	-0.08	W	35	1718.26	0.009	-	-	M	57	3702.66	0.006	1.89	0.54	M	79	3888.50	-0.011	-	-	W
14	1508.06	0.012	2.51	0.84	M	36	1731.76	-0.007	2.01	-0.53	W	58	3708.44	-0.010	3.96	-0.48	W	80	3878.15	-0.011	2.00	-0.05	W
15	1523.49	0.006	4.19	-0.56	M	37	1736.62	0.011	2.00	-0.26	M	59	3712.30	0.012	-	-	M	81	3883.93	-0.010	-	-	W
16	1535.06	0.004	-	-	M	38	1752.98	0.005	-	-	M	60	3729.65	-0.010	-	-	W	82	3889.72	-0.009	1.69	-0.66	W
17	1540.84	0.008	-	-	M	39	1774.19	0.006	3.26	-0.53	M	61	3737.37	0.017	3.38	-0.31	M	83	3897.43	-0.012	4.16	0.09	W
18	1566.27	-0.006	2.32	0.54	W	40	1799.47	0.005	2.18	0.70	M	62	3743.15	-0.015	-	-	W	84	3905.15	0.010	2.86	0.19	M
19	1580.13	0.020	2.57	0.94	M	41	1841.69	-0.004	2.11	0.03	W	63	3748.94	-0.010	-	-	W	85	3914.79	-0.008	3.44	-0.69	M
20	1571.70	0.006	-	-	M	42	1845.54	0.005	2.32	0.62	M	64	3752.80	0.018	2.76	-0.41	M	86	3930.22	-0.005	-	-	W
21	1577.49	0.010	2.80	0.59	M	43	2346.94	0.014	-	-	M	65	3756.65	-0.004	1.74	0.98	W						
22	1617.98	0.014	3.76	0.38	M	44	3657.66	0.020	-	-	M	66	3760.51	0.006	1.42	-0.52	M						

Red Oak Lumber Sample 2

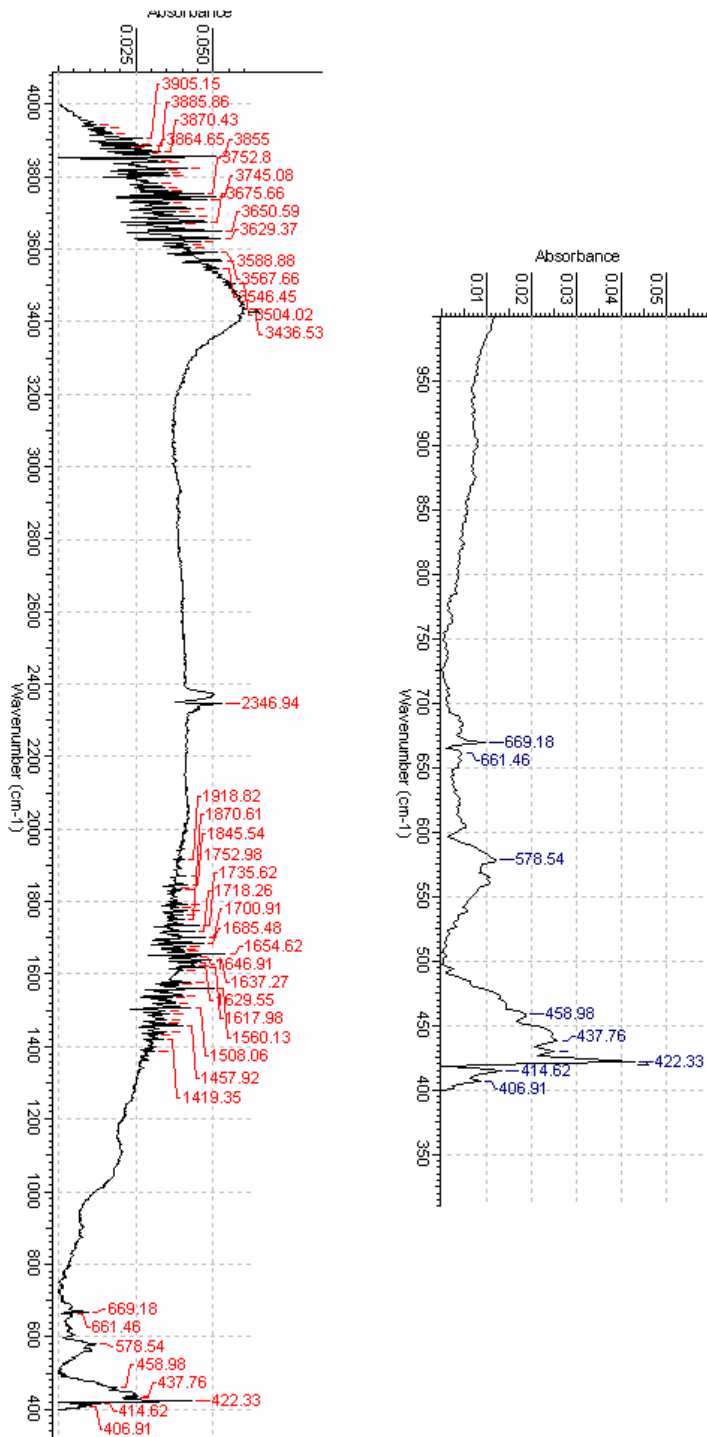


Comment	031704 W56RED oak 1 25turn		
File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS.PADILLA\DESKTOP\PSPECTRA\A2004\031704_OTHER\031704 W56RED OAK 1 25TURN.SPC		
Date Stamp	17/03/2004 15:53:00	Date	17 Mar 2004 16:01:22
Spectral Region	IR	X Axis	Wavenumber (cm-1)
Spectrum Range	399.1926 - 3999.6399	Points Count	1868
		Y Axis	Absorbance
		Data Spacing	1.9285
		Technique	Infrared

Red Oak Lumber Sample 2

Comment		031704.WS6.red.oak.1.25turn															
File Name		C:\DOCUMENTS AND SETTINGS\DIOMARIS.P\ADILL\ADESKTOP\SPECTRA\X2004\031704.OTHER\031704.WS6.RED.OAK.1.25TURN.SPC															
Date Stamp		17/03/2004 15:53:00															
Spectral Region		IR															
Spectral Range		399.1926 - 3999.6399															
X Axis		Wavenumber (cm-1)															
Y Axis		Absorbance															
Points Count		1698															
Data Spacing		1.9285															
No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity
1	408.83	0.018	9.40	0.94	M	23	1424.78	0.013	-	-	M	45	1714.41	0.012	-	-	M
2	422.33	0.029	5.07	0.06	S	24	1424.06	0.013	-	-	M	46	1722.12	0.012	-	-	M
3	430.06	0.017	-	-	M	25	1471.42	0.012	-	-	M	47	1731.76	0.012	-	-	M
4	447.40	0.010	-	-	W	26	1424.56	0.011	-	-	M	48	1737.55	0.012	-	-	M
5	472.47	0.007	-	-	W	27	1504.20	0.012	-	-	M	49	1778.05	0.010	-	-	W
6	466.97	0.007	-	-	W	28	1631.20	0.012	-	-	M	50	1789.62	0.010	-	-	W
7	508.12	0.003	-	-	VW	29	1636.99	0.013	-	-	M	51	1841.69	0.010	-	-	W
8	526.47	0.004	5.91	-0.73	W	30	1666.27	0.014	-	-	M	52	1868.75	0.011	-	-	W
9	541.90	0.005	-	-	W	31	1667.84	0.014	-	-	M	53	1914.97	0.010	-	-	W
10	566.04	0.006	-	-	W	32	1573.63	0.014	-	-	M	54	2096.10	0.012	-	-	M
11	582.40	0.007	-	-	W	33	1614.13	0.018	-	-	M	55	2301.80	0.014	-	-	M
12	618.04	0.004	9.28	-0.78	VW	34	1621.84	0.020	-	-	M	56	3440.38	0.036	-	-	VS
13	667.25	0.005	-	-	W	35	1633.41	0.021	-	-	M	57	3571.52	0.021	-	-	M
14	676.89	0.005	-	-	W	36	1644.98	0.019	-	-	M	58	3566.02	0.020	-	-	M
15	786.81	0.004	9.28	-0.64	VW	37	1660.77	0.018	-	-	M	59	3604.30	0.016	-	-	M
16	823.46	0.004	9.23	0.46	W	38	1660.41	0.016	-	-	M	60	3616.88	0.014	-	-	M
17	800.69	0.006	-	-	W	39	1666.20	0.014	-	-	M	61	3626.52	0.016	-	-	M
18	1128.15	0.013	-	-	M	40	1673.91	0.012	-	-	M	62	3633.23	0.011	-	-	M
19	1206.29	0.013	-	-	M	41	1681.62	0.014	-	-	M	63	3644.80	0.013	-	-	M
20	1263.15	0.013	-	-	M	42	1683.19	0.013	-	-	M	64	3654.44	0.011	-	-	M
21	1392.35	0.011	-	-	M	43	1688.98	0.013	-	-	M	65	3667.94	0.012	-	-	M
22	1417.42	0.012	-	-	M	44	1704.76	0.012	-	-	M	66	3673.73	0.011	-	-	M
												67	3685.30	0.011	-	-	M
												68	3698.80	0.009	-	-	W
												69	3708.44	0.010	-	-	W
												70	3729.66	0.009	-	-	W
												71	3741.23	0.010	6.66	-0.24	W
												72	3756.66	0.007	-	-	W
												73	3762.44	0.008	-	-	W
												74	3775.94	0.008	-	-	W
												75	3799.08	0.009	-	-	W
												76	3804.96	0.008	-	-	W
												77	3812.86	0.008	7.50	0.03	W
												78	3824.16	0.006	-	-	W
												79	3835.72	0.007	-	-	W
												80	3851.16	0.009	-	-	W
												81	3860.79	0.007	-	-	W
												82	3868.60	0.007	-	-	W
												83	3878.16	0.007	-	-	W
												84	3883.69	0.006	-	-	W
												85	3889.72	0.006	-	-	W
												86	3897.49	0.006	-	-	W
												87	3928.29	0.004	-	-	W
												88	3939.99	0.004	-	-	W

Red Oak Lumber Sample 3



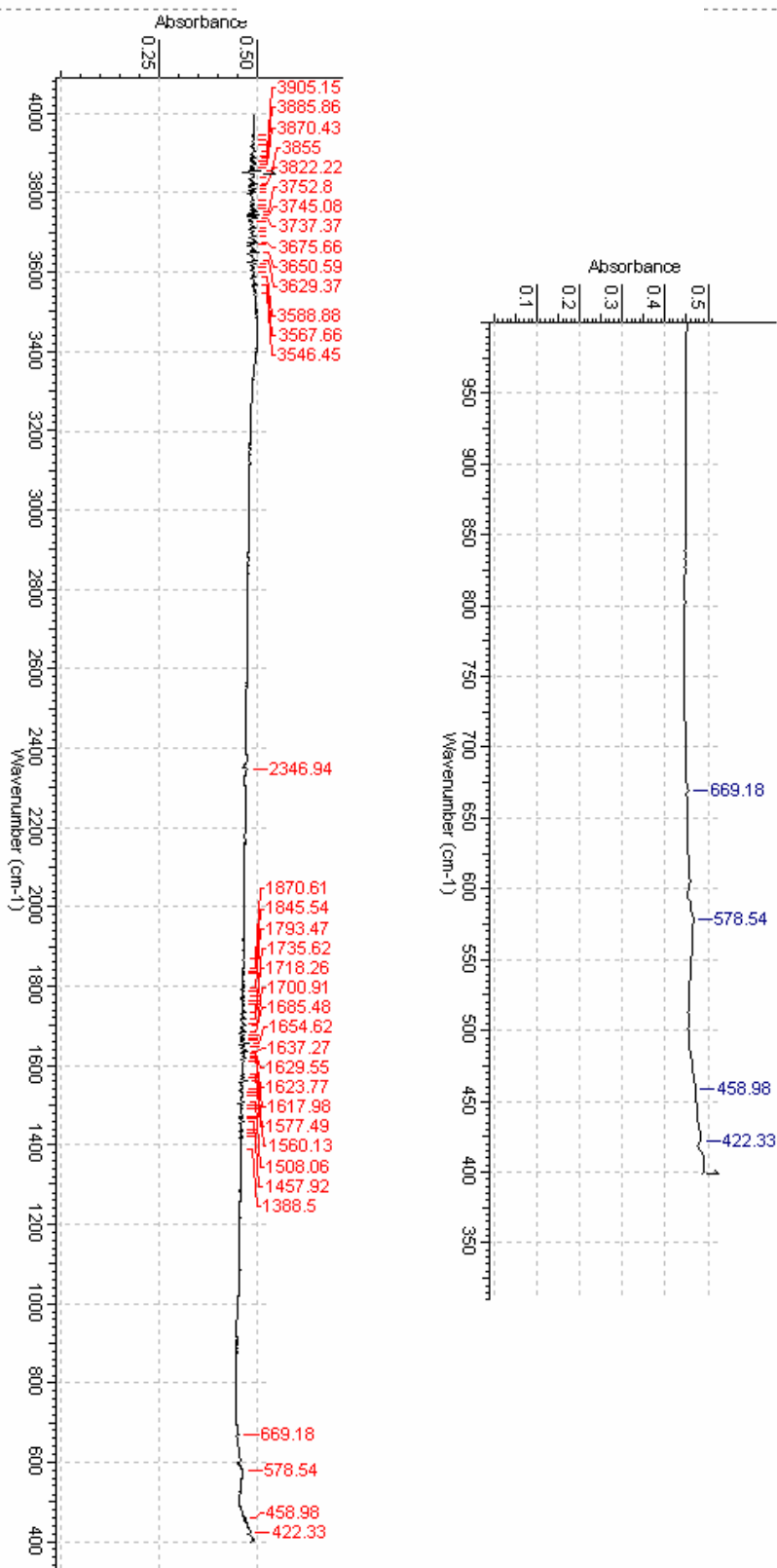
Comment	File Name	Date	Technique	Spectral Range	Spectral Region	Points Count
021104 FS1B RedOak 2	C:\DOCUMENTS AND SETTINGS\DIOMARIS P ADILL\DESKTOP\SPECTRA\AV004\021104SP.C\021104 FS1B REDOAK 2.SPC	13 Feb 2004 02:27:32	Infrared	399.1926 - 3999.6399	IR	1868
Date Stamp	11/02/2004 15:48:00					
X Axis	Wavenumber (cm-1)					
Y Axis	Absorbance					
Date Spacing	1.9285					

Red Oak Lumber Sample 3

Comment		021104 FS1B redoak 2	File Name		C:\DOCUMENTS AND SETTINGS\DIOMARIS PADILLA\DESKTOP\SPSPECTRA\2004021104SPC\021104 FS1B REDOAK 2.SPC												
Date Stamp		11/02/2004 15:48:00	Date		13 Feb 2004 02:27:32												
X Axis		Wavenumber (cm-1)	Absorbance														
Data Spacing		1.9285	Spectrum Range		399.1926 - 3999.6399												
			Technique		Infrared												
			Spectral Region		IR												
			Points Count		1868												
No	cm-1	A	Fw/HH	Asym	Intensity	No	cm-1	A	Fw/HH	Asym	Intensity	No	cm-1	A	Fw/HH	Asym	Intensity
1	406.91	0.009	-	-	W	46	1832.04	0.040	-	-	S	67	3737.37	0.048	-	-	S
2	414.62	0.013	-	-	W	48	1837.83	0.038	-	-	S	68	3746.08	0.061	4.41	0.86	S
3	422.33	0.043	5.80	0.93	S	47	1846.64	0.042	-	-	S	69	3762.80	0.047	-	-	S
4	430.05	0.025	-	-	M	48	1870.61	0.041	-	-	S	70	3780.51	0.036	-	-	M
5	437.76	0.026	-	-	M	49	1918.82	0.040	-	-	S	71	3770.15	0.034	-	-	M
6	438.98	0.019	-	-	M	50	2346.94	0.063	-	-	S	72	3779.79	0.032	-	-	M
7	578.64	0.012	-	-	W	51	3486.63	0.060	-	-	V/S	73	3802.94	0.036	-	-	M
8	661.46	0.005	-	-	VW	52	3604.02	0.057	-	-	V/S	74	3808.72	0.036	-	-	M
9	668.18	0.010	-	-	W	53	3646.46	0.063	-	-	S	75	3816.44	0.034	-	-	M
10	1388.90	0.031	-	-	M	54	3667.66	0.063	-	-	S	76	3822.22	0.042	-	-	S
11	1419.36	0.034	-	-	M	55	3688.88	0.051	-	-	S	77	3839.68	0.034	-	-	M
12	1430.82	0.032	-	-	M	56	3602.38	0.043	-	-	S	78	3846.36	0.032	-	-	M
13	1438.64	0.036	-	-	M	57	3613.95	0.042	-	-	S	79	3865.00	0.051	5.98	0.62	S
14	1467.82	0.040	-	-	S	58	3619.73	0.046	-	-	S	80	3864.66	0.029	-	-	M
15	1466.63	0.034	-	-	M	59	3629.37	0.052	-	-	S	81	3870.43	0.033	-	-	M
16	1473.36	0.036	-	-	M	60	3660.69	0.063	-	-	S	82	3880.07	0.023	-	-	M
17	1480.70	0.036	-	-	M	61	3669.87	0.040	-	-	S	83	3886.86	0.030	5.36	0.97	M
18	1498.42	0.036	-	-	M	62	3676.66	0.048	-	-	S	84	3891.66	0.026	-	-	M
19	1608.06	0.043	-	-	S	63	3691.09	0.044	-	-	S	85	3905.15	0.027	14.14	0.23	M
20	1621.66	0.038	-	-	S	64	3702.66	0.038	-	-	S	86	3918.64	0.017	-	-	W
21	1636.06	0.037	-	-	S	65	3712.30	0.043	-	-	S	87	3924.07	0.016	-	-	W
22	1640.64	0.040	-	-	S	66	3727.73	0.036	-	-	M	88	3943.71	0.012	-	-	W

Maple Lumber Sample 1

Comment	021104.FS4A.maple.drv		
File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS.PADILLA\DESKTOP\SPECTRACOPY\021104.FS4A.MAPLE.DRV.SPC		
Date Stamp	11/02/2004 16:38:00	Date	13 Feb 2004 02:30:40
Spectral Region	IR	X Axis	Wavenumber (cm-1)
Spectral Range	399.1926 - 3999.6399	Points Count	1868
		Y Axis	Absorbance
		Data Spacing	1.9285

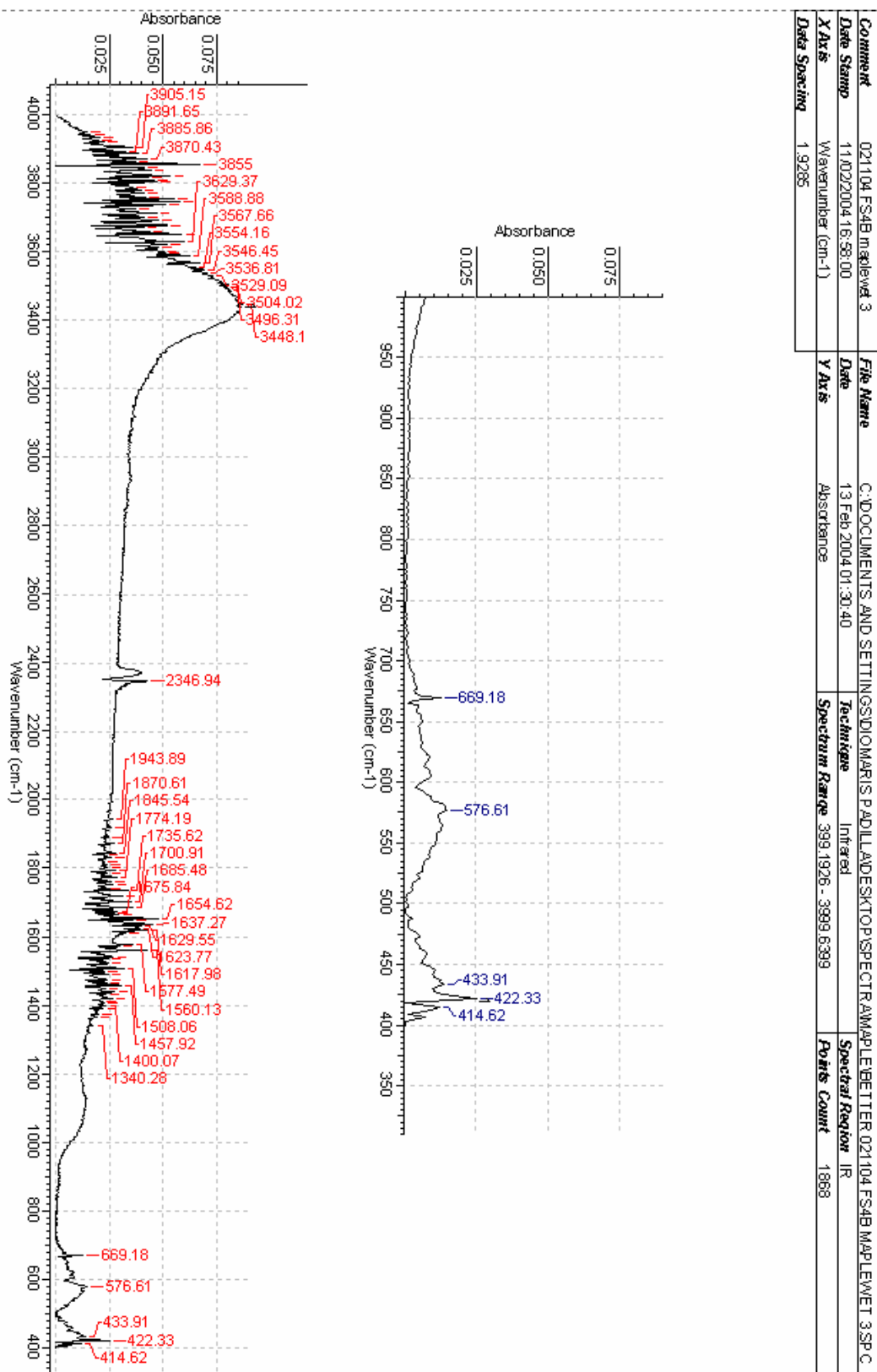


Maple Lumber Sample 1

Comment	021104 F S4A maple dry		
File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS PADILLAV\ESKTOP\SPECTRA\COPY OF 021104SP\021104 F S4A MAPLE DRY.SPC		
Date Stamp	11/02/2004 18:38:00	Date	13 Feb 2004 02:30:40
Spectral Region	IR	X Axis	Wavenumber (cm-1)
Spectrum Range	399.1926 - 3999.6399	Points Count	1898
		Y Axis	Technique
			Infrared
		Data Spacing	1.9285
			Absorbance

No	cm-1	A	Intensity	No	cm-1	A	Intensity	No	cm-1	A	Intensity	No	cm-1	A	Intensity
1	422.33	0.464	M	21	1610.27	0.467	M	41	1832.04	0.468	M	61	3745.08	0.505	S
2	458.98	0.471	M	22	1617.98	0.473	M	42	1837.83	0.467	M	62	3752.80	0.503	S
3	578.54	0.466	M	23	1623.77	0.470	M	43	1845.54	0.470	M	63	3760.51	0.494	S
4	669.18	0.456	WV	24	1629.55	0.470	M	44	1870.61	0.470	M	64	3770.15	0.494	S
5	1388.50	0.462	WV	25	1637.27	0.475	M	45	2346.94	0.478	M	65	3779.79	0.493	S
6	1421.28	0.463	WV	26	1646.91	0.469	M	46	3546.45	0.499	S	66	3802.94	0.497	S
7	1430.92	0.462	WV	27	1654.62	0.479	M	47	3667.66	0.500	S	67	3808.72	0.496	S
8	1438.64	0.465	WV	28	1664.27	0.468	M	48	3688.88	0.499	S	68	3816.44	0.495	S
9	1457.92	0.468	M	29	1670.05	0.467	M	49	3800.45	0.493	S	69	3822.22	0.502	S
10	1465.63	0.463	WV	30	1675.84	0.469	M	50	3613.95	0.492	S	70	3839.58	0.496	S
11	1473.35	0.464	WV	31	1685.48	0.473	M	51	3619.73	0.496	S	71	3855.00	0.512	VS
12	1490.70	0.465	WV	32	1700.91	0.473	M	52	3629.37	0.503	S	72	3864.65	0.494	S
13	1498.42	0.464	WV	33	1706.69	0.467	M	53	3650.59	0.504	S	73	3870.43	0.498	S
14	1508.06	0.469	M	34	1718.26	0.471	M	54	3669.87	0.493	S	74	3880.07	0.492	S
15	1523.49	0.465	WV	35	1735.62	0.472	M	55	3675.66	0.501	S	75	3885.86	0.499	S
16	1535.06	0.465	WV	36	1752.98	0.468	M	56	3691.09	0.498	S	76	3891.65	0.496	S
17	1540.84	0.466	M	37	1762.62	0.468	M	57	3702.66	0.493	S	77	3905.15	0.500	S
18	1560.13	0.477	M	38	1774.19	0.470	M	58	3712.30	0.498	S	78	3918.64	0.493	S
19	1571.70	0.467	M	39	1785.76	0.467	M	59	3727.73	0.490	S	79	3934.07	0.494	S
20	1577.49	0.470	M	40	1793.47	0.469	M	60	3737.37	0.501	S	80	3943.71	0.493	S

Maple Lumber Sample 2

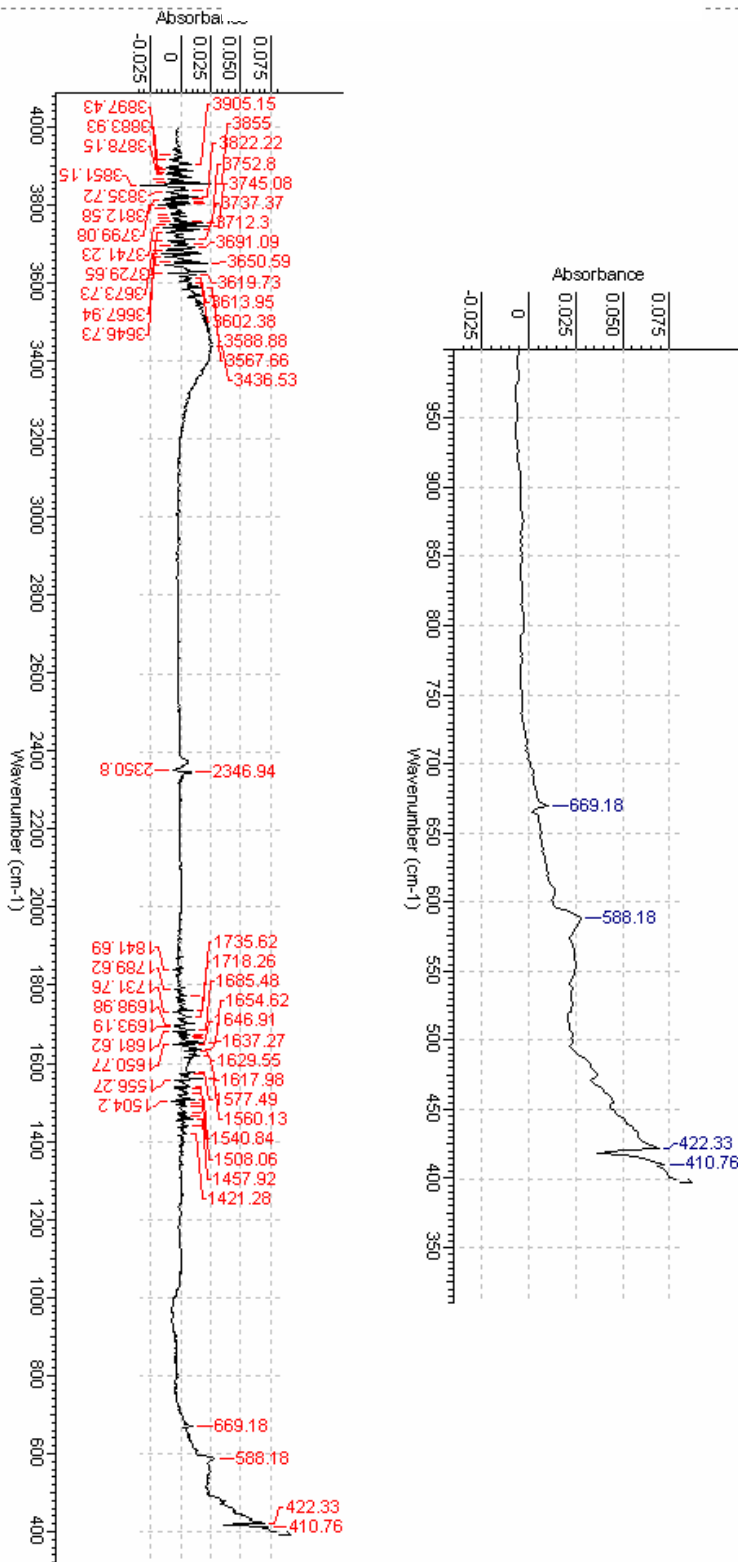


Maple Lumber Sample 2

Comment				File Name				Technique				Spectral Region					
021104 FS48 maplewet 3				C:\DOCUMENTS AND SETTINGS\DIOMARIS PADILLA\DESKTOP\SPEC TRAM\APLEWBETTER 021104 FS48 MAPLEWET 3.SPC				Infrared				IR					
Date Stamp				Date				Spectrum Range				Points Count					
11/02/2004 16:58:00				13 Feb 2004 01:30:40				399.1926 - 3999.6399				1898					
X Axis				Y Axis													
Wavenumber (cm-1)				Absorbance													
Data Spacing																	
1.9285																	
No	cm-1	A	FW/HH	Asym	Intensity	No	cm-1	A	FW/HH	Asym	Intensity	No	cm-1	A	FW/HH	Asym	Intensity
1	414.62	0.012	-	-	W	27	1571.70	0.030	-	-	M	53	1837.83	0.023	-	-	W
2	422.33	0.025	5.79	0.46	W	28	1577.49	0.036	-	-	M	54	1846.54	0.028	-	-	M
3	433.91	0.014	-	-	W	29	1610.27	0.033	-	-	M	55	1870.61	0.027	-	-	M
4	578.61	0.015	-	-	W	30	1617.98	0.048	-	-	M	56	1889.90	0.025	-	-	W
5	609.18	0.012	3.23	0.58	W	31	1623.77	0.039	-	-	M	57	1918.82	0.026	-	-	M
6	1340.28	0.018	-	-	W	32	1629.56	0.040	-	-	M	58	1943.89	0.026	-	-	M
7	1363.48	0.019	-	-	W	33	1637.27	0.046	-	-	M	59	2346.94	0.042	-	-	M
8	1375.00	0.020	-	-	W	34	1646.91	0.036	-	-	M	60	3448.10	0.087	-	-	VS
9	1388.50	0.022	-	-	W	35	1654.62	0.048	-	-	M	61	3496.31	0.080	-	-	VS
10	1400.07	0.023	-	-	W	36	1664.27	0.029	-	-	M	62	3504.02	0.080	-	-	VS
11	1405.85	0.023	-	-	W	37	1670.06	0.027	-	-	M	63	3529.09	0.073	-	-	S
12	1411.64	0.022	-	-	W	38	1675.84	0.029	-	-	M	64	3536.81	0.070	-	-	S
13	1421.28	0.026	-	-	M	39	1686.48	0.036	-	-	M	65	3546.46	0.069	-	-	S
14	1430.92	0.023	-	-	W	40	1700.91	0.035	-	-	M	66	3554.16	0.065	-	-	S
15	1438.84	0.028	-	-	M	41	1718.26	0.031	-	-	M	67	3567.66	0.067	-	-	S
16	1448.28	0.023	-	-	W	42	1736.62	0.034	-	-	M	68	3588.88	0.062	-	-	S
17	1467.92	0.031	-	-	M	43	1741.41	0.024	-	-	W	69	3596.59	0.061	-	-	M
18	1466.63	0.024	-	-	W	44	1762.98	0.027	-	-	M	70	3602.38	0.060	-	-	M
19	1473.36	0.024	-	-	W	45	1762.62	0.026	-	-	M	71	3613.95	0.048	-	-	M
20	1480.70	0.024	-	-	W	46	1774.19	0.029	-	-	M	72	3619.73	0.052	-	-	M
21	1488.42	0.023	-	-	W	47	1785.76	0.024	-	-	W	73	3629.37	0.060	-	-	S
22	1508.06	0.032	-	-	M	48	1793.47	0.028	-	-	M	74	3650.59	0.059	6.48	0.39	S
23	1523.49	0.024	-	-	W	49	1803.76	0.024	-	-	W	75	3669.30	0.044	-	-	M
24	1535.06	0.024	-	-	W	50	1812.42	0.024	-	-	W	76	3689.87	0.041	5.32	0.96	M
25	1542.77	0.027	-	-	M	51	1818.54	0.023	-	-	W	77	3676.66	0.052	-	-	M
26	1560.13	0.043	-	-	M	52	1832.04	0.026	-	-	W	78	3691.09	0.048	-	-	M

Maple Lumber Sample 3

Comment	*091704.WS2.Made 1.25.tum		
File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS.PADIL\LADESKTOP\SPECTRAMCOPY OF 031704.SP.C\CA 091704.WS2.MAPLE.1.25.TURN.SPC		
Date Stamp	17032004 14:45:00	Date	17 Mar 2004 14:53:00
Spectral Region	IR	X Axis	Wavenumber (cm ⁻¹)
Spectral Range	399.1926 - 3999.6399	Points Count	1868
		Y Axis	Absorbance
		Data Spacing	1.9285



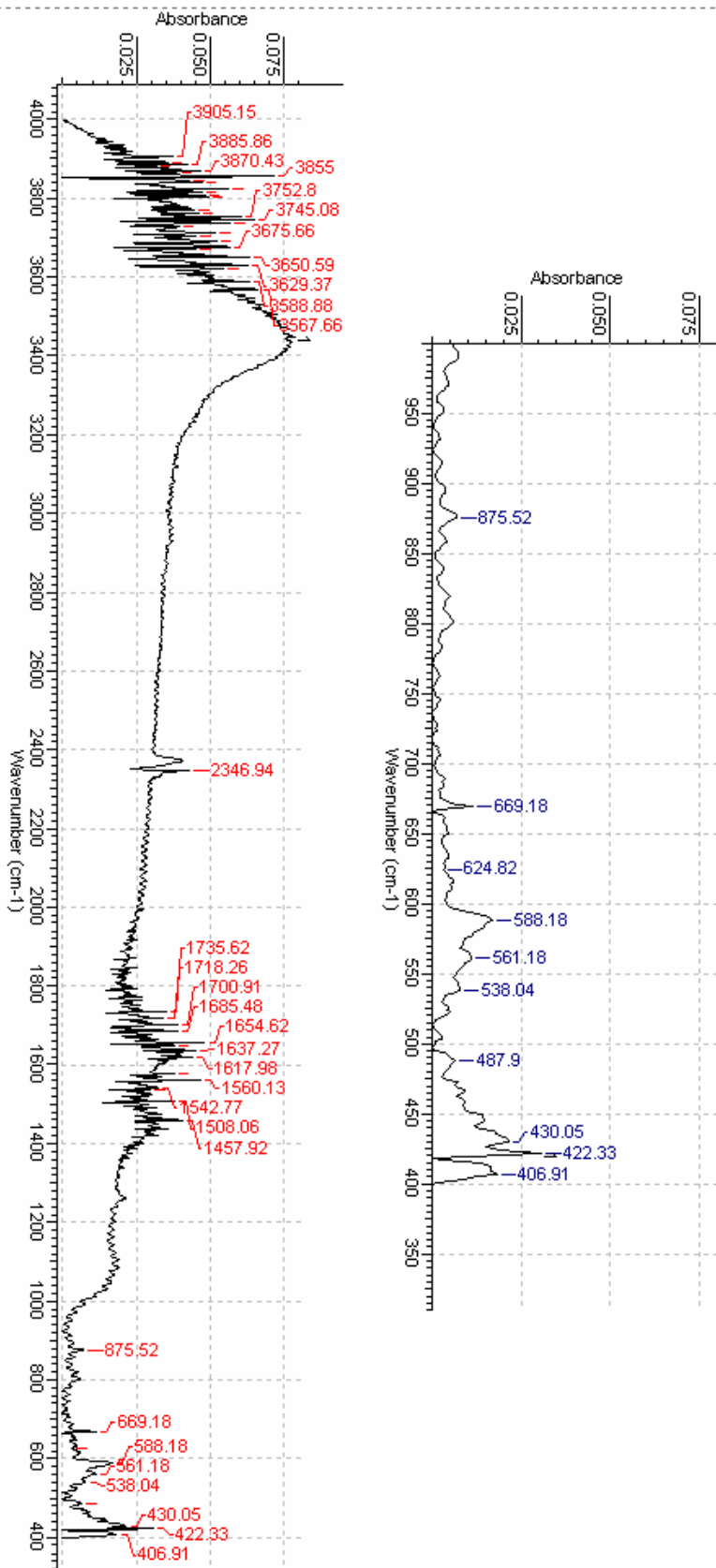
Maple Lumber Sample 3

Comment	*031704 W S2 Maple 1.25 Turn		
File Name	C:\DOCUMENTS AND SETTINGS\MARIS PADILLAVESKTO\P\SPECTRACOPY OF 031704 SPC\CA 031704 W S2 MAPLE 1.25 TURN.SPC		
Date Stamp	17032004 14:46:00	Date	17 Mar 2004 14:53:00
Spectral Region	IR	X Axis	Wavenumber (cm-1)
Spectrum Range	399.1926 - 3999.6399	Points Count	1668
		Y Axis	Absorbance
		Date Spacing	1.9285

No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity
1	410.76	0.072	-	-	V/S	24	1648.91	0.011	-	-	M	70	3793.29	-0.009	-	-	W
2	422.33	0.089	-	-	V/S	25	1650.77	-0.005	0.84	0.56	W	71	3799.08	-0.018	2.07	-0.37	W
3	688.18	0.028	-	-	M	26	1654.62	0.020	3.07	0.44	M	72	3802.94	0.007	-	-	M
4	689.18	0.010	-	-	M	27	1664.27	0.007	-	-	M	73	3808.72	0.007	-	-	M
5	1421.28	0.005	4.03	-0.77	M	28	1670.05	0.005	-	-	M	74	3812.88	-0.014	-	-	W
6	1438.64	0.006	3.87	-0.48	M	29	1675.84	0.007	-	-	M	75	3816.44	0.006	0.62	0.05	M
7	1457.92	0.009	-	-	M	30	1681.62	-0.005	2.03	0.36	W	76	3822.22	0.014	1.60	0.11	M
8	1485.63	0.004	-	-	M	31	1686.48	0.012	2.43	0.72	M	77	3835.72	-0.012	-	-	W
9	1473.35	0.005	-	-	M	32	1693.19	-0.005	-	-	W	78	3839.88	0.006	2.64	-0.22	M
10	1480.70	0.005	2.68	0.56	M	33	1698.98	-0.005	-	-	W	79	3851.15	-0.032	-	-	V/W
11	1498.42	0.004	-	-	M	34	1718.26	0.009	-	-	M	80	3855.00	0.026	2.60	0.07	M
12	1604.20	-0.008	2.07	0.01	W	35	1731.76	-0.005	1.72	-0.39	W	81	3860.79	-0.008	4.55	0.25	W
13	1608.06	0.011	2.63	0.76	M	36	1735.62	0.010	2.11	-0.25	M	82	3868.50	-0.010	-	-	W
14	1623.49	0.006	-	-	M	37	1744.19	0.005	2.97	-0.52	M	83	3878.15	-0.012	2.15	-0.25	W
15	1625.06	0.005	-	-	M	38	1759.62	-0.005	3.16	0.21	W	84	3883.83	-0.010	-	-	W
16	1640.84	0.008	-	-	M	39	1841.69	-0.005	2.95	0.07	W	85	3889.72	-0.009	-	-	W
17	1656.27	-0.004	1.77	0.98	W	40	2246.94	0.009	-	-	M	86	3897.43	-0.012	4.59	0.25	W
18	1690.13	0.019	-	-	M	41	2390.80	-0.006	-	-	W	87	3905.15	0.009	2.69	0.20	M
19	1671.70	0.007	-	-	M	42	3438.53	0.026	162.36	0.22	M	88	3914.79	-0.008	3.59	-0.64	W
20	1677.49	0.011	-	-	M	43	3597.66	0.020	-	-	M	89	3930.22	-0.005	-	-	W
21	1617.98	0.016	5.21	0.71	M	44	3588.88	0.018	4.52	-0.01	M						
22	1629.55	0.013	-	-	M	45	3902.38	0.009	-	-	M						
23	1637.27	0.017	6.42	0.67	M	46	3813.95	0.008	-	-	M						

Cherry Lumber Sample 1

Comment	031704 WSS Cherrywood 1.25turn		
File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS.PADILLA\DESKTOP\SPECTRA\2004\031704 OTHER\031704 WSS CHERRYWOOD 1.25 TURN SPC		
Date Stamp	17/03/2004 14:07:00	Date	17 Mar 2004 14:13:08
Spectral Region	IR	X Axis	Wavenumber (cm ⁻¹)
Spectrum Range	3991.926 - 399.6399	Points Count	1888
		Y Axis	Absorbance
		Data Spacing	1.9285



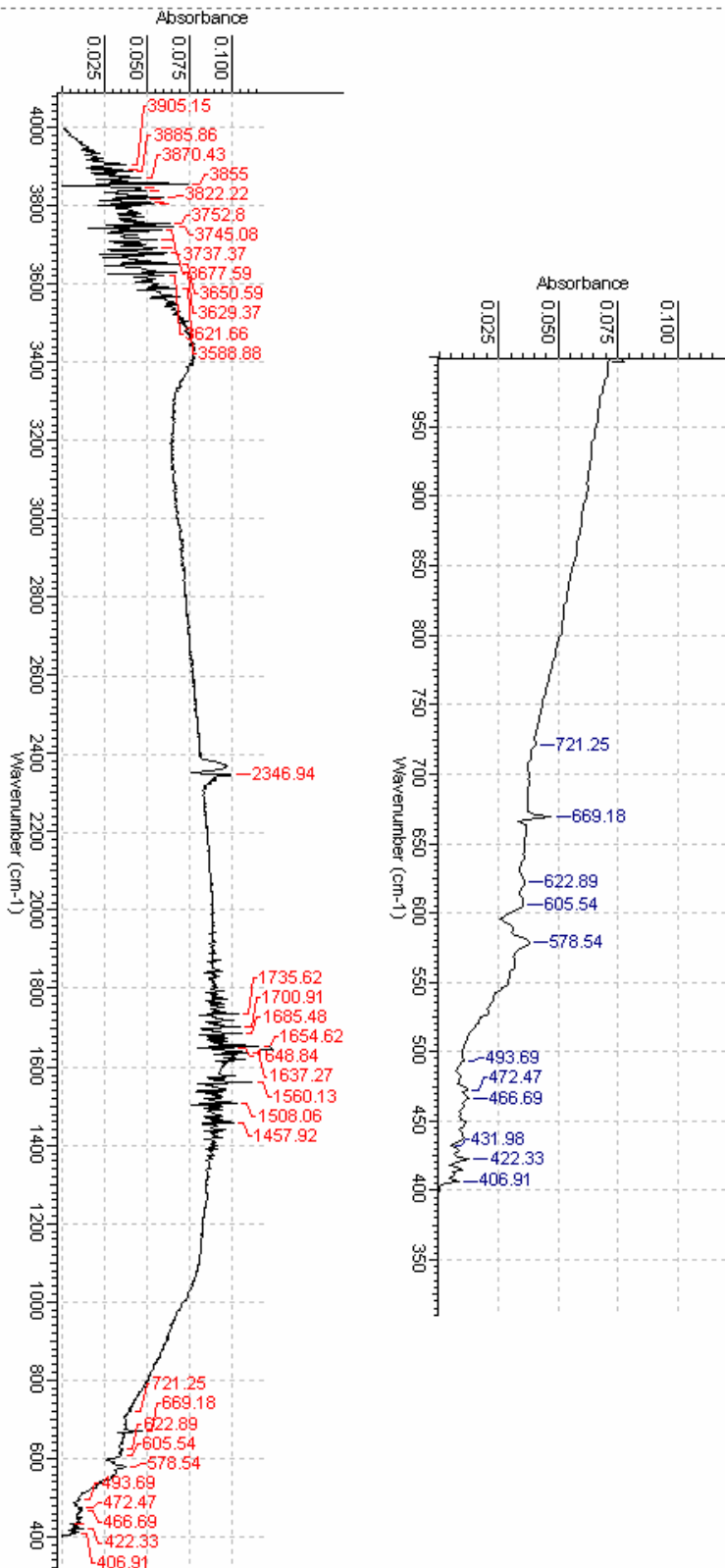
Cherry Lumber Sample 1

Comment		031704.W56 Cherry.Wood 1.25 Turn	
File Name	C:\DOCUMENTS AND SETTINGS\DOMARIS PADILLA\ESKTOP\SPEC\TRA2004\031704.OTHER\031704.W56 CHERRY.WOOD 1.25 TURN.SPC	Date	17 Mar 2004 14:13:08
Date Stamp	1703/2004 14:07:00	Technique	Infrared
Spectral Region	IR	X Axis	Wavenumber (cm-1)
Spectral Range	399.1926 - 3999.6399	Points Count	1868
		Y Axis	Absorbance
		Data Spacing	1.9285

No	cm-1	A	FW/HH	Asym	Intensity	No	cm-1	A	FW/HH	Asym	Intensity	No	cm-1	A	FW/HH	Asym	Intensity	No	cm-1	A	FW/HH	Asym	Intensity
1	406.94	0.018	-	-	W	15	1680.13	0.047	-	-	M	29	3629.37	0.063	-	-	S	43	3808.72	0.048	-	-	S
2	422.33	0.034	-	-	M	16	1677.49	0.038	-	-	M	30	3660.59	0.063	-	-	S	44	3816.44	0.047	-	-	M
3	430.06	0.022	-	-	W	17	1647.98	0.044	-	-	M	31	3689.87	0.046	-	-	M	45	3822.22	0.066	-	-	S
4	487.90	0.006	15.23	-0.51	VW	18	1637.27	0.046	-	-	M	32	3675.66	0.067	-	-	S	46	3839.58	0.047	-	-	M
5	538.04	0.008	-	-	VW	19	1646.91	0.038	-	-	M	33	3681.09	0.062	-	-	S	47	3846.36	0.043	-	-	M
6	561.18	0.014	-	-	W	20	1654.62	0.048	-	-	S	34	3702.66	0.046	-	-	M	48	3866.00	0.071	-	-	VS
7	588.18	0.017	-	-	W	21	1666.48	0.039	-	-	M	35	3712.30	0.062	-	-	S	49	3864.66	0.039	-	-	M
8	624.82	0.003	-	-	VW	22	1700.91	0.039	-	-	M	36	3727.73	0.039	-	-	M	50	3870.43	0.046	-	-	M
9	669.18	0.014	-	-	W	23	1718.26	0.034	-	-	M	37	3737.37	0.067	-	-	S	51	3880.07	0.032	-	-	M
10	876.62	0.007	11.74	0.30	VW	24	1736.62	0.036	-	-	M	38	3746.08	0.066	-	-	S	52	3886.86	0.042	-	-	M
11	1467.92	0.044	-	-	M	25	2349.94	0.043	-	-	M	39	3762.80	0.060	-	-	S	53	3891.66	0.036	-	-	M
12	1608.06	0.038	-	-	M	26	3667.66	0.066	-	-	S	40	3780.51	0.046	-	-	M	54	3906.16	0.037	-	-	M
13	1636.06	0.030	-	-	M	27	3688.88	0.063	-	-	S	41	3770.16	0.044	-	-	M						
14	1642.77	0.032	-	-	M	28	3619.73	0.064	-	-	S	42	3802.94	0.049	-	-	S						

Cherry Lumber Sample 2

Comment	021104 WET CHERRY.FS1A.2		
File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS.PADILLA\DESKTOP\SPECTRA\2004\021104SP.C\021104WET CHERRY.FS1A.2.SP.C		
Date Stamp	11/02/2004 14:43:00	Date	13 Feb 2004 02:27:26
Spectral Region	IR	X Axis	Wavenumber (cm-1)
Spectrum Range	399.1926 - 3999.6399	Points Count	1868
		Y Axis	Absorbance
		Data Spacing	1.9285

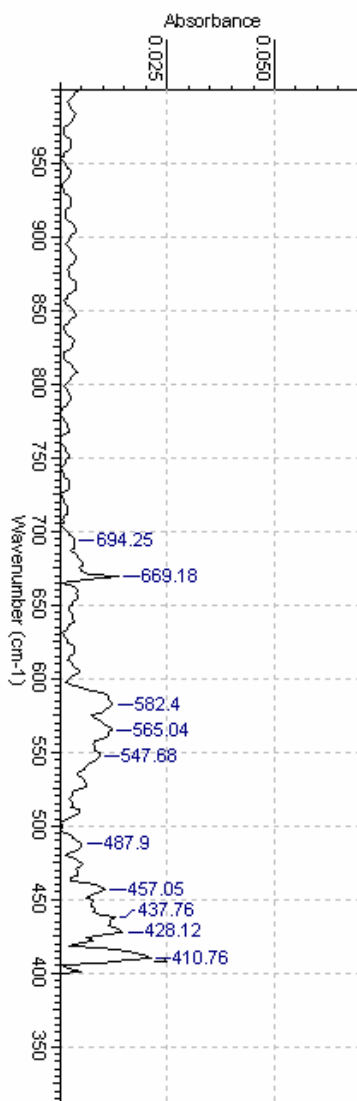
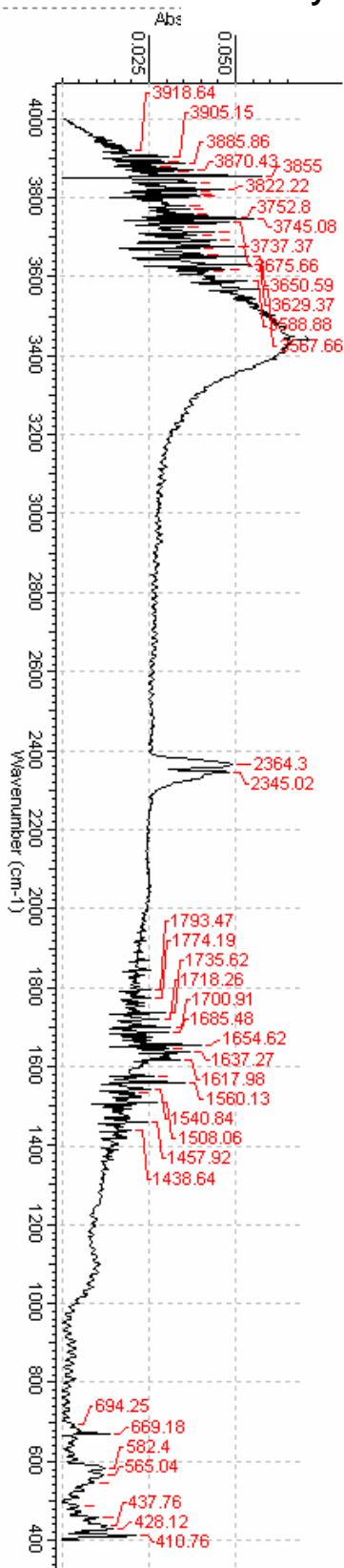


Cherry Lumber Sample 2

<i>Comment</i>		021104 W ET Cherry FS1A.2	
<i>File Name</i>	C:\DOCUMENTS AND SETTINGS\ADMARIUS PADILLAD\ESKTOP\SPECTRA\2004\021104 W ET CHERRY FS1A.2.SPC	<i>Date</i>	13 Feb 2004 02:27:26
<i>Date Stamp</i>	11/02/2004 14:43:00	<i>Technique</i>	Infrared
<i>Spectral Region</i>	IR	<i>Y Axis</i>	Absorbance
<i>Spectrum Range</i>	399.1926 - 3999.6399	<i>Data Spacing</i>	1.9285
	<i>Points Count</i>	1898	

No	cm-1	A	Intensity	No	cm-1	A	Intensity	No	cm-1	A	Intensity	No	cm-1	A	Intensity
1	406.91	0.008	WV	12	1457.92	0.101	S	23	3621.66	0.060	M	34	3816.44	0.049	M
2	422.33	0.013	W	13	1508.06	0.103	S	24	3629.37	0.068	M	35	3822.22	0.060	M
3	431.98	0.005	WV	14	1560.13	0.112	VS	25	3690.59	0.068	M	36	3839.58	0.049	M
4	466.69	0.012	W	15	1637.27	0.110	VS	26	3677.59	0.062	M	37	3845.36	0.046	M
5	472.47	0.012	W	16	1648.84	0.102	S	27	3691.09	0.066	M	38	3855.00	0.075	S
6	493.69	0.011	WV	17	1654.62	0.116	VS	28	3712.30	0.066	M	39	3870.43	0.047	M
7	578.54	0.038	M	18	1685.48	0.106	VS	29	3737.37	0.059	M	40	3885.86	0.041	M
8	605.54	0.035	M	19	1700.91	0.105	VS	30	3745.08	0.066	M	41	3893.57	0.036	M
9	622.89	0.036	M	20	1736.62	0.104	S	31	3762.80	0.064	M	42	3905.15	0.038	M
10	669.18	0.047	M	21	2346.94	0.100	S	32	3802.94	0.054	M				
11	721.25	0.040	M	22	3588.88	0.068	M	33	3806.72	0.052	M				

Cherry Lumber Sample 3



Comment	031704 M95 Cherry KBr 5.2 25turn		
File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS PADILLA\DESKTOP\SPECTRA\2004\031704 OTHER\031704 M95 CHERRY KBR 5.2 25TURN.SPC		
Date Stamp	17/03/2004 16:55:00	Date	17 Mar 2004 17:10:50
Spectral Region	IR	X Axis	Wavenumber (cm ⁻¹)
Spectrum Range	399.1926 - 3999.6399	Points Count	1868
		Y Axis	Absorbance
		Data Spacing	1.9285

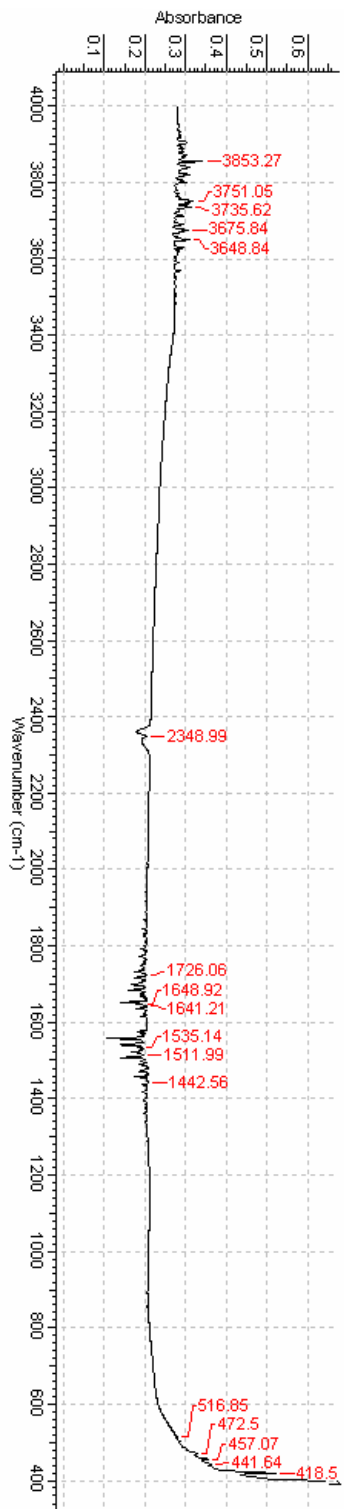
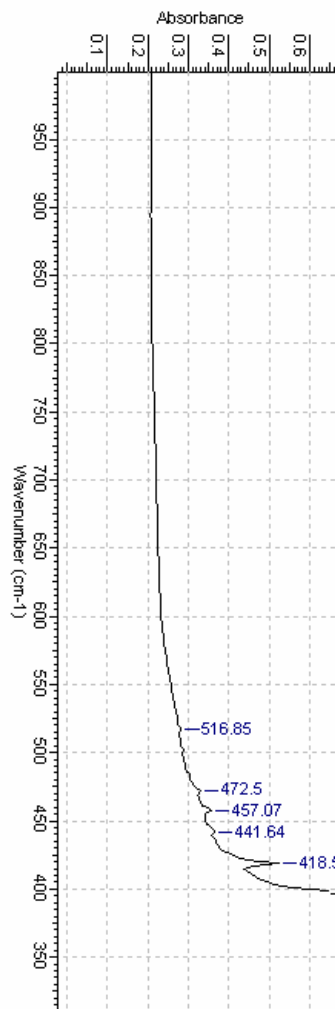
Cherry Lumber Sample 3

Comment		031704 M95 Cherry KBr 5.2 .25turn	
File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS PADILLA\DESKTOP\SPECTRA\2004\031704 OTHER\031704 M95 CHERRY KBR 5.2 .25TURN.SPC	Date	17 Mar 2004 17:10:50
Date Stamp	1703/2004 16:56:00	X Axis	Wavenumber (cm-1)
Spectral Region	IR	Points Count	1888
Spectrum Range	399.1926 - 3999.6399	Y Axis	Absorbance
		Data Spacing	1.9295

No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity
1	410.76	0.021	-	-	M	17	1577.49	0.026	-	-	M	33	3619.73	0.047	-	-	S
2	428.12	0.016	-	-	W	18	1617.98	0.034	-	-	M	34	3629.37	0.054	-	-	S
3	437.76	0.013	28.59	-0.01	W	19	1637.27	0.037	-	-	M	35	3660.69	0.054	-	-	S
4	457.05	0.011	-	-	W	20	1646.91	0.031	-	-	M	36	3656.37	0.041	-	-	S
5	487.90	0.006	11.19	-0.16	WW	21	1664.62	0.040	-	-	M	37	3669.87	0.040	-	-	M
6	547.68	0.009	-	-	W	22	1685.48	0.031	-	-	M	38	3675.66	0.050	-	-	S
7	666.04	0.012	-	-	W	23	1700.91	0.031	-	-	M	39	3691.09	0.044	-	-	S
8	682.40	0.012	-	-	W	24	1718.26	0.028	-	-	M	40	3702.66	0.039	-	-	M
9	669.18	0.014	-	-	W	25	1735.62	0.030	-	-	M	41	3712.30	0.044	-	-	S
10	694.25	0.003	-	-	WW	26	1774.19	0.026	-	-	M	42	3727.73	0.035	-	-	M
11	1488.64	0.020	-	-	W	27	1793.47	0.025	-	-	M	43	3737.37	0.048	-	-	S
12	1467.92	0.024	-	-	M	28	2345.02	0.048	-	-	S	44	3745.08	0.055	-	-	S
13	1508.06	0.027	-	-	M	29	2364.30	0.049	-	-	S	45	3762.80	0.050	-	-	S
14	1526.06	0.021	-	-	M	30	3667.66	0.057	-	-	S	46	3760.51	0.038	-	-	M
15	1540.84	0.025	-	-	M	31	3688.88	0.054	-	-	S	47	3770.15	0.037	-	-	M
16	1590.13	0.035	-	-	M	32	3613.95	0.042	-	-	S	48	3779.79	0.035	-	-	M
												49	3802.94	0.040	-	-	M
												50	3808.72	0.039	-	-	M
												51	3816.44	0.039	-	-	M
												52	3822.22	0.047	-	-	S
												53	3839.58	0.039	-	-	M
												54	3855.00	0.058	-	-	S
												55	3864.85	0.032	-	-	M
												56	3870.43	0.038	-	-	M
												57	3880.07	0.027	-	-	M
												58	3885.86	0.035	-	-	M
												59	3891.65	0.029	-	-	M
												60	3905.15	0.031	-	-	M
												61	3918.64	0.020	-	-	W

Pine Greenwood Sample 1

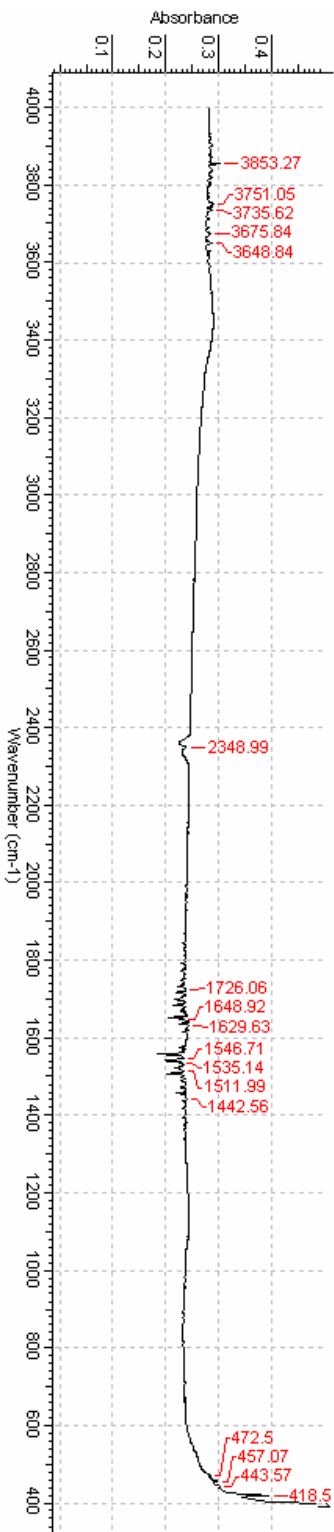
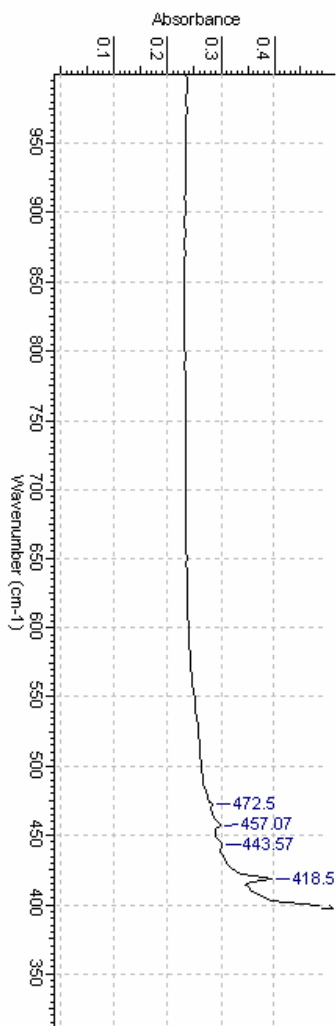
Comment	092104 Pine Samples 2	File Name	C:\DOCUMENTS AND SETTINGS\JLWOMARIS\PAULLA\DESKTOP\SPECTRA\04092104\PINE_SAMP49-2.SPC
Date Stamp	21/09/2004 14:04:00	Date	21 Sep 2004 14:27:30
Spectral Region	IR	X Axis	Wavenumber (cm-1)
Points Count	1868	Data Spacing	1.9286
		Y Axis	Absorbance
		Restroom	OMNIC
		Spectrum Range	399 2123 - 3999 8375



No	cm-1	A	Intensity	No	cm-1	A	Intensity
1	418.50	0.522	S	10	1648.92	0.195	W
2	441.64	0.362	M	11	1726.06	0.204	W
3	457.07	0.355	M	12	2348.99	0.204	W
4	472.50	0.328	M	13	3648.84	0.311	M
5	516.85	0.280	M	14	3675.84	0.306	M
6	1442.56	0.208	W	15	3735.62	0.313	M
7	1511.99	0.196	W	16	3751.05	0.319	M
8	1535.14	0.194	W	17	3853.27	0.342	M
9	1641.21	0.206	W				

Pine Greenwood Sample 2

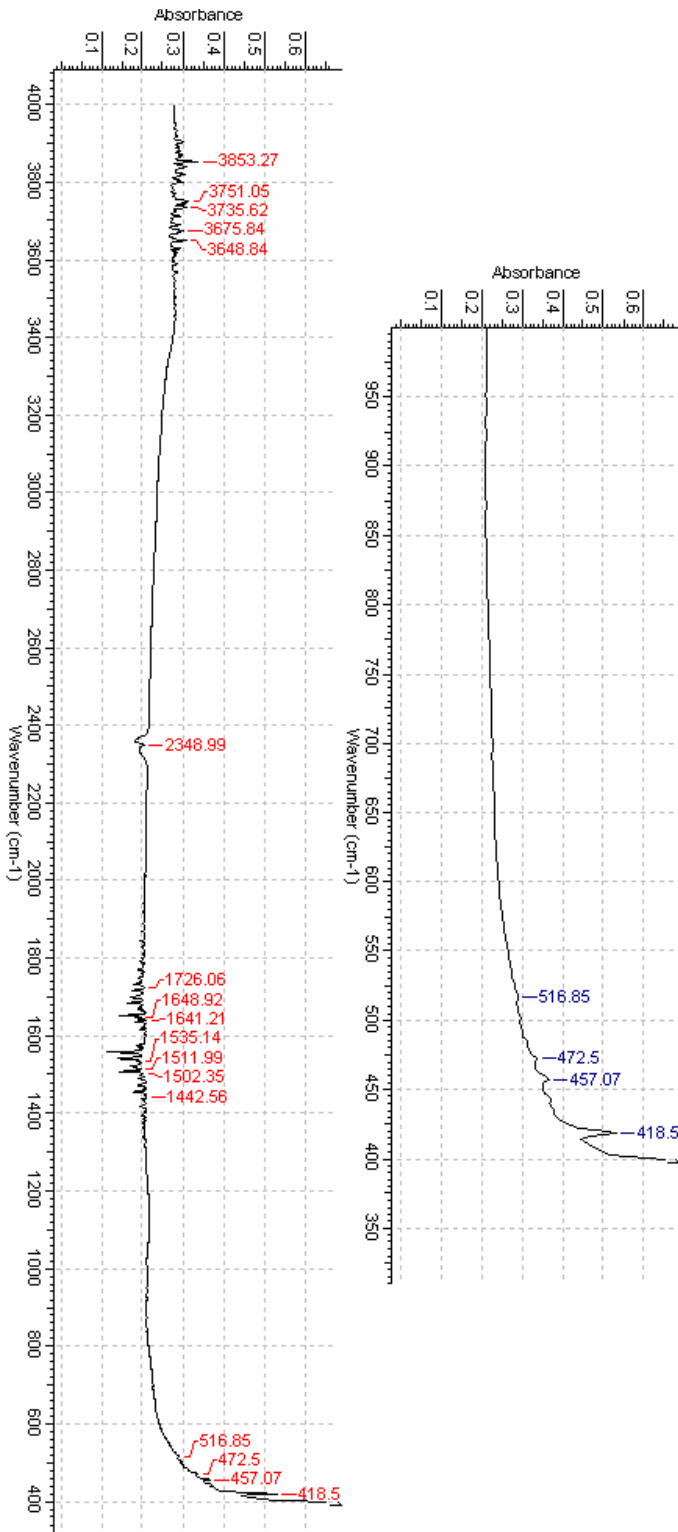
Comment	092104 Pine Sample 4.dchfile		
File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS PADILLADESKTOP\PSPE CTR A\2004\092104\092104.PINE_SAMP48-4.OTHER.DIE.SPC		
Date Stamp	21/09/2004 13:20:00	Date	21 Sep 2004 13:34:46
Spectral Region	IR	X Axis	Wavenumber (cm-1)
Points Count	1868	Data Spacing	1.9286
Y Axis	Absorbance	Technique	Infrared
Instrument	OMNIC		
Spectrum Range	399.2123 - 3999.8375		



No	cm-1	A	Intensity	No	cm-1	A	Intensity
1	418.50	0.395	S	10	1648.92	0.234	W
2	443.57	0.302	M	11	1726.06	0.238	W
3	457.07	0.297	M	12	2348.99	0.239	W
4	472.50	0.283	M	13	3648.84	0.287	M
5	1442.56	0.240	W	14	3675.84	0.285	M
6	1511.99	0.233	W	15	3735.62	0.287	M
7	1535.14	0.231	W	16	3751.05	0.290	M
8	1546.71	0.233	W	17	3853.27	0.301	M
9	1629.63	0.243	W				

Pine Greenwood Sample 3

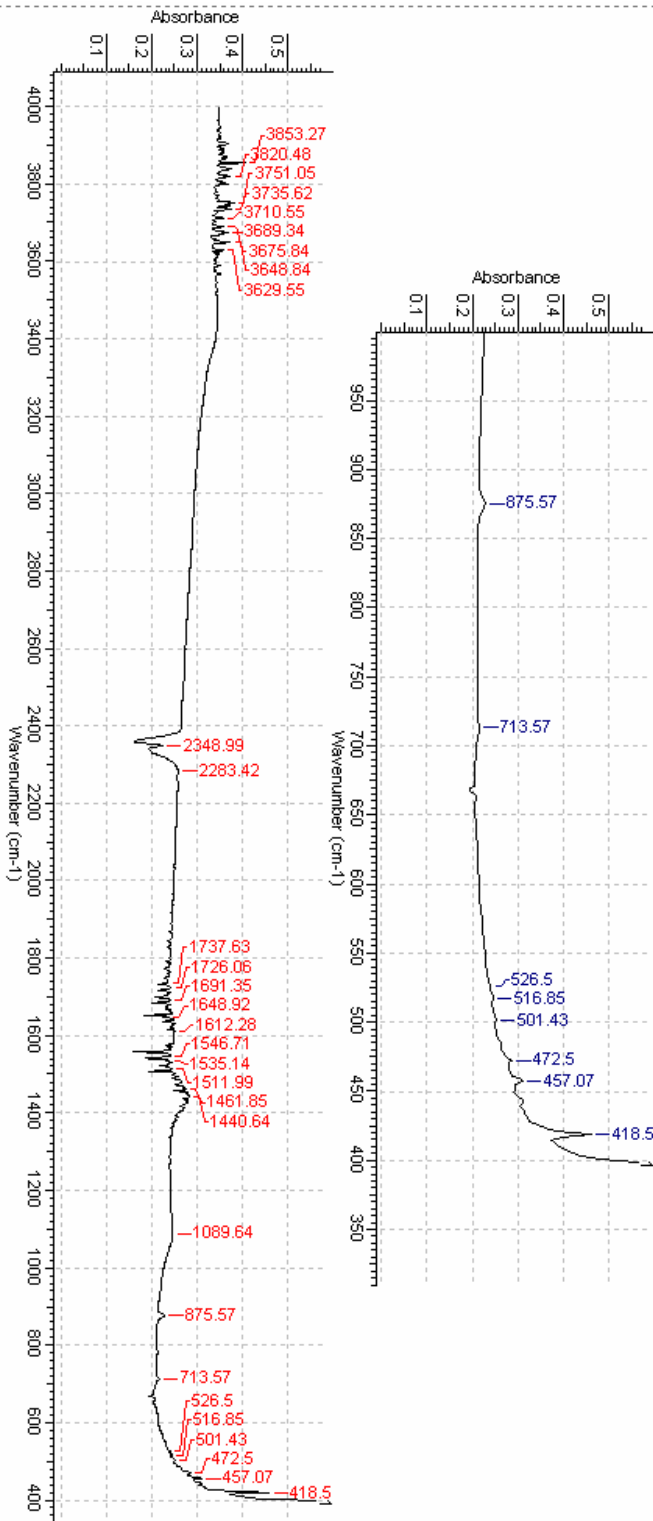
Comment	092104 Pine Sample49	File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS PADILLA\DESKTOP\SPECTRA\004\092104\092104 PINE_SAMP49.SPC
Date Stamp	21/09/2004 13:59:00	Date	21 Sep 2004 14:27:40
Spectral Region	IR	X Axis	Wavenumber (cm-1)
Points Count	1868	Data Spacing	1.9286
		Y Axis	Absorbance
		Instrument	OMNIC
		Spectrum Range	399.2123 - 3999.8875



No	cm-1	A	Intensity	No	cm-1	A	Intensity
1	418.50	0.531	S	10	1648.92	0.198	W
2	457.07	0.365	M	11	1726.06	0.205	W
3	472.50	0.337	M	12	2348.99	0.205	W
4	516.85	0.290	M	13	3648.84	0.308	M
5	1442.56	0.210	W	14	3675.84	0.301	M
6	1502.35	0.203	W	15	3735.62	0.309	M
7	1511.99	0.198	W	16	3751.05	0.314	M
8	1535.14	0.196	W	17	3853.27	0.337	M
9	1641.21	0.210	W				

Maple Greenwood Sample 1

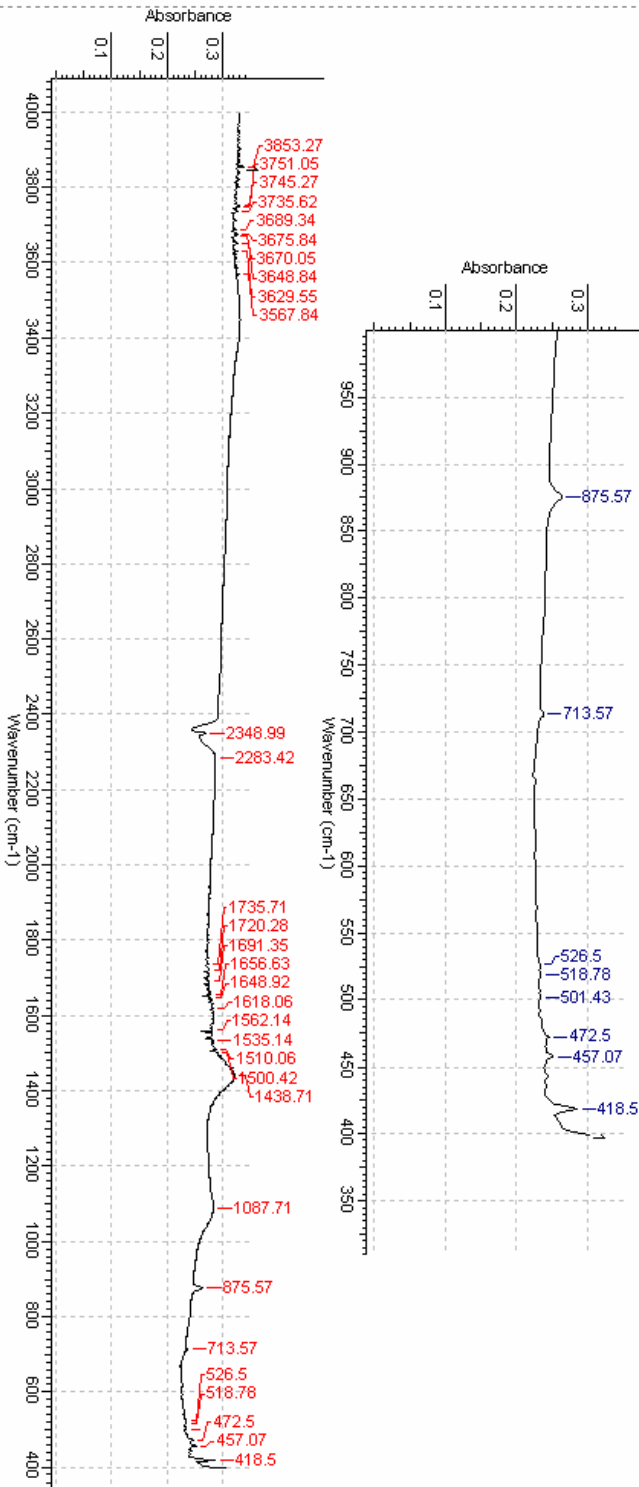
Comment	092104 Maple Soot Samr34		
File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS PAOLLA\DESKTOP\SPECTRA\MAPLE\092104 MAPLE SOOT SAMP 34.SPC		
Date	21 Sep 2004 16:42:14	Technique	Infrared
X Axis	Wavenumber (cm-1)	Y Axis	Absorbance
Data Spacing	1.9286	Instrument	OMNIC
		Spectrum Range	399.2123 - 3999.8375
		Points Count	1868
		Date Stamp	21/09/2004 16:07:00
		Spectral Region	IR



No	cm-1	A	Intensity	No	cm-1	A	Intensity
1	418.50	0.460	S	11	1461.85	0.275	W
2	457.07	0.310	M	12	1511.99	0.246	W
3	472.50	0.286	M	13	1535.14	0.240	W
4	501.43	0.252	W	14	1546.71	0.242	W
5	516.85	0.245	W	15	1612.28	0.250	W
6	526.50	0.241	W	16	1648.92	0.237	W
7	713.57	0.216	W	17	1891.35	0.241	W
8	875.57	0.229	W	18	1726.06	0.242	W
9	1089.64	0.246	W	19	1737.63	0.236	W
10	1440.64	0.282	M	20	2283.42	0.258	W
				21	2348.99	0.223	W
				22	3629.55	0.357	M
				23	3648.84	0.373	M
				24	3675.84	0.367	M
				25	3689.34	0.358	M
				26	3710.55	0.357	M
				27	3735.62	0.374	M
				28	3751.05	0.381	M
				29	3820.48	0.373	M
				30	3853.27	0.406	S

Maple Greenwood Sample 2

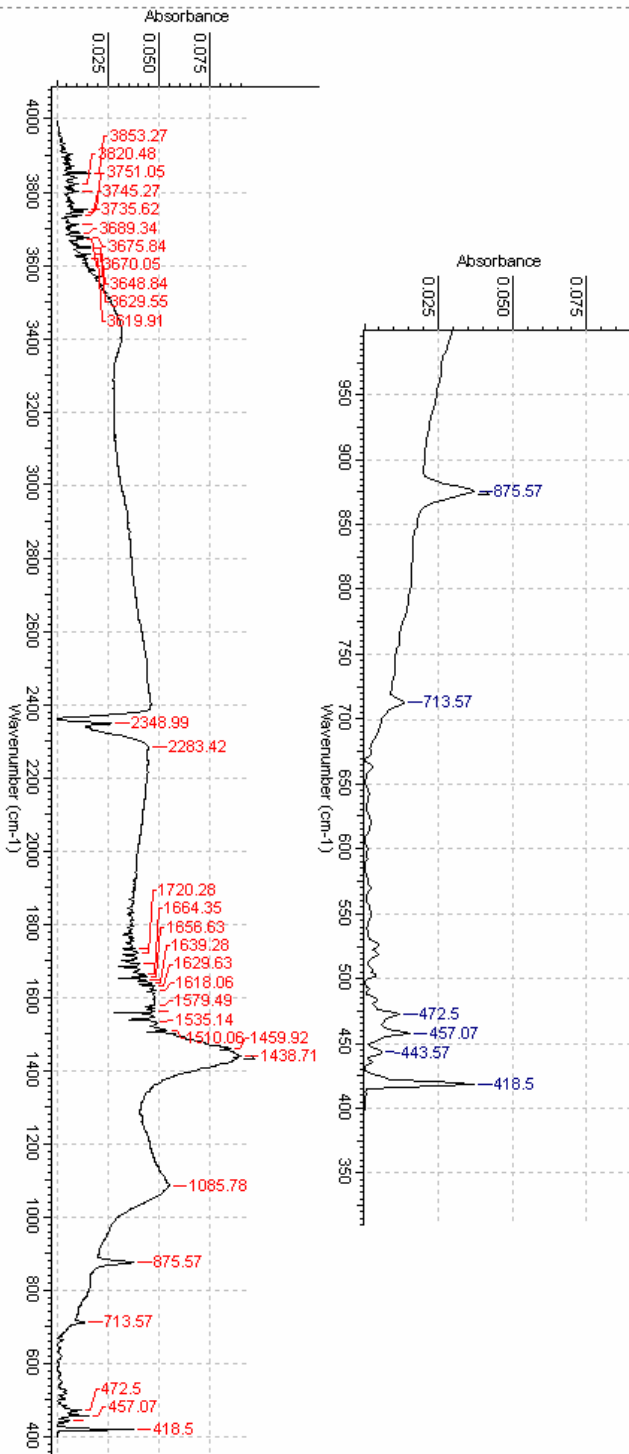
Comment	092104 Maple Soot_Samp34-3		
File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS PAJILL\DESKTOP\SPECTRAM\92104_MAPLE SOOT_SAMP34-3.SPC		
Date Sampl	21/09/2004 16:11:00	Date	21 Sep 2004 16:41:44
Spectral Region	IR	X Axis	Wavenumber (cm-1)
Points Count	1868	Data Spacing	1.9288
		Y Axis	Absorbance
		Instrument	OMNIC
		Spectrum Range	399.2123 - 3999.8375



No	cm-1	A	Intensity	No	cm-1	A	Intensity	No	cm-1	A	Intensity
1	418.50	0.286	M	12	1510.06	0.287	M	23	3667.84	0.328	VS
2	457.07	0.252	W	13	1535.14	0.282	M	24	3629.55	0.326	VS
3	472.50	0.246	W	14	1562.14	0.282	M	25	3648.84	0.327	VS
4	501.43	0.235	VW	15	1618.06	0.283	M	26	3670.05	0.324	S
5	518.78	0.235	VW	16	1648.92	0.278	M	27	3675.84	0.327	VS
6	526.50	0.234	VW	17	1656.63	0.279	M	28	3689.34	0.324	S
7	713.57	0.238	W	18	1691.35	0.276	M	29	3735.62	0.327	VS
8	875.57	0.263	M	19	1720.28	0.276	M	30	3745.27	0.330	VS
9	1087.71	0.283	M	20	1735.71	0.274	M	31	3751.05	0.330	VS
10	1438.71	0.322	S	21	2283.42	0.287	M	32	3853.27	0.337	VS
11	1500.42	0.291	M	22	2348.99	0.289	M				

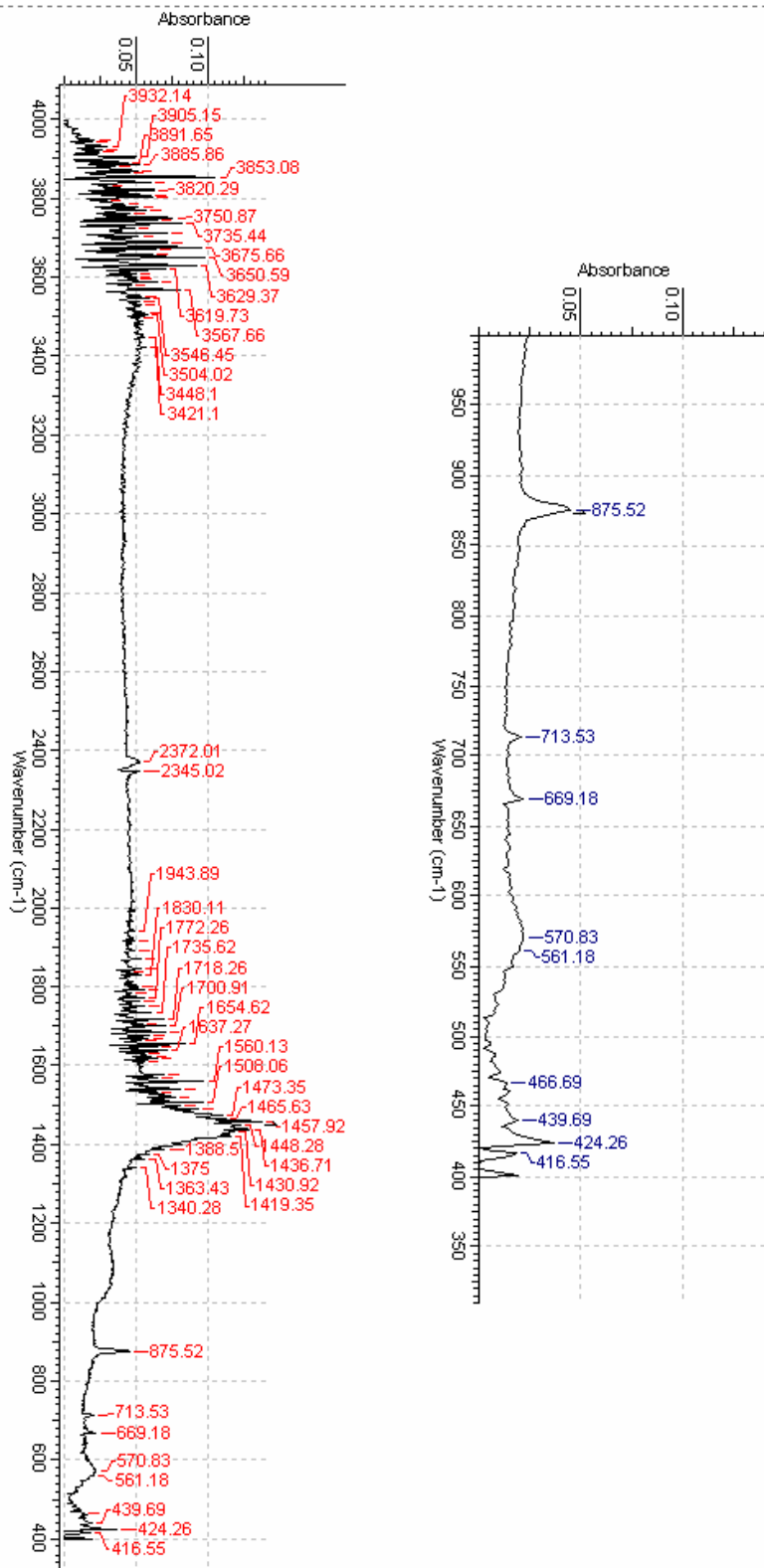
Maple Greenwood Sample 3

Comment	092104 Maple Soot Sample 3		
File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS P ADILL\ADESKTOP\PSPEC\CTR\A092104\092104 MAPLE SOOT SAMP34-3.SPC		
Date Stamp	Date	Technique	Instrument
21/09/2004 16:11:00	21 Sep 2004 16:41:44	Infrared	OMNIC
Spectral Region	X Axis	Y Axis	Spectrum Range
IR	Wavenumber (cm-1)	Absorbance	399.2123 - 3999.8375
Points Count	Date Spec'ing		
1888	1.9288		



No	cm-1	A	FWHM	Asym	Intensity	No	cm-1	A	FWHM	Asym	Intensity
1	418.50	0.037	4.05	0.76	M	14	1618.06	0.048	-	-	M
2	443.57	0.006	5.90	-0.01	VW	15	1629.63	0.048	-	-	M
3	457.07	0.015	-	-	W	16	1639.28	0.046	-	-	M
4	472.50	0.012	-	-	W	17	1648.92	0.043	-	-	M
5	713.57	0.013	-	-	W	18	1656.63	0.044	-	-	M
6	875.57	0.037	-	-	M	19	1664.35	0.042	-	-	M
7	1085.78	0.055	-	-	S	20	1691.35	0.040	-	-	M
8	1438.71	0.080	-	-	V/S	21	1720.28	0.040	-	-	M
9	1459.92	0.085	-	-	V/S	22	1735.71	0.038	-	-	M
10	1510.06	0.054	-	-	M	23	2283.42	0.045	-	-	M
11	1535.14	0.048	-	-	M	24	2346.99	0.026	-	-	W
12	1562.14	0.048	-	-	M	25	3619.91	0.015	-	-	W
13	1579.49	0.048	-	-	M	26	3629.55	0.016	-	-	W
						27	3648.84	0.016	-	-	W
						28	3670.05	0.012	-	-	W
						29	3675.84	0.015	-	-	W
						30	3689.34	0.011	9.20	0.89	W
						31	3712.48	0.010	7.54	-0.09	W
						32	3735.62	0.012	7.13	0.02	W
						33	3745.27	0.013	-	-	W
						34	3751.05	0.014	-	-	W
						35	3801.20	0.010	15.09	0.44	W
						36	3820.48	0.010	13.84	0.15	W
						37	3853.27	0.016	-	-	W

White Oak Greenwood Sample 1

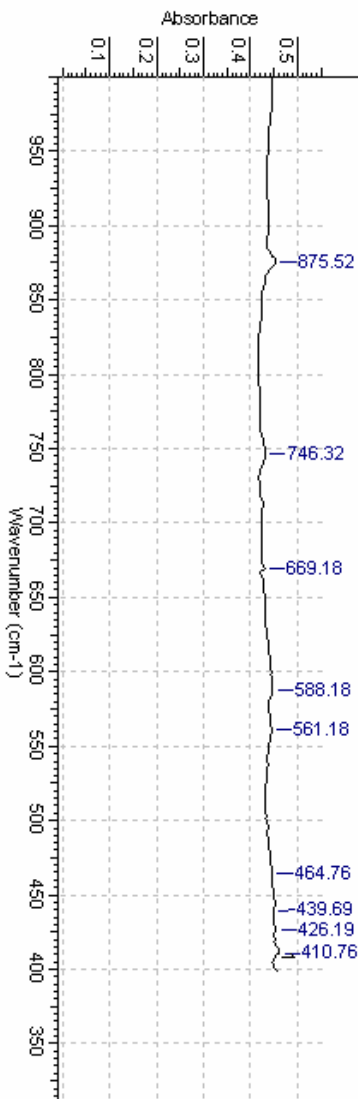
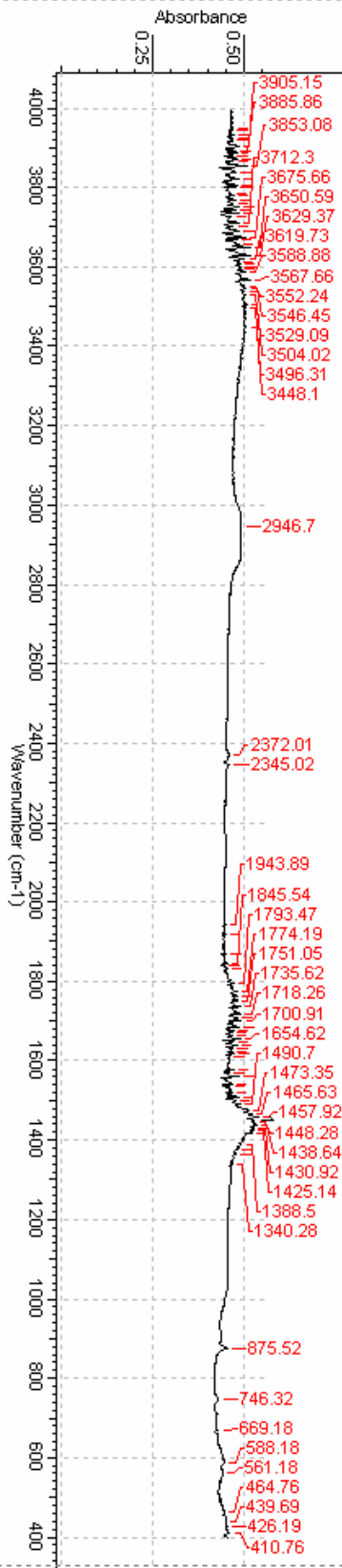


Comment	090104 White Oak Samp 2 4 green		
File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS PADILLADESKTOP\SPECTRA\SPECTRA\ASPECTR\A2\02004\090104\090104 WHITE OAK SAMP 2 4 GREEN.SPC		
Date Stamp	01/09/2004 16:45:00	Date	01 Sep 2004 16:56:34
Spectral Region	IR	X Axis	Wavenumber (cm-1)
Spectrum Range	399.1926 - 3999.6399	Points Count	1868
		Y Axis	Absorbance
		Technique	Infrared
		Data Spacing	1.9285

White Oak Greenwood Sample 1

Comment		090104 White Oak Samp 2 4 green									
File Name	C:\D\DOCUMENTS\AND\SETTING\ID\MARIS PAULLAD\ESKTOP\SPECTRA\SPECTRA2\2004090104090104 WHITE OAK SAMP 2 4 GREEN.SPC	Date	01 Sep 2004 16:56:34								
Date Stamp	01/09/2004 16:46:00	Y Axis	Absorbance								
Spectral Region	IR	X Axis	Wavenumber (cm-1)								
Spectrum Range	399 - 1926 - 3999 6399	Points Count	1868								
		Data Spacing	1.9285								
		Technique	Infrared								
No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity
1	416.66	0.018	-	-	W	79	3669.87	0.064	3.11	0.08	M
2	424.26	0.037	-	-	W	80	3675.66	0.096	-	-	S
3	439.89	0.019	-	-	W	81	3689.16	0.072	-	-	M
4	469.89	0.014	-	-	VW	82	3702.66	0.062	-	-	M
5	561.18	0.020	-	-	W	83	3742.30	0.072	6.22	0.20	M
6	570.83	0.022	-	-	W	84	3756.80	0.049	-	-	M
7	689.18	0.022	-	-	W	85	3756.44	0.082	5.20	0.88	S
8	713.63	0.020	-	-	W	86	3746.08	0.064	3.42	-0.79	M
9	876.62	0.046	21.33	0.14	M	87	3760.87	0.076	-	-	M
10	1340.28	0.060	-	-	M	88	3760.51	0.048	-	-	M
11	1363.43	0.066	-	-	M	89	3770.15	0.067	10.49	-0.88	M
12	1376.00	0.069	-	-	M	90	3779.79	0.062	-	-	M
13	1388.60	0.070	-	-	M	91	3789.68	0.041	-	-	M
14	1419.35	0.116	-	-	S	92	3796.22	0.029	-	-	W
15	1430.92	0.119	-	-	S	93	3801.01	0.061	-	-	M
16	1436.71	0.129	-	-	S	94	3806.79	0.060	5.08	0.99	M
17	1448.28	0.122	-	-	S	95	3820.29	0.063	-	-	M
18	1467.92	0.137	-	-	VS	96	3831.96	0.030	-	-	W
19	1466.63	0.113	-	-	S	97	3839.68	0.060	9.66	0.78	M
20	1473.35	0.110	-	-	S	98	3853.08	0.106	-	-	M
21	1480.70	0.093	-	-	S	99	3864.66	0.046	-	-	M
22	1488.42	0.081	-	-	M	100	3870.43	0.061	-	-	M
23	1509.06	0.097	-	-	S						
24	1621.66	0.077	-	-	M						
25	1633.13	0.064	-	-	M						
26	1640.84	0.081	-	-	M						

White Oak Greenwood Sample 2

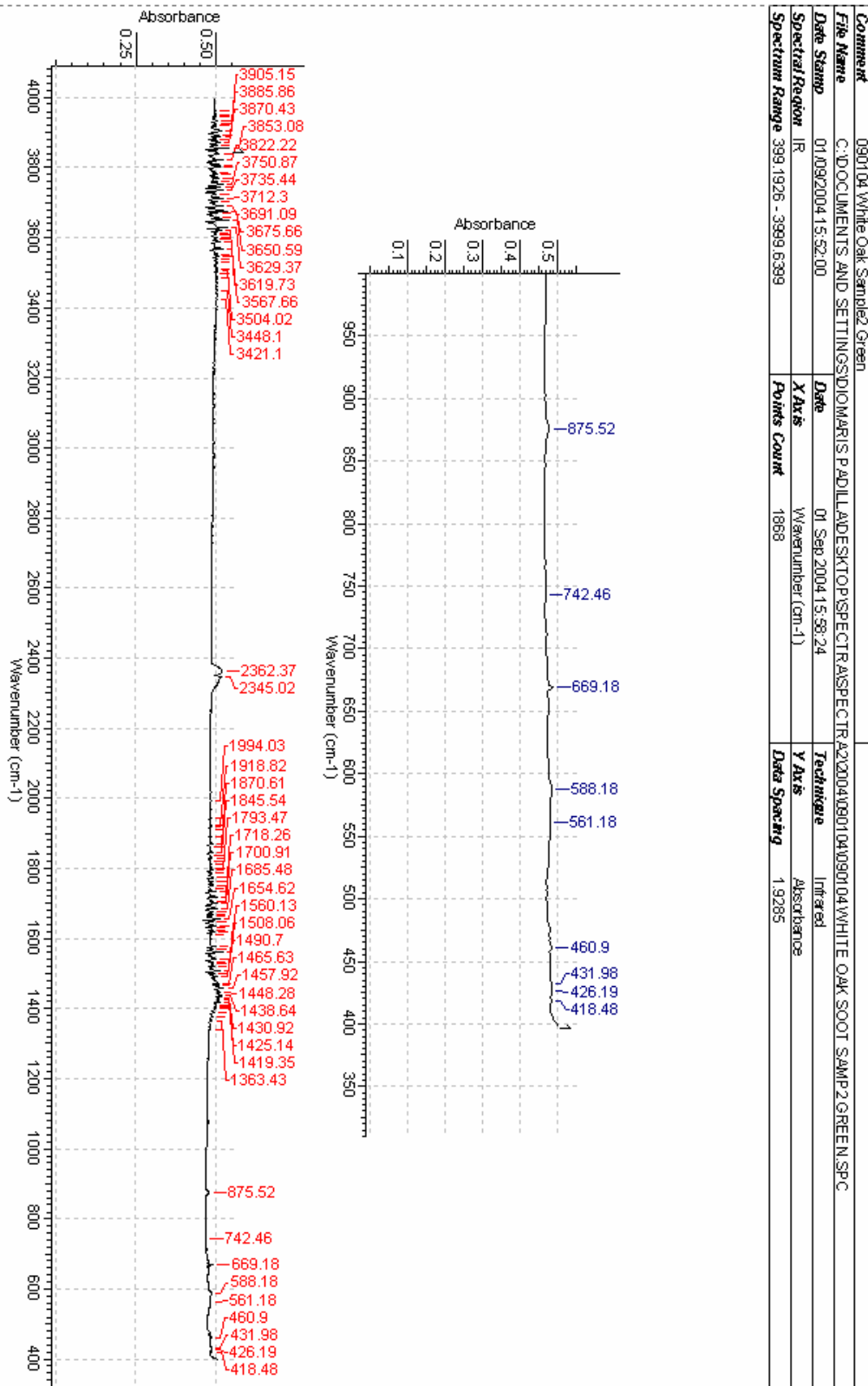


Comment	090104 White Oak Soot		
File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS PADILLA\DESKTOP\SPECTRA\SPECTRA\22004090104\090104 WHITE OAK SOOT GREEN.SPC		
Date Stamp	01/09/2004 15:26:00	Date	01 Sep 2004 15:27:58
Spectral Region	IR	X Axis	Wavenumber (cm-1)
Spectrum Range	399.1926 - 3999.6399	Points Count	1658
		Y Axis	Absorbance
		Data Spacing	1.9285

White Oak Greenwood Sample 2

Comment		090104 White Oak Soot					
File Name		C:\DOCUMENTS AND SETTINGS\DIOMARIS P ADILL\DESKTOP\SPECTRA\SPECTR.A2\2004090104\090104WHITE OAK SOOT GREEN.SPC					
Date Stamp	01/09/2004 15:26:00	Date	01 Sep 2004 15:27:58				
Spectral Region	IR	X Axis	Wavenumber (cm-1)				
Spectrum Range	399.1926 - 3999.6399	Points Count	1988				
		Y Axis	Absorbance				
		Data Spacing	1.9285				
No	1	cm-1	410.76	A	0.461	Intensity	M
	2		426.19		0.454		M
	3		439.69		0.449		M
	4		464.76		0.446		M
	5		561.18		0.443		M
	6		588.18		0.448		M
	7		669.18		0.430		M
	8		746.32		0.430		M
	9		875.52		0.454		M
	10		1340.28		0.469		M
	11		1363.43		0.480		M
	12		1375.00		0.484		M
	13		1388.50		0.493		M
	14		1419.35		0.523		M
	15		1425.14		0.525		M
	16		1430.92		0.528		M
	17		1438.64		0.536		M
	18		1448.28		0.530		M
	19		1457.92		0.539		M
	20		1465.63		0.523		M
	21		1473.35		0.514		M
	22		1490.70		0.492		M
	23		1498.42		0.477		M
	24		1508.06		0.486		M
	25		1521.56		0.468		M
	26		1535.06		0.463		M
	27		1540.84		0.469		M
	28		1560.13		0.488		M
	29		1569.77		0.462		M
	30		1577.49		0.473		M
	31		1610.27		0.461		M
	32		1617.98		0.473		M
	33		1623.77		0.468		M
	34		1629.55		0.469		M
	35		1637.27		0.481		M
	36		1646.91		0.471		M
	37		1654.62		0.492		M
	38		1664.27		0.488		M
	39		1670.05		0.469		M
	40		1675.84		0.473		M
	41		1685.48		0.488		M
	42		1700.91		0.493		M
	43		1706.69		0.482		M
	44		1718.26		0.493		M
	45		1735.62		0.489		M
	46		1751.05		0.483		M
	47		1762.62		0.481		M
	48		1774.19		0.482		M
	49		1793.47		0.473		M
	50		1830.11		0.455		M
	51		1837.83		0.449		M
	52		1845.54		0.454		M
	53		1870.61		0.452		M
	54		1918.82		0.449		M
	55		1943.89		0.449		M
	56		2345.02		0.461		M
	57		2372.01		0.459		M
	58		2946.70		0.494		M
	59		3448.10		0.507		M
	60		3496.31		0.503		M
	61		3504.02		0.508		M
	62		3529.09		0.504		M
	63		3536.61		0.502		M
	64		3546.45		0.507		M
	65		3552.24		0.502		M
	66		3567.66		0.517		M
	67		3588.88		0.505		M
	68		3594.66		0.491		M
	69		3600.45		0.492		M
	70		3608.16		0.490		M
	71		3613.95		0.487		M
	72		3619.73		0.503		M
	73		3629.37		0.518		M
	74		3650.59		0.517		M
	75		3656.37		0.487		M
	76		3669.87		0.482		M
	77		3675.66		0.505		M
	78		3691.09		0.488		M
	79		3702.66		0.471		M
	80		3712.30		0.487		M
	81		3725.80		0.467		M
	82		3735.44		0.487		M
	83		3745.08		0.480		M
	84		3750.87		0.489		M
	85		3760.51		0.471		M
	86		3770.15		0.476		M
	87		3779.79		0.473		M
	88		3785.58		0.466		M
	89		3801.01		0.479		M
	90		3806.79		0.480		M
	91		3822.22		0.487		M
	92		3839.58		0.478		M
	93		3853.08		0.509		M
	94		3864.65		0.471		M
	95		3870.43		0.481		M
	96		3880.07		0.469		M
	97		3885.86		0.482		M
	98		3891.65		0.478		M
	99		3905.15		0.485		M
	100		3918.64		0.470		M

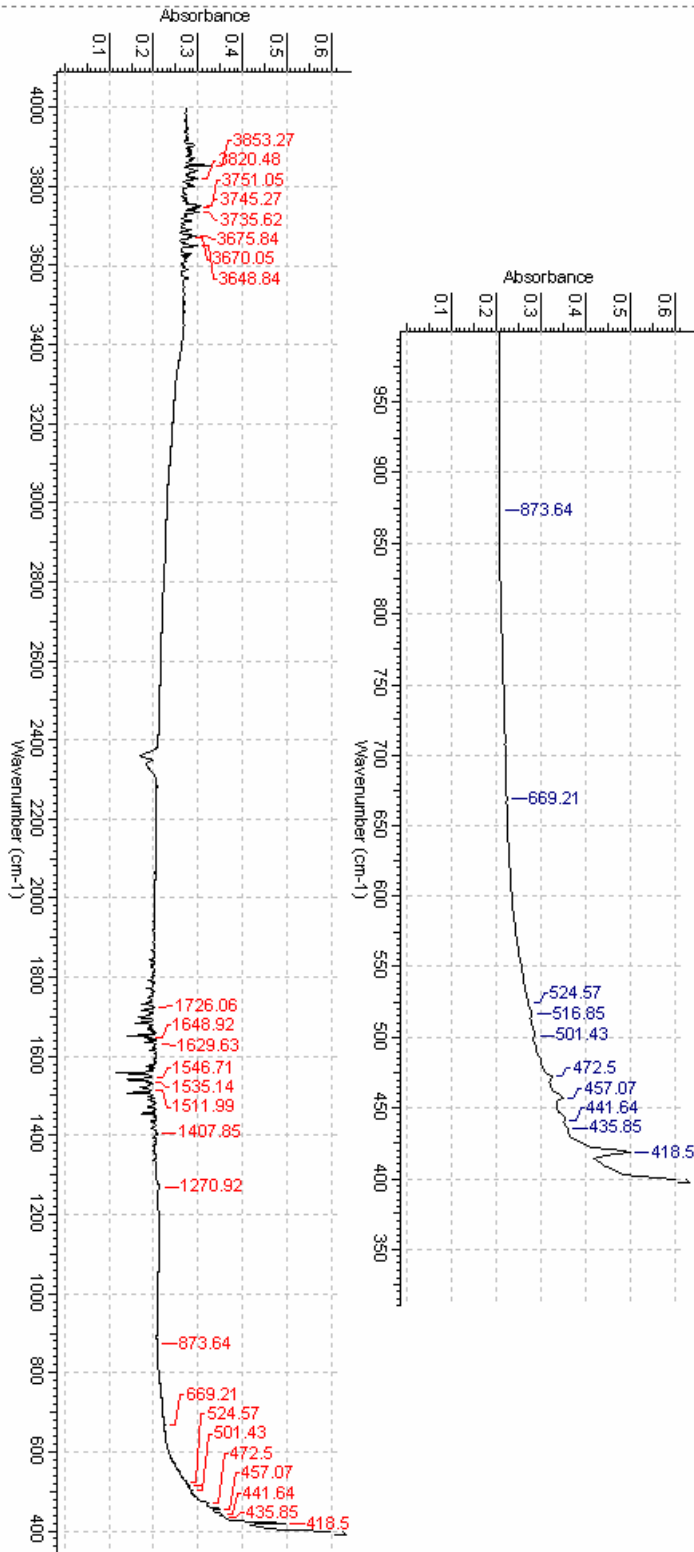
White Oak Greenwood Sample 3



Comment	090104 White Oak Sample2 Green		
File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS.PADILLA\DESKTOP\ASPECTRA\ASPECTRA\2004\090104\090104 WHITE OAK SOOT SAMP2 GREEN.SPC		
Date Stamp	01/09/2004 15:52:00	Date	01 Sep 2004 15:58:24
Spectral Region	IR	X Axis	Wavenumber (cm-1)
Spectral Range	399.1926 - 3999.6399	Points Count	1868
		Y Axis	Absorbance
		Technique	Infrared
		Data Spacing	1.9285

Pin Oak Greenwood Sample 1

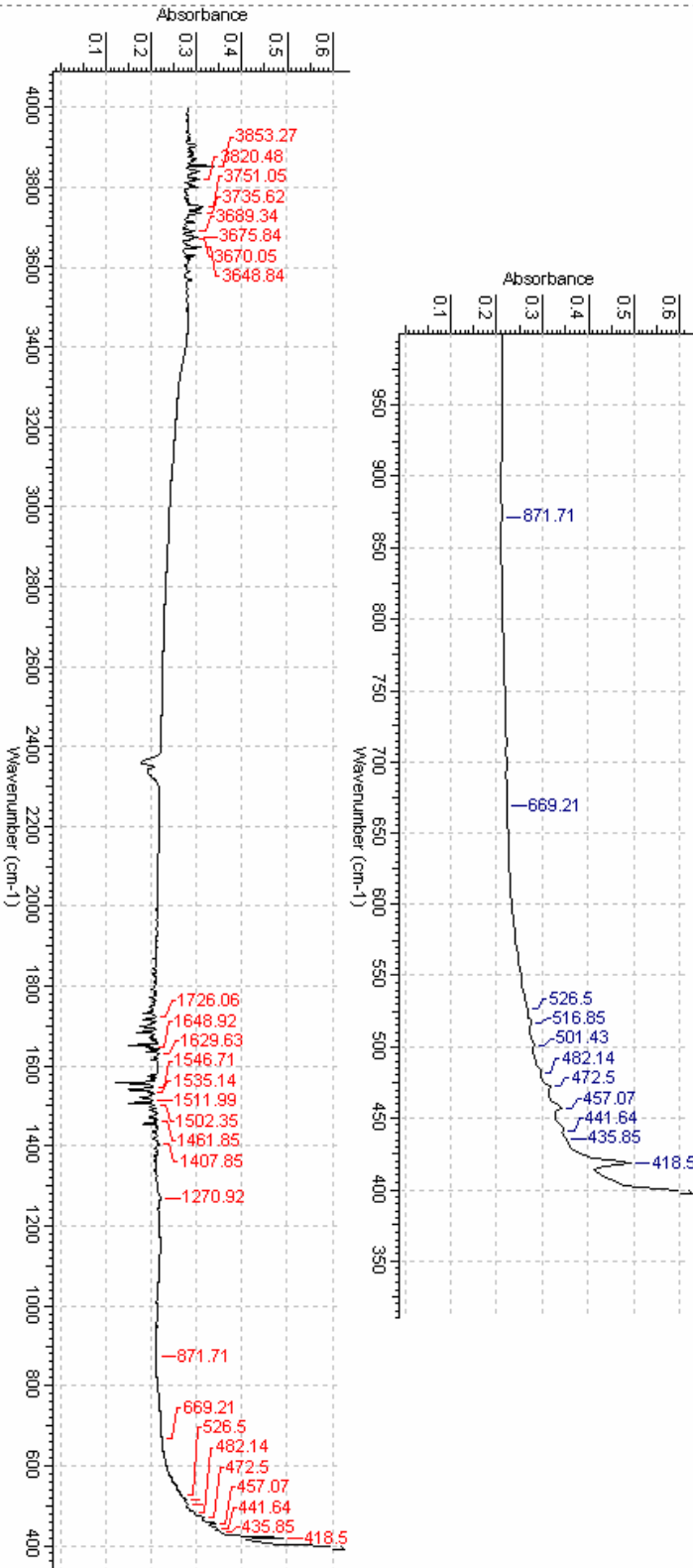
Comment	092104.P:PinOak Sample 1	File Name	C:\DOCUMENTS AND SETTINGS\SDJ\OM\ARIS PAD\ILLADESKTOP\SPECTRA\2004\092104\092104.PIN.OAK.SAMP1.6.SPC
Date Stamp	21/09/2004 15:07:00	Date	21 Sep 2004 15:15:38
Spectral Region	IR	X Axis	Wavenumber (cm-1)
Points Count	1868	Data Spacing	1.9286
		Y Axis	Absorbance
		Instrument	OMNIC
		Spectrum Range	389.2123 - 3899.8375



No	cm-1	A	Intensity	No	cm-1	A	Intensity	No	cm-1	A	Intensity
1	418.50	0.498	S	10	873.64	0.209	W	19	3648.84	0.300	M
2	435.85	0.360	M	11	1270.92	0.214	W	20	3670.05	0.285	M
3	441.64	0.354	M	12	1407.85	0.208	W	21	3675.84	0.296	M
4	457.07	0.348	M	13	1511.99	0.195	W	22	3735.62	0.302	M
5	472.50	0.323	M	14	1535.14	0.194	W	23	3745.27	0.301	M
6	501.43	0.287	M	15	1546.71	0.196	W	24	3751.05	0.307	M
7	516.85	0.280	M	16	1629.63	0.207	W	25	3820.48	0.298	M
8	524.57	0.273	M	17	1648.92	0.195	W	26	3853.27	0.330	M
9	669.21	0.225	W	18	1726.06	0.201	W				

Pin Oak Greenwood Sample 2

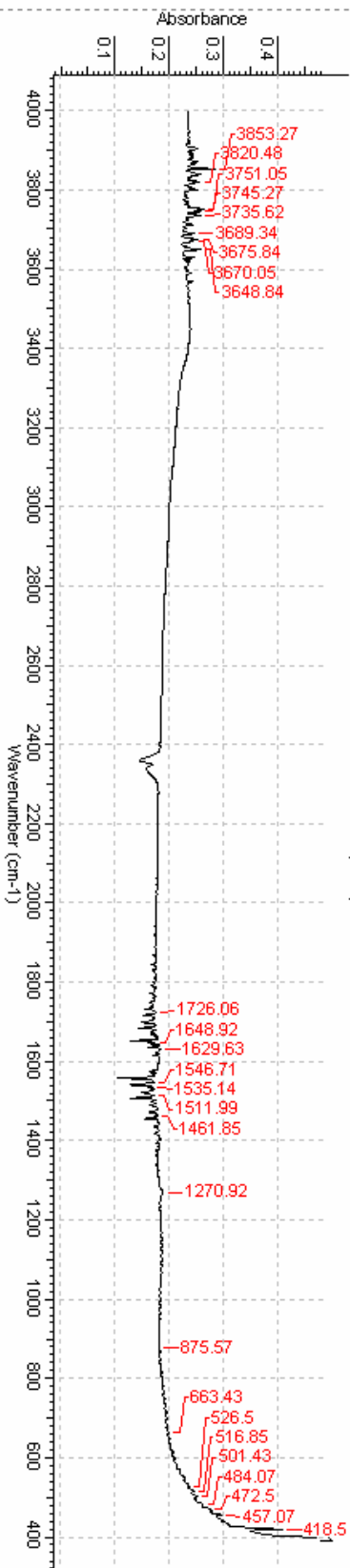
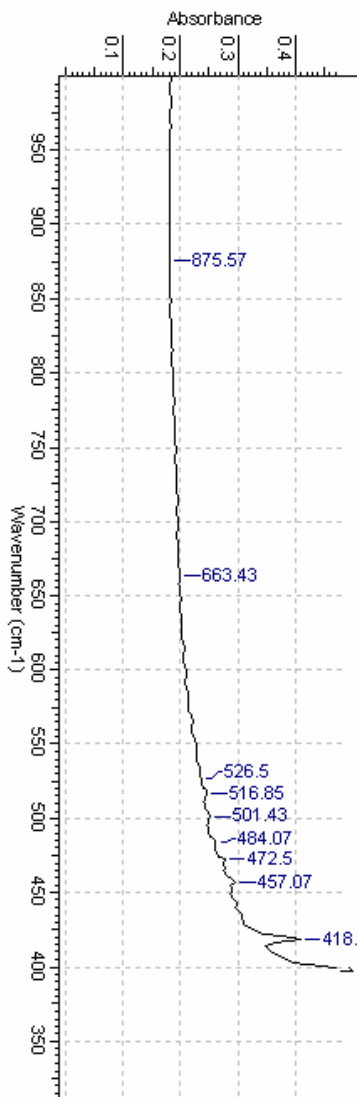
Comment	092104 PINOAK Sampl 6-2	File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS PADILLA\DESKTOP\SPECTRA\004092104092104 PINOAK_SAMP16-2.SPC
Date Stamp	21/09/2004 15:10:00	Date	21 Sep 2004 15:15:26
Spectral Region	IR	X Axis	Wavenumber (cm-1)
Points Count	1868	Data Spacing	1.9296
		Y Axis	Absorbance
		Instrument	OMNIC
		Spectrum Range	399.2123 - 3999.8375



No	cm-1	A	Intensity	No	cm-1	A	Intensity	No	cm-1	A	Intensity
1	418.50	0.492	S	11	871.71	0.211	W	21	1726.06	0.210	W
2	435.86	0.353	M	12	1270.92	0.221	W	22	3648.84	0.309	M
3	441.64	0.346	M	13	1407.86	0.216	W	23	3670.05	0.294	M
4	457.07	0.342	M	14	1461.86	0.212	W	24	3675.84	0.303	M
5	472.50	0.317	M	15	1502.36	0.207	W	25	3689.34	0.296	M
6	482.14	0.295	M	16	1511.99	0.203	W	26	3735.62	0.311	M
7	501.43	0.282	M	17	1535.14	0.201	W	27	3751.05	0.315	M
8	516.86	0.276	M	18	1546.71	0.204	W	28	3820.48	0.306	M
9	526.50	0.266	M	19	1629.63	0.216	W	29	3853.27	0.337	M
10	669.21	0.223	W	20	1648.92	0.204	W				

Pin Oak Greenwood Sample 3

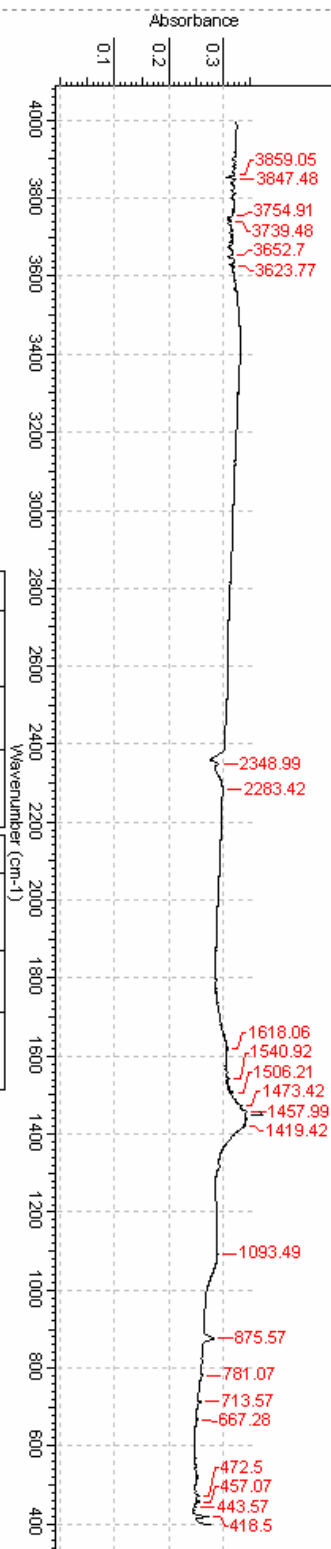
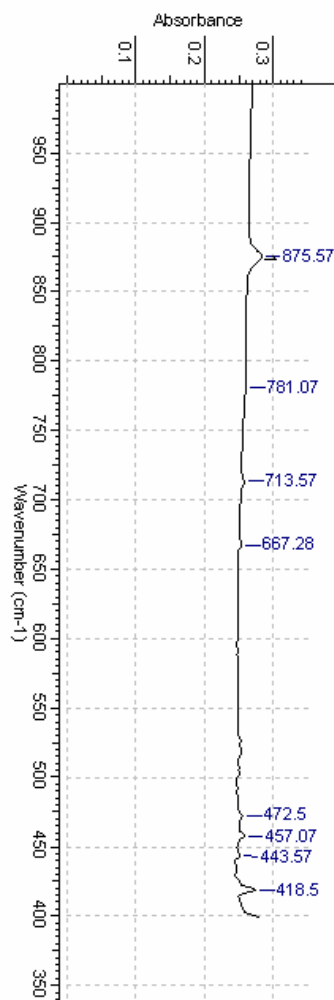
Comment	092104 P. Oak Sampl B-3	File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS_PADILLA\DESKTOP\SPECTRA\04092104092104 PINOAK SAMPL B-3.SPC
Date Stamp	21/09/2004 15:12:00	Date	21 Sep 2004 15:15:12
Spectral Region	IR	X Axis	Wavenumber (cm-1)
Points Count	1868	Data Spacing	1.9286
		Y Axis	Absorbance
		Instrument	OMNIC
		Spectrum Range	399.2123 - 3999.8375



No	cm-1	A	Intensity	No	cm-1	A	Intensity	No	cm-1	A	Intensity
1	418.50	0.409	S	10	1270.92	0.189	W	19	3670.05	0.244	M
2	457.07	0.295	M	11	1461.85	0.178	W	20	3675.84	0.253	M
3	472.50	0.276	M	12	1511.99	0.171	W	21	3689.34	0.245	M
4	484.07	0.261	M	13	1535.14	0.169	W	22	3735.62	0.256	M
5	501.43	0.251	M	14	1546.71	0.172	W	23	3745.27	0.258	M
6	516.85	0.245	M	15	1629.63	0.184	W	24	3751.05	0.263	M
7	526.50	0.236	M	16	1648.92	0.173	W	25	3820.48	0.255	M
8	663.43	0.199	W	17	1726.06	0.174	W	26	3853.27	0.263	M
9	875.57	0.181	W	18	3648.84	0.257	M				

Sweetgum Greenwood Sample 1

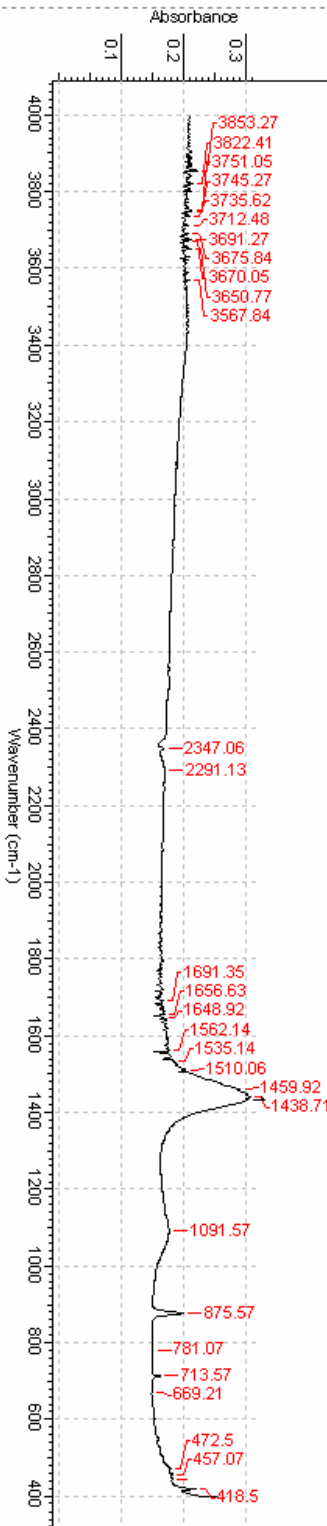
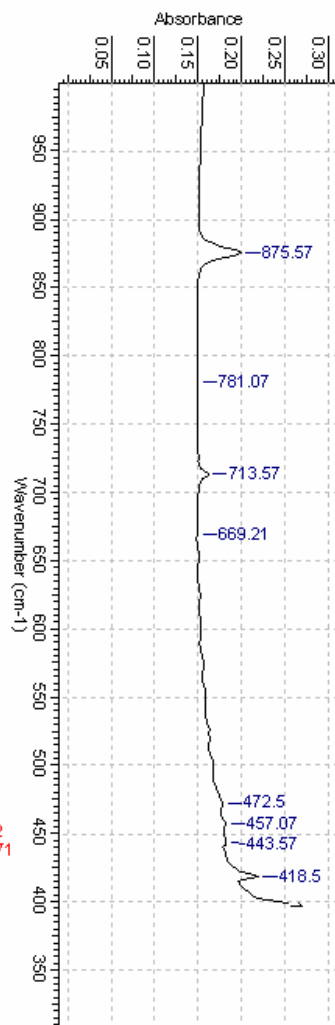
Comment	091504 SweetGum Scot Sample#60-3		
File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS PADILLA\DESKTOP\SPECTRA\200409138091504091504 SWEETGUM SCOT SAMP #60-3.SPC		
Date Stamp	15/09/2004 15:53:00	Date	15 Sep 2004 15:57:40
Instrument	OMNIC	Spectral Region	IR
Y Axis	Absorbance	Spectrum Range	399.2123 - 3999.8375
Data Spacing	1.9286	X Axis	Wavenumber (cm ⁻¹)
		Points Count	1868



No	cm-1	A	Intensity	No	cm-1	A	Intensity
1	418.50	0.274	W	13	1506.21	0.319	S
2	443.57	0.250	VW	14	1540.92	0.312	S
3	457.07	0.257	W	15	1618.06	0.308	S
4	472.50	0.256	W	16	2283.42	0.299	M
5	667.28	0.254	VW	17	2348.99	0.292	M
6	713.57	0.258	W	18	3623.77	0.321	S
7	781.07	0.261	W	19	3652.70	0.317	S
8	875.57	0.283	M	20	3739.48	0.315	S
9	1093.49	0.290	M	21	3754.91	0.318	S
10	1419.42	0.339	VS	22	3847.48	0.322	S
11	1457.99	0.344	VS	23	3859.05	0.322	S
12	1473.42	0.334	S				

Sweetgum Greenwood Sample 2

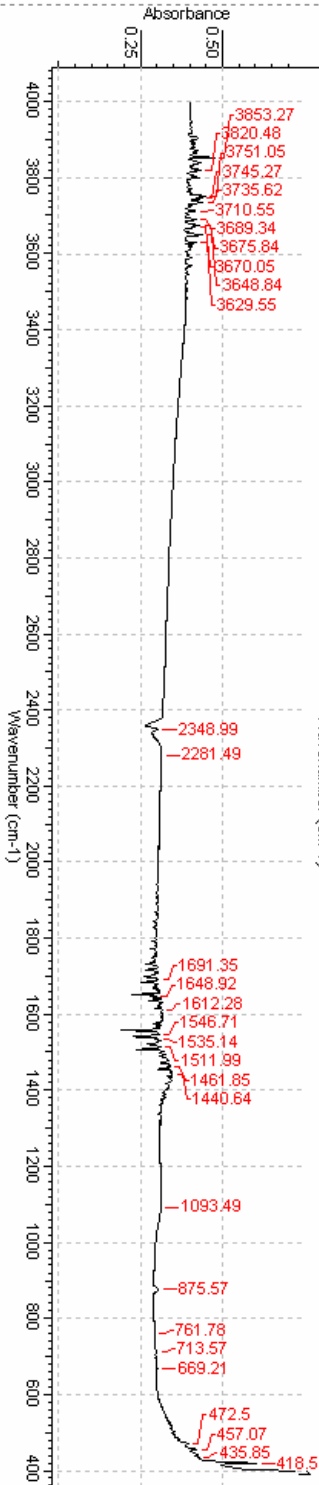
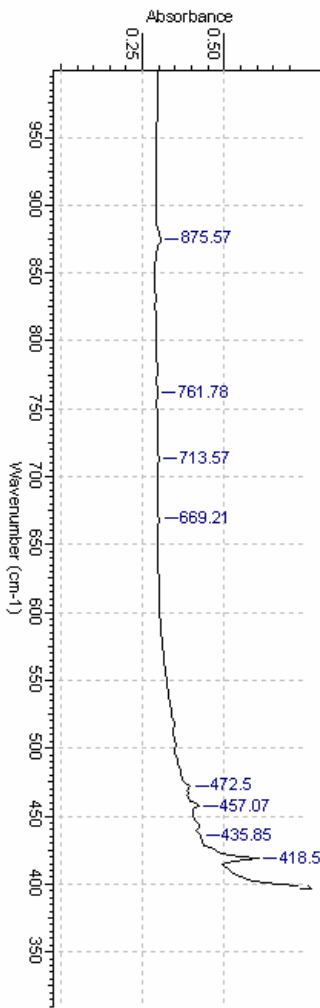
Comment	092104.Sweetgum_Samp59-2		
File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS PAJILLADESK\TOP\SPECTRA\2004092104092104_SWEETGUM_SAMP59-2.SPC		
Date Stamp	21/09/2004 12:58:00	Date	21 Sep 2004 13:36:02
Spectral Region	IR	X Axis	Wavenumber (cm-1)
Points Count	1868	Data Spacing	1.9286
		Y Axis	Absorbance
		Technique	Infrared
		Instrument	OMNIC
		Spectrum Range	399.2123 - 3999.8375



No	cm-1	A	Intensity	No	cm-1	A	Intensity
1	418.50	0.219	M	11	1459.92	0.290	S
2	443.57	0.182	W	12	1510.06	0.203	M
3	457.07	0.182	W	13	1535.14	0.185	W
4	472.50	0.179	W	14	1562.14	0.177	W
5	669.21	0.150	VW	15	1648.92	0.168	W
6	713.57	0.162	VW	16	1656.63	0.170	W
7	781.07	0.199	M	17	1691.35	0.166	W
8	875.57	0.199	M	18	2291.13	0.169	W
9	1091.57	0.176	W	19	2347.06	0.168	W
10	1438.71	0.306	V/S	20	3567.84	0.208	M
				21	3660.77	0.212	M
				22	3670.05	0.206	M
				23	3675.84	0.211	M
				24	3691.27	0.206	M
				25	3712.48	0.208	M
				26	3735.62	0.210	M
				27	3745.27	0.212	M
				28	3751.05	0.212	M
				29	3822.41	0.213	M
				30	3853.27	0.221	M

Sweetgum Greenwood Sample 3

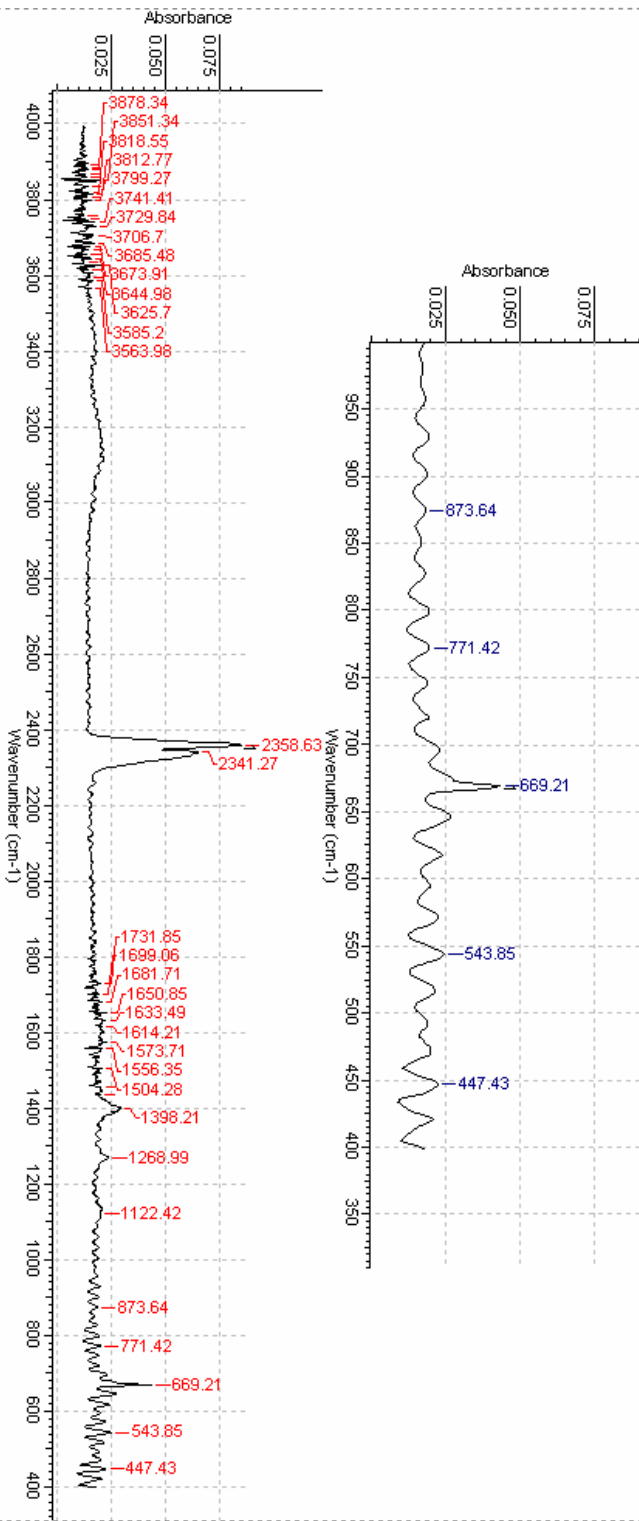
Comment	091504 SweetGum Soot Sample#60		
File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS P ADILL\DESKTOP\ISPE CTR\AV004\09138091504\091504 SWEETGUM SOOT SAMP#60.SPC		
Date Stamp	15/09/2004 15:47:00	Date	15 Sep 2004 15:57:56
Instrument	OMNIC	Spectral Region	IR
Y Axis	Absorbance	Spectrum Range	399.2123 - 3999.8375
Data Spacing	1.9286	X Axis	Wavenumber (cm-1)
		Points Count	1988



No	cm-1	A	Intensity	No	cm-1	A	Intensity	No	cm-1	A	Intensity
1	418.50	0.605	S	11	1461.85	0.340	W	21	3648.84	0.439	M
2	435.85	0.429	M	12	1511.99	0.311	W	22	3670.05	0.417	M
3	457.07	0.423	M	13	1535.14	0.305	W	23	3675.84	0.432	M
4	472.50	0.396	M	14	1546.71	0.308	W	24	3689.34	0.420	M
5	669.21	0.302	W	15	1612.28	0.316	W	25	3710.55	0.419	M
6	713.57	0.300	W	16	1648.92	0.299	W	26	3735.62	0.442	M
7	761.78	0.294	W	17	1691.35	0.304	W	27	3745.27	0.438	M
8	875.57	0.305	W	18	2281.49	0.313	W	28	3751.05	0.448	M
9	1093.49	0.311	W	19	2348.99	0.304	W	29	3820.48	0.435	M
10	1440.64	0.348	W	20	3629.55	0.421	M	30	3853.27	0.477	M

American Basswood Greenwood Sample 2

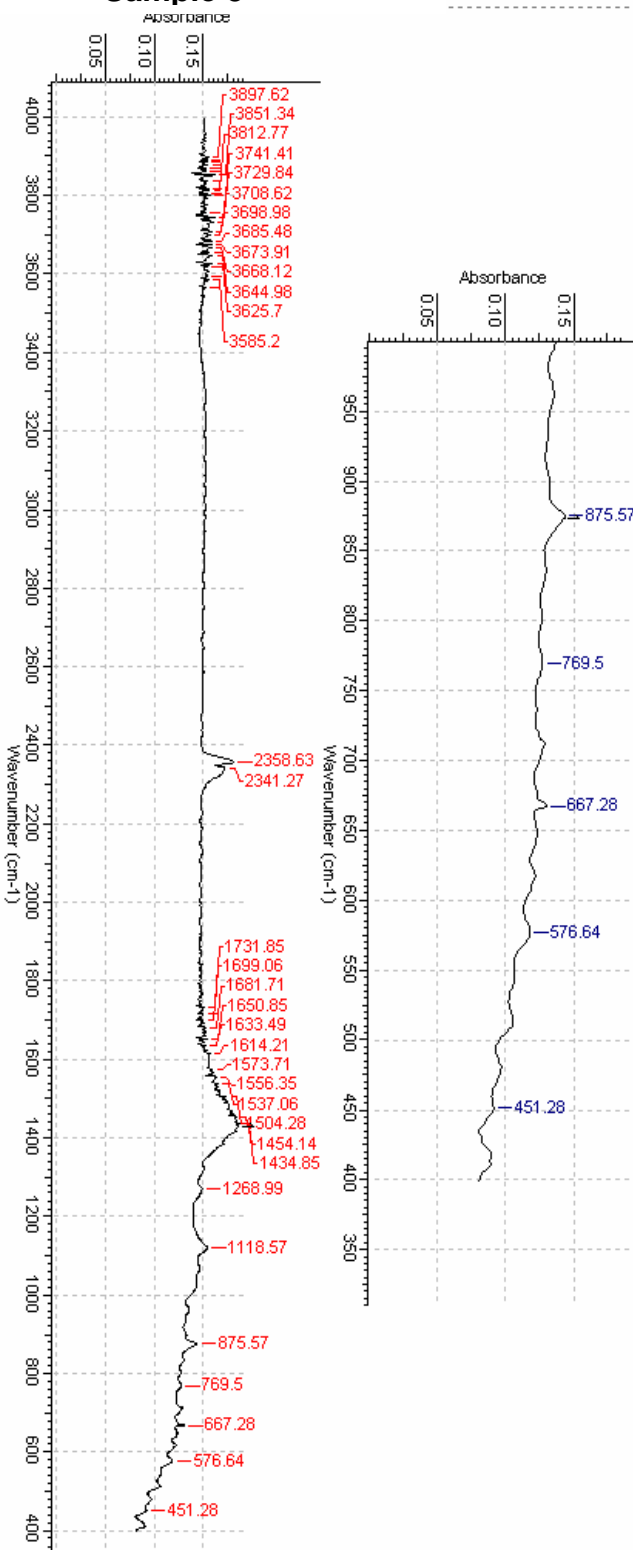
Comment	020205 AMBASSWGD KBP S28 100104 3	Date	02 Feb 2005 15:55:42	Technique	Infrared
File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS PAULL\DESKTOP\SPECTRA\ALL SPECTRA\020205 AMBASSWGD KBP S28 100104 3.SPC	Spectral Region	IR	X Axis	Wavenumber (cm-1)
Date Stamp	02/02/2005 14:42:00	Spectrum Range	399.2123 - 3999.8375	Points Count	1888
Instrument	OMNIC				
Y Axis	Absorbance				
Data Spacing	1.9286				



No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity
1	447.43	0.022	21.63	0.00	W	13	1573.71	0.022	-	-	W	25	3616.05	0.014	-	-	W	37	3756.84	0.012	-	-	W
2	543.85	0.025	-	-	W	14	1614.21	0.021	-	-	W	26	3625.70	0.019	8.81	-0.68	W	38	3799.27	0.015	-	-	W
3	669.21	0.043	-	-	M	15	1633.49	0.022	-	-	W	27	3633.41	0.012	-	-	W	39	3805.05	0.014	-	-	W
4	771.42	0.019	-	-	W	16	1650.85	0.023	-	-	W	28	3644.98	0.016	-	-	W	40	3812.77	0.018	-	-	W
5	873.64	0.018	-	-	W	17	1681.71	0.020	-	-	W	29	3654.83	0.013	-	-	W	41	3818.55	0.014	-	-	W
6	1122.42	0.020	-	-	W	18	1699.06	0.019	-	-	W	30	3668.12	0.014	-	-	W	42	3836.91	0.014	-	-	W
7	1268.99	0.023	-	-	W	19	1731.85	0.020	-	-	W	31	3673.81	0.015	-	-	W	43	3851.34	0.019	-	-	W
8	1398.21	0.029	-	-	M	20	2341.27	0.085	-	-	S	32	3685.48	0.017	12.85	-0.40	W	44	3860.98	0.013	-	-	W
9	1434.86	0.020	-	-	W	21	2368.63	0.085	-	-	V/S	33	3706.70	0.016	-	-	W	45	3866.77	0.013	-	-	W
10	1464.14	0.020	-	-	W	22	3563.98	0.015	-	-	W	34	3729.84	0.018	-	-	W	46	3878.34	0.014	-	-	W
11	1504.28	0.020	-	-	W	23	3585.20	0.016	-	-	W	35	3741.41	0.017	5.81	-0.17	W	47	3884.12	0.014	-	-	W
12	1556.35	0.021	-	-	W	24	3592.91	0.015	-	-	W	36	3747.20	0.013	-	-	W	48	3889.91	0.013	-	-	W

American Basswood Greenwood Sample 3

Comment	020205 AMBASSWD ST S25 80704 3		
File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS P ADILL\DESKTOP\SPE CTR\AWLL SPE CTR\AWLL SPE CTR\AW020205 AMBASSWD ST S25 80704 3.SPC		
Date Stamp	Date	Technique	Infrared
02/02/2005 14:18:00	02 Feb 2005 15:19:40		
Instrument	Spectral Region	X Axis	Wavenumber (cm-1)
OMNIC	IR	Points Count	1868
Y Axis	Spectrum Range		
Absorbance	399.2123 - 3999.8375		
Data Spacing	1.9286		

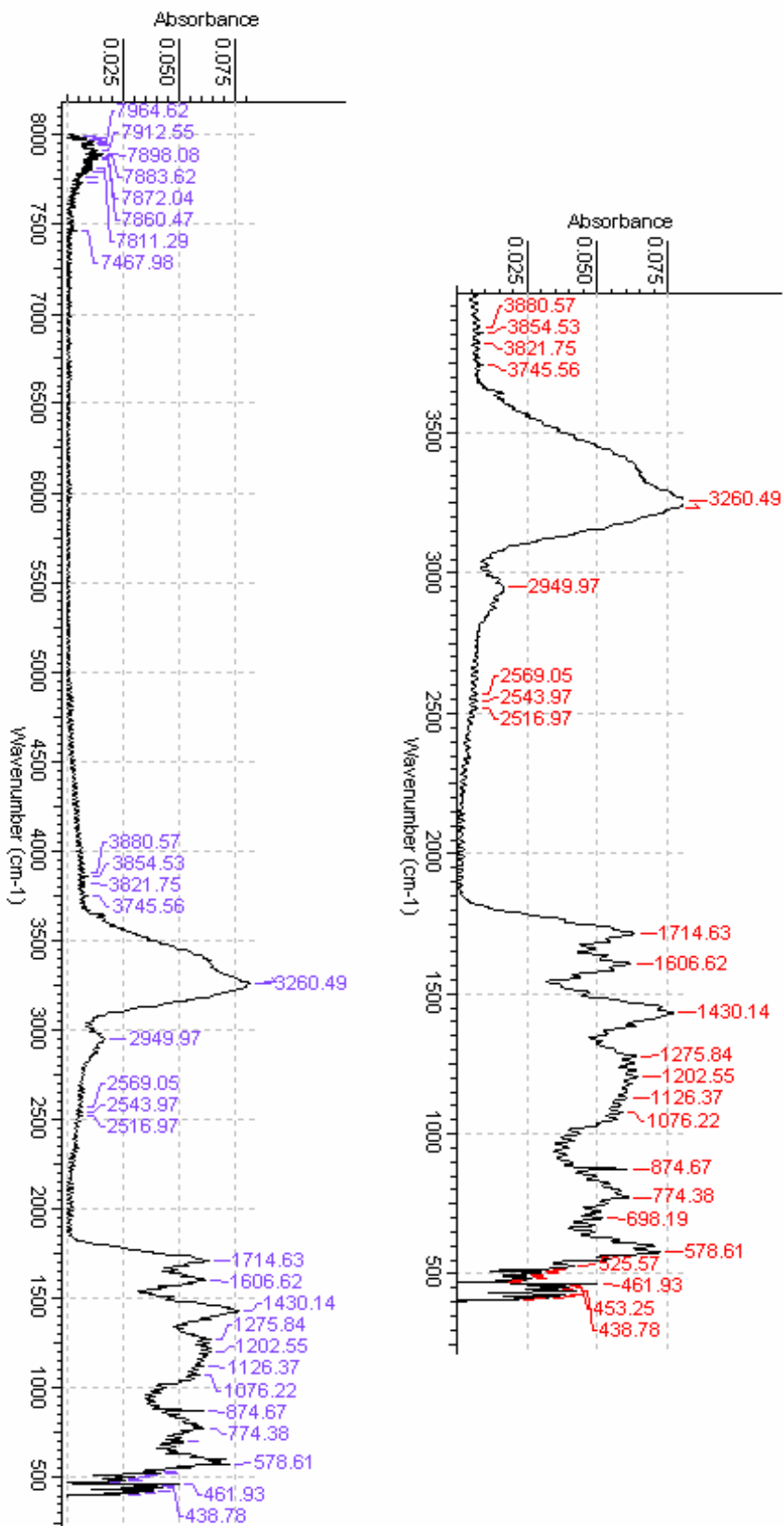


No	cm-1	A	Intensity	No	cm-1	A	Intensity	No	cm-1	A	Intensity
1	451.28	0.091	W	14	1614.21	0.156	S	27	3625.70	0.159	S
2	576.64	0.118	M	15	1633.49	0.152	S	28	3644.98	0.159	S
3	667.28	0.130	M	16	1660.85	0.154	S	29	3654.83	0.156	S
4	769.50	0.127	M	17	1681.71	0.153	S	30	3668.12	0.159	S
5	875.57	0.144	M	18	1699.06	0.150	S	31	3673.91	0.158	S
6	1118.57	0.154	S	19	1714.49	0.150	S	32	3685.48	0.158	S
7	1268.99	0.149	S	20	1731.85	0.151	S	33	3698.98	0.156	S
8	1434.85	0.186	V/S	21	2341.27	0.172	S	34	3708.62	0.158	S
9	1454.14	0.184	V/S	22	2368.63	0.181	V/S	35	3729.84	0.160	S
10	1504.28	0.173	S	23	3363.98	0.152	S	36	3741.41	0.161	S
11	1537.06	0.165	S	24	3385.20	0.155	S	37	3756.84	0.152	S
12	1556.35	0.163	S	25	3592.91	0.154	S	38	3799.27	0.156	S
13	1573.71	0.159	S	26	3616.05	0.154	S	39	3805.05	0.154	S
								40	3812.77	0.156	S
								41	3818.55	0.155	S
								42	3835.91	0.154	S
								43	3851.34	0.162	S
								44	3860.96	0.152	S
								45	3868.70	0.152	S
								46	3878.34	0.154	S
								47	3884.12	0.154	S
								48	3889.91	0.153	S
								49	3897.62	0.155	S

Cedar Tar Sample 1

File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS P ADIL\DESKTOP\SPECTRAT\US FIR\2007\04190\VTTRANS_M\1\CDST1A.SPC	Technique	Infrared	Spectral Region	NIR/JR
Date	27 Apr 2007 13:31:38	Spectrum Range	400 2083 - 8000 3035	Points Count	7882
Y Axis	Absorbance				
Date Stamp	27/04/2007 13:31:00				
X Axis	Wavenumber (cm-1)				
Data Spacing	0.9644				

Cedar Tar Sample 1



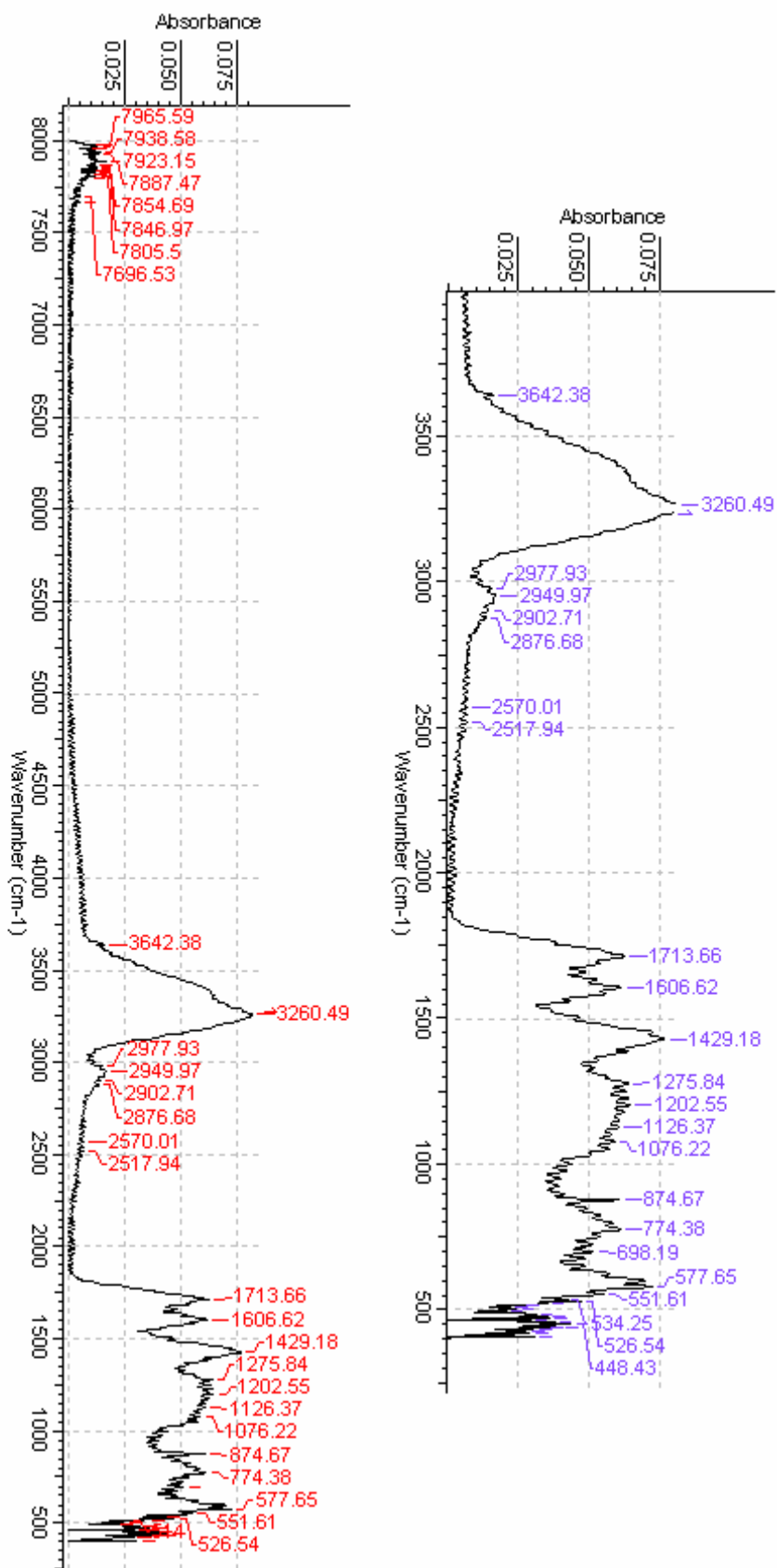
Cedar Tar Sample 1

File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIUS.PADILLA\DESKTOP\SPECTRAT\U.S.F.TIR\2007\041907\TIRANS.M\Y1CDS1TA.SPC
Date	27 Apr 2007 13:31:38
Y Axis	Absorbance
X Axis	Wavenumber (cm ⁻¹)
Date Stamp	27/04/2007 13:31:00
X Axis	Wavenumber (cm ⁻¹)
Data Spacing	0.9644
Technique	Infrared
Spectral Range	400.2083 - 8000.3035
Spectral Region	NIR-IR
Points Count	7882

No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity
1	405.99	0.022	-	-	W	16	500.50	0.030	-	-	M	31	1714.83	0.063	-	-	S	46	7860.47	0.014	-	-	W
2	409.85	0.025	-	-	M	17	506.29	0.030	-	-	M	32	2516.97	0.007	-	-	VW	47	7872.04	0.013	-	-	W
3	413.71	0.032	-	-	M	18	515.93	0.033	-	-	M	33	2543.97	0.007	-	-	VW	48	7883.82	0.015	-	-	W
4	421.42	0.036	-	-	M	19	526.57	0.042	-	-	M	34	2669.05	0.007	-	-	VW	49	7898.08	0.016	-	-	W
5	426.25	0.039	-	-	M	20	531.36	0.041	-	-	M	35	2949.97	0.017	-	-	W	50	7912.55	0.013	-	-	W
6	438.78	0.042	-	-	M	21	578.61	0.072	-	-	S	36	3260.49	0.082	356.56	0.88	VS	51	7938.58	0.011	-	-	W
7	443.60	0.036	-	-	M	22	698.19	0.062	-	-	S	37	3745.56	0.009	-	-	W	52	7968.84	0.011	-	-	W
8	463.25	0.040	-	-	M	23	774.38	0.061	-	-	S	38	3821.75	0.008	-	-	VW	53	7964.62	0.011	-	-	W
9	467.11	0.038	-	-	M	24	874.67	0.061	-	-	S	39	3854.53	0.009	-	-	W	54	7974.27	0.007	-	-	VW
10	461.93	0.050	-	-	S	25	1076.22	0.059	-	-	S	40	3880.57	0.008	-	-	VW	55	7977.16	0.007	-	-	VW
11	470.61	0.016	-	-	W	26	1126.37	0.061	-	-	S	41	7467.98	0.004	4.84	-0.34	VW	56	7981.98	0.008	-	-	W
12	475.43	0.018	-	-	W	27	1202.55	0.064	-	-	S	42	7735.11	0.007	11.41	-0.21	VW	57	7995.48	0.005	-	-	VW
13	482.18	0.026	-	-	M	28	1279.84	0.064	-	-	S	43	7760.18	0.006	-	-	VW						
14	488.93	0.025	-	-	M	29	1430.14	0.077	-	-	VS	44	7792.00	0.009	-	-	W						
15	494.72	0.025	-	-	M	30	1606.62	0.062	-	-	S	45	7811.29	0.011	-	-	W						

Cedar Tar Sample 2

File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS P ADILLADESKTOP\SPEC\TRAVIUS.FIR\2007041902\TRANS_MYICDS\ITB.SPC		
Date	27 Apr 2007 13:32:04	Technique	Infrared
Y Axis	Absorbance	Spectrum Range	400.2083 - 8000.3035
Date Stamp	27/04/2007 13:32:00	Spectral Region	NIR-JR
X Axis	Wavenumber (cm ⁻¹)	Points Count	7882
Data Spacing	0.9644		

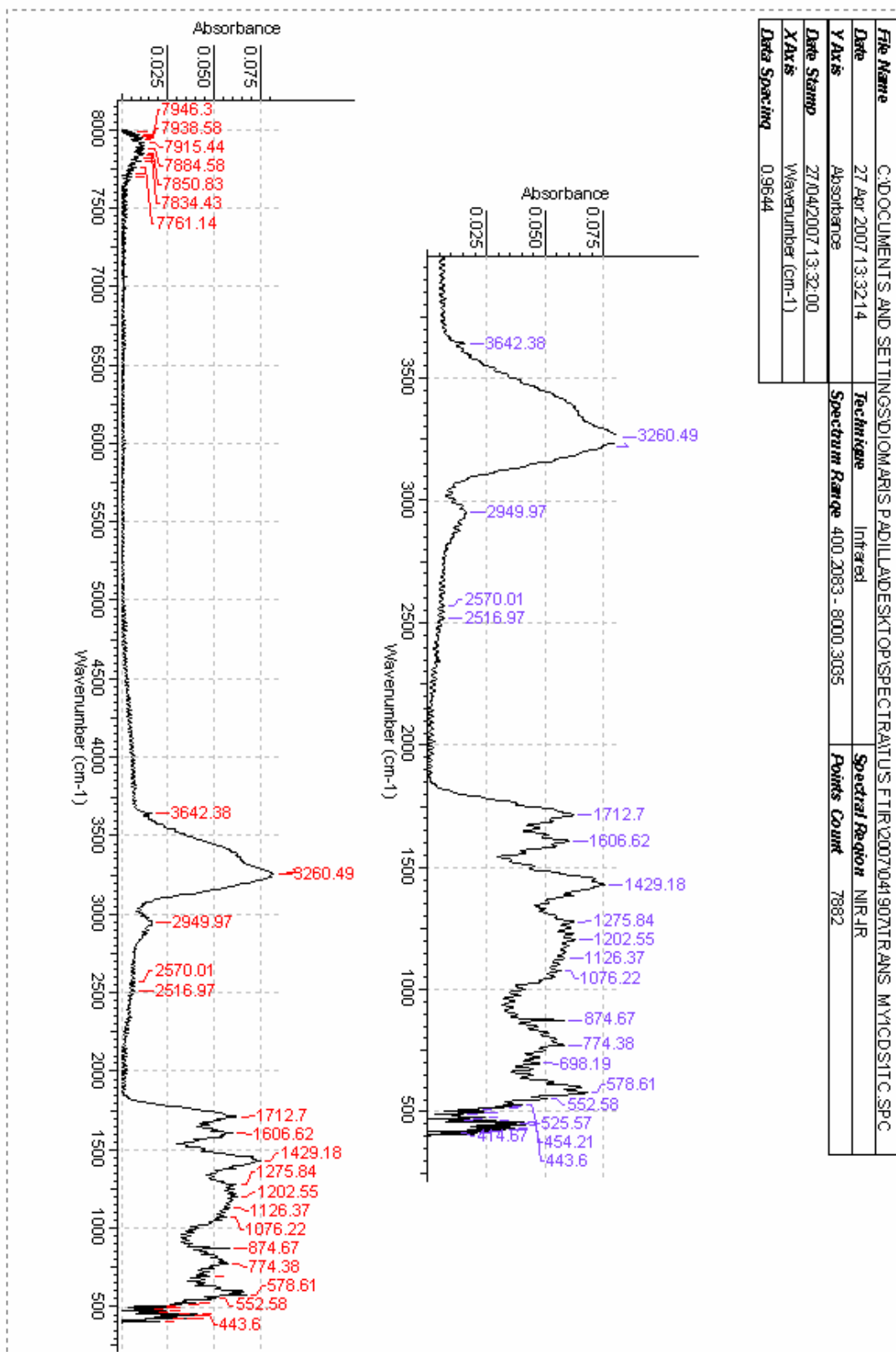


Cedar Tar Sample 2

File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS PADILLA\DESKTOP\SPECTRATUS.FTR\2007\04\19\QTIRANS_MYICD51TB.SPC		
Date	27 Apr 2007 13:32:04	Technique	Infrared
Y Axis	Absorbance	Spectral Range	400.2083 - 8000.3035
Date Stamp	27/04/2007 13:32:00	Spectral Region	NIR-JR
X Axis	Wavenumber (cm-1)	Points Count	7882
Data Spacing	0.9644		

No	cm-1	A	Fw/HH	Asym	Intensity	No	cm-1	A	Fw/HH	Asym	Intensity	No	cm-1	A	Fw/HH	Asym	Intensity	No	cm-1	A	Fw/HH	Asym	Intensity
1	407.92	0.030	4.55	-0.18	M	16	514.00	0.026	-	-	M	31	1713.66	0.063	-	-	S	46	7835.40	0.010	-	-	W
2	420.46	0.029	-	-	M	17	520.75	0.035	-	-	M	32	2517.94	0.007	-	-	VW	47	7840.22	0.012	-	-	W
3	426.25	0.028	-	-	M	18	526.54	0.047	-	-	M	33	2570.01	0.007	-	-	VW	48	7846.97	0.013	-	-	W
4	430.10	0.030	-	-	M	19	534.25	0.042	-	-	M	34	2876.68	0.014	-	-	W	49	7854.69	0.013	-	-	W
5	435.89	0.040	-	-	M	20	551.61	0.055	-	-	S	35	2902.71	0.014	-	-	W	50	7869.15	0.012	-	-	W
6	439.75	0.034	-	-	M	21	577.65	0.072	-	-	S	36	2949.97	0.017	-	-	W	51	7887.47	0.017	-	-	W
7	448.43	0.043	-	-	M	22	698.19	0.051	-	-	S	37	2977.93	0.015	-	-	W	52	7923.15	0.013	-	-	W
8	454.21	0.038	-	-	M	23	774.38	0.061	-	-	S	38	3260.49	0.082	343.41	0.78	VS	53	7938.58	0.014	-	-	W
9	460.96	0.029	-	-	M	24	874.67	0.061	-	-	S	39	3642.38	0.016	-	-	W	54	7953.05	0.009	-	-	W
10	471.57	0.036	-	-	M	25	1076.22	0.059	-	-	S	40	7668.56	0.005	-	-	VW	55	7957.87	0.010	-	-	W
11	476.39	0.035	-	-	M	26	1126.37	0.061	-	-	S	41	7696.53	0.005	-	-	VW	56	7965.59	0.013	-	-	W
12	486.04	0.031	-	-	M	27	1202.55	0.064	-	-	S	42	7798.75	0.009	-	-	W	57	7973.30	0.012	-	-	W
13	493.75	0.020	-	-	W	28	1275.84	0.064	-	-	S	43	7805.50	0.012	-	-	W	58	7981.02	0.010	5.59	0.10	W
14	500.50	0.024	-	-	W	29	1429.18	0.077	-	-	VS	44	7819.00	0.010	-	-	W						
15	508.22	0.022	-	-	W	30	1606.62	0.061	-	-	S	45	7829.61	0.012	-	-	W						

Cedar Tar Sample 3

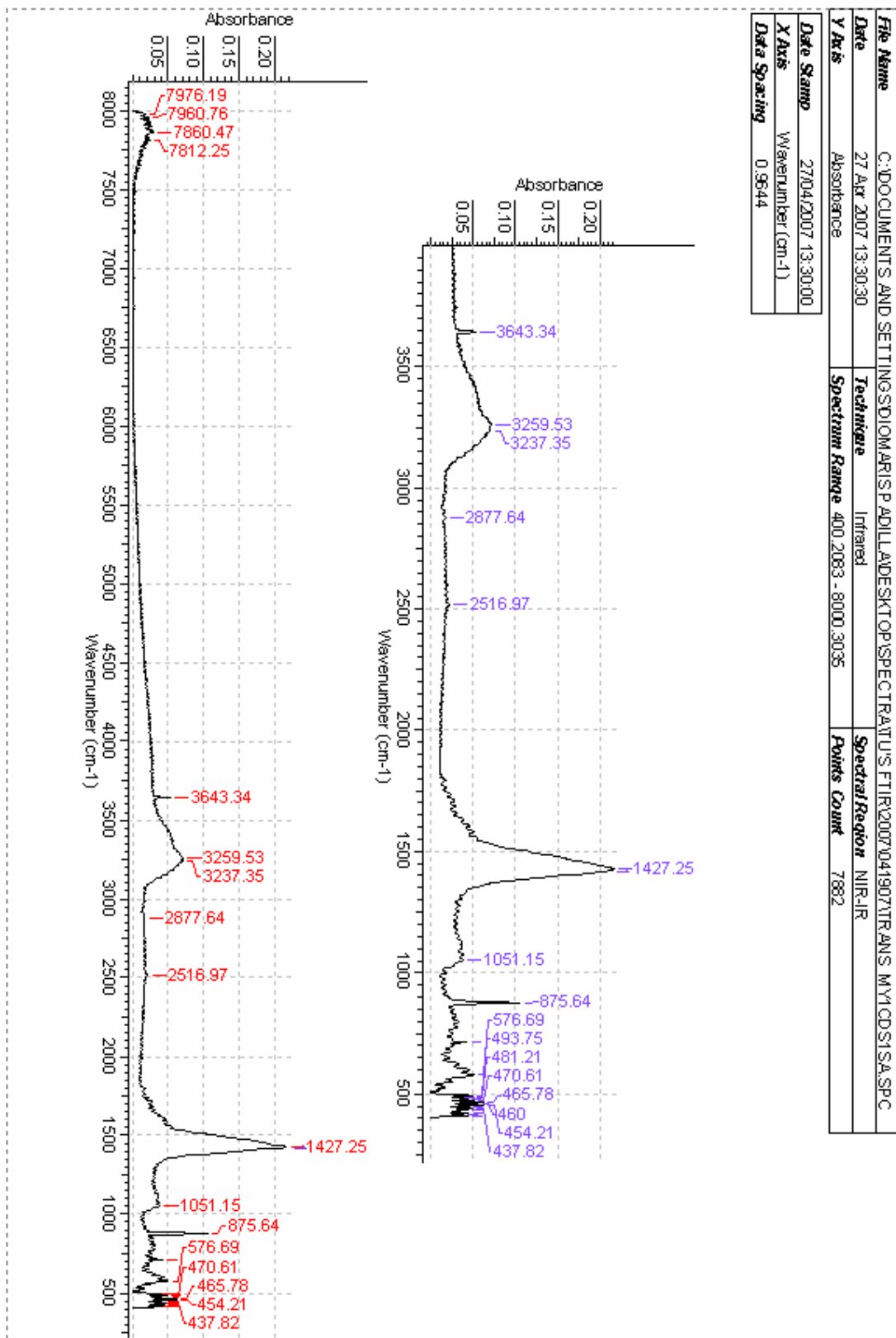


Cedar Tar Sample 3

File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS.PADILLA\DESKTOP\SPECTRA\TUS.FTR\200704190Z\TRANS_M\Y1CDS\TIC.SPC	Technique	Infrared	Spectral Region	NIR-JR
Date	27 Apr 2007 13:32:14	Spectrum Range	400.2083 - 8000.3035	Points Count	7882
Y Axis	Absorbance				
Date Stamp	27/04/2007 13:32:00				
X Axis	Wavenumber (cm-1)				
Data Spacing	0.9644				

No	1	cm-1	A	FWHH	Asym	Intensity	No	14	cm-1	A	FWHH	Asym	Intensity	No	27	cm-1	A	FWHH	Asym	Intensity	No	40	cm-1	A	FWHH	Asym	Intensity
	409.86	0.021	6.61	-0.87	W	W		483.76	0.022	-	-	-	W		1202.66	0.062	-	-	-	S		7803.57	0.010	-	-	W	
	414.67	0.012	2.96	-0.66	W	W		488.57	0.024	-	-	-	W		1276.84	0.062	-	-	-	S		7815.15	0.009	-	-	W	
	420.46	0.026	-	-	M	M		507.26	0.022	-	-	-	W		1429.18	0.076	-	-	-	S		7834.43	0.011	-	-	W	
	426.26	0.033	-	-	M	M		514.97	0.033	-	-	-	M		1606.62	0.060	-	-	-	S		7850.83	0.012	-	-	W	
	431.07	0.037	-	-	M	M		520.76	0.034	-	-	-	M		1712.70	0.062	-	-	-	S		7884.68	0.012	-	-	W	
	443.60	0.042	-	-	M	M		526.67	0.040	-	-	-	M		2616.97	0.007	-	-	-	VW		7915.44	0.013	-	-	W	
	460.36	0.037	-	-	M	M		562.68	0.061	-	-	-	S		2670.01	0.007	-	-	-	VW		7938.68	0.010	-	-	W	
	464.21	0.041	-	-	M	M		578.61	0.068	-	-	-	S		2949.97	0.017	-	-	-	W		7946.30	0.011	12.11	0.51	W	
	460.96	0.029	-	-	M	M		698.19	0.048	-	-	-	M		3260.49	0.082	338.43	0.76	-	VW		7966.91	0.008	-	-	VW	
	465.78	0.013	-	-	W	W		724.38	0.068	-	-	-	S		3642.38	0.016	-	-	-	W		7962.69	0.008	-	-	W	
	469.64	0.018	-	-	W	W		874.67	0.068	-	-	-	S		7704.26	0.006	-	-	-	VW		7972.34	0.010	-	-	W	
	477.36	0.024	5.57	0.76	W	W		1076.22	0.066	-	-	-	S		7716.78	0.006	-	-	-	VW		7976.23	0.009	-	-	W	
	487.00	0.016	-	-	W	W		1126.37	0.068	-	-	-	S		7761.14	0.008	24.76	-0.38	-	VW		7990.66	0.006	3.36	-0.10	VW	

Cedar Soot Sample 1



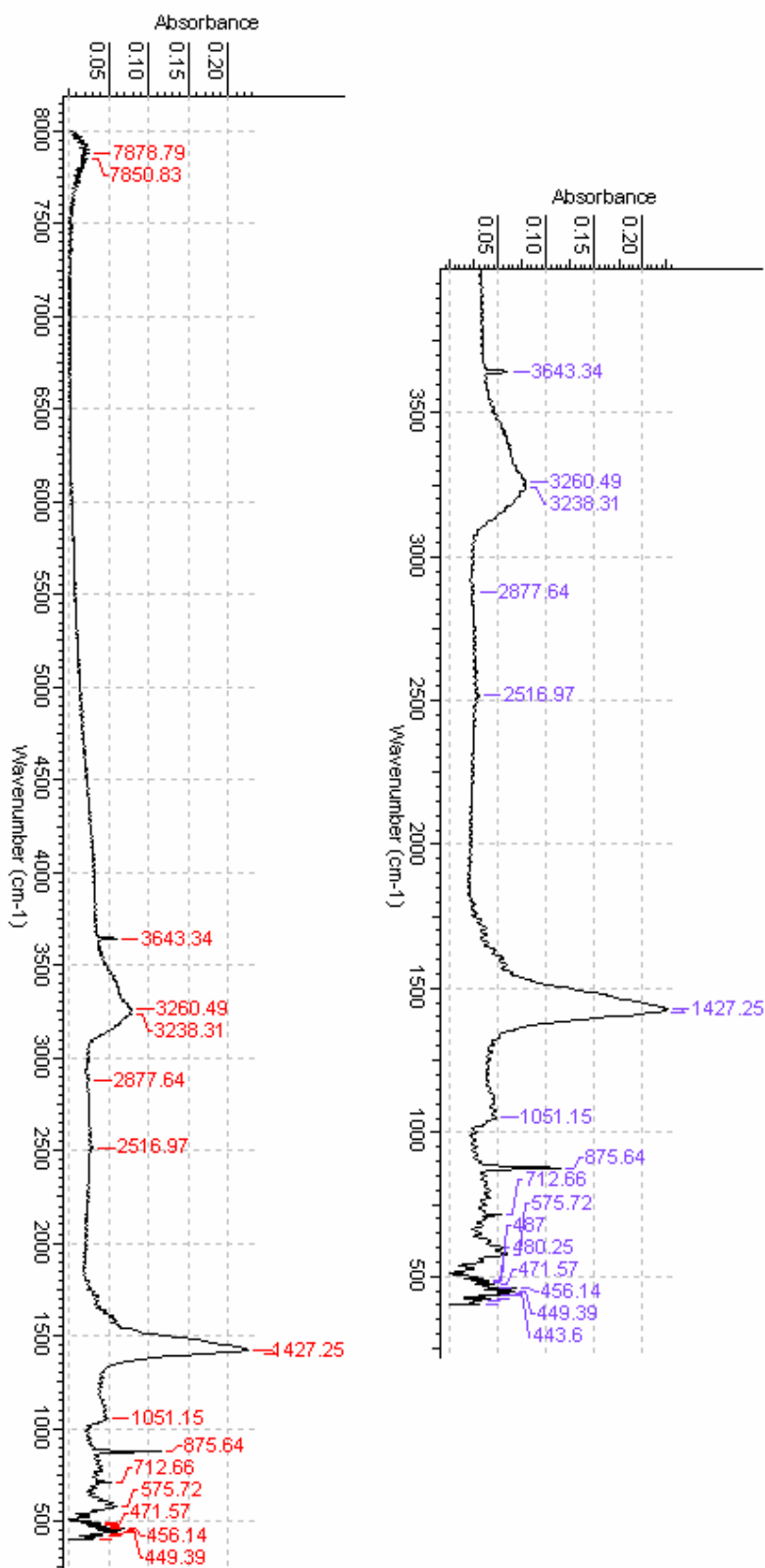
Cedar Soot Sample 1

File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS PADILLA\DESKTOP\SPECTRA\TUS_FIR\2007041907\TRANS_MY\CDS1SA.SPC
Date	27 Apr 2007 13:30:30
Y Axis	Absorbance
Date Stamp	27/04/2007 13:30:00
X Axis	Wavenumber (cm-1)
Data Spacing	0.9644
Technique	Infrared
Spectrum Range	400 2083 - 8000 .3035
Spectral Region	NIR/FIR
Points Count	7882

No	cm-1	A	FWHH	Asym	Intensity
1	409.85	0.043	-	-	W
2	413.71	0.037	-	-	W
3	421.42	0.044	-	-	W
4	431.07	0.042	-	-	W
5	437.82	0.049	-	-	W
6	445.53	0.045	-	-	W
7	454.21	0.062	7.95	-0.93	W
8	460.00	0.056	-	-	W
9	465.78	0.062	-	-	W
10	470.61	0.050	-	-	W
11	477.36	0.043	-	-	W
12	481.21	0.048	-	-	W
13	487.96	0.036	-	-	W
14	493.75	0.049	-	-	W
15	576.69	0.050	-	-	W
16	712.66	0.042	39.97	-0.11	W
17	875.64	0.106	10.83	0.07	M
18	1051.15	0.038	-	-	W
19	1427.25	0.216	120.92	0.74	VS
20	2516.97	0.021	-	-	WV
21	2877.64	0.017	-	-	VW
22	3237.36	0.070	-	-	M
23	3259.53	0.071	-	-	M
24	3643.34	0.053	-	-	W
25	7812.25	0.024	-	-	W
26	7860.47	0.029	-	-	W
27	7960.76	0.022	-	-	W
28	7976.19	0.018	-	-	VW

Cedar Soot Sample 2

File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS P ADILL\DESKTOP\SPECTR\ATIUS.FTIR\2007041907\IR.ANS.MY1\CD\SI\SB.SPC
Date	27 Apr 2007 13:30:42
Y Axis	Absorbance
Date Stamp	27/04/2007 13:30:00
X Axis	Wavenumber (cm ⁻¹)
Data Spacing	0.9644
Technique	Infrared
Spectrum Range	400.2083 - 8000.3035
Spectral Region	NIR/LIR
Points Count	7882



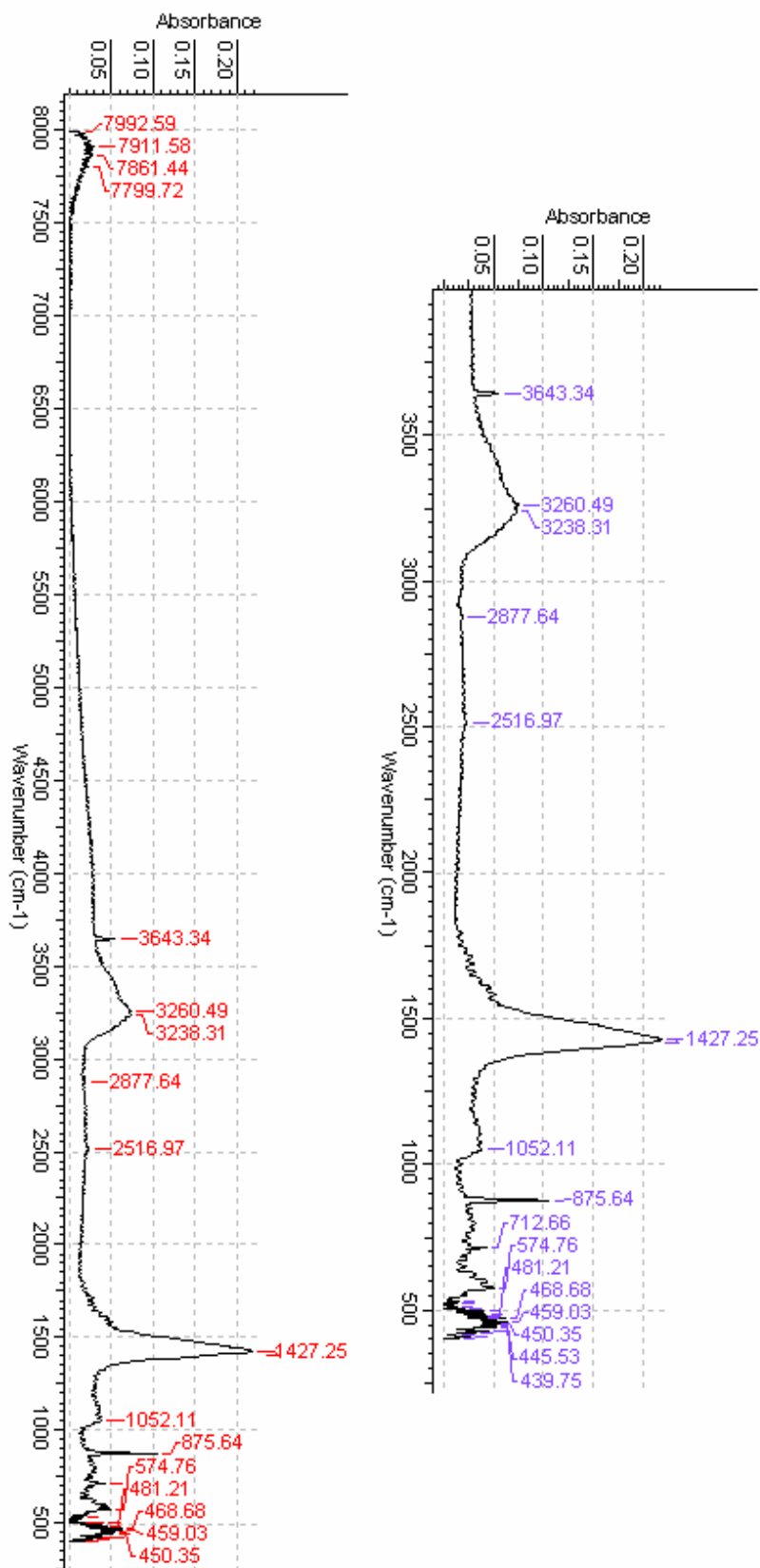
Cedar Soot Sample 2

File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS PADILLA\DESKTOP\SPECTRA\TUS FTIR\2007\041907\TRANS_M\1\CD\1 SB.SPC	
Date	27 Apr 2007 13:30:42	Technique Infrared
Y Axis	Absorbance	Spectral Range 400.2063 - 8000.3035
Date Stamp	27/04/2007 13:30:00	Points Count 7882
X Axis	Wavenumber (cm-1)	
Data Spacing	0.9644	

No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity
1	404.07	0.030	-	-	W	13	575.72	0.059	85.73	0.99	W
2	414.67	0.033	-	-	W	14	712.66	0.053	-	-	W
3	420.46	0.042	-	-	W	15	875.64	0.115	11.89	0.10	M
4	430.10	0.045	-	-	W	16	1051.15	0.048	-	-	W
5	436.85	0.055	-	-	W	17	1427.25	0.226	124.74	0.74	VS
6	443.60	0.061	-	-	W	18	2516.97	0.030	-	-	W
7	449.39	0.066	-	-	W	19	2877.64	0.025	-	-	W
8	456.14	0.069	-	-	M	20	3238.31	0.078	-	-	M
9	460.96	0.046	-	-	W	21	3260.49	0.079	-	-	M
10	471.57	0.046	-	-	W	22	3643.34	0.060	932.90	-0.42	W
11	480.25	0.039	-	-	W	23	7850.83	0.022	-	-	WW
12	487.00	0.040	-	-	W	24	7878.79	0.024	-	-	W

Cedar Soot Sample 3

File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS.PADILLA\DESKTOP\SPECTRATUS.FTIR\20070419\7ITRANS.MYICDS\SC.SP.C
Date	27 Apr 2007 13:30:52
Y Axis	Absorbance
Date Stamp	27/04/2007 13:30:00
X Axis	Wavenumber (cm ⁻¹)
Data Spacing	0.9644
Technique	Infrared
Spectrum Range	400.2083 - 8000.3035
Spectral Region	NIR/IR
Points Count	7882



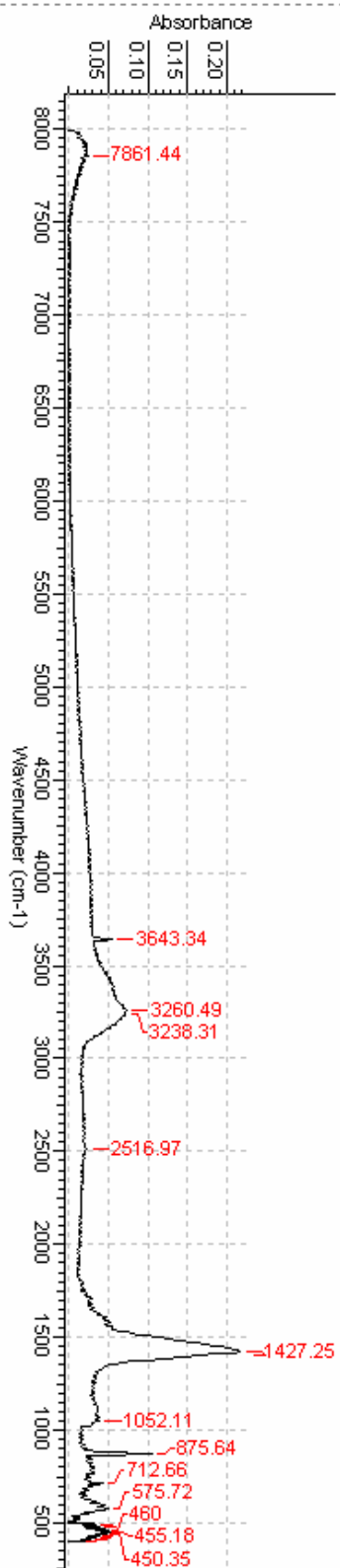
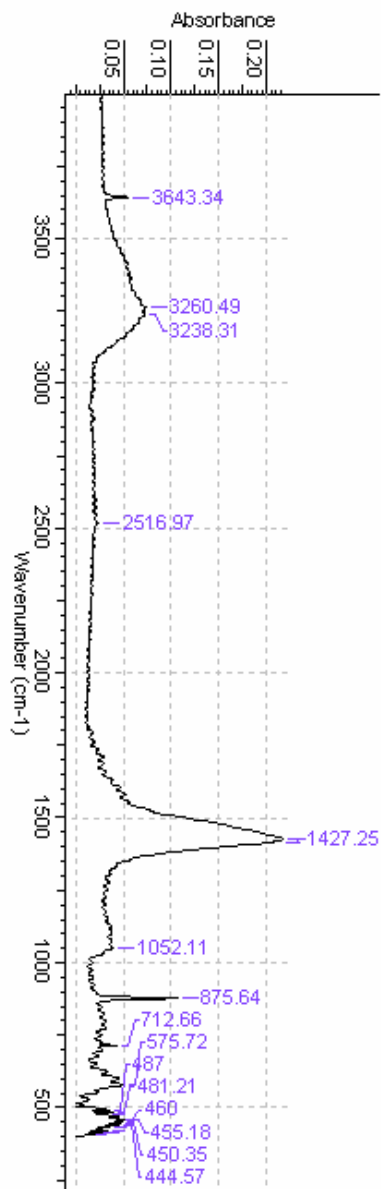
Cedar Soot Sample 3

File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS PADILLA\DESKTOP\SPECTRAT\US FTIR\2007041907\TRANS_M\1\CD51SC.SPC
Date	27 Apr 2007 13:30:52
Y Axis	Absorbance
Date Stamp	27/04/2007 13:30:00
X Axis	Wavenumber (cm-1)
Data Spacing	0.9644
Technique	Infrared
Spectrum Range	400 2063 - 8000 3035
Spectral Region	NIR-IR
Points Count	7882

No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity
1	403.10	0.015	-	-	VW	12	477.36	0.039	-	-	W	23	1052.11	0.039	-	-	W
2	409.85	0.027	-	-	W	13	481.21	0.044	-	-	W	24	1427.25	0.217	121.31	0.74	VS
3	413.71	0.014	-	-	VW	14	487.00	0.042	7.85	0.76	W	25	2516.97	0.024	-	-	W
4	419.50	0.033	-	-	W	15	497.61	0.041	5.26	-0.40	W	26	2877.64	0.020	-	-	VW
5	427.21	0.045	-	-	W	16	504.36	0.021	2.86	0.60	VW	27	3238.31	0.073	-	-	M
6	439.75	0.053	-	-	W	17	509.18	0.013	-	-	VW	28	3260.49	0.074	399.37	0.98	M
7	445.53	0.052	-	-	W	18	524.61	0.014	-	-	VW	29	3643.34	0.065	-	-	W
8	450.35	0.053	-	-	W	19	529.43	0.015	-	-	VW	30	7799.72	0.022	-	-	W
9	459.03	0.063	-	-	W	20	574.76	0.090	-	-	W	31	7861.44	0.027	-	-	W
10	468.68	0.062	-	-	W	21	712.66	0.043	40.58	-0.10	W	32	7911.58	0.030	-	-	W
11	472.54	0.040	-	-	W	22	875.64	0.105	10.86	0.07	M	33	7992.59	0.012	-	-	VW

File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS PADILLA\DESKTOP\SPECTRATU\S FTIR\2007041907\TRANS_MYICDSS_AVERAGE.SPC		
Date Stamp	27/04/2007 15:01:00	Date	27 Apr 2007 15:01:08
Spectral Region	NIR-IR	X Axis	Wavenumber (cm ⁻¹)
Spectrum Range	400.2083 - 8000.3035	Points Count	7882
		Data Spacing	0.9544
		Technique	Infrared
		Y Axis	Absorbance

Cedar Soot Average



File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS P ADILLADESKT\OP\SPECTRAT\US.FTIR\2007041907YTR\ANS.MY1 CDSS.AVERAGE.SPC		
Date Stamp	27.04.2007 15:01:00	Date	27 Apr 2007 15:01:08
Spectral Region	NIR-FIR	X Axis	Wavenumber (cm-1)
Spectrum Range	400.2083 - 8000.3035	Points Count	7882
		Y Axis	Absorbance
		Data Spacing	0.9644

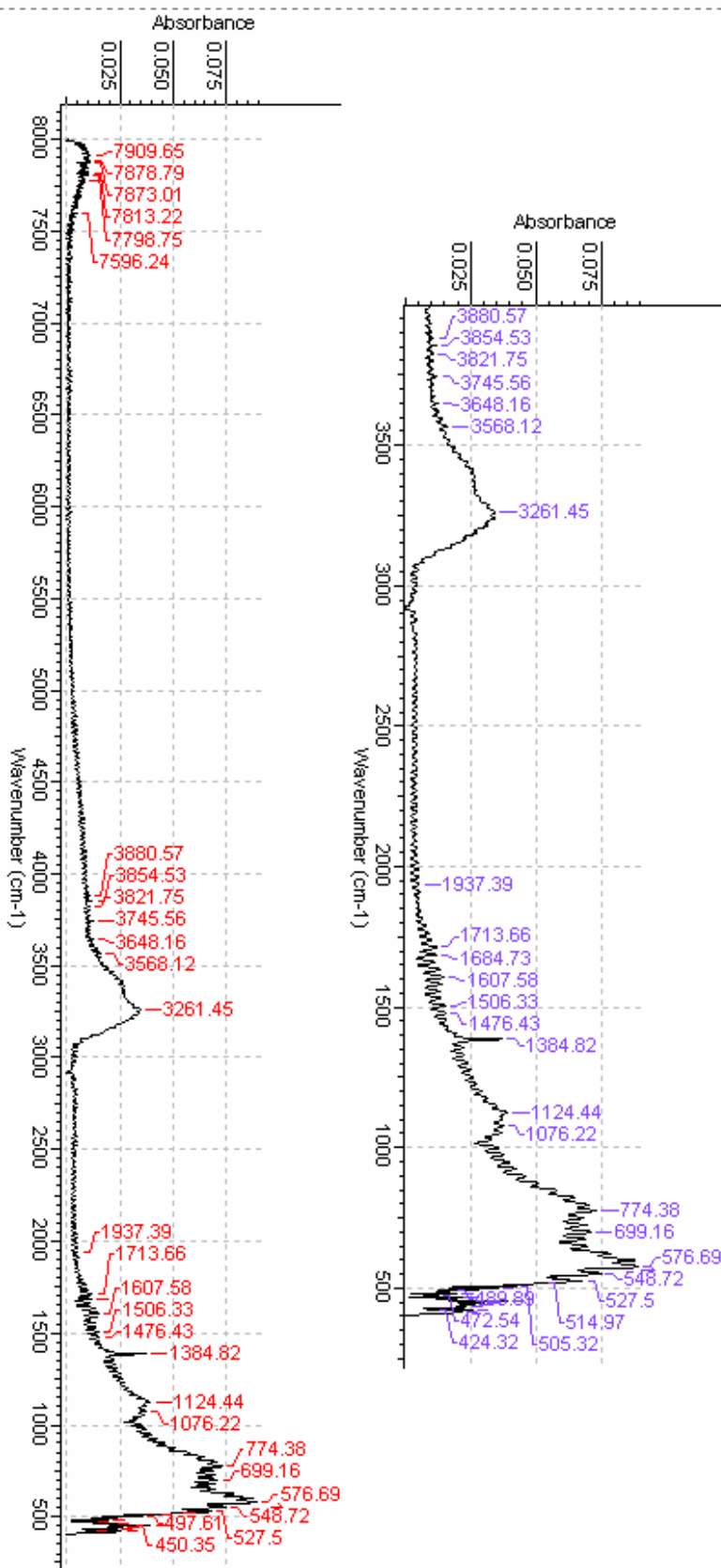
Cedar Soot Average

No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity
1	403.10	0.015	-	-	VW	13	487.00	0.034	-	-	W
2	409.86	0.028	-	-	W	14	575.72	0.050	-	-	W
3	413.71	0.024	-	-	W	15	712.66	0.043	41.08	-0.09	W
4	420.46	0.033	-	-	W	16	875.64	0.106	10.90	0.07	M
5	430.10	0.036	-	-	W	17	1052.11	0.039	-	-	W
6	439.75	0.044	-	-	W	18	1427.25	0.217	121.42	0.74	VS
7	444.57	0.047	-	-	W	19	2516.97	0.023	-	-	W
8	450.36	0.049	-	-	W	20	3238.31	0.072	-	-	M
9	455.18	0.054	-	-	W	21	3260.49	0.073	400.90	1.00	M
10	460.00	0.047	-	-	W	22	3643.34	0.055	-	-	W
11	477.36	0.033	-	-	W	23	7861.44	0.024	194.12	-0.14	W
12	481.21	0.039	-	-	W						

Cedar Set 1 Sample 1

Date Stamp	27/04/2007 13:27:00	File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS P ADILL\DESKTOP\SPECTRAT\US FTIR\2007\041907\1RANS_MY\CD\1A.SP.C
X Axis	Wavenumber (cm-1)	Date	27 Apr 2007 13:27:06
Data Spacing	0.9644	Y Axis	Absorbance
		Spectrum Range	400.2083 - 8000.3035
		Technique	Infrared
		Spectral Region	NIR-IR
		Points Count	7882

Cedar Sample 1



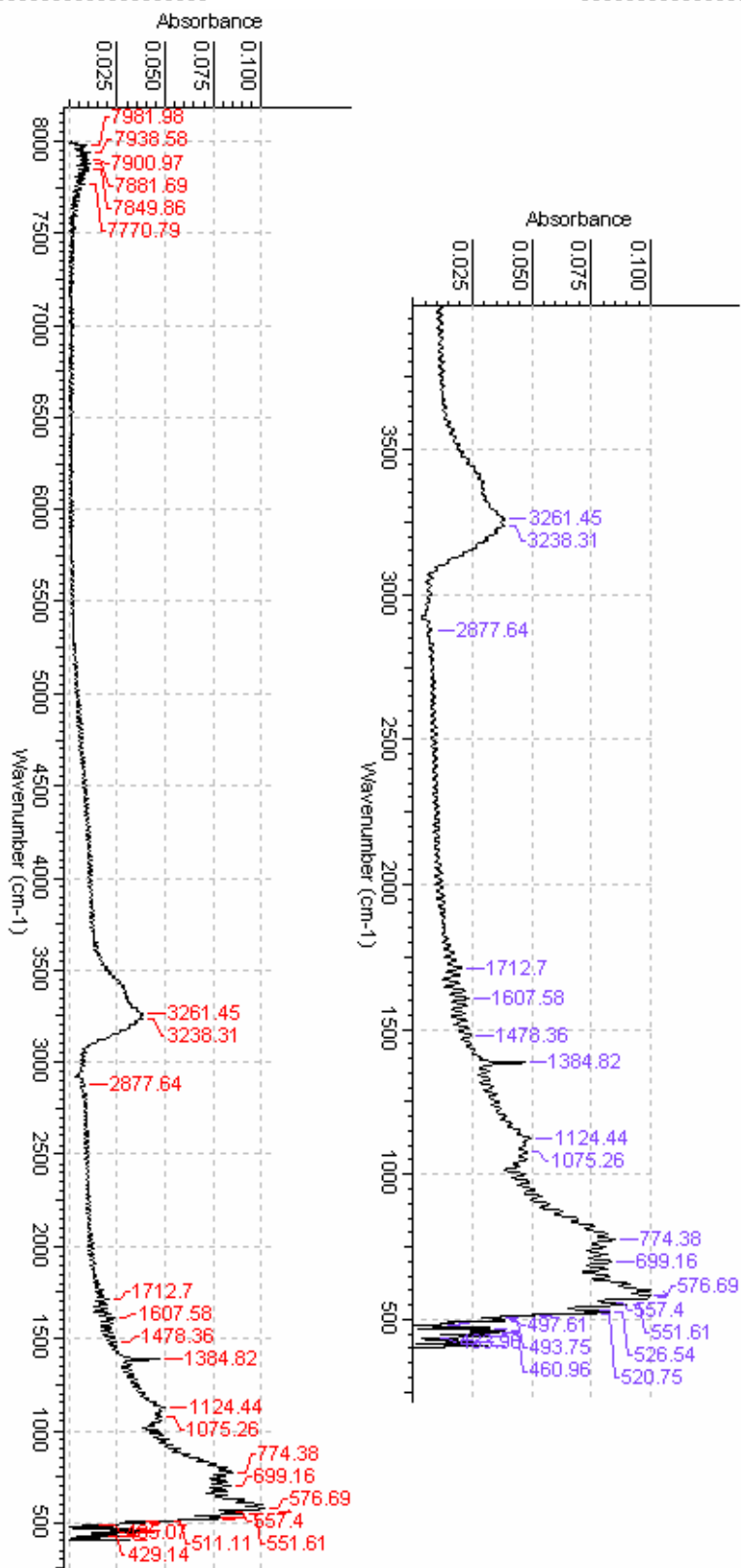
Cedar Set 1 Sample 1

Date Stamp	27/04/2007 13:27:00	File Name	C:\DOCUMENTS AND SETTINGS\SIDOMARIS PADILLAD\ESKTO\PSPEC TRAITUS F TIR\0007041907\TRANS_M\11CD S1A.SPC
X Axis	Wavenumber (cm-1)	Date	27 Apr 2007 13:27:06
Data Spacing	0.9644	Y Axis	Absorbance
		Technique	Infrared
		Spectrum Range	400.2083 - 8000.3035
		Spectral Region	NIR-IR
		Points Count	7882

No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity
1	4146.7	0.022	-	-	W	13	483.14	0.020	-	-	W	25	1384.82	0.037	39.67	0.40	M	37	3854.53	0.012	-	-	W
2	419.50	0.026	-	-	W	14	489.89	0.018	-	-	W	26	1476.43	0.015	-	-	W	38	3880.57	0.011	-	-	W
3	424.32	0.011	-	-	W	15	497.61	0.035	7.94	-0.24	M	27	1506.33	0.015	-	-	W	39	7596.24	0.005	20.51	0.84	W
4	432.03	0.023	-	-	W	16	505.32	0.042	-	-	M	28	1807.58	0.015	-	-	W	40	7771.75	0.008	-	-	W
5	438.78	0.026	-	-	W	17	514.97	0.053	-	-	M	29	1884.73	0.012	-	-	W	41	7798.75	0.010	-	-	W
6	445.53	0.030	-	-	M	18	527.50	0.068	-	-	S	30	1713.66	0.012	-	-	W	42	7813.22	0.010	-	-	W
7	450.35	0.030	-	-	M	19	548.72	0.075	-	-	S	31	1937.39	0.005	-	-	W	43	7873.01	0.011	-	-	W
8	454.21	0.039	-	-	M	20	576.69	0.089	-	-	S	32	3261.45	0.034	363.87	0.87	M	44	7878.79	0.011	-	-	W
9	462.99	0.022	-	-	W	21	699.16	0.071	-	-	S	33	3568.12	0.016	-	-	W	45	7909.65	0.011	-	-	W
10	465.78	0.020	-	-	W	22	774.38	0.073	-	-	S	34	3648.16	0.012	-	-	W						
11	472.54	0.012	-	-	W	23	1076.22	0.037	-	-	M	35	3746.56	0.012	-	-	W						
12	477.36	0.020	3.88	-0.74	W	24	1124.44	0.039	-	-	M	36	3821.75	0.011	-	-	W						

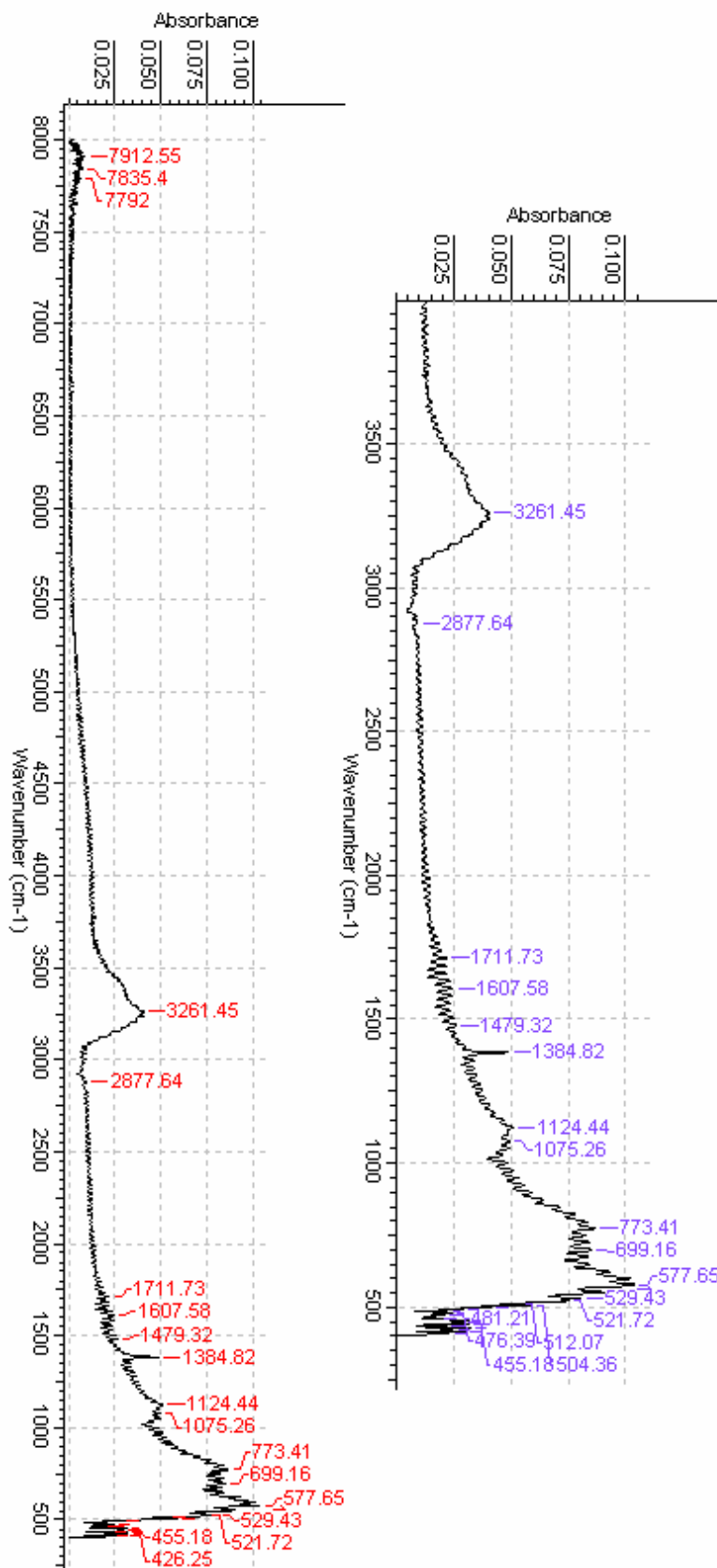
Cedar Set 1 Sample 2

File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS.PADILLA\DESKTOP\SP ECTRA\TUS FTIR\2007041907\IR.ANS.MY1\CD\S1B.SPC
Date	27 Apr 2007 13:27:56
Y Axis	Absorbance
Date Stamp	27/04/2007 13:27:00
X Axis	Wavenumber (cm-1)
Data Spacing	0.9644
Technique	Infrared
Spectral Range	400.2083 - 8000.3035
Spectral Region	NIR-IR
Points Count	7882



Cedar Set1 Sample 3

File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS PADILLA\DESKTOP\SPECTRAT\US_FTIR\20071041907\1\TRANS_M\YCD51C.SPC
Date	ZT Apr 2007 13:28:36
Y Axis	Absorbance
Date Stamp	27/04/2007 13:28:00
X Axis	Wavenumber (cm ⁻¹)
Data Source	0.9644
Technique	Infrared
Spectrum Range	400.2083 - 8000.3035
Spectral Region	NIR-IR
Points Count	7882

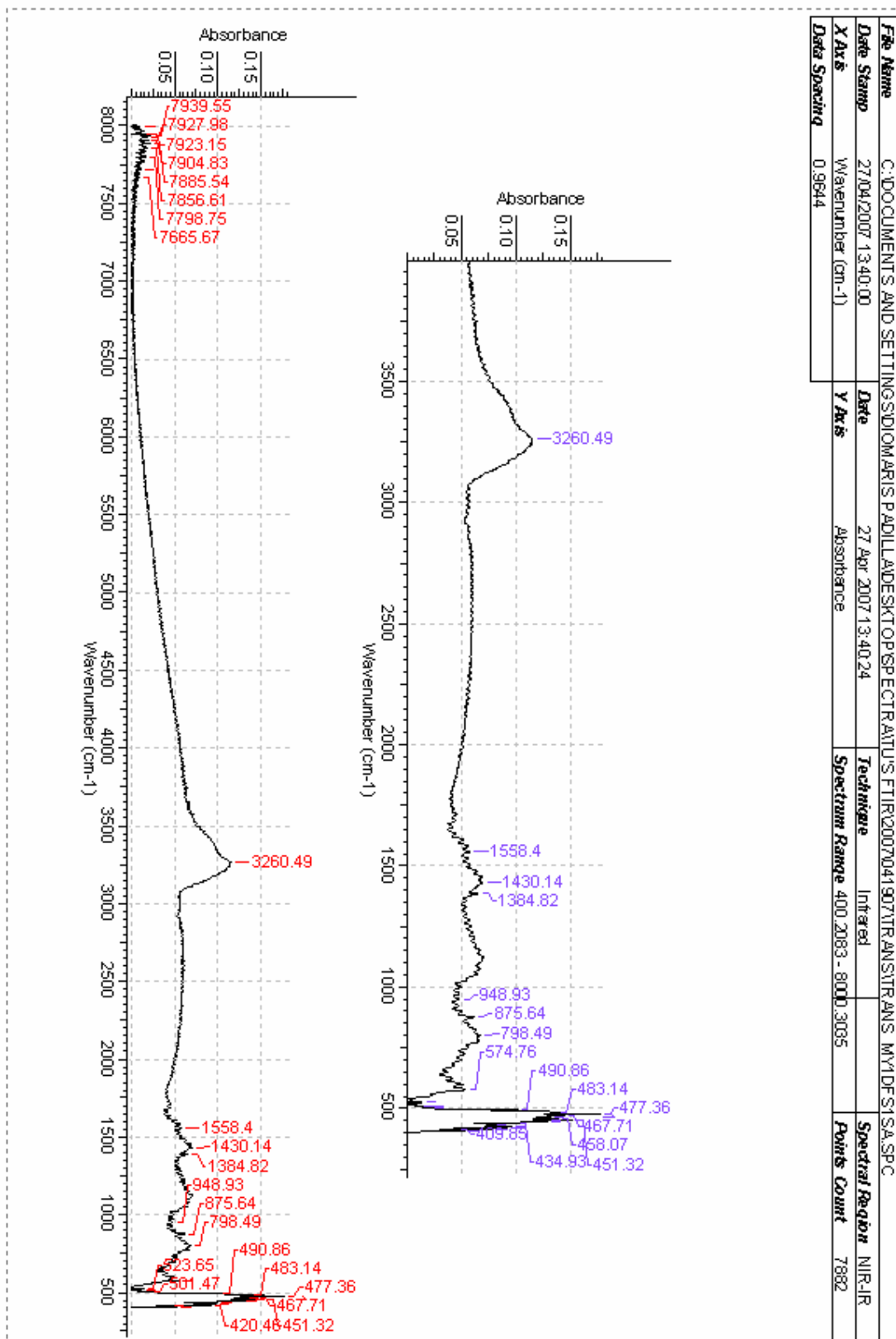


Cedar Set 1 Sample 3

File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS.PADILLA\DESKTOP\SPECTRATU\S FTIR\2007\041907\TRANS.MYICD\S1C.SPC	Technique	Infrared	Spectral Region	NIR:IR
Date	27 Apr 2007 13:28:36	Spectral Range	400.2083 - 8000.3035	Points Count	7882
Y Axis	Absorbance				
Date Stamp	27/04/2007 13:28:00				
X Axis	Wavenumber (cm-1)				
Data Spacing	0.9644				

No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity
1	408.89	0.023	6.55	-0.28	WV	12	481.21	0.022	-	-	WV	23	1124.44	0.051	-	-	M
2	415.64	0.030	-	-	WV	13	492.79	0.029	-	-	WV	24	1384.82	0.049	-	-	M
3	420.46	0.024	-	-	WV	14	499.54	0.041	-	-	M	25	1479.32	0.026	-	-	WV
4	426.25	0.032	-	-	M	15	504.36	0.059	-	-	M	26	1607.58	0.025	-	-	WV
5	431.07	0.022	-	-	WV	16	512.07	0.054	-	-	M	27	1711.73	0.022	-	-	WV
6	439.75	0.031	-	-	M	17	521.72	0.075	-	-	S	28	2877.64	0.009	-	-	VWV
7	447.46	0.029	-	-	WV	18	529.43	0.080	-	-	S	29	3261.45	0.041	369.46	0.79	M
8	455.18	0.032	-	-	M	19	577.65	0.104	-	-	VS	30	7792.00	0.006	-	-	VWV
9	460.96	0.019	-	-	WV	20	699.16	0.085	-	-	S	31	7835.40	0.007	-	-	VWV
10	469.64	0.021	-	-	WV	21	773.41	0.087	-	-	S	32	7912.55	0.009	-	-	VWV
11	476.39	0.024	-	-	WV	22	1075.26	0.049	-	-	M						

Douglas Fir Soot Sample 1

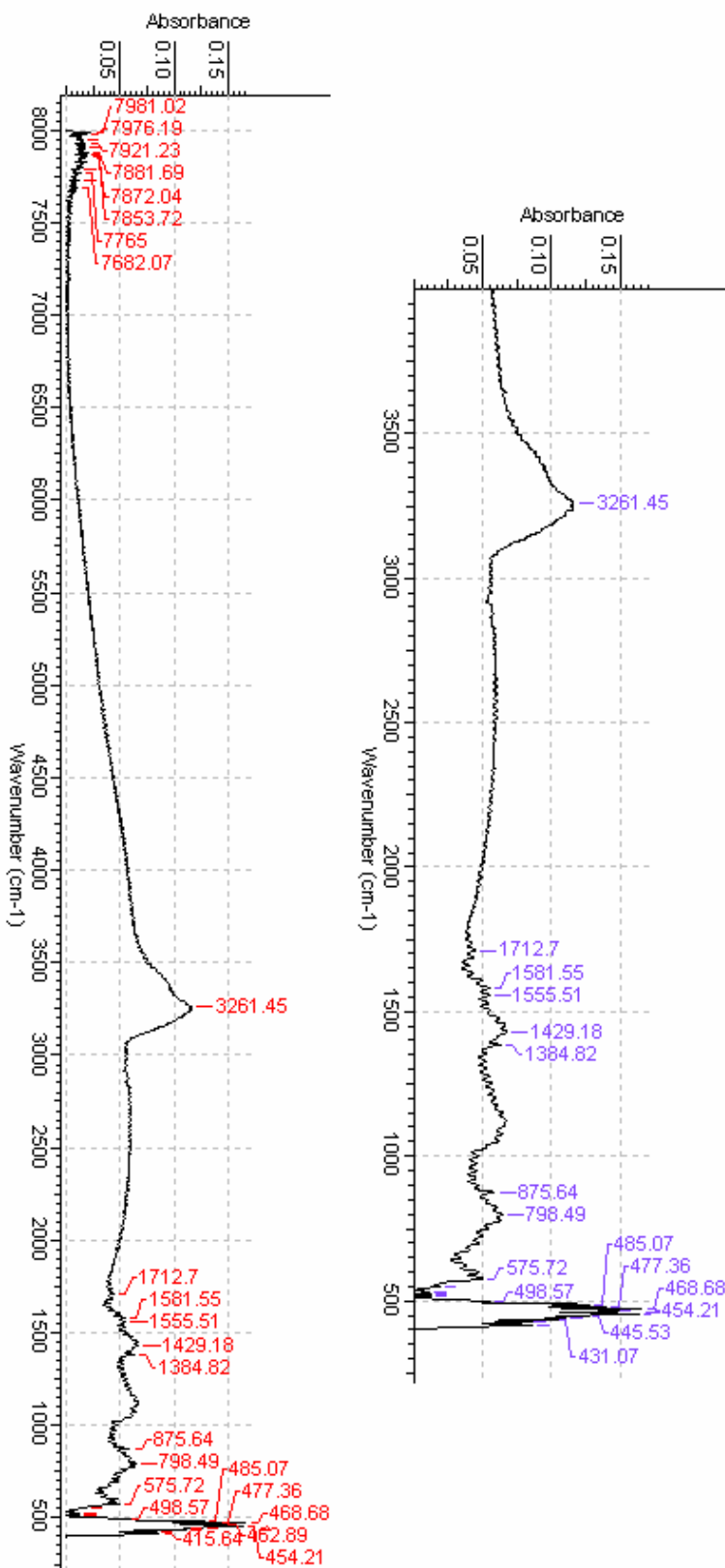


Douglas Fir Soot Sample 1

File Name		C:\DOCUMENTS AND SETTINGS\DIOMARIS.PADILLA\DESKTOP\SPECTRA\U/S FTIR\2007\041907\TRANSYTRANS_M\Y1DFS1SA.SPC			
Date Stamp		27/04/2007 13:40:00		Date	27 Apr 2007 13:40:24
X Axis		Wavenumber (cm-1)		Y Axis	Absorbance
Data Spacing		0.9644		Spectrum Range 400.2083 - 800.0.3035	
				Spectral Region NIR-FR	
				Points Count 7882	
No	cm-1	A	FWHH	Asym	Intensity
1	405.03	0.062	-	-	W
2	409.86	0.046	-	-	W
3	413.71	0.079	-	-	M
4	420.46	0.091	-	-	M
5	424.32	0.096	-	-	M
6	429.14	0.079	-	-	M
7	434.93	0.100	-	-	M
8	443.60	0.129	-	-	S
9	447.46	0.128	-	-	S
10	461.32	0.162	-	-	S
No	cm-1	A	FWHH	Asym	Intensity
11	468.07	0.139	-	-	S
12	482.89	0.132	-	-	S
13	487.71	0.144	-	-	S
14	477.36	0.177	-	-	VS
15	483.14	0.138	-	-	S
16	480.86	0.102	-	-	M
17	501.47	0.021	-	-	W
18	505.32	0.020	-	-	W
19	511.11	0.012	-	-	VW
20	523.65	0.014	5.24	-0.42	VW
No	cm-1	A	FWHH	Asym	Intensity
21	574.76	0.054	-	-	M
22	798.49	0.068	-	-	M
23	875.64	0.062	-	-	M
24	948.93	0.048	-	-	W
25	1384.82	0.065	-	-	M
26	1430.14	0.069	-	-	M
27	1568.40	0.057	-	-	M
28	3260.49	0.115	-	-	S
29	7665.67	0.009	21.01	0.12	VW
30	7717.75	0.010	39.39	0.09	VW
No	cm-1	A	FWHH	Asym	Intensity
31	7798.75	0.016	-	-	VW
32	7866.61	0.018	51.85	-0.76	VW
33	7885.54	0.021	-	-	W
34	7904.83	0.018	-	-	W
35	7909.66	0.015	-	-	VW
36	7923.16	0.017	-	-	VW
37	7927.98	0.018	-	-	W
38	7939.55	0.022	-	-	W
39	7948.23	0.012	4.60	0.98	VW
40	7995.48	0.009	3.07	-0.01	VW

Douglas Fir Soot Sample 2

File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS P ADILLA\DESKTOP\PEPECTRATUS.FIR\2007041907VIRANS\STRANS.MY1DF.S1.SB.SPC		
Date Stamp	27/04/2007 13:40:00	Date	27 Apr 2007 13:41:00
X Axis	Wavenumber (cm-1)	Y Axis	Absorbance
Data Spacing	0.9644	Spectral Range	400.2083 - 8000.3095
		Points Count	7882

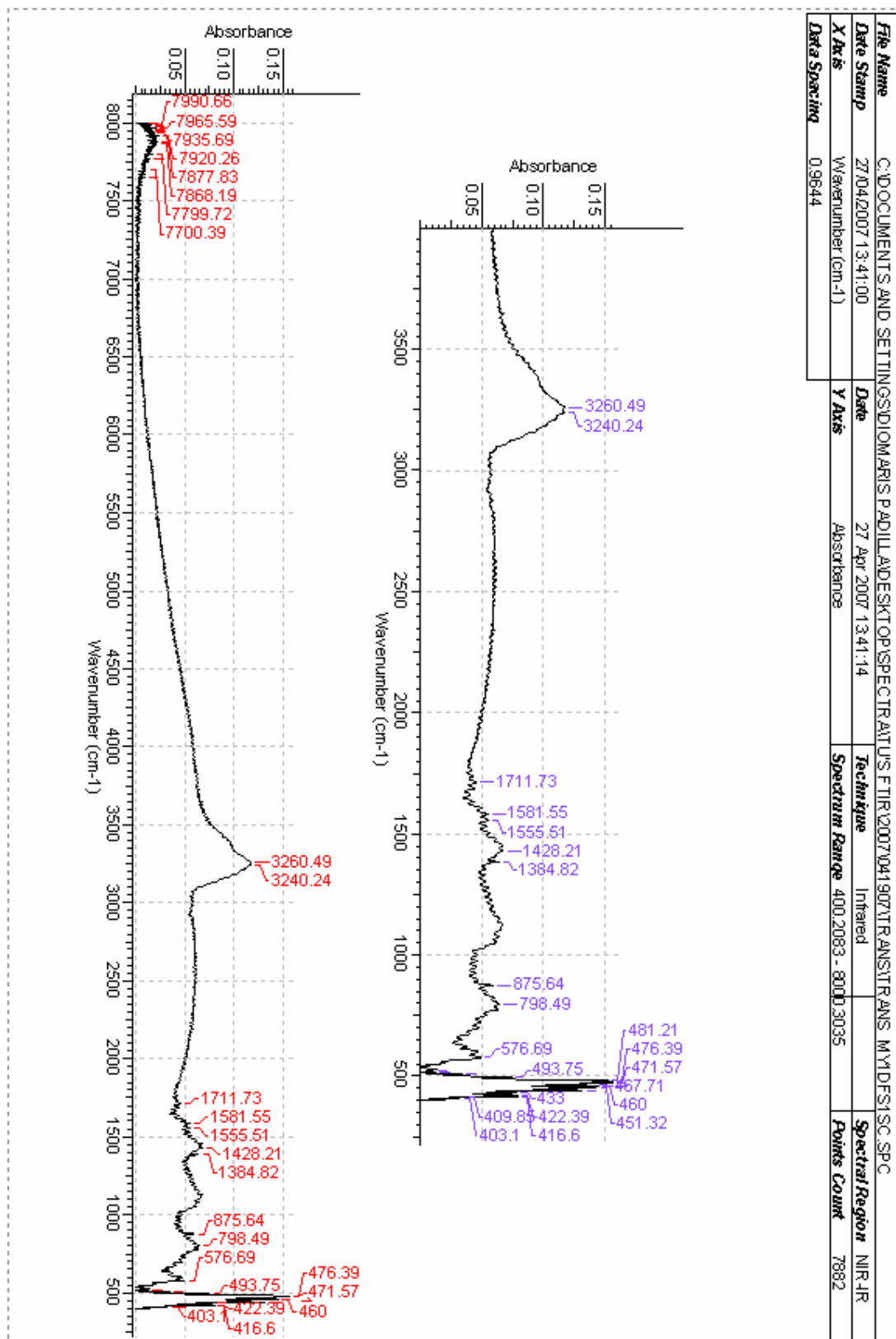


Douglas Fir Soot Sample 2

File Name	C:\DOCUMENTS AND SETTINGS\DIOWM\ARIS P\ADILL\ADESKTOP\SPECTRATUS FTIR\2007041907XIRANSVTRANS.M\Y1DFS1SB.SPC	Date	27 Apr 2007 13:41:00	Technique	Infrared	Spectral Region	NIR-IR
Date Stamp	27/04/2007 13:40:00	Y Axis	Absorbance	Spectral Range	400-8000.3035	Points Count	7882
X Axis	Wavenumber (cm-1)						
Data Spacing	0.9644						

No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity
1	415.64	0.086	-	-	M	14	523.65	0.012	-	-	VW	27	7724.50	0.012	5.36	-0.16	VW
2	427.21	0.083	-	-	M	15	528.47	0.011	-	-	VW	28	7765.00	0.013	39.54	0.06	VW
3	431.07	0.102	-	-	S	16	548.72	0.018	-	-	W	29	7790.07	0.012	-	-	VW
4	435.89	0.110	-	-	S	17	575.72	0.049	-	-	W	30	7853.72	0.019	-	-	W
5	439.75	0.110	-	-	S	18	798.49	0.064	-	-	M	31	7872.04	0.019	-	-	W
6	445.53	0.126	-	-	S	19	875.64	0.058	-	-	M	32	7881.89	0.021	-	-	W
7	454.21	0.163	-	-	VS	20	1384.82	0.063	-	-	M	33	7903.87	0.017	-	-	W
8	462.89	0.145	-	-	S	21	1429.18	0.067	-	-	M	34	7921.23	0.018	-	-	W
9	468.68	0.166	-	-	VS	22	1565.51	0.055	-	-	M	35	7946.30	0.015	-	-	VW
10	477.36	0.140	-	-	S	23	1581.55	0.054	-	-	M	36	7976.19	0.018	-	-	W
11	485.07	0.128	-	-	S	24	1712.70	0.044	-	-	W	37	7981.02	0.022	5.50	0.03	W
12	498.57	0.055	-	-	M	25	3261.45	0.116	-	-	S						
13	514.97	0.012	2.72	-0.08	VW	26	7882.07	0.010	-	-	VW						

Douglas Fir Soot Sample 3



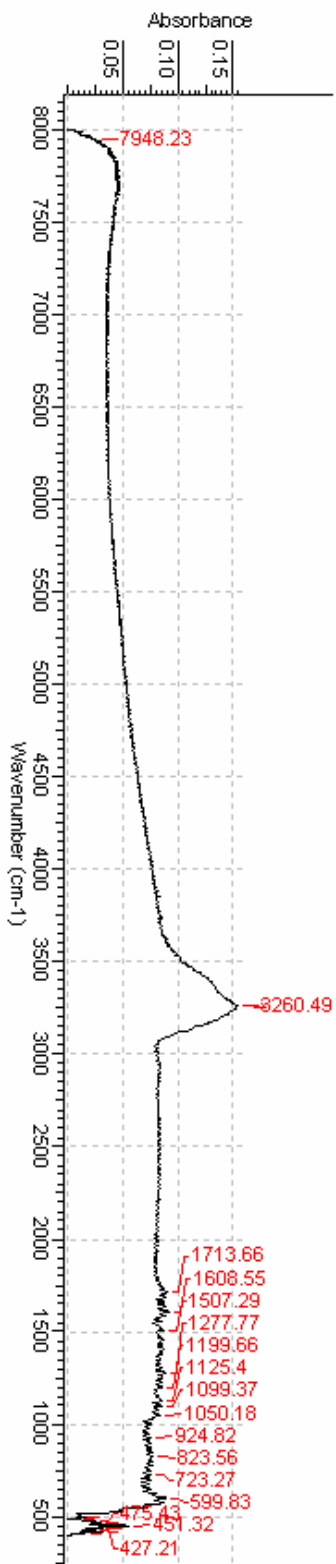
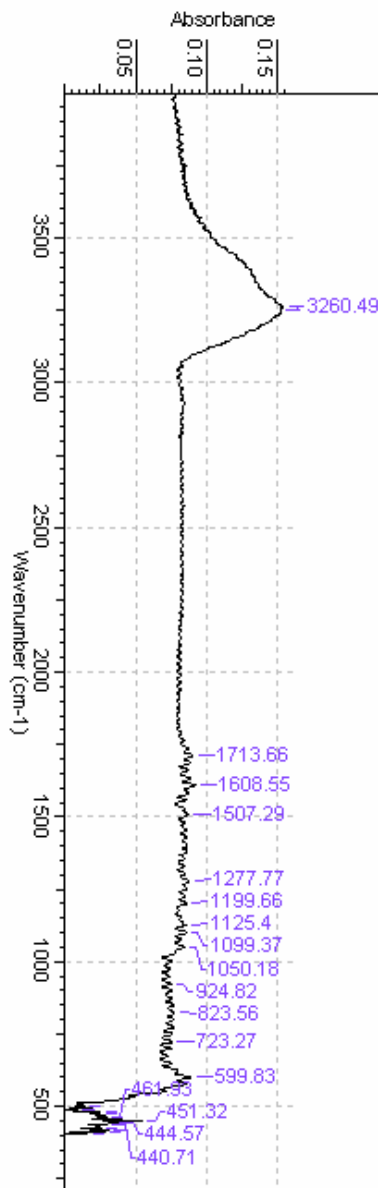
Douglas Fir Soot Sample 3

File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS P ADILLA\DESKTOP\SPECTRATUS FTIR\2007041907NIRANS\TRANS_M\YDFST\SC.SPC		
Date Stamp	27/04/2007 13:41:00	Date	27 Apr 2007 13:41:14
X Axis	Wavenumber (cm-1)	Y Axis	Absorbance
Data Spacing	0.9644	Technique	Infrared
		Spectrum Range	400 2083 - 8000 3035
		Spectral Region	NIR,IR
		Points Count	7882

No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity
1	403.10	0.031	3.70	0.33	WV	11	476.39	0.156	-	-	VS	21	1428.21	0.067	-	-	M	31	7868.19	0.021	-	-	WV
2	409.85	0.036	-	-	WV	12	481.21	0.153	-	-	VS	22	1555.51	0.065	-	-	M	32	7877.83	0.022	-	-	WV
3	416.60	0.079	-	-	M	13	493.75	0.075	-	-	M	23	1581.55	0.065	-	-	M	33	7920.26	0.023	-	-	WV
4	422.39	0.080	-	-	M	14	506.29	0.034	-	-	WV	24	1711.73	0.046	-	-	WV	34	7935.89	0.018	-	-	WV
5	433.00	0.078	-	-	M	15	514.97	0.012	2.44	0.16	VWV	25	3240.24	0.117	-	-	S	35	7946.30	0.016	-	-	VWV
6	441.88	0.132	-	-	S	16	519.79	0.011	-	-	VWV	26	3260.49	0.117	-	-	S	36	7954.01	0.015	-	-	VWV
7	451.32	0.143	-	-	VS	17	576.89	0.049	-	-	M	27	7853.14	0.009	8.42	-0.27	VWV	37	7965.59	0.020	-	-	WV
8	460.00	0.145	-	-	VS	18	798.49	0.064	-	-	M	28	7700.39	0.010	-	-	VWV	38	7972.34	0.014	-	-	VWV
9	467.71	0.142	-	-	VS	19	875.64	0.059	-	-	M	29	7770.79	0.014	-	-	VWV	39	7990.66	0.016	-	-	WV
10	471.57	0.156	-	-	VS	20	1384.82	0.064	-	-	M	30	7798.72	0.017	-	-	WV	40	7997.41	0.009	-	-	VWV

Douglas Fir Set 1 Sample 1

File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS.PADILLA\DESKTOP\SPECTRATUS.FIR\200704190711RANSITRANS.M\1DF51A.SPC		
Date Stamp	27/04/2007 13:39:00	Date	27 Apr 2007 13:39:38
X Axis	Wavenumber (cm ⁻¹)	Y Axis	Absorbance
Data Spacing	0.9644	Spectral Range	400.2083 - 8000.3035
		Spectral Region	NIR-FR
		Points Count	7882



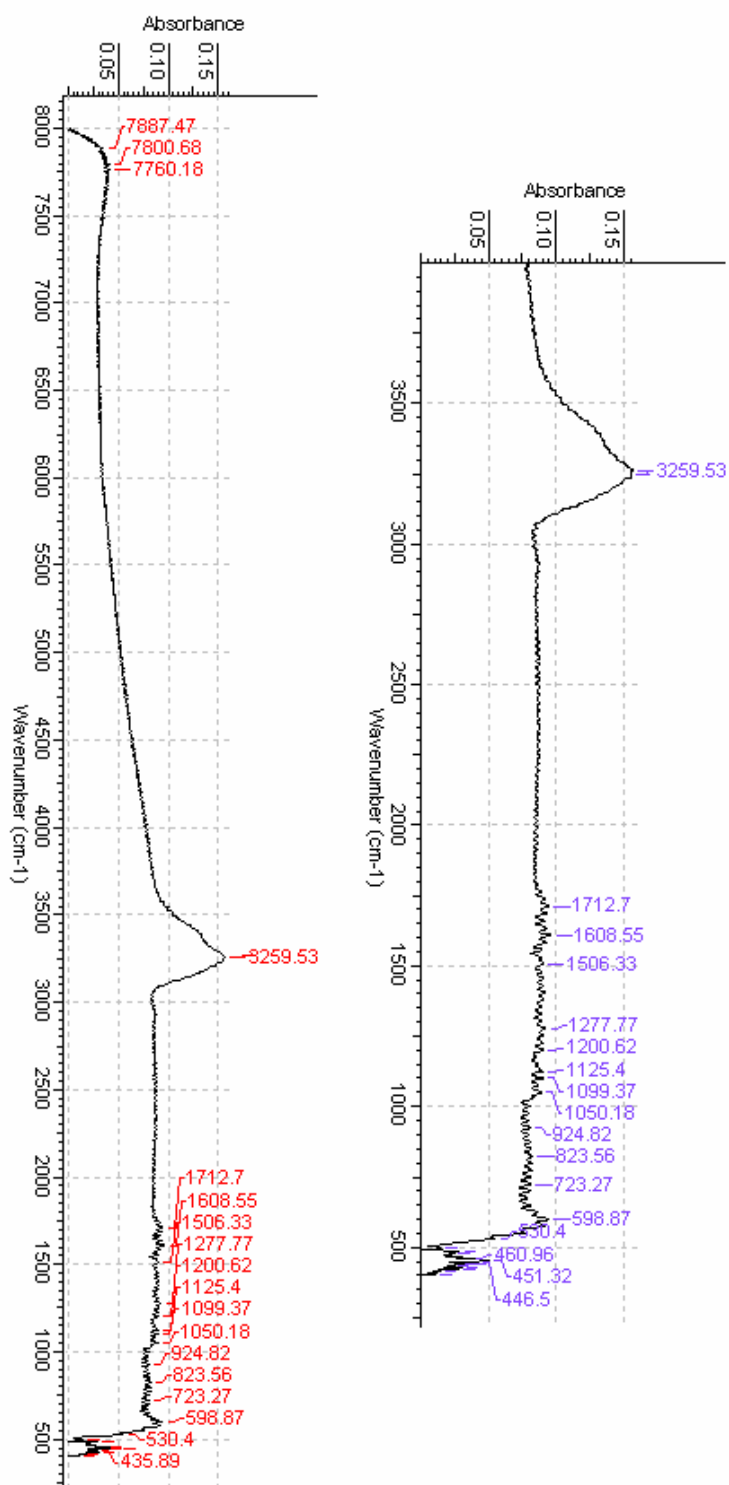
Douglas Fir Set 1 Sample 1

File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS P ADILLADESKTOP\SPEC TRAU\US FTIR\2007041907\TRANS\TRANS_MY1DFS1.A.SPC
Date Stamp	27/04/2007 13:39:00
X Axis	Wavenumber (cm ⁻¹)
Data Spacing	0.9644
Date	27 Apr 2007 13:39:38
Y Axis	Absorbance
Technique	Infrared
Spectrum Range	400.2083 - 8000.3035
Spectral Region	NIR-FIR
Points Count	7882

No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity
1	408.89	0.016	3.26	-0.32	W	11	475.43	0.025	-	-	W	21	1125.40	0.086	-	-	M
2	414.67	0.028	-	-	W	12	481.21	0.025	-	-	W	22	1199.66	0.086	-	-	M
3	418.53	0.031	-	-	W	13	487.00	0.009	2.70	-0.35	WV	23	1277.77	0.088	-	-	M
4	427.21	0.025	-	-	W	14	501.47	0.013	-	-	WV	24	1507.29	0.087	-	-	M
5	435.89	0.030	-	-	W	15	599.83	0.089	-	-	M	25	1608.55	0.092	-	-	M
6	440.71	0.034	-	-	W	16	723.27	0.076	-	-	M	26	1713.66	0.090	-	-	M
7	444.57	0.040	-	-	W	17	823.56	0.077	-	-	M	27	3260.49	0.154	-	-	VS
8	451.32	0.055	-	-	M	18	924.82	0.075	-	-	M	28	7948.23	0.025	-	-	W
9	461.93	0.030	-	-	W	19	1050.18	0.084	-	-	M						
10	465.78	0.029	-	-	W	20	1099.37	0.086	-	-	M						

Douglas Fir Set 1 Sample 2

File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS P ADILL\DESKTOP\SPECTRA\US_FIR\20071041907\1\TRANS\TRAMS_M\1\DFS\1B.SPC
Date Stamp	27/04/2007 13:39:00
Date	27 Apr 2007 13:39:48
X Axis	Wavenumber (cm-1)
Y Axis	Absorbance
Spectral Range	400.2083 - 8000.3035
Technique	Infrared
Data Spacing	0.9644
Spectral Region	NIR-IR
Points Count	7882



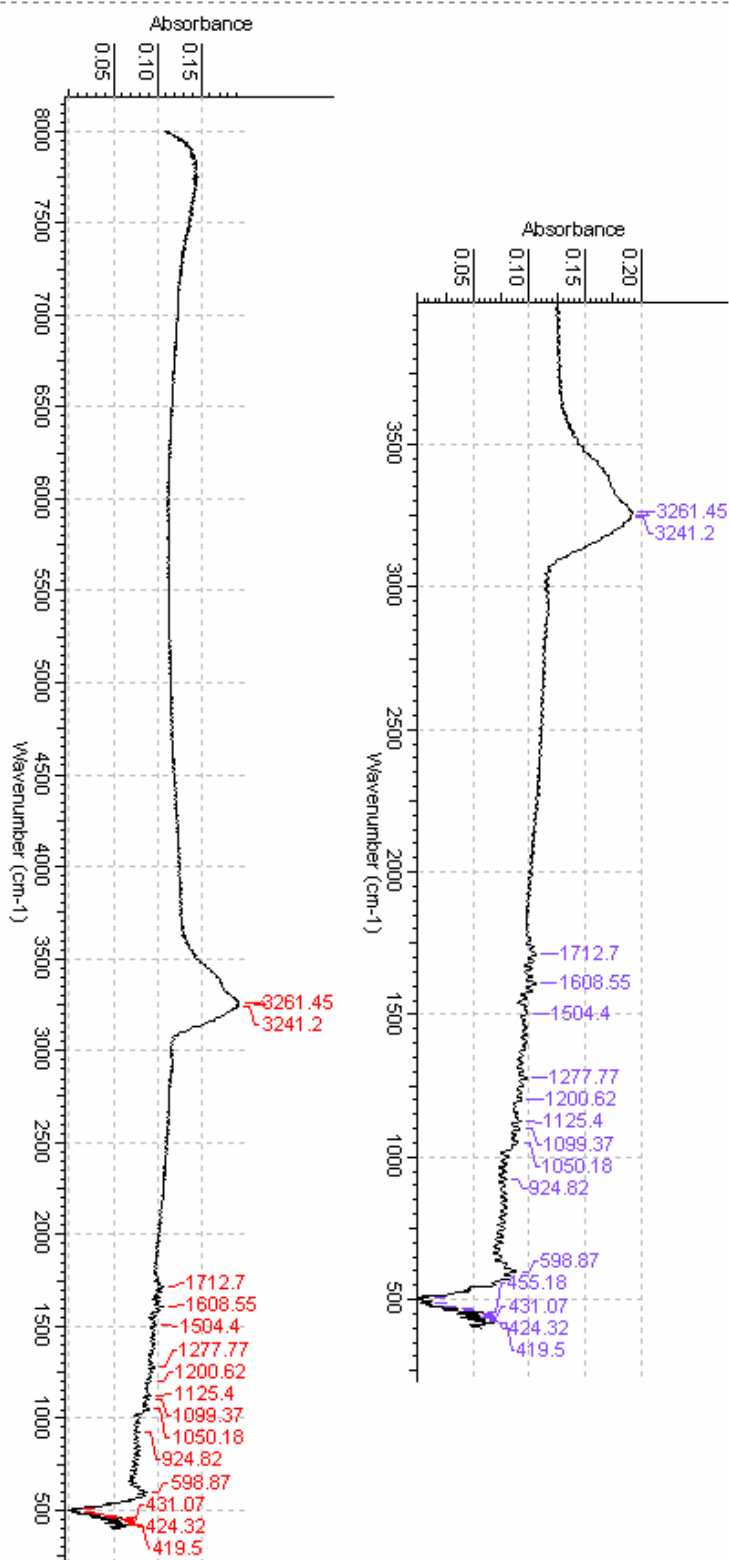
Douglas Fir Set 1 Sample 2

File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS PADILLADESKTOP\SPECTRATU\S FTIR\2007041907VTR\ANS\STR\ANS_MY1DF_S1B.SPC				
Date Stamp	27/04/2007 13:39:00	Date	27 Apr 2007 13:39:48	Technique	Infrared
X Axis	Wavenumber (cm ⁻¹)	Y Axis	Absorbance	Spectrum Range	400.2083 - 800.03035
Data Spacing	0.9644			Spectral Region	NIR-IR
				Points Count	7882

No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity
1	405.03	0.011	3.34	0.15	WV	11	476.39	0.024	-	-	W	21	1125.40	0.090	-	-	M
2	411.78	0.014	-	-	WV	12	482.18	0.029	-	-	W	22	1200.62	0.090	-	-	M
3	422.39	0.028	-	-	WV	13	499.54	0.015	-	-	WV	23	1277.77	0.092	-	-	M
4	426.25	0.030	-	-	WV	14	530.40	0.055	-	-	M	24	1506.33	0.090	-	-	M
5	431.07	0.023	-	-	WV	15	598.87	0.095	-	-	S	25	1608.55	0.096	-	-	S
6	435.89	0.029	-	-	WV	16	723.27	0.081	-	-	M	26	1712.70	0.095	-	-	S
7	439.75	0.037	-	-	WV	17	823.56	0.082	-	-	M	27	3259.53	0.157	-	-	VS
8	446.50	0.042	-	-	WV	18	924.82	0.080	-	-	M	28	7760.18	0.042	-	-	WV
9	451.32	0.051	-	-	M	19	1050.18	0.089	-	-	M	29	7800.68	0.041	-	-	WV
10	460.96	0.037	-	-	WV	20	1099.37	0.090	-	-	M	30	7887.47	0.035	-	-	WV

Douglas Fir Set 1 Sample 3

File Name	C:\DOCUMENTS AND SETTINGS\MARIS.PADILLA\DESKTOP\SPECTRATU\S_FTIR\20070419071RANSITRANS.MY1DFS1C.SPC		
Date Stamp	27/04/2007 13:40:00	Date	27 Apr 2007 13:40:00
X Axis	Wavenumber (cm-1)	Y Axis	Absorbance
Data Spacing	0.9644	Spectrum Range	400.2083 - 8000.3035
		Technical	FTIR\20070419071RANSITRANS.MY1DFS1C.SPC
		Spectral Region	NIR-IR
		Points Count	7882

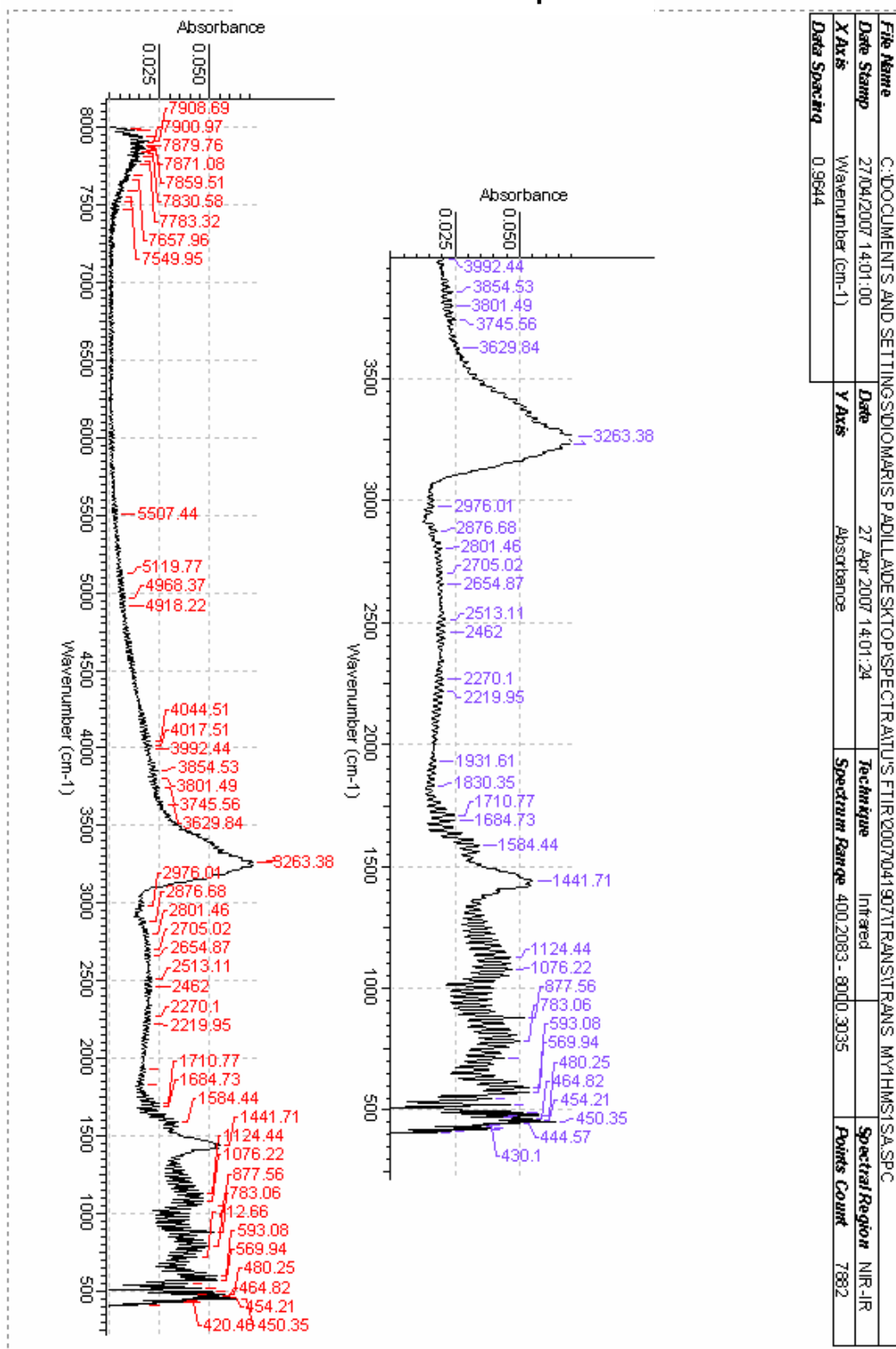


Douglas Fir Set 1 Sample 3

File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS PADILLADESKTOP\SPECTRAT\U.S.FTIR\2007041907\TRANS\TRANS_MY1DFSTIC.SPC		
Date Stamp	27/04/2007 13:40:00	Date	27 Apr 2007 13:40:00
X Axis	Wavenumber (cm ⁻¹)	Y Axis	Absorbance
Data Spacing	0.9644	Technique	Infrared
		Spectrum Range	400.2083 - 8000.3035
		Spectral Region	NIR-R
		Points Count	7882

No	cm-1	A	Intensity	No	cm-1	A	Intensity	No	cm-1	A	Intensity
1	419.50	0.068	M	10	470.61	0.035	W	19	1200.62	0.093	M
2	424.32	0.060	M	11	475.43	0.020	W	20	1277.77	0.097	M
3	431.07	0.060	M	12	486.04	0.011	WV	21	1504.40	0.098	M
4	435.89	0.052	WV	13	506.29	0.010	WV	22	1608.55	0.106	M
5	439.75	0.057	WV	14	598.87	0.088	M	23	1712.70	0.106	M
6	443.60	0.055	WV	15	924.82	0.079	M	24	3241.20	0.191	VS
7	450.35	0.053	WV	16	1090.18	0.090	M	25	3261.45	0.193	VS
8	455.18	0.059	M	17	1099.37	0.092	M				
9	462.89	0.036	WV	18	1125.40	0.092	M				

Hemlock Soot Sample 1

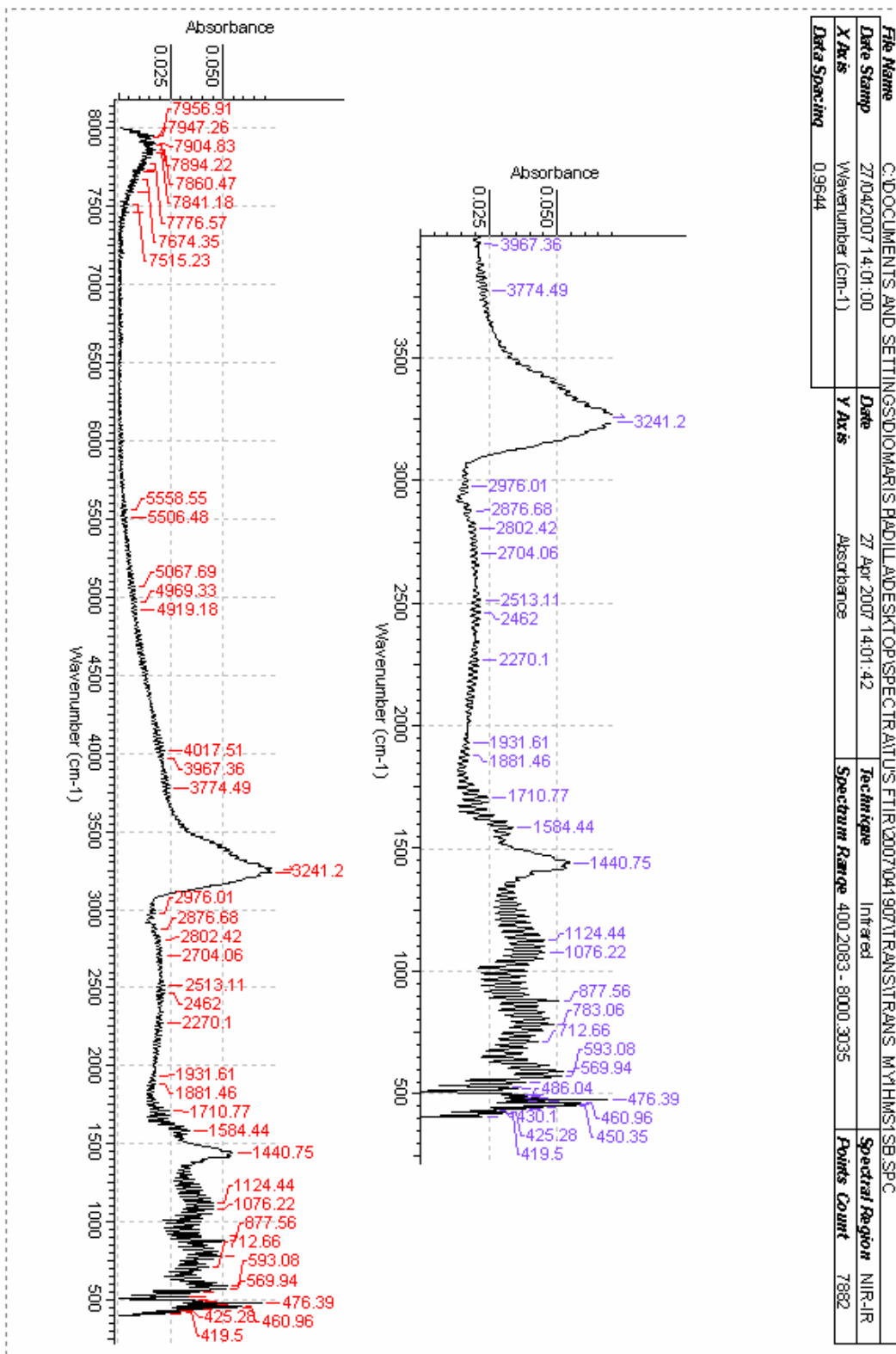


Hemlock Soot Sample 1

File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS PAJILLALADESKT\O.P.S.PECTRA\TUS FTIR\007041907\TRANSITRANS_M\Y\HMS1\SA.SPC
Date Stamp	27.04.2007 14:01:00
X Axis	Wavenumber (cm-1)
Y Axis	Absorbance
Date Stamp	27 Apr 2007 14:01:24
X Axis	Technique
Y Axis	Hitred
Date Stamp	27 Apr 2007 14:01:24
X Axis	Spectrum Range
Y Axis	400.2083 - 8.000.3035
Date Stamp	27 Apr 2007 14:01:24
X Axis	Spectral Region
Y Axis	Points Count
Date Stamp	27 Apr 2007 14:01:24
X Axis	7882
Y Axis	

No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity
1	407.92	0.018	4.88	0.56	W	20	783.06	0.050	-	-	S	39	3263.38	0.072	341.73	0.58	V/S	58	7765.98	0.013	-	-	W
2	413.71	0.023	4.35	-0.09	M	21	877.58	0.052	-	-	S	40	3628.84	0.026	-	-	M	59	7783.32	0.015	-	-	W
3	420.46	0.037	-	-	M	22	1076.22	0.047	-	-	S	41	3746.56	0.025	-	-	M	60	7812.25	0.015	-	-	W
4	425.28	0.038	-	-	M	23	1124.44	0.047	-	-	S	42	3801.49	0.024	-	-	M	61	7830.58	0.017	-	-	W
5	430.10	0.035	-	-	M	24	1441.71	0.055	-	-	S	43	3854.53	0.024	-	-	M	62	7835.40	0.014	-	-	W
6	436.85	0.037	-	-	M	25	1584.44	0.034	-	-	M	44	3992.44	0.020	-	-	W	63	7839.26	0.013	-	-	W
7	444.57	0.050	-	-	S	26	1684.73	0.025	-	-	M	45	4017.51	0.021	-	-	W	64	7853.72	0.016	-	-	W
8	460.35	0.064	-	-	S	27	1710.77	0.025	-	-	M	46	4044.51	0.020	-	-	W	65	7859.51	0.018	-	-	W
9	464.21	0.056	-	-	S	28	1830.35	0.017	-	-	W	47	4018.22	0.008	-	-	W	66	7871.08	0.017	-	-	W
10	464.82	0.056	-	-	S	29	1931.61	0.017	-	-	W	48	4068.37	0.008	-	-	W	67	7879.78	0.016	-	-	W
11	471.57	0.042	-	-	M	30	2219.95	0.020	-	-	W	49	5119.77	0.007	-	-	V/W	68	7900.97	0.017	-	-	W
12	475.43	0.044	-	-	S	31	2270.10	0.020	-	-	W	50	5507.44	0.004	24.40	-0.64	V/W	69	7908.69	0.019	-	-	W
13	480.25	0.067	-	-	S	32	2462.00	0.021	-	-	W	51	7467.01	0.005	11.49	0.14	V/W	70	7946.30	0.016	-	-	W
14	481.82	0.051	-	-	S	33	2513.11	0.021	-	-	W	52	7517.16	0.005	18.46	0.83	V/W	71	7977.16	0.012	-	-	W
15	520.75	0.046	9.41	0.56	S	34	2654.87	0.020	-	-	W	53	7549.95	0.006	-	-	V/W	72	7981.98	0.011	-	-	W
16	546.79	0.039	16.71	-0.17	M	35	2705.02	0.020	-	-	W	54	7593.34	0.007	-	-	V/W	73	7992.59	0.008	-	-	W
17	569.94	0.053	-	-	S	36	2801.46	0.019	-	-	W	55	7657.96	0.009	-	-	W						
18	593.08	0.054	-	-	S	37	2876.68	0.018	-	-	W	56	7690.75	0.010	-	-	W						
19	712.66	0.044	-	-	S	38	2976.01	0.017	-	-	W	57	7760.18	0.013	-	-	W						

Hemlock Soot Sample 2

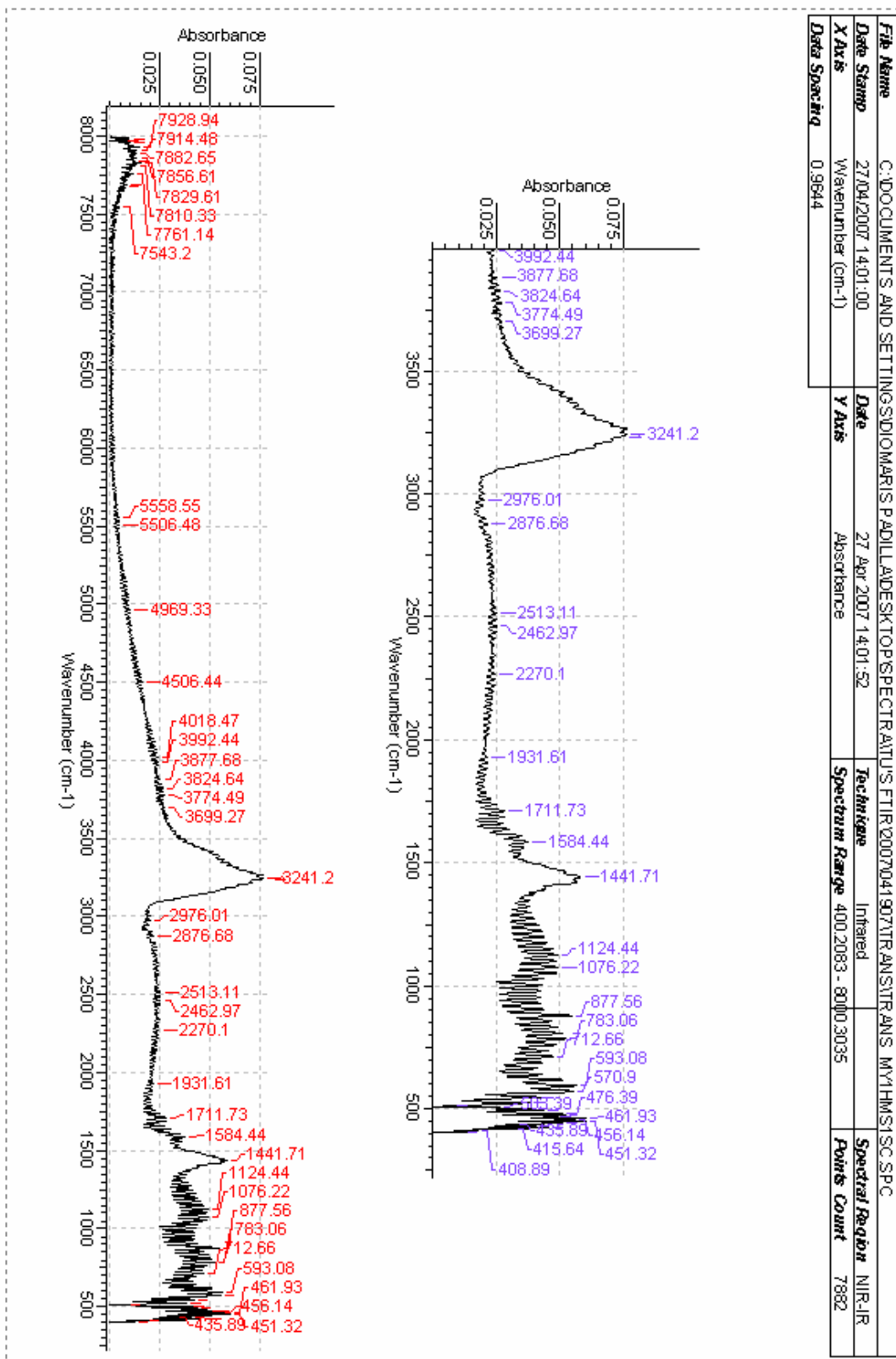


Hemlock Soot Sample 2

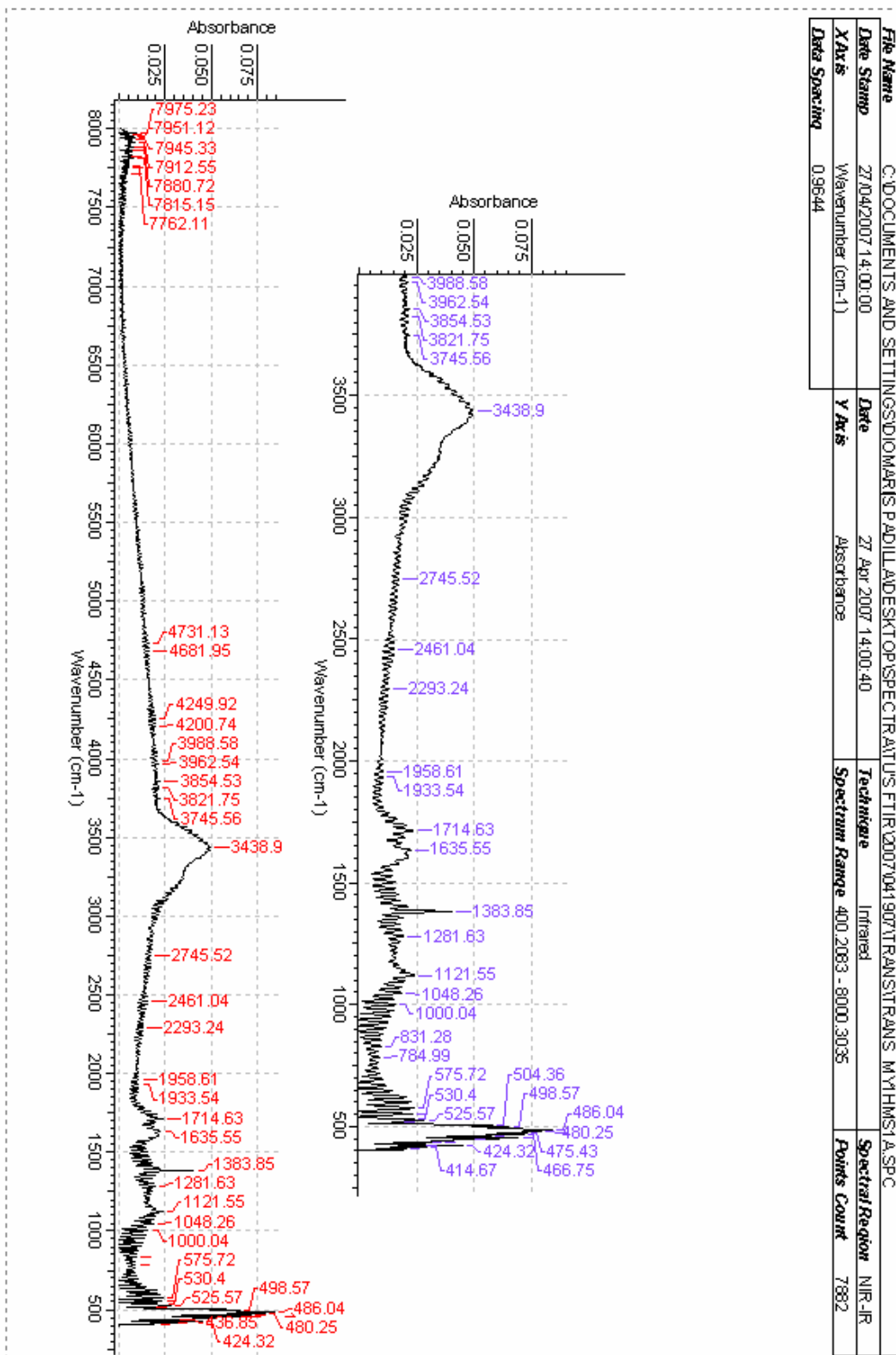
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Date Stamp	Z7\04\2007 14:01:00
X Axis	Wavenumber (cm-1)
Data Spacing	0.9644
Date	Z7 Apr 2007 14:01:42
Y Axis	Absorbance
Technique	Infrared
Spectrum Range	400-2083 - 8000-3035
Spectral Region	NIR-IR
Points Count	7882

No	cm-1	A	FWHM	Asym	Intensity	No	cm-1	A	FWHM	Asym	Intensity	No	cm-1	A	FWHM	Asym	Intensity	No	cm-1	A	FWHM	Asym	Intensity
1	407.82	0.022	4.06	-0.09	M	17	488.57	0.036	-	-	M	33	2270.10	0.021	-	-	W	49	7467.01	0.005	-	-	W
2	419.60	0.030	-	-	M	18	519.79	0.035	-	-	M	34	2462.00	0.022	-	-	M	50	7515.23	0.005	19.34	0.49	W
3	425.28	0.031	-	-	M	19	524.61	0.032	-	-	M	35	2513.11	0.022	-	-	M	51	7596.24	0.007	-	-	W
4	430.10	0.027	-	-	M	20	546.79	0.038	15.99	-0.17	M	36	2704.06	0.021	-	-	W	52	7674.35	0.009	-	-	W
5	439.75	0.038	-	-	M	21	569.94	0.051	-	-	S	37	2802.42	0.020	-	-	W	53	7724.50	0.010	-	-	W
6	444.57	0.044	-	-	S	22	593.08	0.052	-	-	S	38	2876.88	0.019	-	-	W	54	7735.11	0.012	-	-	W
7	450.35	0.057	-	-	S	23	712.86	0.043	-	-	M	39	2976.01	0.017	-	-	W	55	7776.57	0.013	-	-	W
8	454.21	0.057	-	-	S	24	783.06	0.049	-	-	S	40	3241.20	0.073	-	-	V/S	56	7841.18	0.016	-	-	W
9	460.96	0.059	-	-	S	25	877.56	0.051	-	-	S	41	3774.49	0.025	-	-	M	57	7860.47	0.018	-	-	W
10	467.71	0.038	-	-	M	26	1076.22	0.046	-	-	S	42	3967.36	0.022	-	-	W	58	7894.22	0.016	-	-	W
11	471.57	0.045	-	-	S	27	1124.44	0.045	-	-	S	43	4017.51	0.022	-	-	W	59	7904.83	0.017	-	-	W
12	476.39	0.069	-	-	V/S	28	1440.75	0.055	282.37	-0.72	S	44	4919.18	0.009	-	-	W	60	7947.26	0.014	-	-	W
13	482.18	0.042	-	-	M	29	1584.44	0.034	-	-	M	45	4969.33	0.009	-	-	W	61	7956.91	0.016	-	-	W
14	486.04	0.036	-	-	M	30	1710.77	0.025	-	-	M	46	5067.69	0.008	-	-	W	62	7962.69	0.014	-	-	W
15	488.93	0.039	-	-	M	31	1881.46	0.018	-	-	W	47	5506.48	0.004	21.01	-0.10	VW						
16	493.75	0.040	-	-	M	32	1931.61	0.018	-	-	W	48	5558.55	0.004	20.40	-0.19	VW						

Hemlock Soot Sample 3



Hemlock Set 1 Sample 1

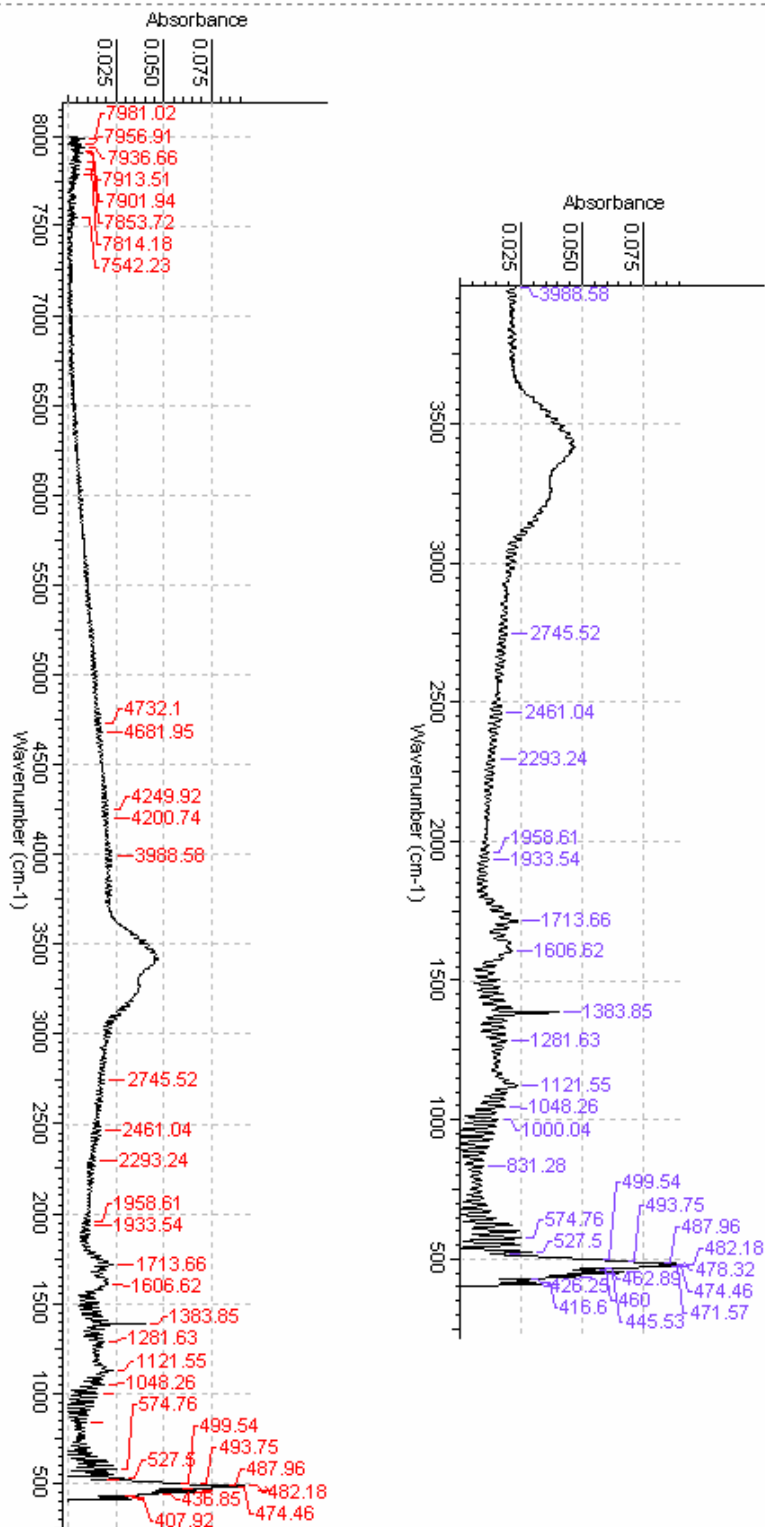


Hemlock Set 1 Sample 1

File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS.PADJL\ADESKTOP\SPECTRAT\US_FIR\20071041907\ITRANS\ITRANS_M\YHMS1A.SPC
Date Stamp	27/04/2007 14:00:00
X Axis	Wavenumber (cm-1)
Data Spacing	0.9644
Date	27 Apr 2007 14:00:40
Y Axis	Absorbance
Technique	Infrared
Spectrum Range	400 - 8000 3035
Spectral Region	NIR-IR
Points Count	7892

No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity
1	407.92	0.020	5.68	0.55	W	16	504.36	0.068	-	-	S	31	1933.64	0.010	-	-	W	46	7717.76	0.004	-	-	W
2	414.67	0.029	-	-	M	17	516.90	0.018	-	-	W	32	1969.61	0.010	-	-	W	47	7751.50	0.005	-	-	W
3	419.50	0.028	-	-	M	18	526.57	0.028	-	-	M	33	2293.24	0.013	-	-	W	48	7762.11	0.005	7.76	0.42	W
4	424.32	0.046	4.61	0.46	M	19	530.40	0.024	-	-	W	34	2461.04	0.015	-	-	W	49	7815.15	0.008	-	-	W
5	432.03	0.030	-	-	M	20	551.61	0.023	12.74	-0.06	W	35	2746.62	0.017	-	-	M	50	7820.93	0.005	-	-	W
6	436.86	0.036	-	-	M	21	575.72	0.024	13.32	-0.06	W	36	3439.90	0.049	507.48	-0.64	M	51	7862.40	0.007	-	-	W
7	444.67	0.049	-	-	M	22	784.99	0.009	-	-	W	37	3746.66	0.022	-	-	W	52	7869.16	0.005	-	-	W
8	461.32	0.066	-	-	S	23	831.28	0.009	16.46	0.00	W	38	3821.76	0.021	-	-	W	53	7880.72	0.008	-	-	W
9	464.21	0.069	-	-	S	24	1000.04	0.016	13.32	-0.02	W	39	3964.63	0.022	-	-	W	54	7888.44	0.006	-	-	W
10	460.96	0.067	-	-	S	25	1049.26	0.019	18.72	0.25	W	40	3962.64	0.021	-	-	W	55	7912.55	0.008	38.13	-0.16	W
11	466.75	0.071	-	-	S	26	1121.56	0.024	-	-	W	41	3988.68	0.021	-	-	W	56	7938.68	0.007	-	-	W
12	475.43	0.073	-	-	S	27	1281.63	0.019	-	-	W	42	4200.74	0.019	-	-	W	57	7946.33	0.008	-	-	W
13	480.26	0.079	-	-	VS	28	1383.86	0.040	13.19	-0.73	M	43	4249.92	0.019	-	-	W	58	7951.12	0.008	-	-	W
14	486.04	0.084	-	-	VS	29	1636.65	0.022	-	-	W	44	4681.96	0.016	-	-	W	59	7966.69	0.005	3.16	0.27	W
15	498.67	0.066	-	-	S	30	1714.63	0.023	-	-	W	45	4731.13	0.016	-	-	W	60	7975.23	0.009	5.55	-0.04	W

Hemlock Set 1 Sample 2



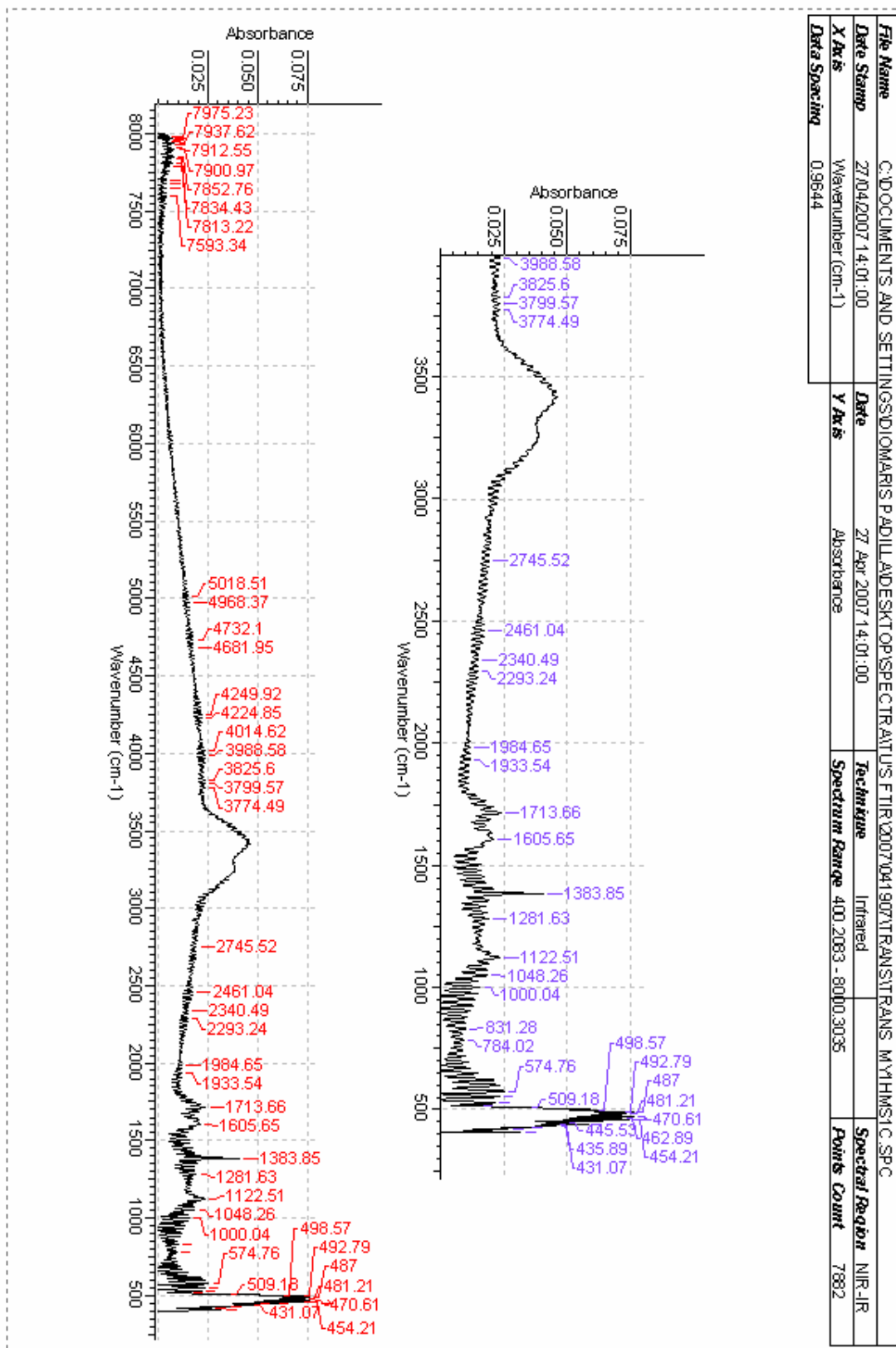
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Date Stamp	27/04/2007 14:00:00
Date	27 Apr 2007 14:00:50
X Axis	Wavenumber (cm⁻¹)
Y Axis	Absorbance
Technique	Infrared
Spectrum Range	400 2093 - 8000 3095
Data Spacing	0.9644
Spectral Region	NIR-IR
Points Count	7882

Hemlock Set 1 Sample 2

File Name	C:\DOCUMENTS AND SETTINGS\DIOMARIS.PADILLA\DESKTOP\SPECTRA\U\S FTIR\2007\041907\IR ANS\IR.ANS MY1HMS1B1B.SPC
Date Stamp	27/04/2007 14:00:00
X Axis	Wavenumber (cm-1)
Data Spacing	0.9644
Date	27 Apr 2007 14:00:50
Y Axis	Absorbance
Technique	Infrared
Spectral Range	400.2083 - 8000.3035
Spectral Region	NIR-JR
Points Count	7982

No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity
1	407.92	0.033	-	-	M	13	482.18	0.083	-	-	VS	25	1383.85	0.041	12.84	-0.72	M	37	4732.10	0.017	-	-	W
2	416.80	0.031	-	-	M	14	487.96	0.081	-	-	S	26	1606.62	0.021	-	-	W	38	7542.23	0.005	8.01	0.69	VW
3	426.25	0.027	-	-	W	15	493.75	0.067	-	-	S	27	1713.66	0.024	-	-	W	39	7783.32	0.005	20.09	0.48	VW
4	436.85	0.047	-	-	M	16	499.54	0.057	-	-	S	28	1933.54	0.011	-	-	W	40	7814.18	0.006	-	-	VW
5	446.63	0.058	-	-	S	17	519.79	0.018	-	-	W	29	1968.61	0.011	-	-	W	41	7863.72	0.007	-	-	VW
6	460.35	0.066	-	-	S	18	527.50	0.029	-	-	M	30	2293.24	0.014	-	-	W	42	7901.94	0.007	13.68	-0.91	VW
7	464.21	0.067	-	-	S	19	574.76	0.025	13.36	0.28	W	31	2461.04	0.017	-	-	W	43	7913.51	0.006	-	-	VW
8	460.00	0.065	-	-	M	20	831.28	0.010	15.60	0.00	W	32	2746.52	0.019	-	-	W	44	7936.66	0.009	10.86	-0.35	VW
9	462.89	0.057	-	-	S	21	1000.04	0.016	13.46	-0.03	W	33	3988.58	0.023	-	-	W	45	7956.91	0.007	4.02	-0.76	VW
10	471.57	0.085	-	-	VS	22	1048.26	0.018	18.55	0.23	W	34	4200.74	0.021	-	-	W	46	7981.02	0.008	-	-	VW
11	474.46	0.086	-	-	VS	23	1121.55	0.023	-	-	W	35	4249.92	0.021	-	-	W						
12	478.32	0.087	-	-	VS	24	1281.63	0.019	-	-	W	36	4681.95	0.017	-	-	W						

Hemlock Set 1 Sample 3

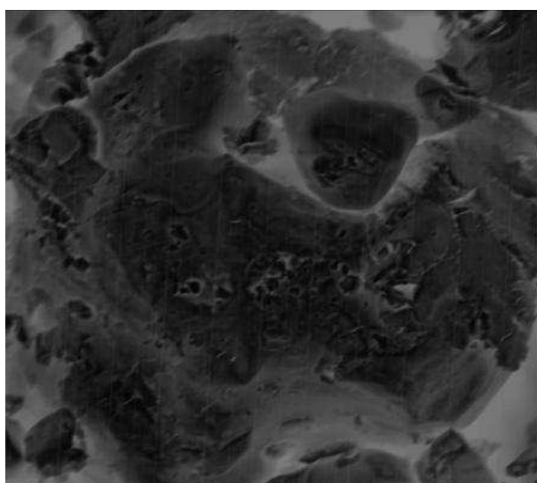


Hemlock Set 1 Sample 3

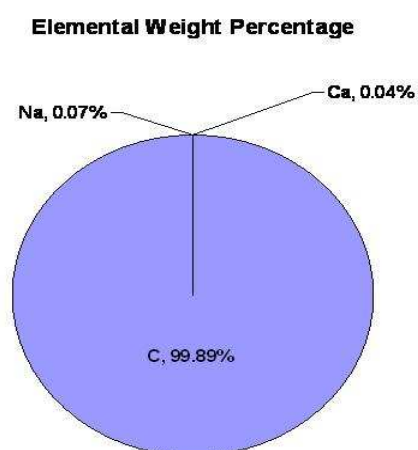
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Date Stamp	27/04/2007 14:01:00	Date	27 Apr 2007 14:01:00	Technique	Infrared						
X Axis	Wavenumber (cm-1)	Y Axis	Absorbance	Spectral Range	400.2083 - 8000.3035						
Data Spacing	0.9644			Spectral Region	NIR-IR						
				Points Count	7892						
No	cm-1	A	FWHH	Asym	Intensity	No	cm-1	A	FWHH	Asym	Intensity
1	406.96	0.031	3.88	0.76	M	17	626.57	0.021	12.25	0.46	W
2	420.46	0.026	-	-	M	18	560.65	0.023	11.33	0.27	M
3	426.25	0.034	-	-	M	19	574.76	0.025	13.02	0.31	M
4	431.07	0.046	-	-	M	20	784.02	0.009	-	-	W
5	435.89	0.046	-	-	M	21	831.28	0.010	15.63	0.01	W
6	440.71	0.058	-	-	S	22	1000.04	0.016	13.25	-0.02	W
7	445.53	0.049	-	-	S	23	1048.26	0.018	18.42	0.23	W
8	464.21	0.074	-	-	V/S	24	1122.51	0.023	-	-	M
9	462.89	0.072	-	-	V/S	25	1261.63	0.019	-	-	W
10	470.61	0.076	-	-	V/S	26	1383.85	0.041	12.74	-0.72	M
11	481.21	0.073	-	-	V/S	27	1605.65	0.021	-	-	W
12	487.00	0.076	-	-	V/S	28	1713.66	0.024	-	-	M
13	492.79	0.071	-	-	V/S	29	1933.54	0.012	-	-	W
14	498.57	0.061	-	-	S	30	1984.65	0.012	-	-	W
15	509.18	0.034	-	-	M	31	2293.24	0.014	-	-	W
16	515.93	0.015	-	-	W	32	2340.49	0.015	-	-	W
						48	7673.39	0.004	-	-	VW
						49	7697.50	0.004	-	-	VW
						50	7784.29	0.005	16.20	-0.99	VW
						51	7813.22	0.007	14.24	-0.84	VW
						52	7834.43	0.006	17.31	-0.16	VW
						53	7852.76	0.007	-	-	VW
						54	7900.97	0.008	-	-	W
						55	7912.55	0.006	-	-	VW
						56	7931.83	0.006	-	-	VW
						57	7937.62	0.008	4.38	-0.04	W
						58	7943.41	0.004	-	-	VW
						59	7955.94	0.005	6.71	0.41	VW
						60	7965.59	0.006	3.75	-0.13	VW
						61	7975.23	0.007	3.41	0.04	VW
						62	7980.05	0.005	3.38	-0.09	VW

APPENDIX B
Select SEM Images & X-Ray Analysis

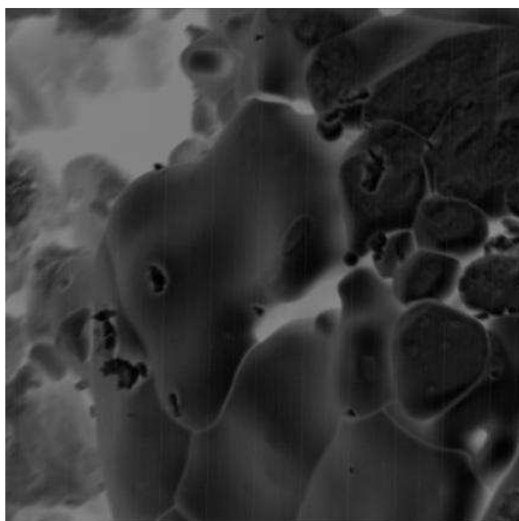
Sweetgum Ash & Soot Particles on KBr Matrix



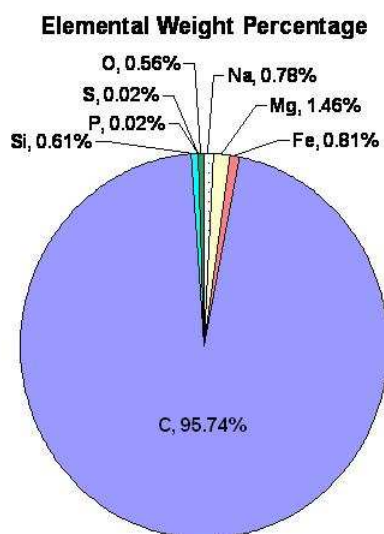
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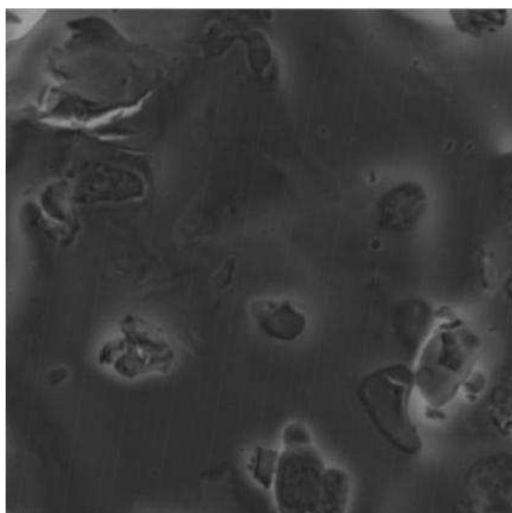
Sweetgum Ash & Soot Particles on KBr Matrix



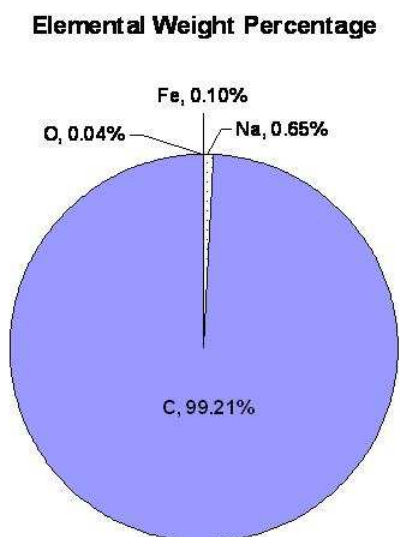
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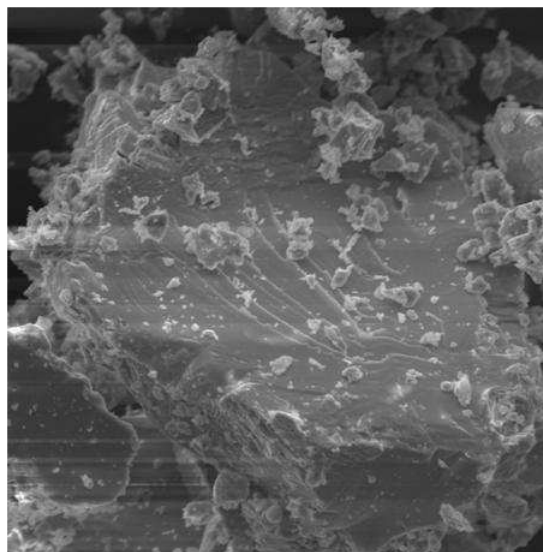
Sweetgum Ash & Soot Particles on KBr Matrix



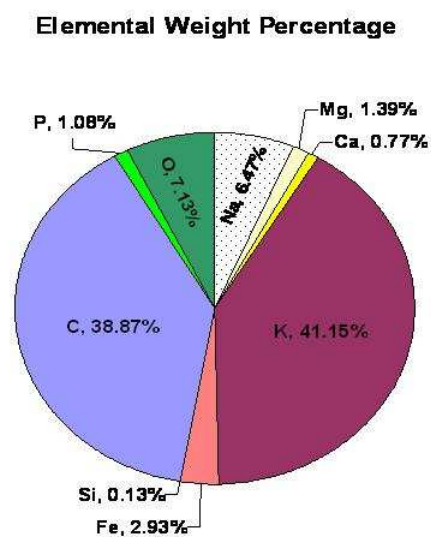
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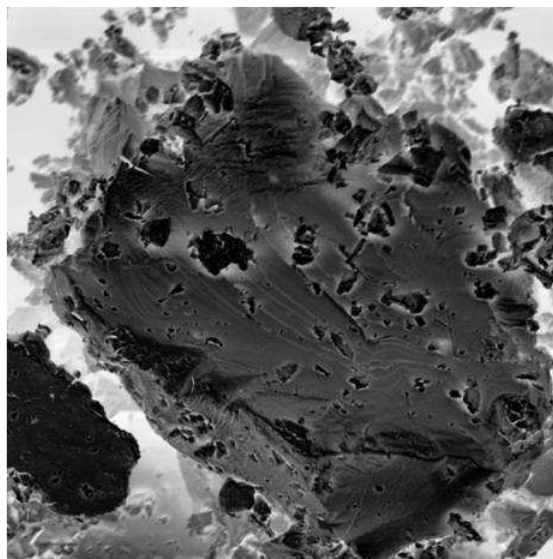
American Basswood Ash & Smoke Particles on KBr Matrix Image2



File Name: XVIII AmerBass 1000x3a

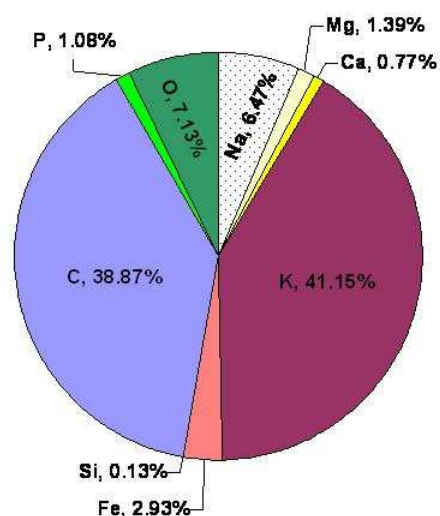


American Basswood Ash & Smoke Particles on KBr Matrix

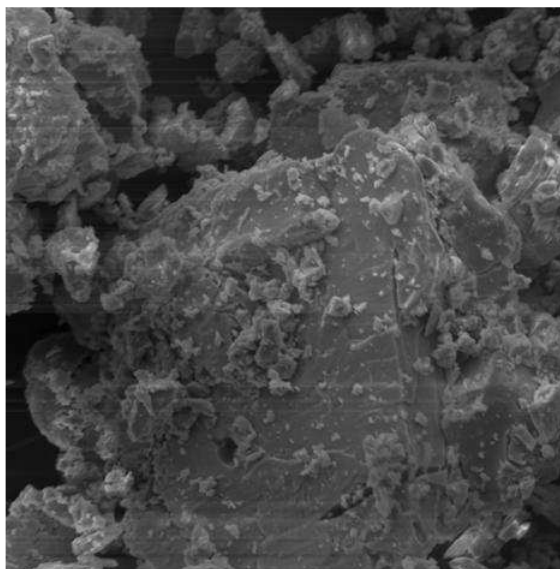


File Name: XVIII AmerBass 1000x3

Elemental Weight Percentage

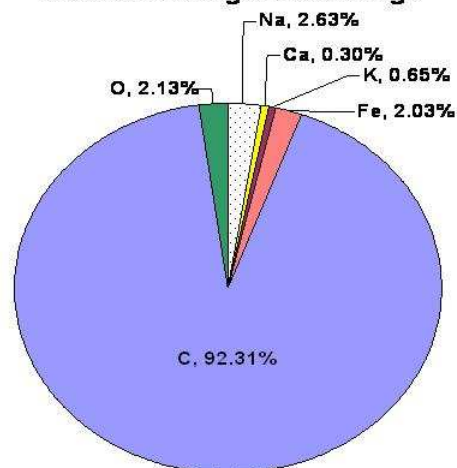


American Basswood Ash & Smoke Particles on KBr Matrix Image2

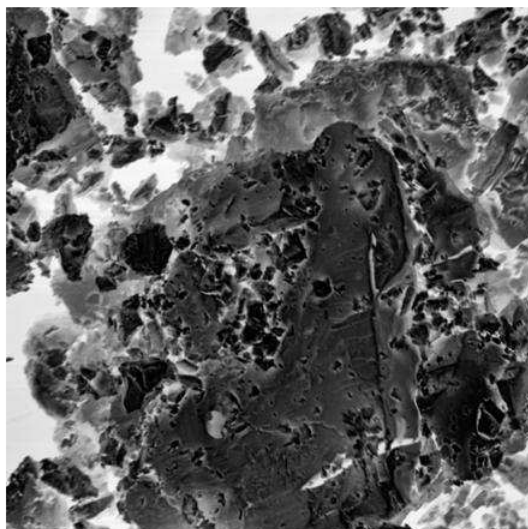


File Name: XVIII AmerBass 1000x2a

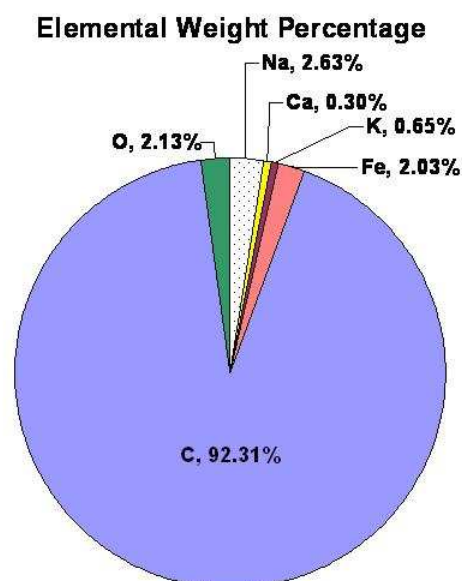
Elemental Weight Percentage



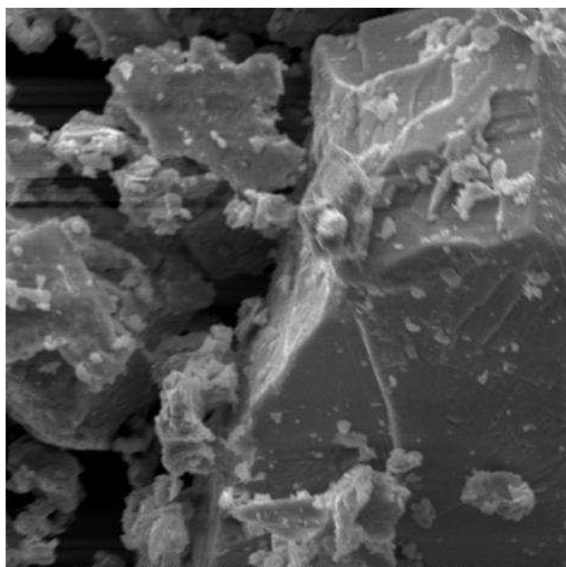
American Basswood Ash & Smoke Particles on KBr Matrix



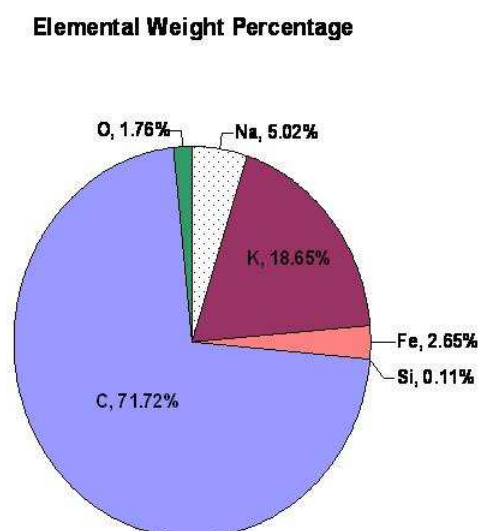
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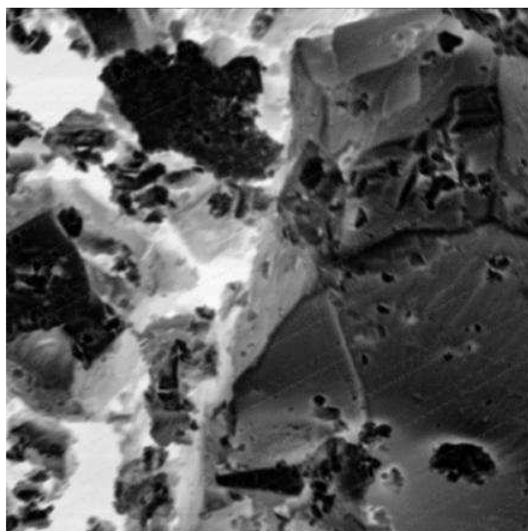
American Basswood Ash & Smoke Particles on KBr Matrix Image2



File Name: XVIII AmerBass 1000x1a

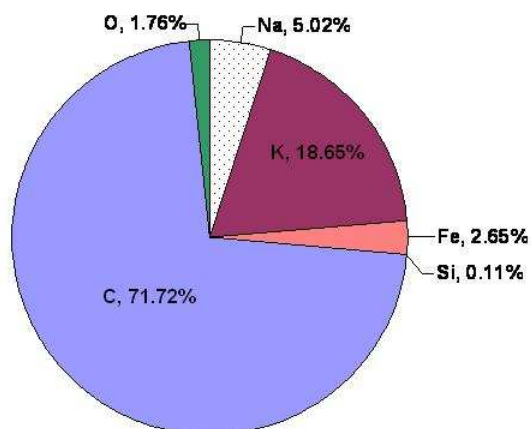


American Basswood Ash & Smoke Particles on KBr Matrix

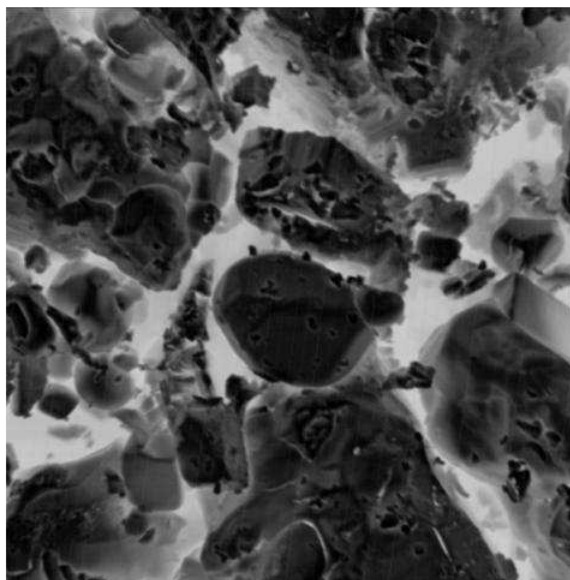


File Name: XVIII AmerBass 1000x1

Elemental Weight Percentage

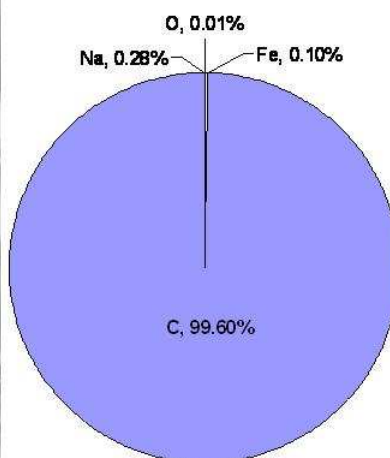


Red Oak Ash & Smoke Particles on KBr Matrix

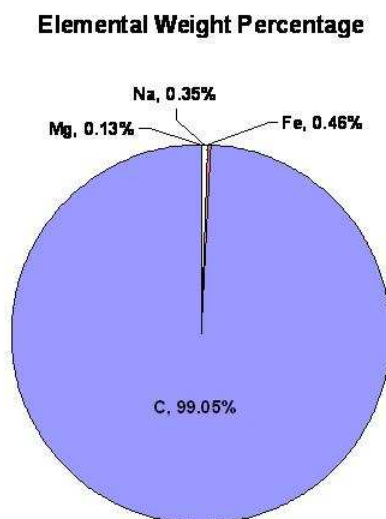
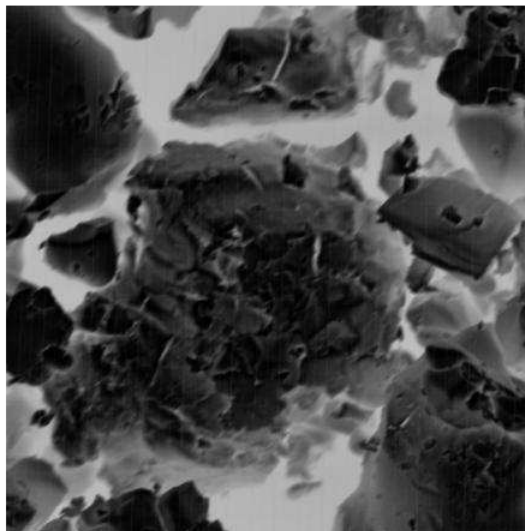


File Name: XVII Red Oak 1000x3

Elemental Weight Percentage

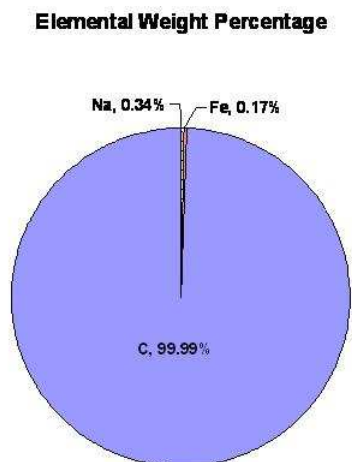
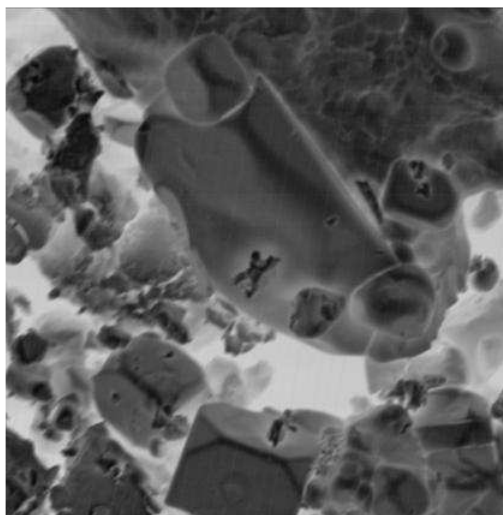


Red Oak Ash & Smoke Particles on KBr Matrix



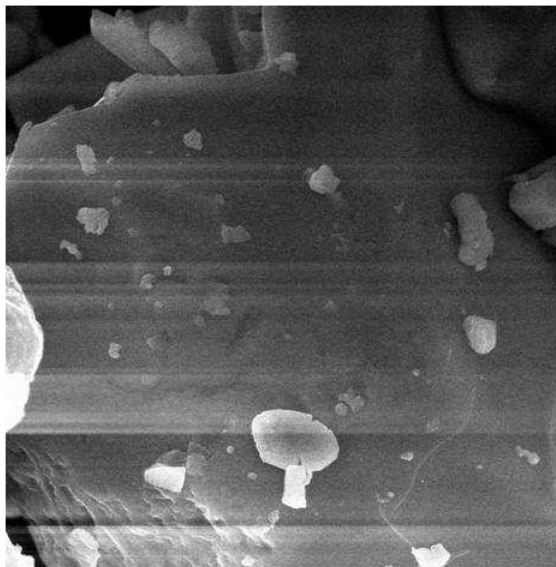
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Red Oak Ash & Smoke Particles on KBr Matrix



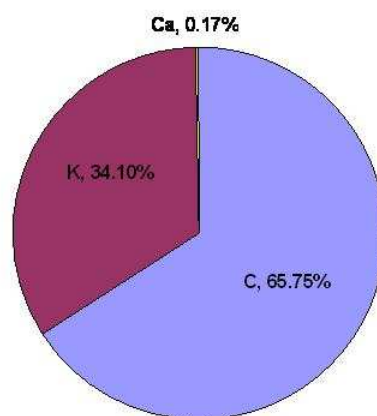
File Name: XVII Red Oak 1000x1

Maple Greenwood Ash & Smoke Particles on KBr Matrix

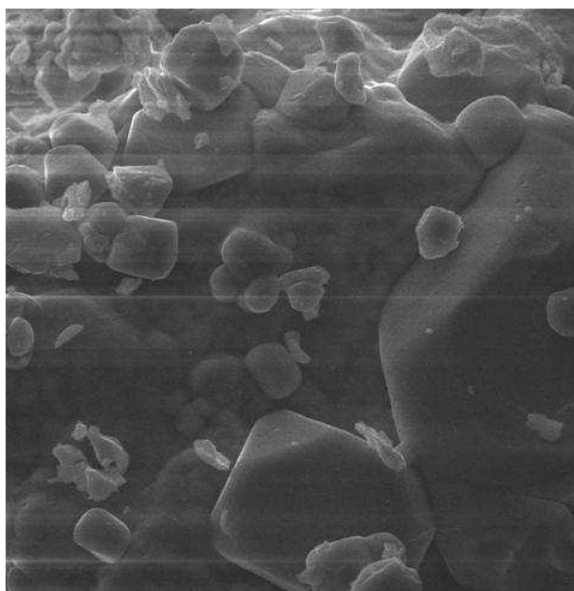


XVI Maple Carbon Coated 2000x3

Elemental Weight Percentage

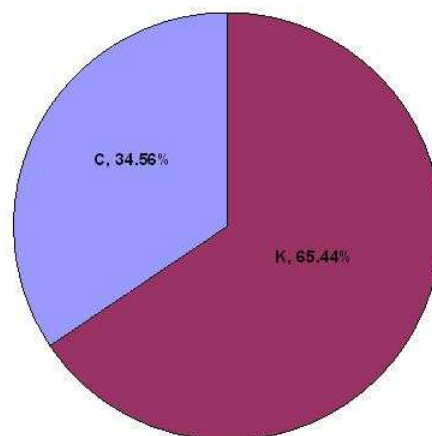


Maple Greenwood Ash & Smoke Particles on KBr Matrix

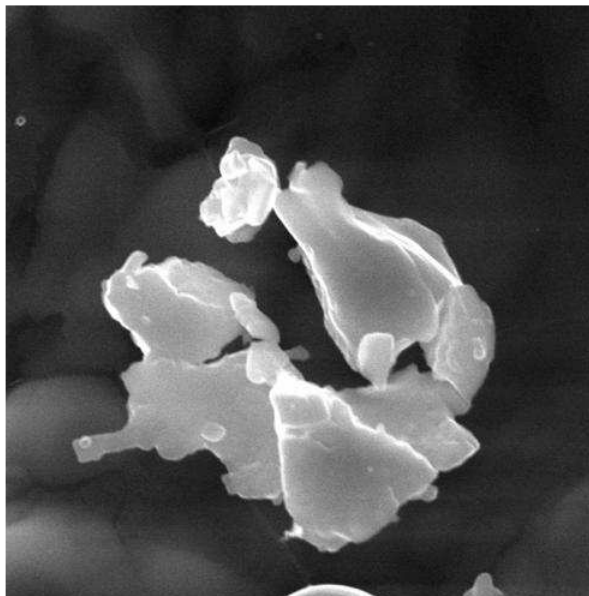


XVI Maple Carbon Coated 5000x

Elemental Weight Percentage

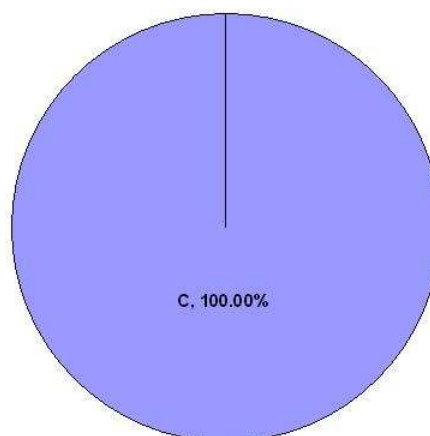


Maple Greenwood Ash & Smoke Particles on KBr Matrix

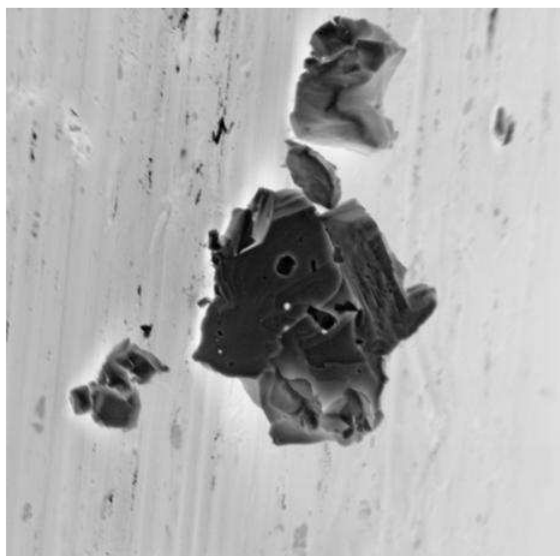


XVI Maple Carbon Coated 5000x2

Elemental Weight Percentage

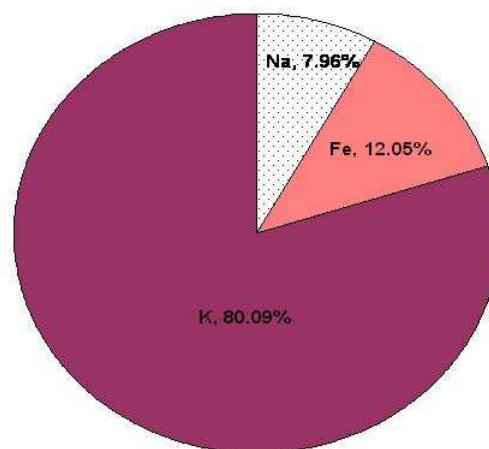


Birch Lumber Ash & Smoke Particles on KBr Matrix

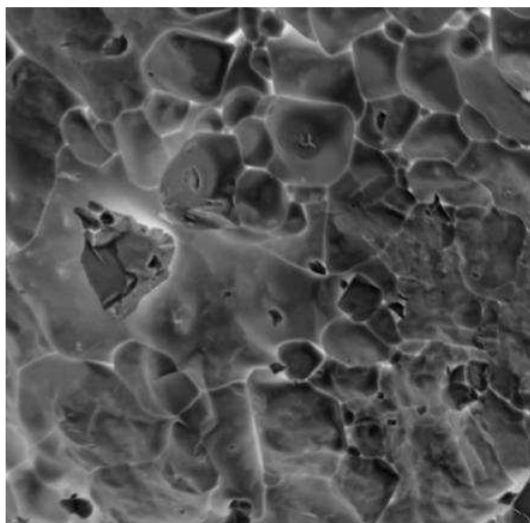


File Name: V Birch Lumber 1000x4

Elemental Weight Percentage

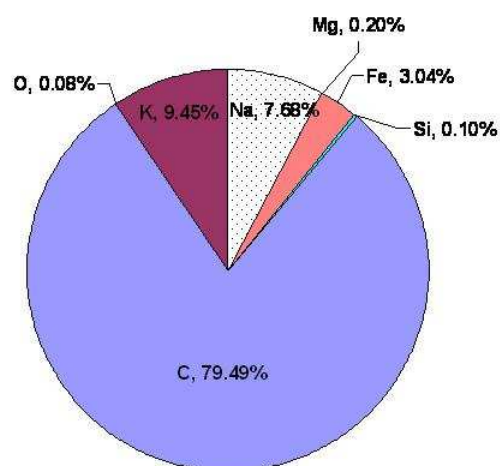


Birch Lumber Ash & Smoke Particles on KBr Matrix

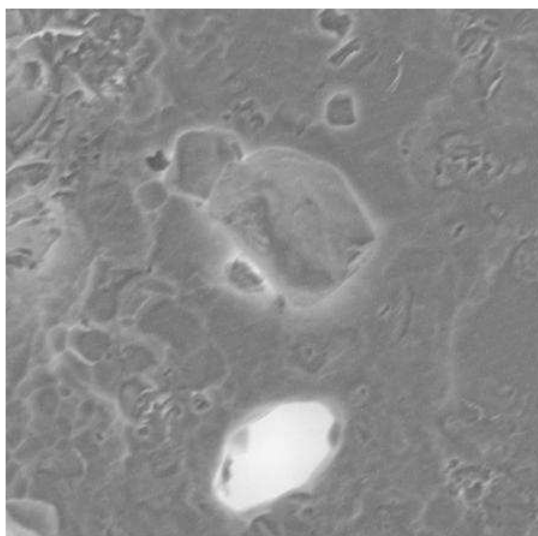


File Name: V Birch Lumber 1000x3

Elemental Weight Percentage

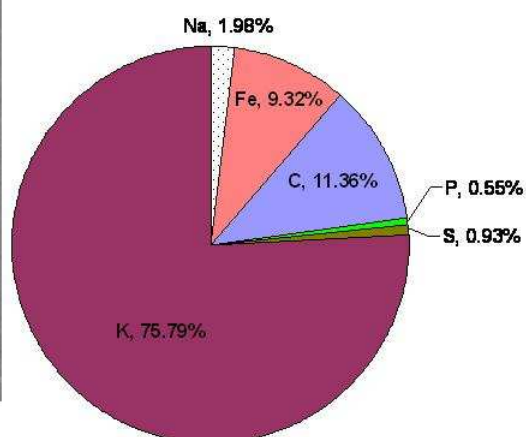


Birch Lumber Ash & Smoke Particles on KBr Matrix

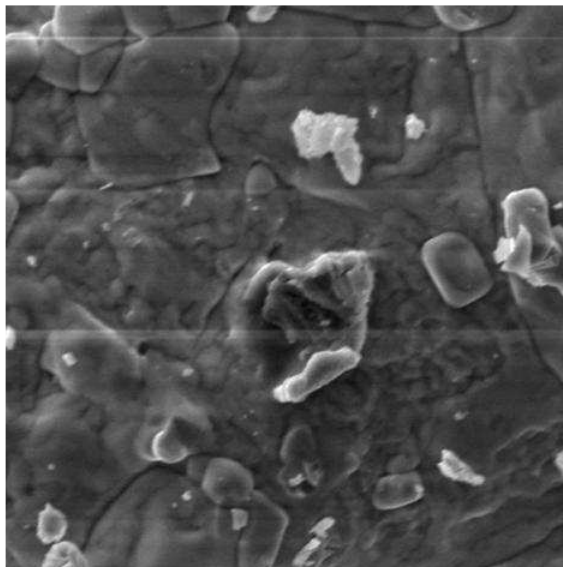


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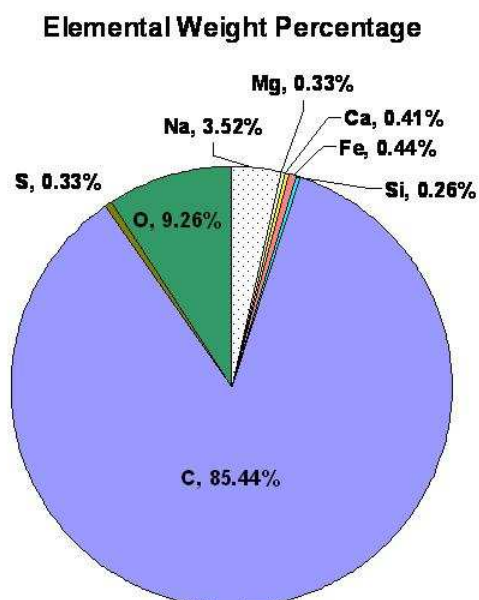
Elemental Weight Percentage



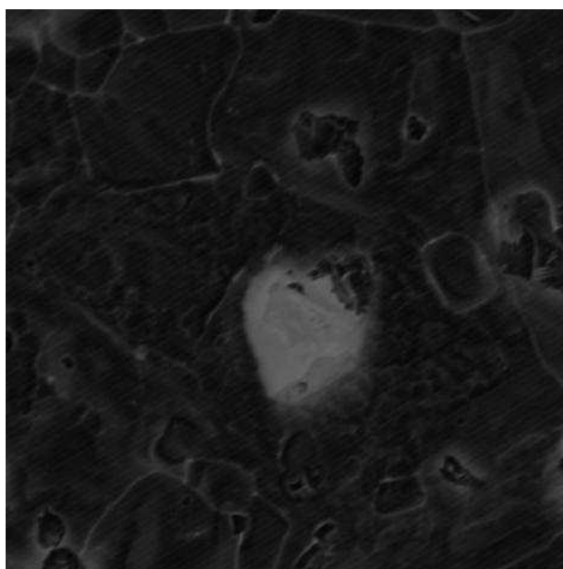
Birch Lumber Ash & Smoke Particles on KBr Matrix



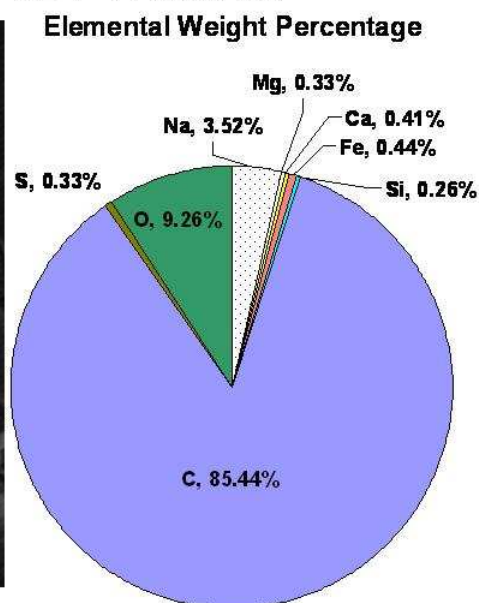
File Name: V Birch Lumber 1000x1a



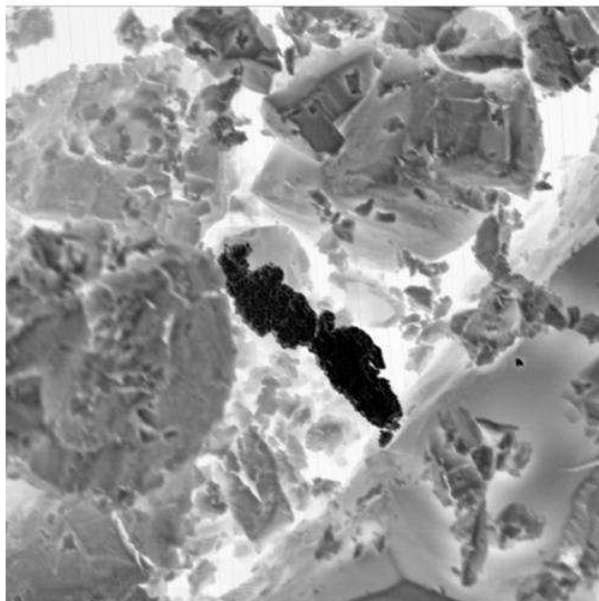
Birch Lumber Ash & Smoke Particles on KBr Matrix



File Name: V Birch Lumber 1000x1

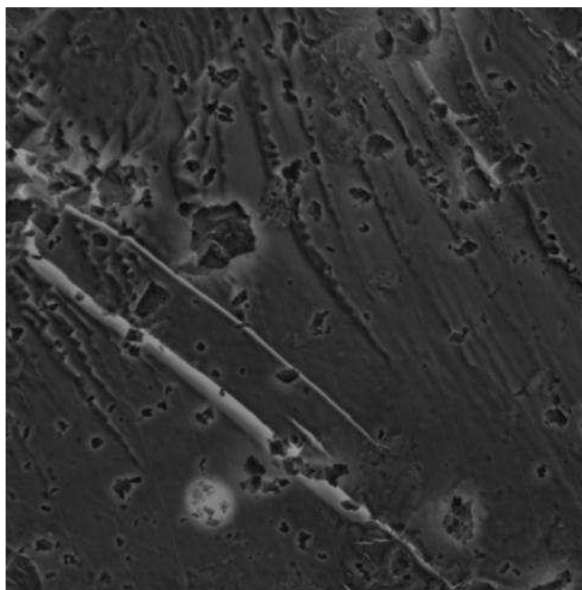


White Oak Lumber Ash & Smoke Particles



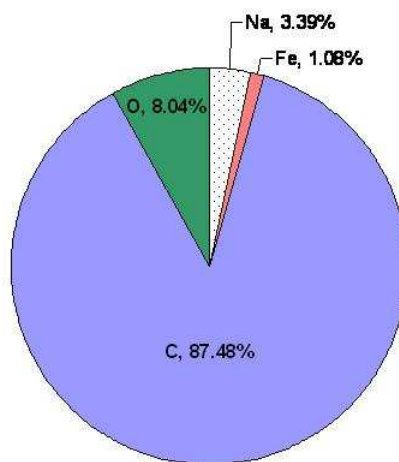
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White Oak Lumber Ash & Smoke Particles

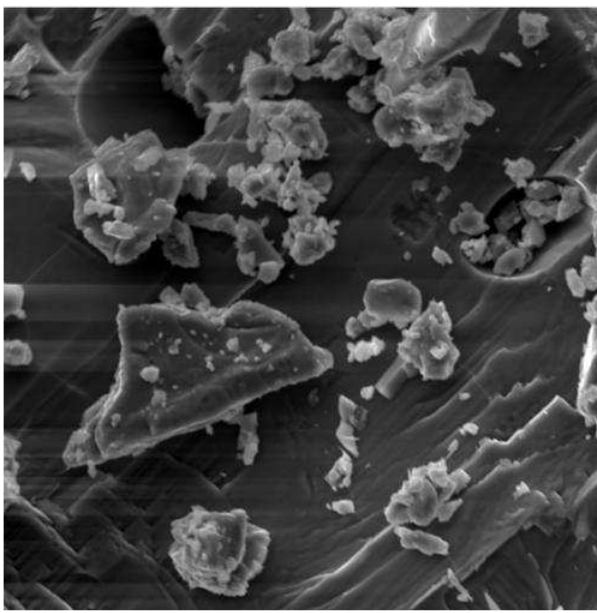


File Name: IV WhiteOak Greenwood 1000x3

Elemental Weight Percentage

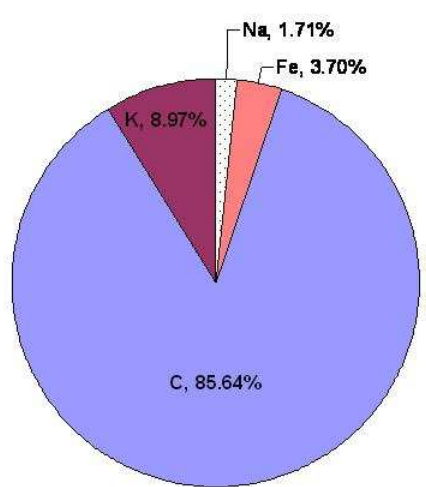


White Oak Lumber Ash & Smoke Particles

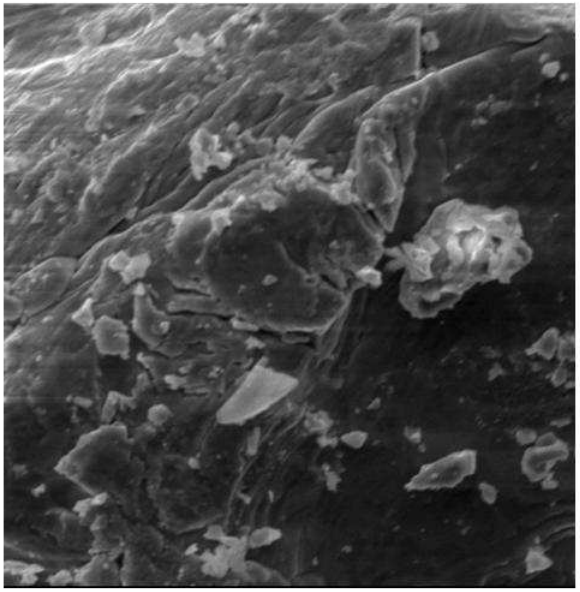


File Name: IV WhiteOak Greenwood 1000x2a

Elemental Weight Percentage

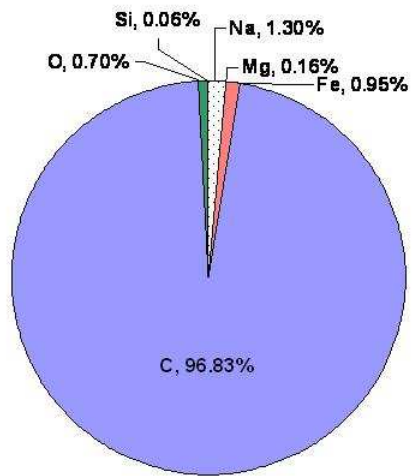


White Oak Lumber Ash & Smoke Particles

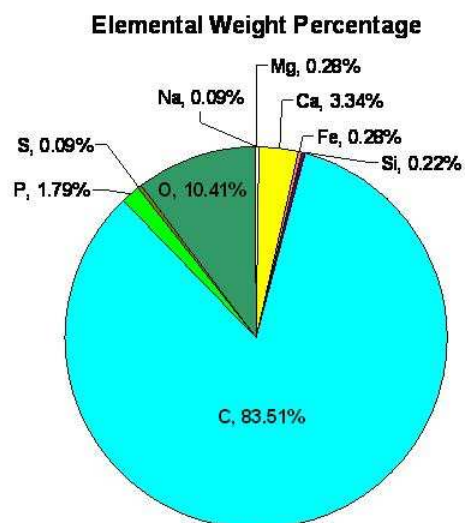
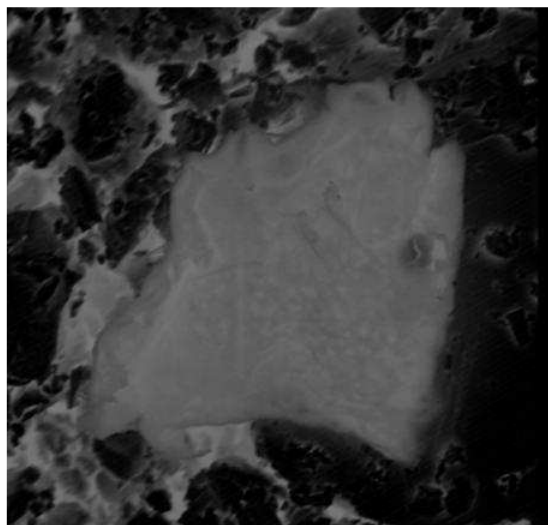


File Name: IV WhiteOak Greenwood 1000x1a

Elemental Weight Percentage

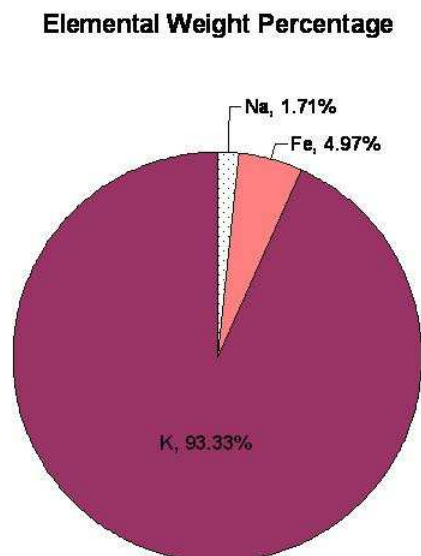
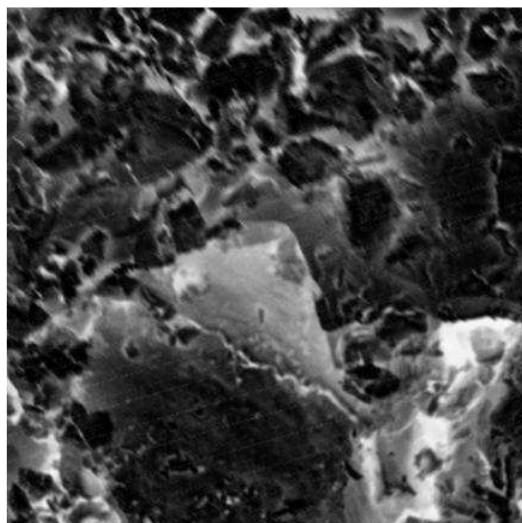


Cherry Wood Lumber Ash & Smoke Particles



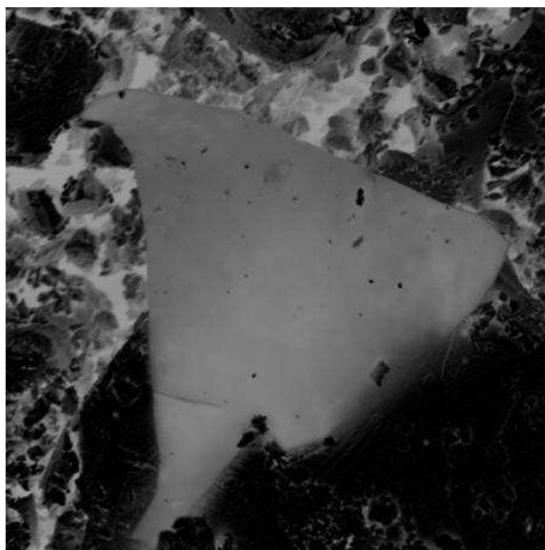
File Name: IV Cherry wood Lumber 1000x3

Cherry Wood Lumber Ash & Smoke Particles

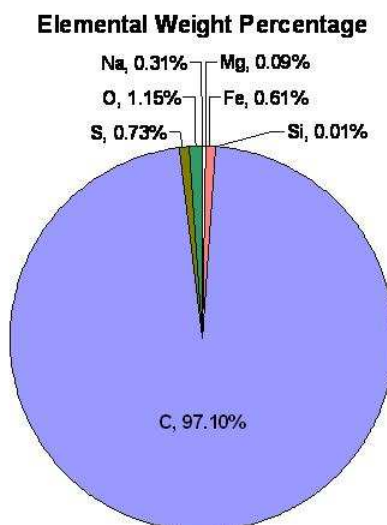


File Name: IV Cherry wood Lumber 1000x1a

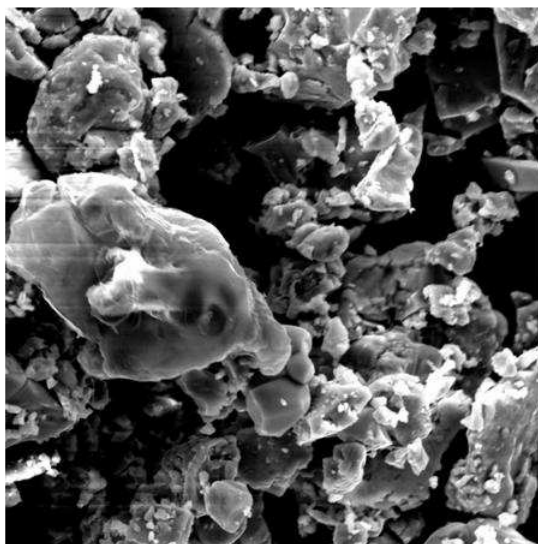
Cherry Wood Lumber Ash & Smoke Particles



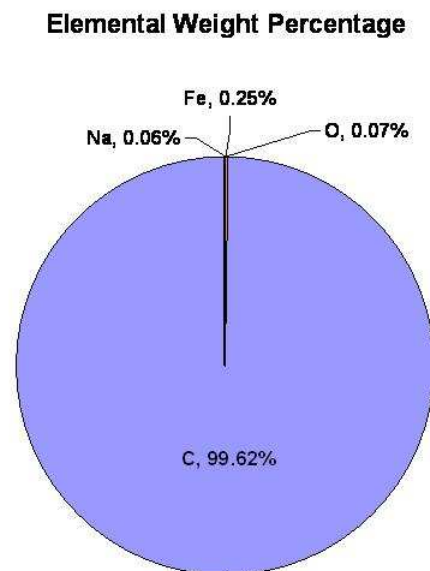
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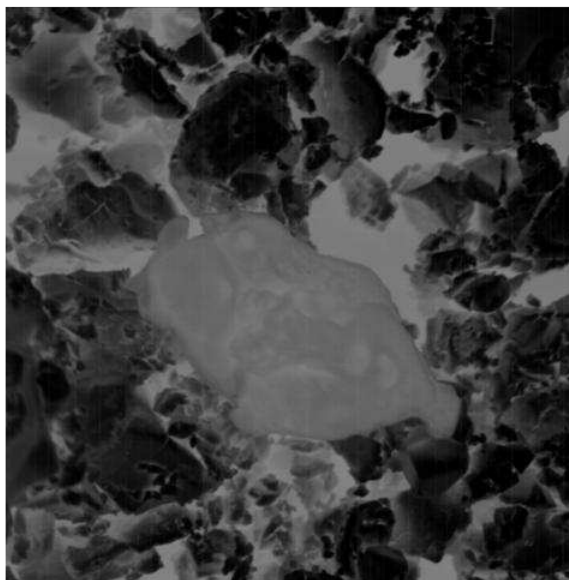
White Oak Greenwood Ash & Smoke Particles



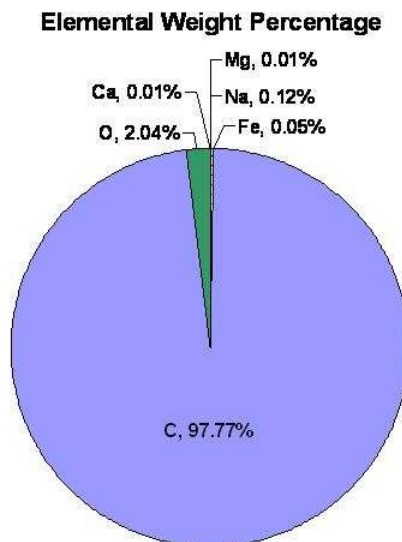
File Name: XX WhiteOak Greenwood 1000x3a



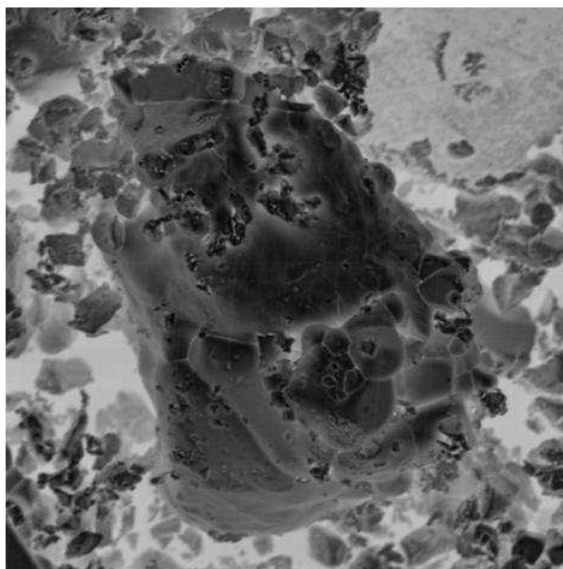
White Oak Greenwood Ash & Smoke Particles



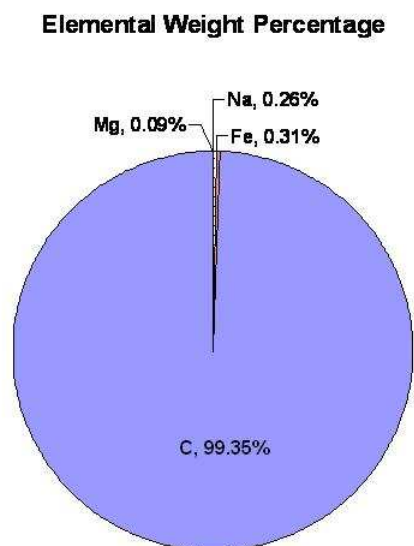
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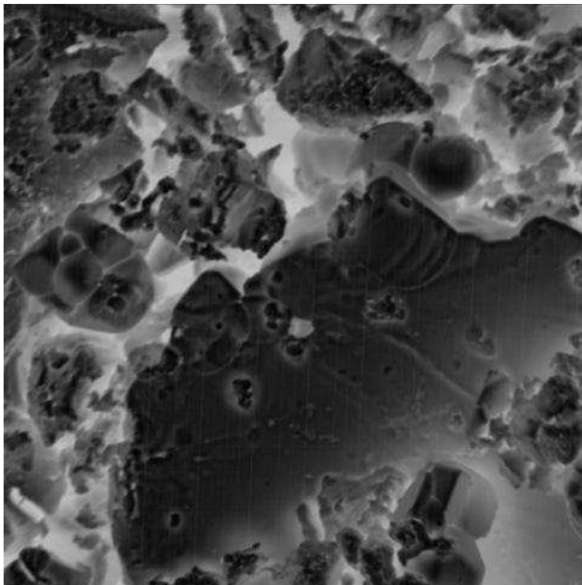
White Oak Greenwood Ash & Smoke Particles



File Name: XX WhiteOak Greenwood 1000x2

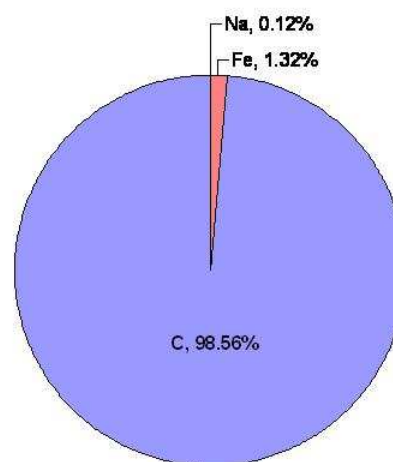


White Oak Greenwood Ash & Smoke Particles

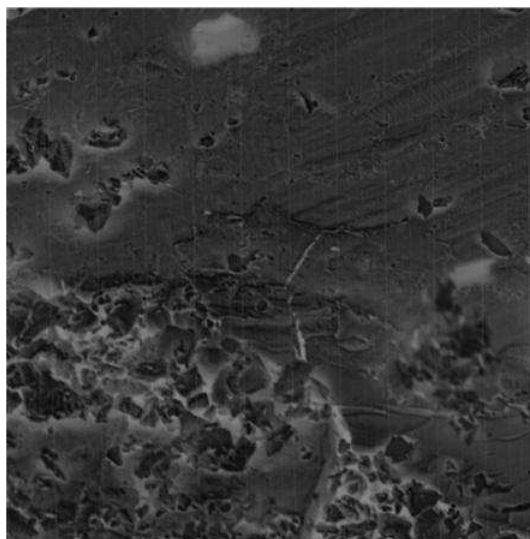


File Name: XX WhiteOak Greenwood 1000x1

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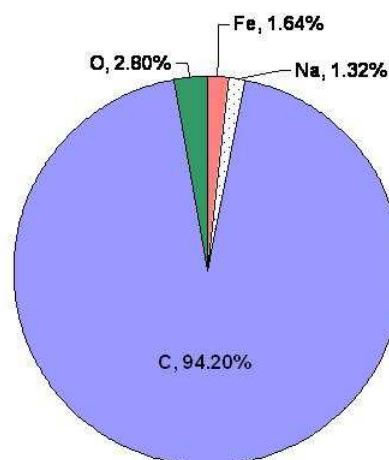


Pine Greenwood Ash & Smoke Particulates

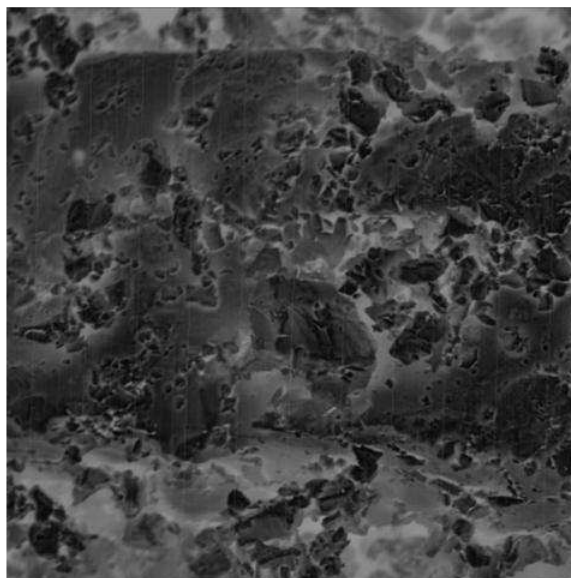


File Name: XXI Pine Greenwood Backscatter 500x3

Elemental Weight Percentage

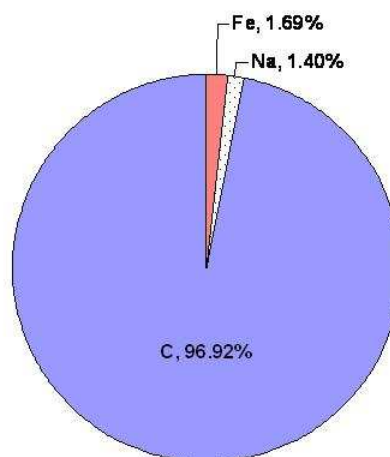


Pine Greenwood Ash & Smoke Particulates

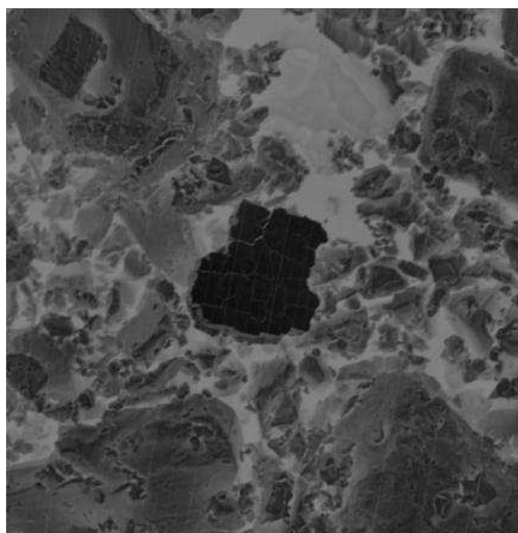


File Name: XXI Pine Greenwood Backscatter 500x2

Elemental Weight Percentage

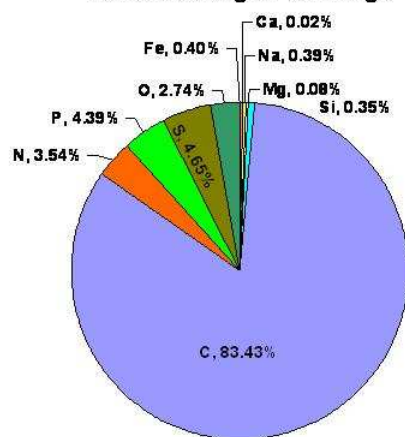


Pine Greenwood Ash & Smoke Particulates

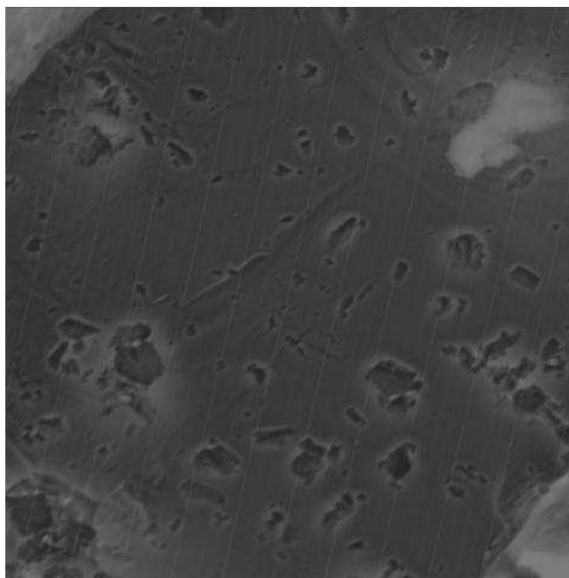


File Name: XXI Pine Greenwood Backscatter 500x1

Elemental Weight Percentage

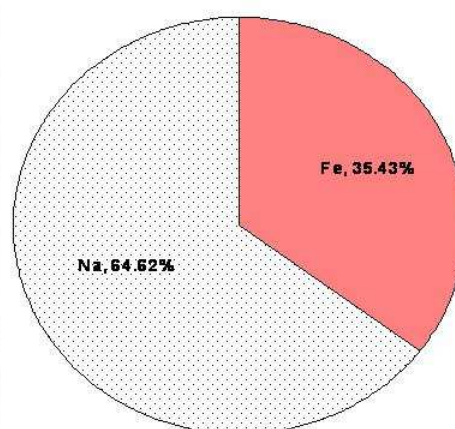


Ash Wood Ash & Smoke Particles on KBr Matrix

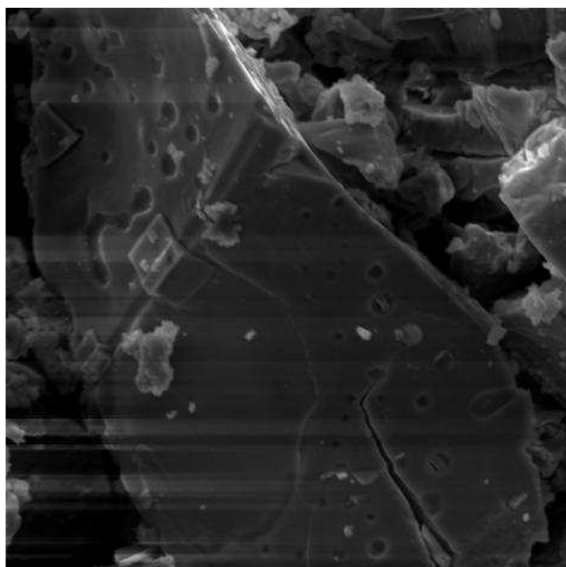


File Name: XXII Ash Backscatter 1000x2

Elemental Weight Percentage

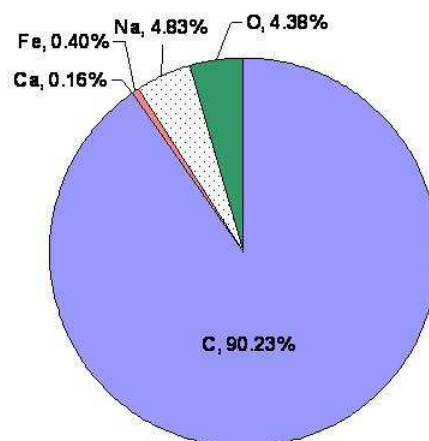


Ash Wood Ash & Smoke Particles on KBr Matrix

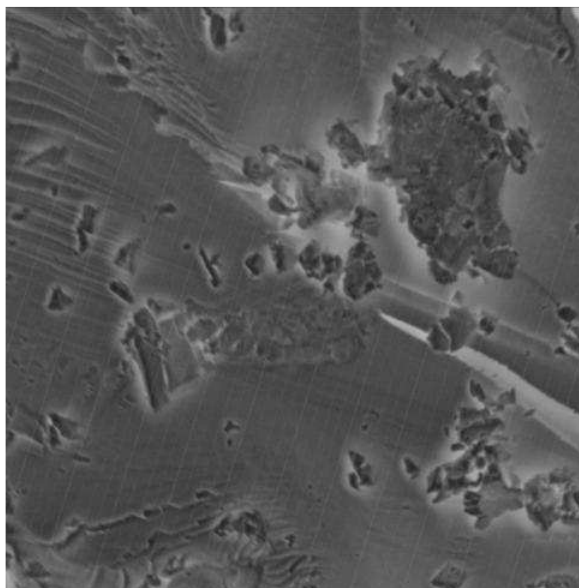


File Name: XXII Ash Backscatter 1000x1

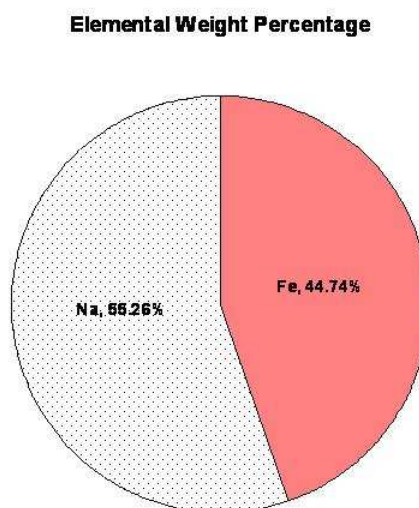
Elemental Weight Percentage



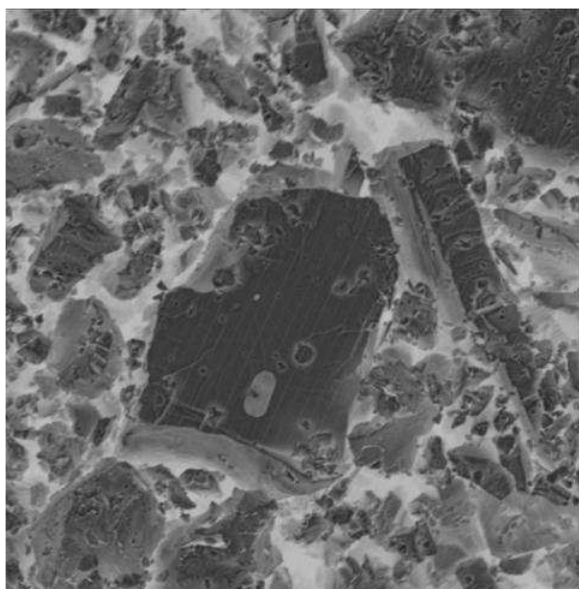
Ash Wood Ash & Smoke Particles on KBr Matrix



File Name: XXII Ash Backscatter 500x2

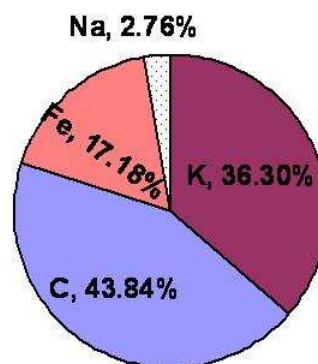


Ash Wood Ash & Smoke Particles on KBr Matrix

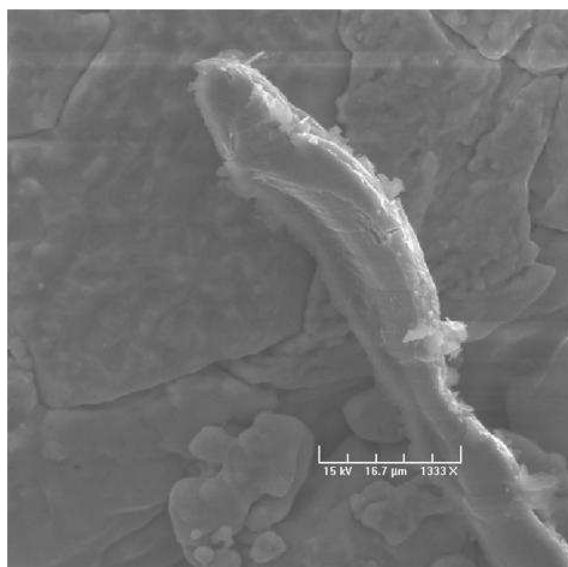


File Name: XXII Ash Backscatter 500x1

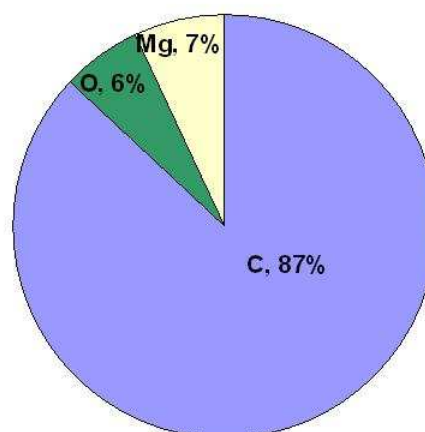
Elemental Weight Percentage



Grass Smoke Cluster on KBr Matrix

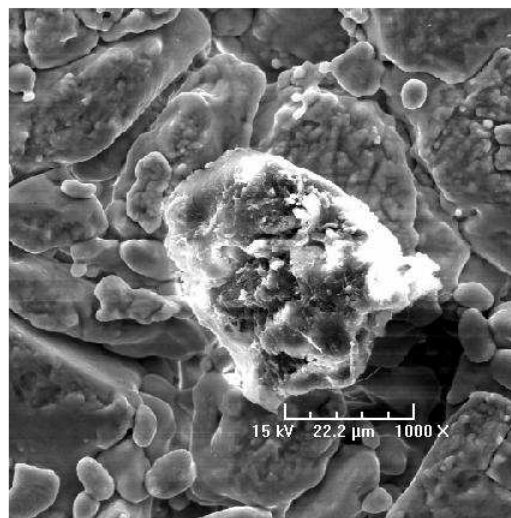


Weight Percentage of Elements

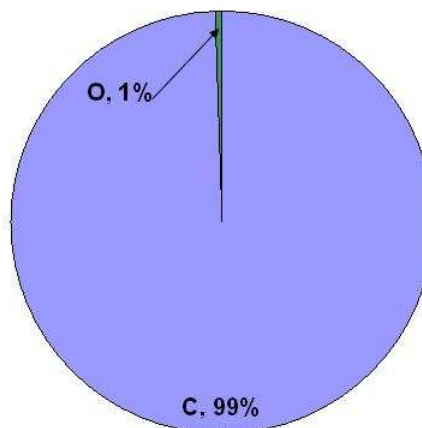


File Name: 060705c

Grass Ash Particle on KBr Matrix

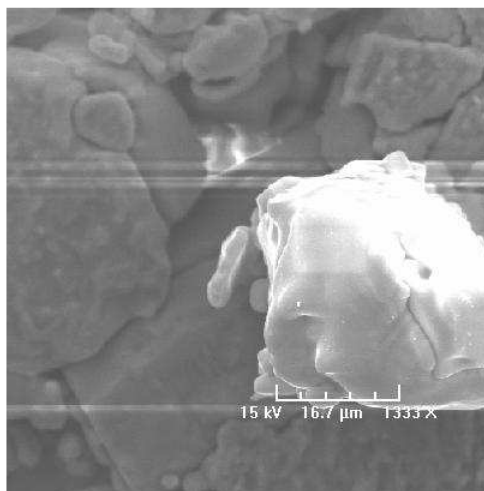


Weight Percent of Elements

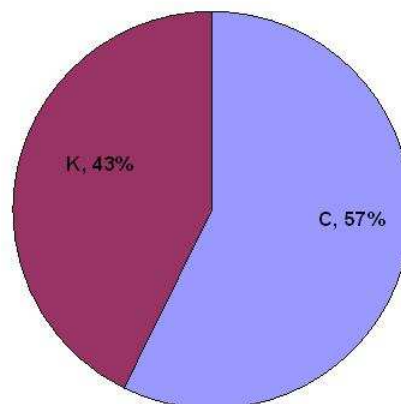


File Name: 060705a

Grass Smoke Particle on KBr Matrix

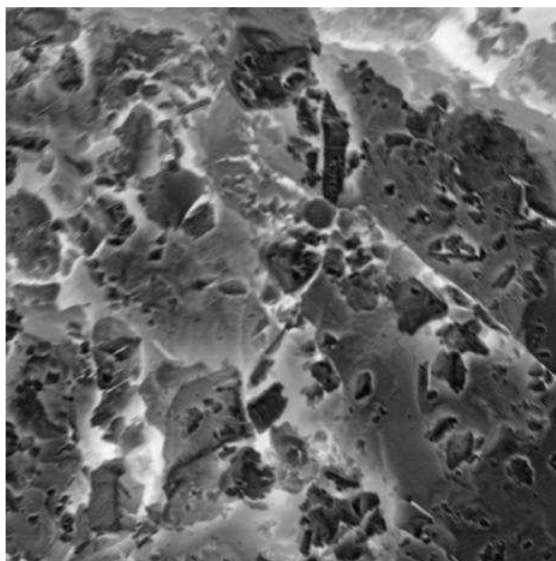


Weight Percent for Elements

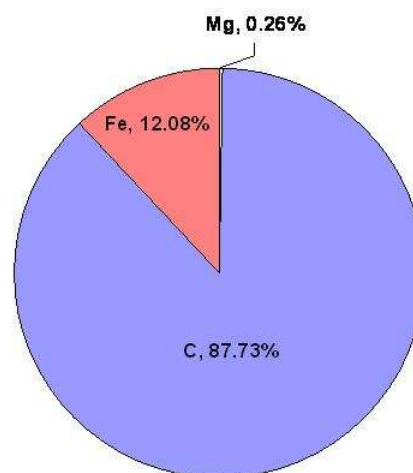


File Name: 060705b

Maple Greenwood Ash & Smoke Particles on KBr Matrix

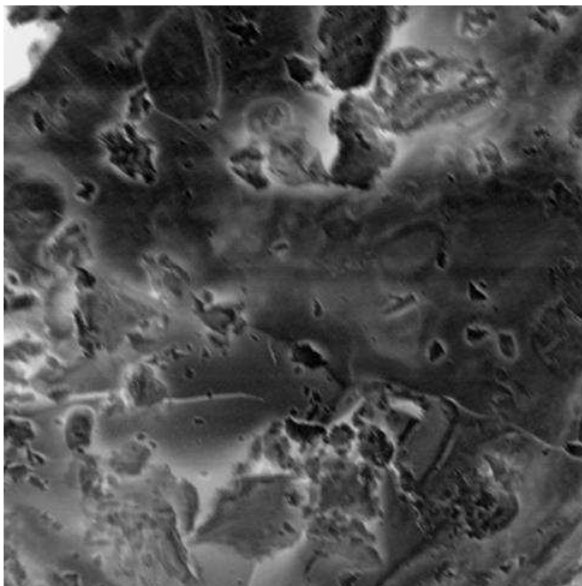


Elemental Weight Percentage



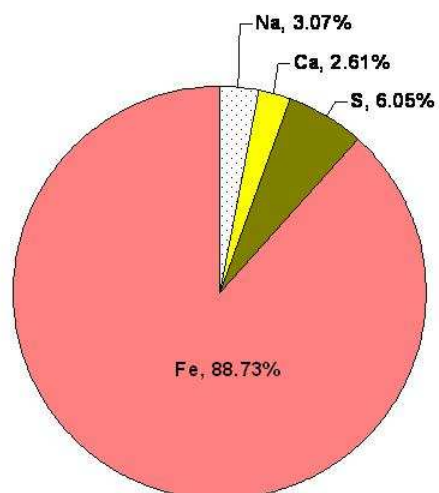
File Name: GC XVI Maple 500x3

Maple Greenwood Ash & Smoke Particles on KBr Matrix

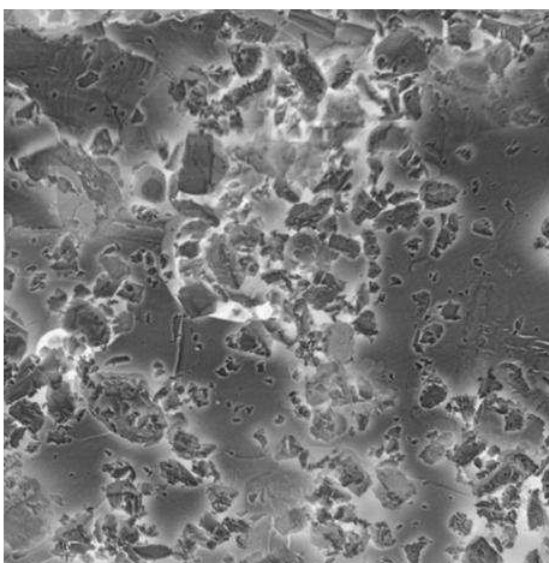


File Name: GC XVI Maple 500x2

Elemental Weight Percentage

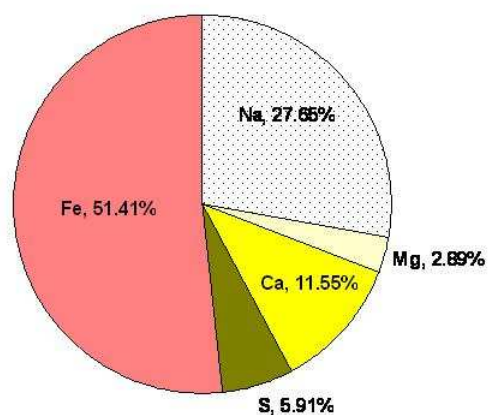


Maple Greenwood Ash & Smoke Particles on KBr Matrix

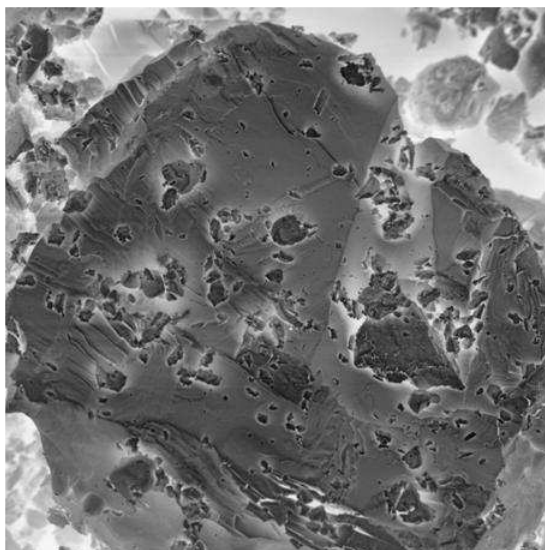


File Name: GC XVI Maple 500x1

Elemental Weight Percentage

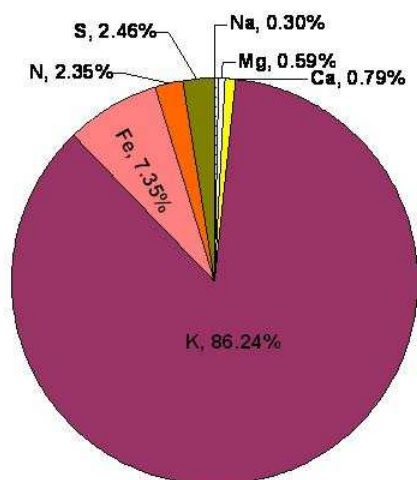


White Oak Greenwood Ash & Smoke Particles on a KBr Matrix

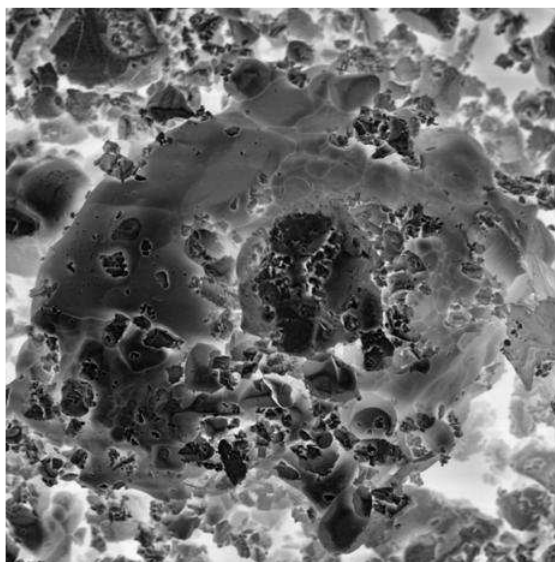


File Name: GC XX White Oak greenwood 500x3

Elemental Weight Percentage

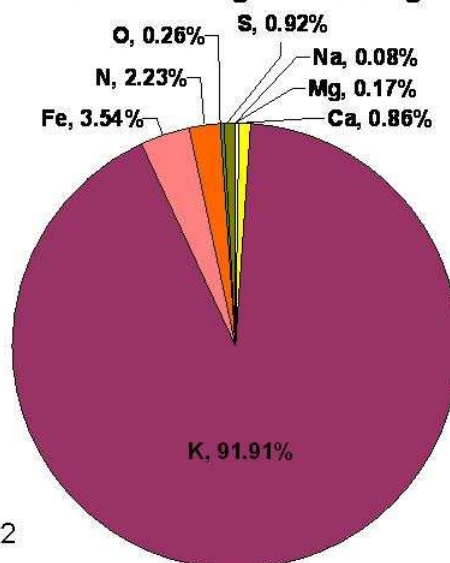


White Oak Greenwood Ash & Smoke Particles on a KBr Matrix

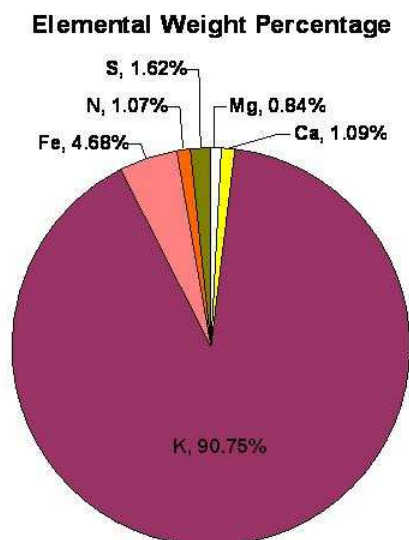
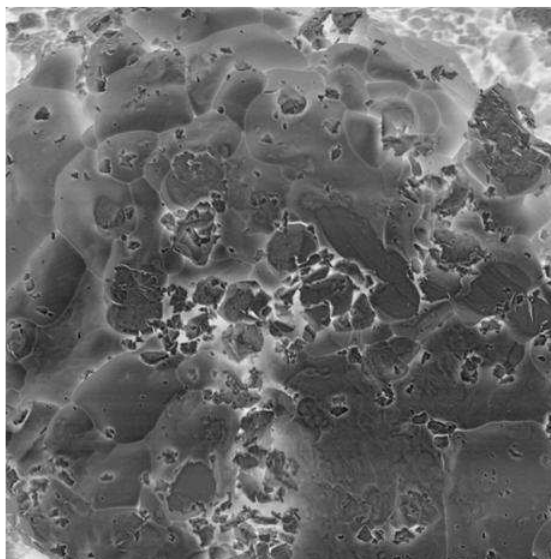


File Name: GC XX White Oak greenwood 500x2

Elemental Weight Percentage

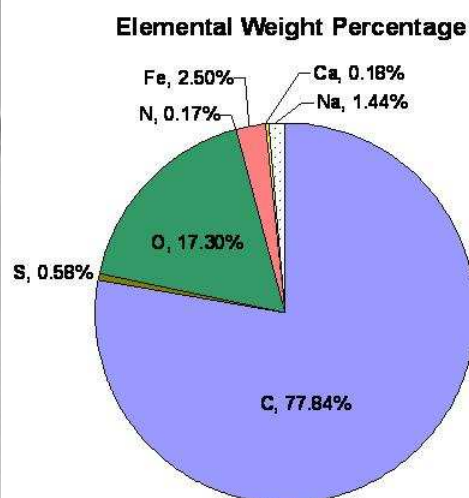
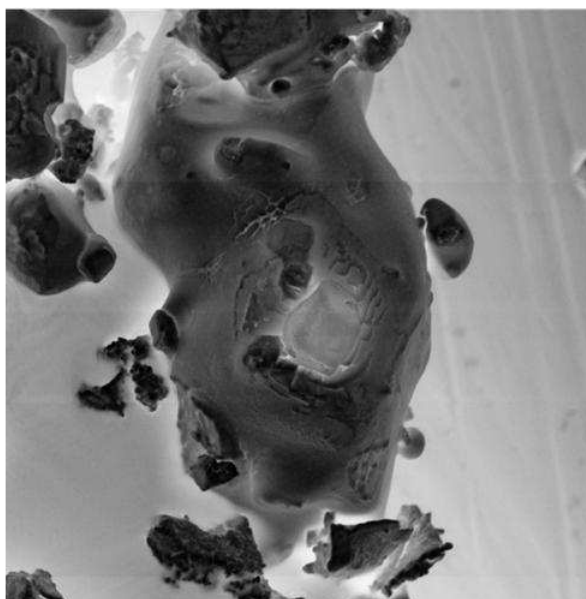


White Oak Greenwood Ash & Smoke Particles on a KBr Matrix



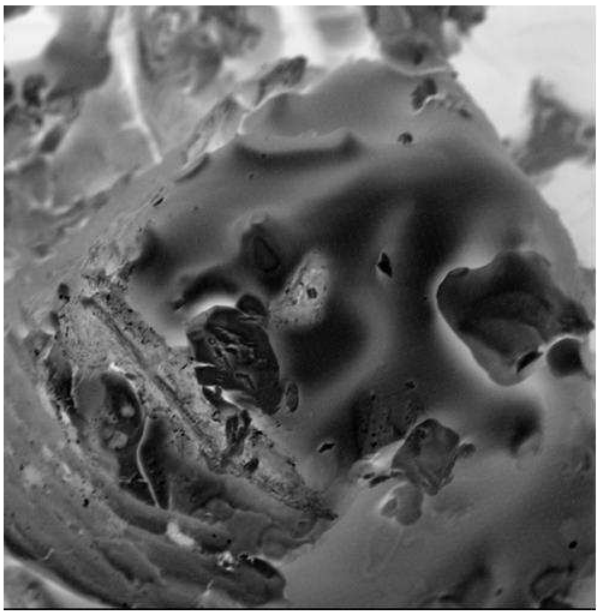
File Name: GC XX White Oak greenwood 500x1

Sweetgum Greenwood ash & Smoke Particles

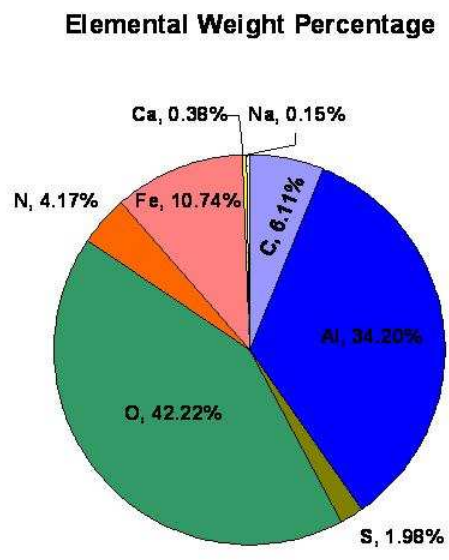


File Name: XV Sweetgum GW 1000x3

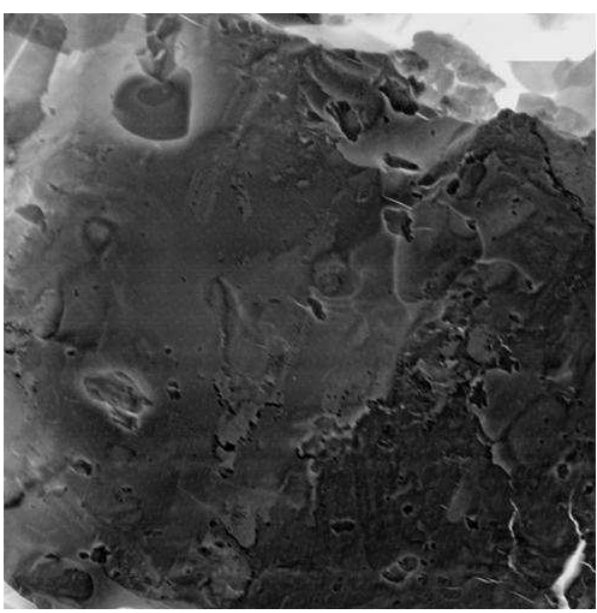
Sweetgum Greenwood ash & Smoke Particles



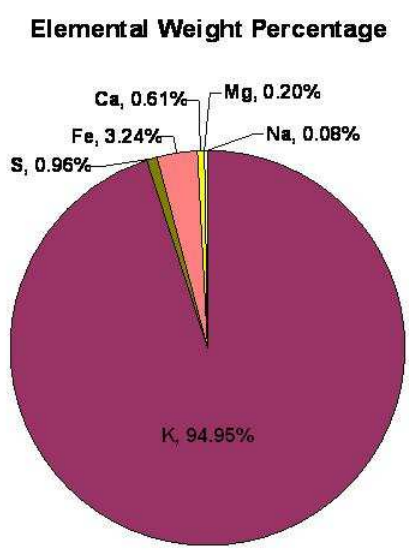
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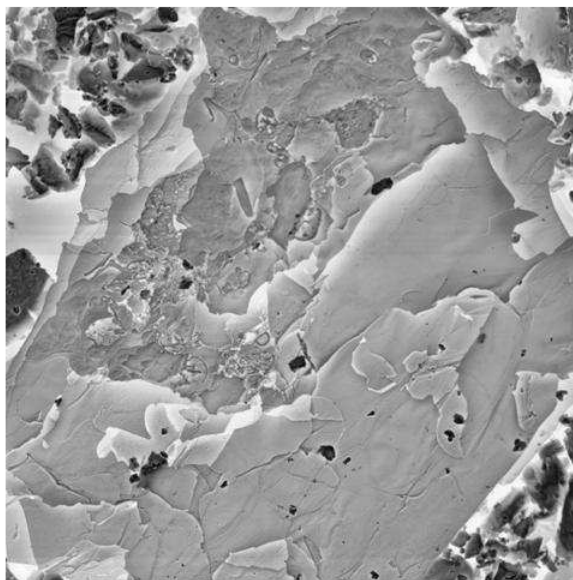
Sweetgum Greenwood ash & Smoke Particles



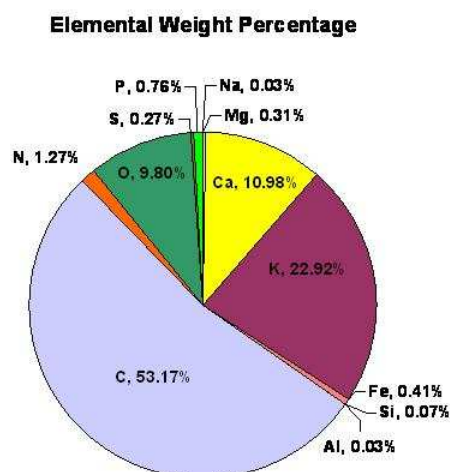
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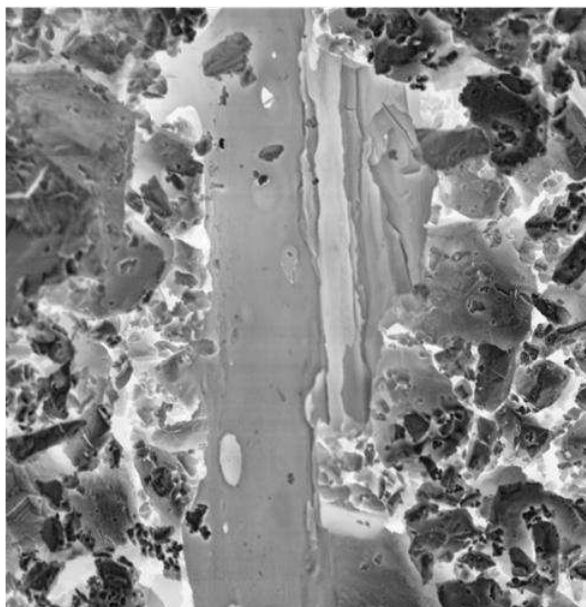
Pine Greenwood Ash & Smoke Particles on KBr Matrix



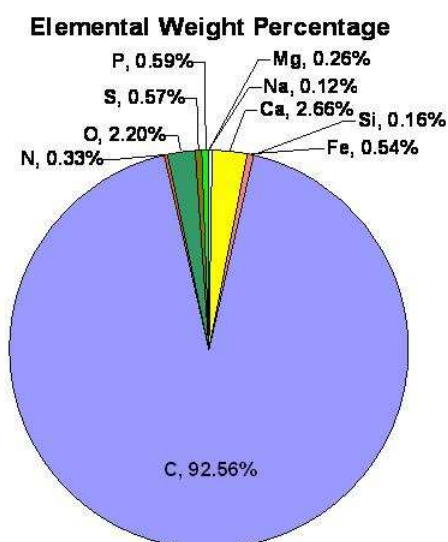
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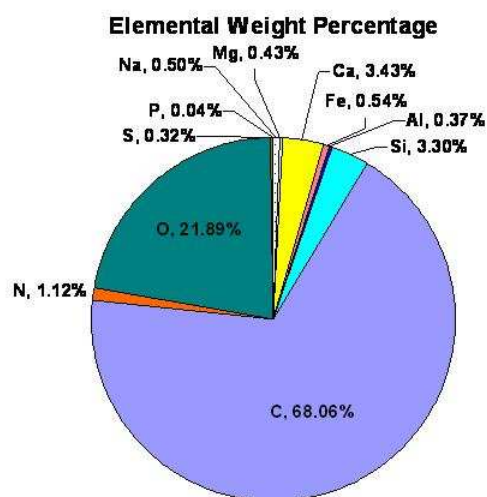
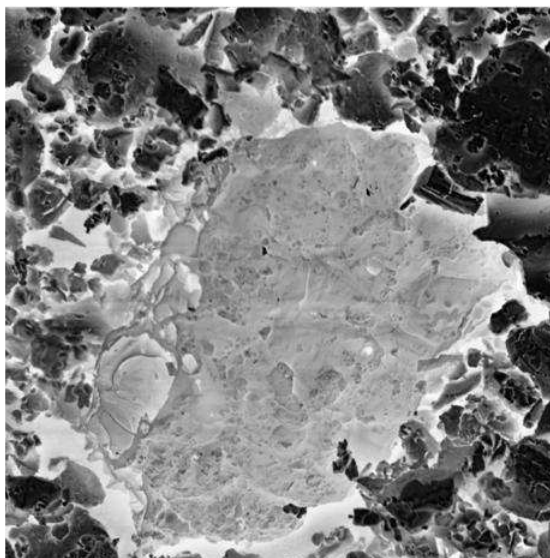
Pine Greenwood Ash & Smoke Particles on KBr Matrix



File Name: GC XXI Pine Greenwood 500x2

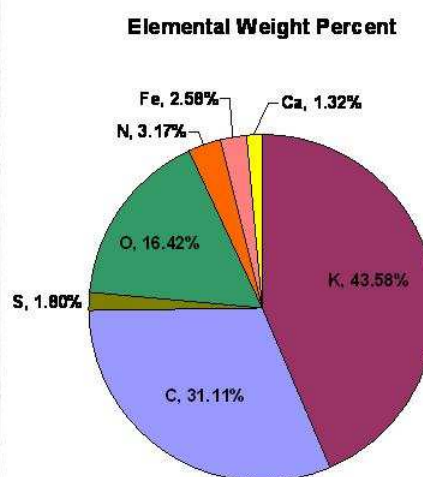
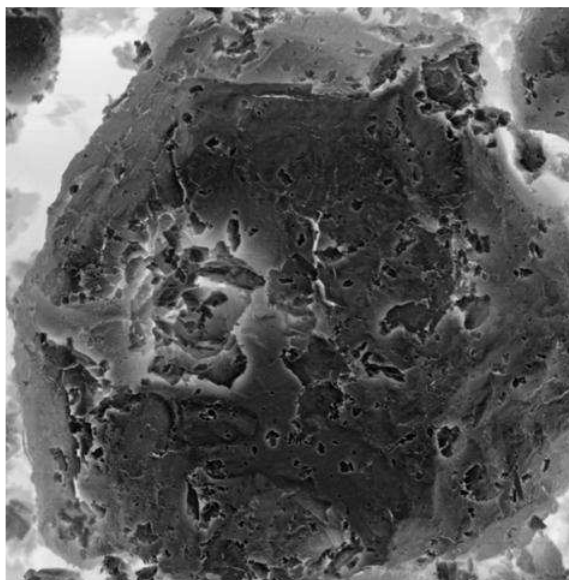


Pine Greenwood Ash & Smoke Particles on KBr Matrix



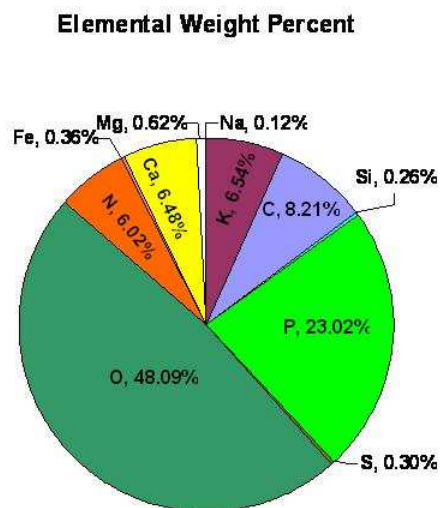
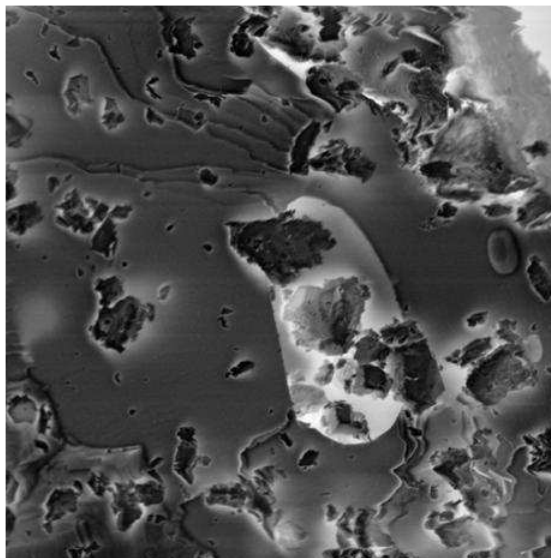
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American Bass Wood Ash & Soot Particles on KBr Matrix



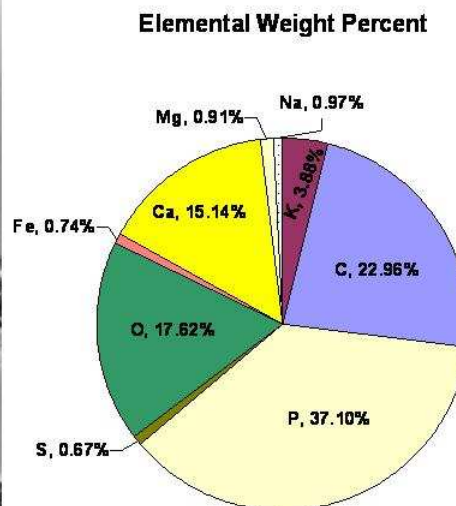
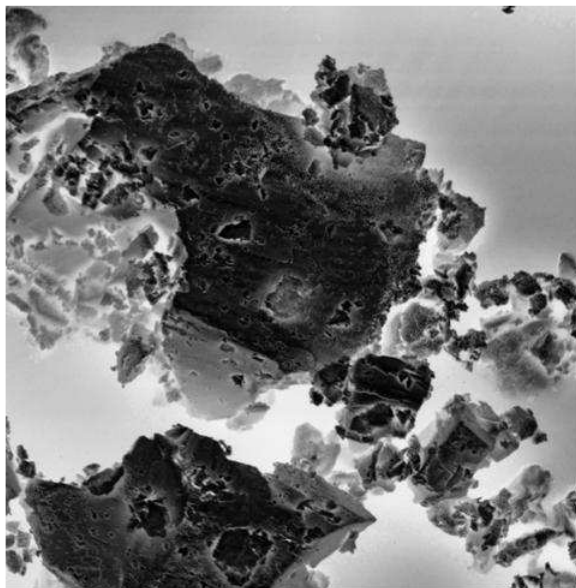
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American Bass Wood Ash & Soot Particles on KBr Matrix



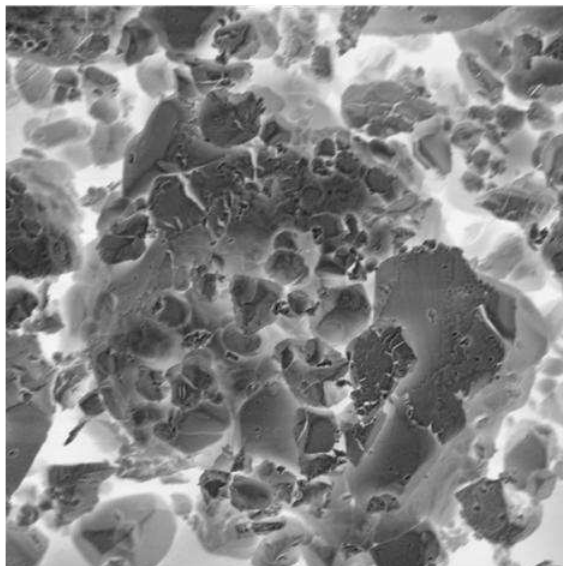
File Name: GC XVIII AmerBass GW 1000x2

American Bass Wood Ash & Soot Particles on KBr Matrix

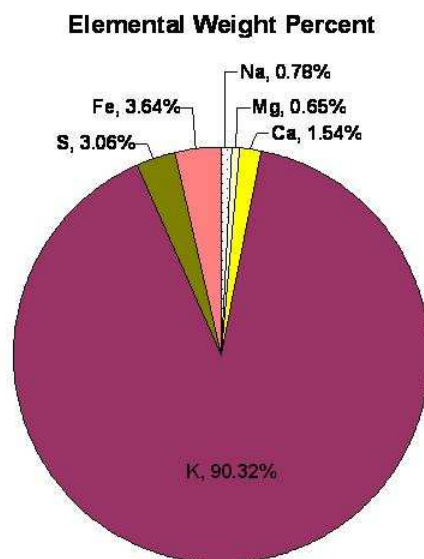


File Name: GC XVIII AmerBass GW 1000x1

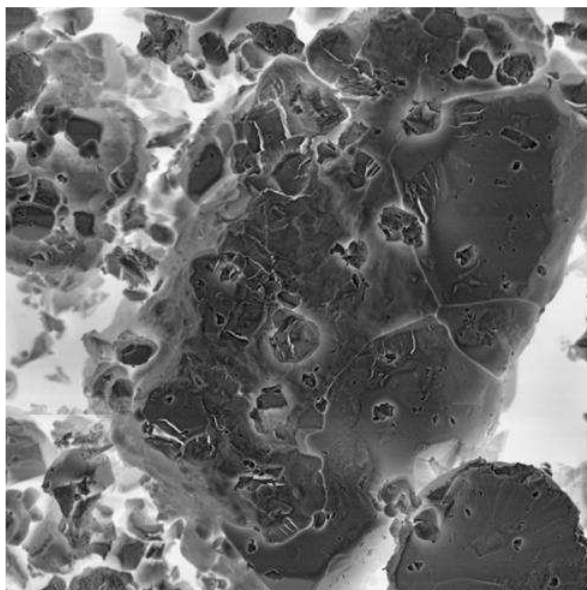
Red Oak Lumber Ash & Soot Particles on KBr Matrix



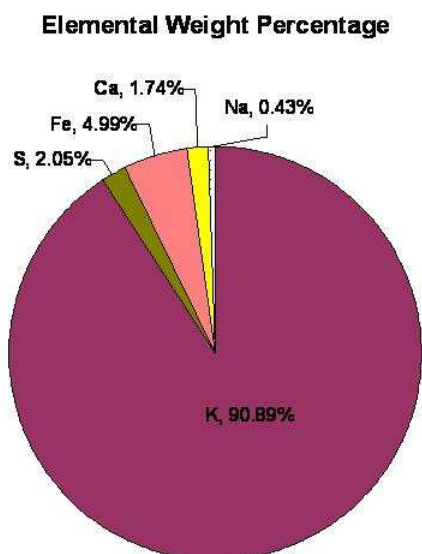
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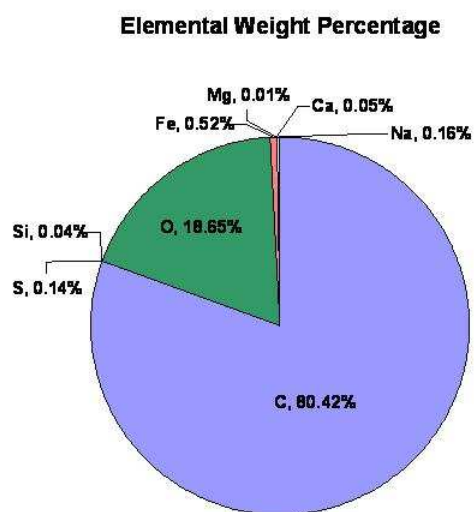
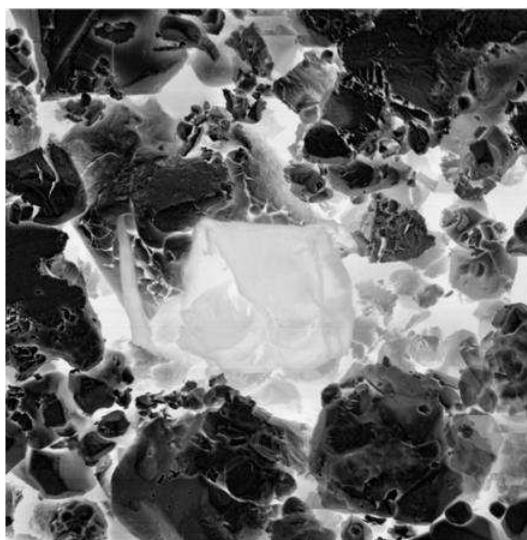
Red Oak Lumber Ash & Soot Particles on KBr Matrix



File Name: GC XVII RedOak 500x2

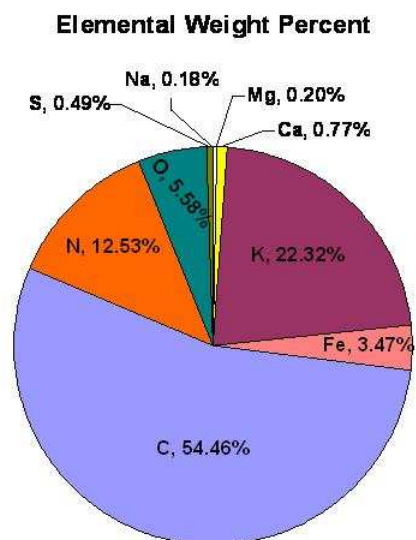
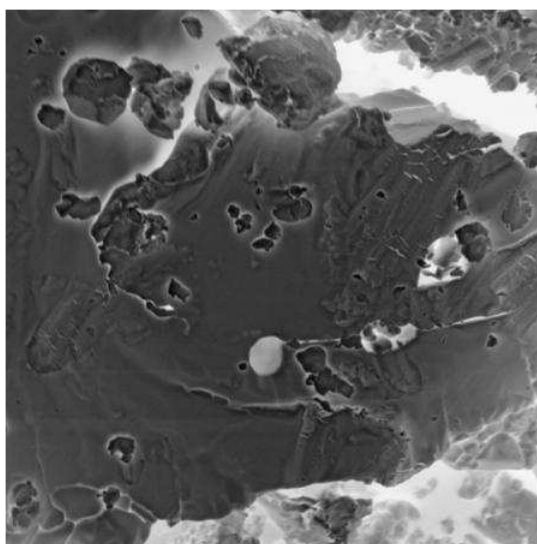


Red Oak Lumber Ash & Soot Particles on KBr Matrix



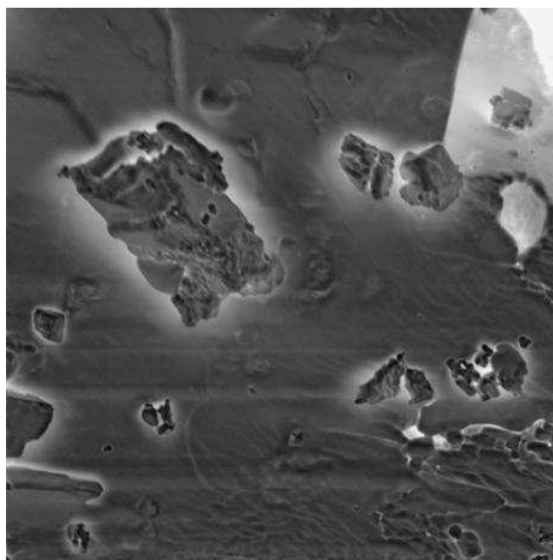
File Name: GC XVII RedOak 500x1

Pine Lumber Ash & Soot Particles on KBr Matrix

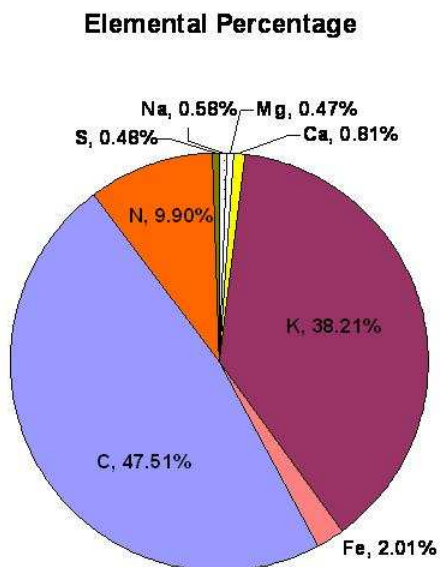


File Name: GC III Pine Lumber 1000x3

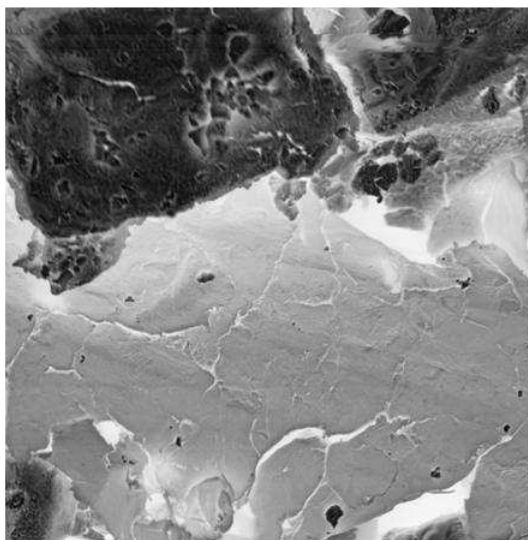
Pine Lumber Ash & Soot Particles on KBr Matrix



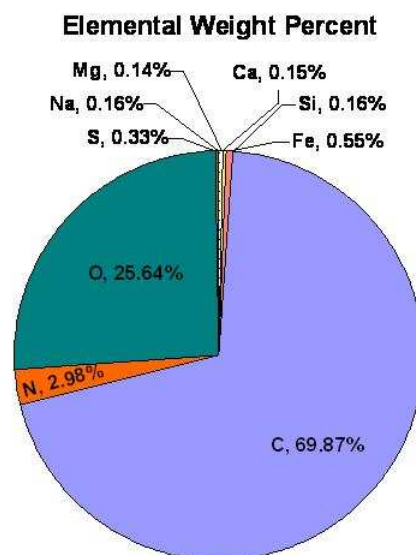
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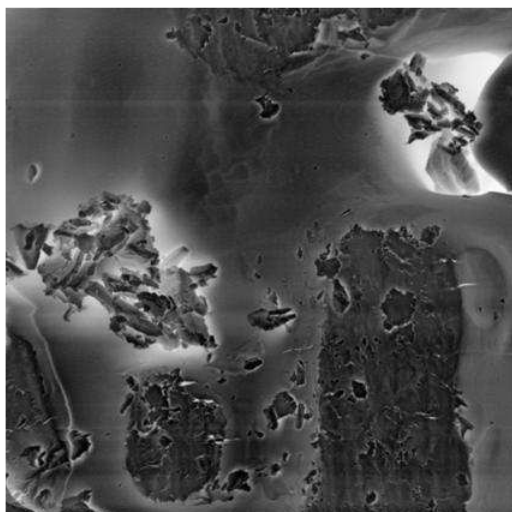
Pine Lumber Ash & Soot Particles on KBr Matrix



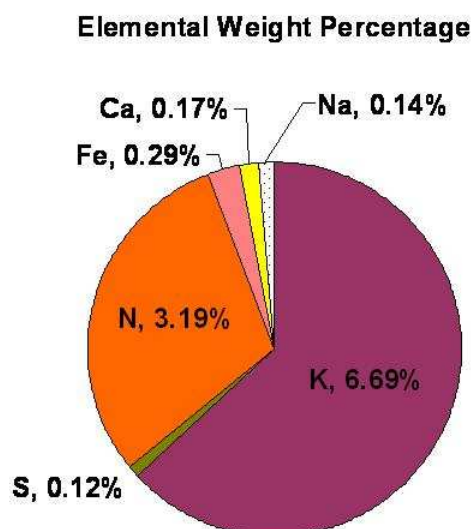
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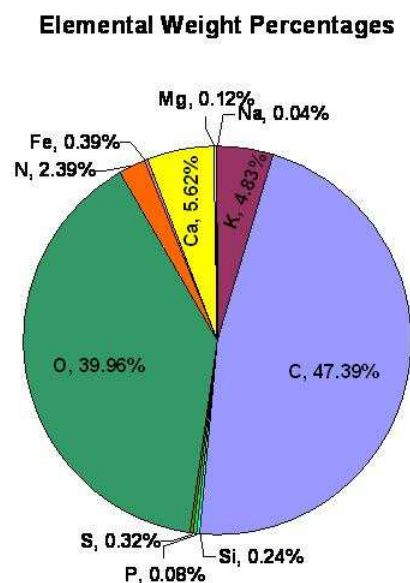
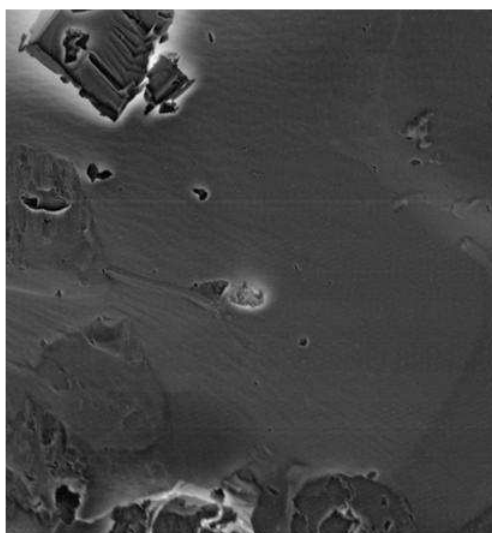
Pin Oak Greenwood Ash Particles on KBr Matrix



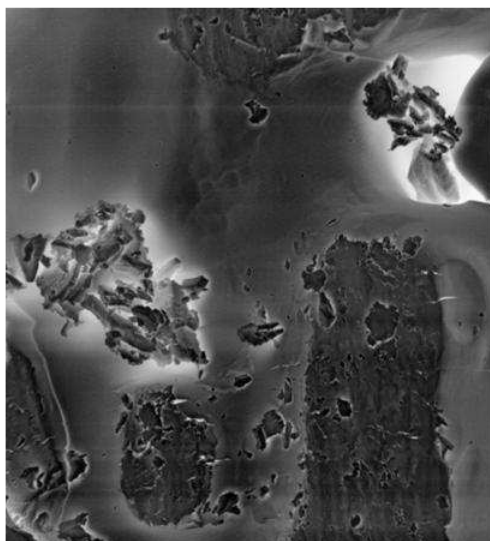
File name: GC II PinOak Greenwood 1000x3



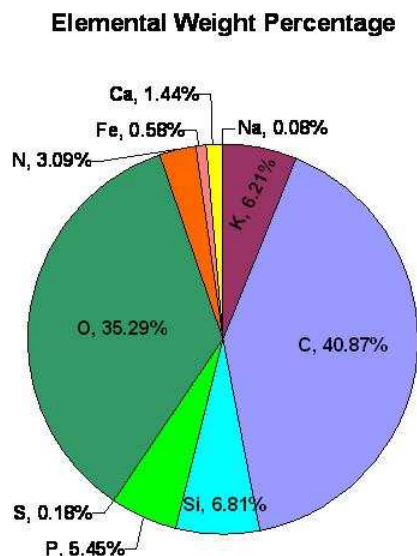
Pin Oak Greenwood Ash Particles on KBr Matrix



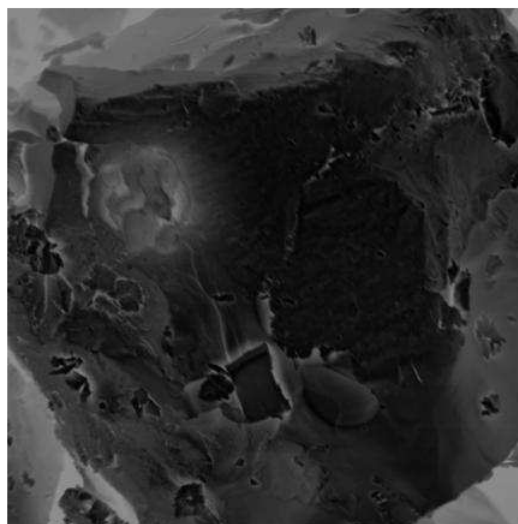
Pin Oak Greenwood Ash Particles on KBr Matrix



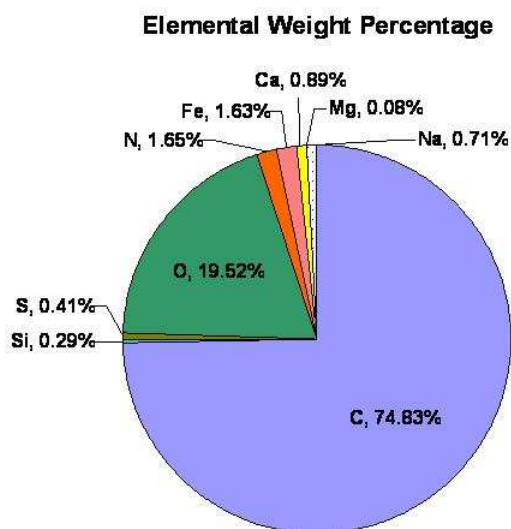
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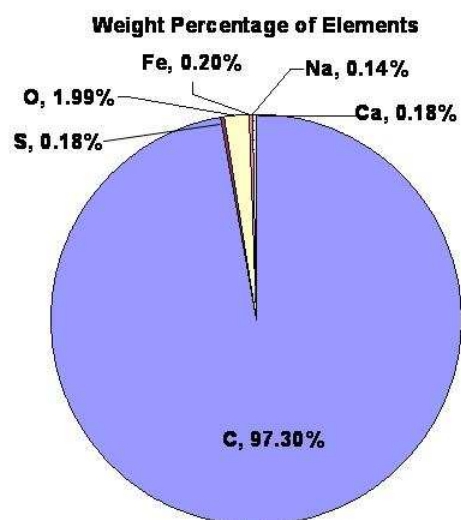
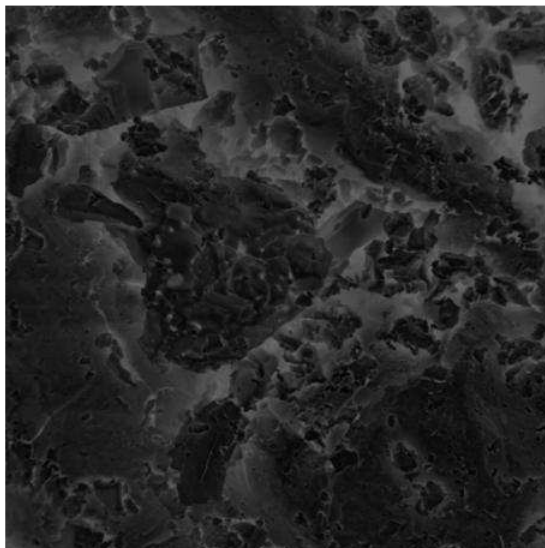
Pin Oak Greenwood Ash Particles on KBr Matrix



File name: GC II PinOak Greenwood 1000x1

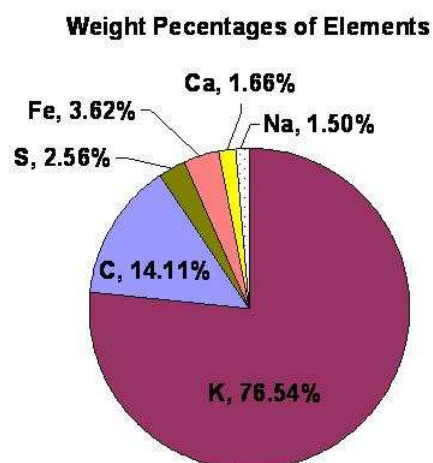
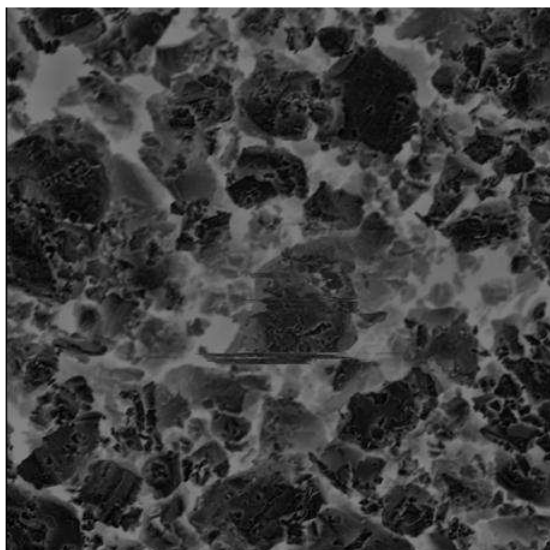


Walnut Lumber Ash Particles on KBr Matrix



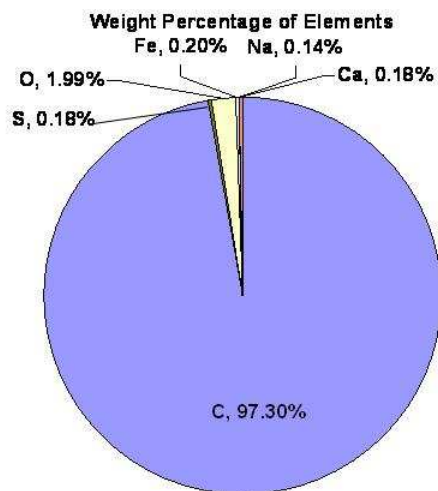
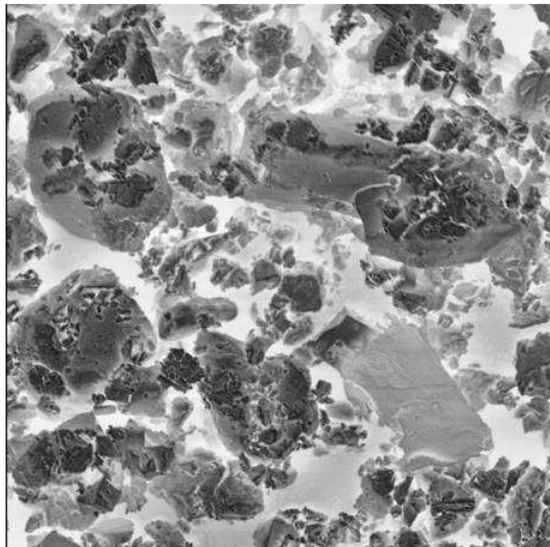
File Name: GC I Walnut Lumber 1000 x 3

Walnut Lumber Ash Particles on KBr Matrix



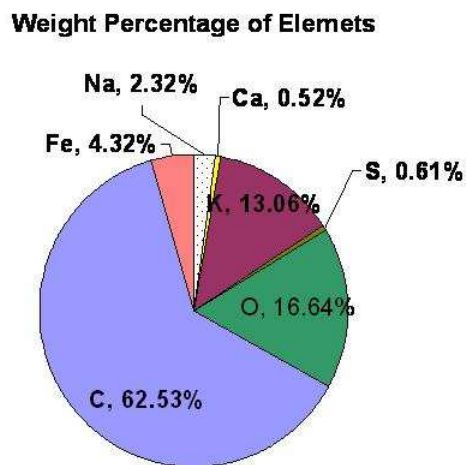
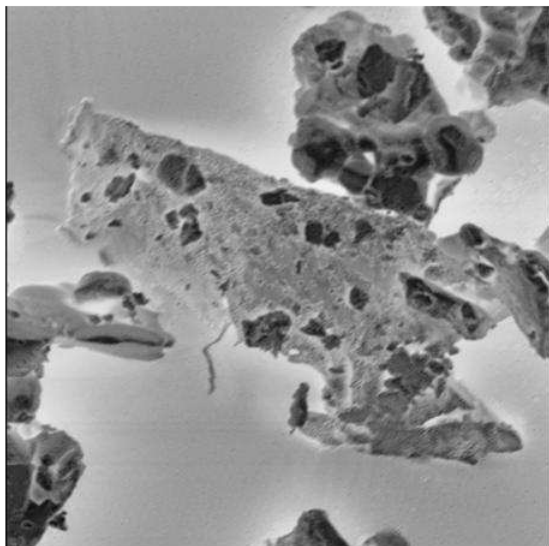
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Walnut Lumber Ash Particles on KBr Matrix



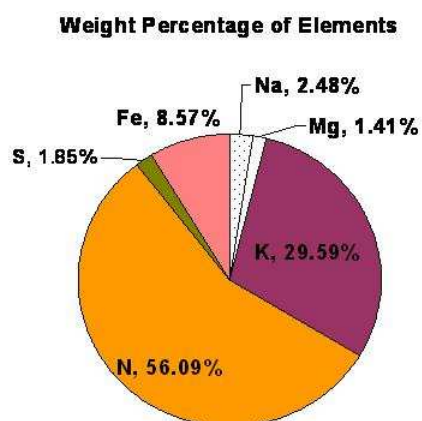
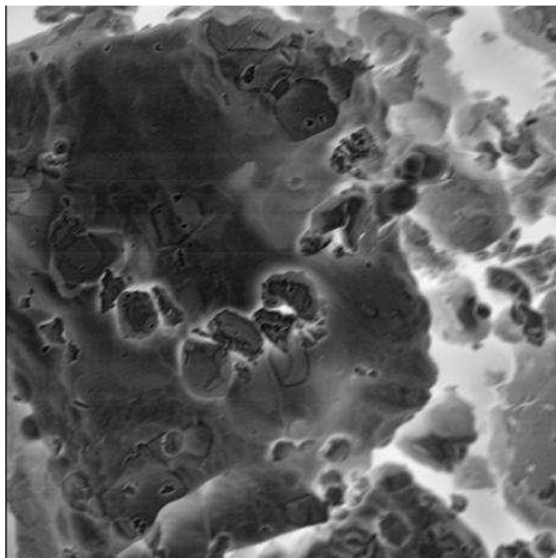
File Name: GC I Walnut Lumber 500 x 1

Ash Wood Smoke Particles on KBr Matrix (Backscatter)



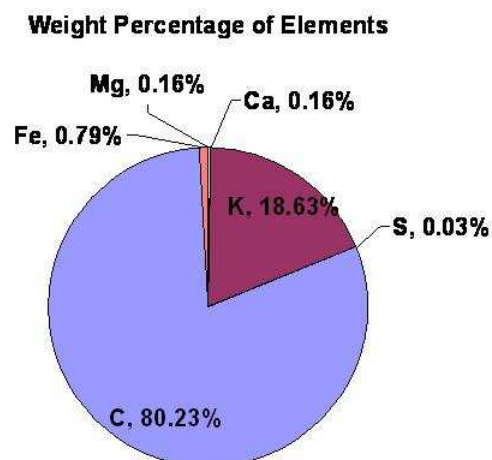
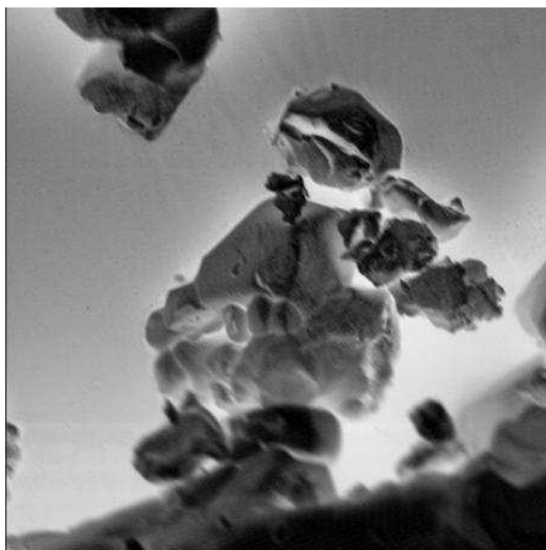
File Name: GC Actual XVI Ash 500x2

Ash Wood Smoke Particles on KBr Matrix (Backscatter)



File Name: GC Actual XVI Ash 500x1

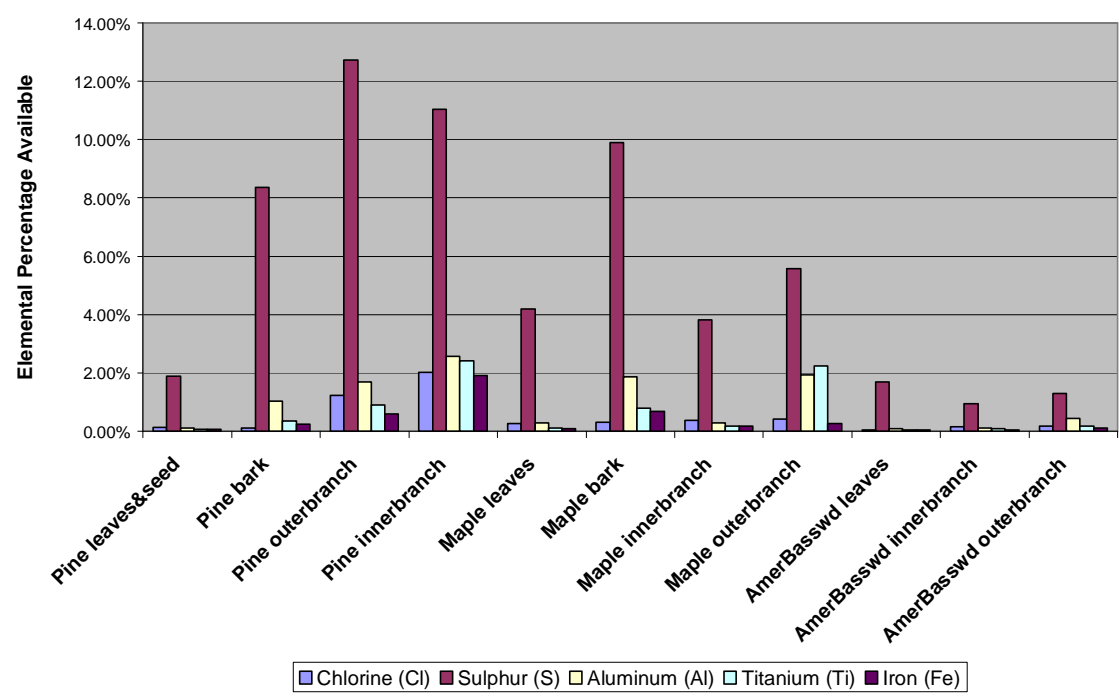
Ash Wood Smoke Particles on KBr Matrix (Backscatter)



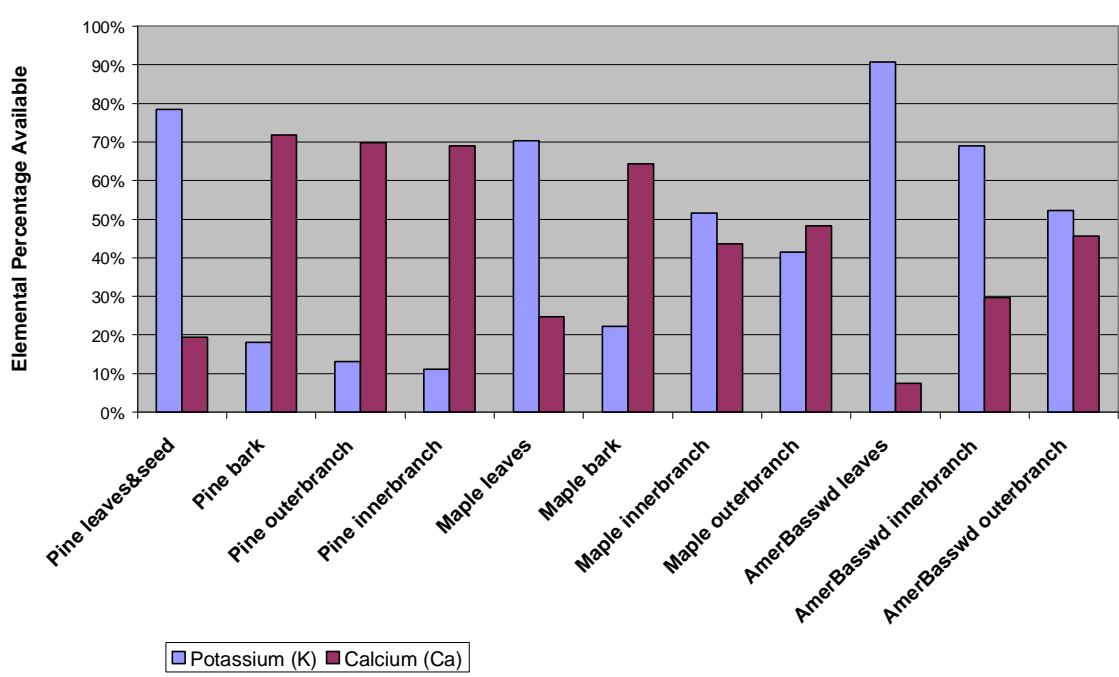
File Name: GC Actual XVI Ash 500x3

Appendix C XRF RESULTS

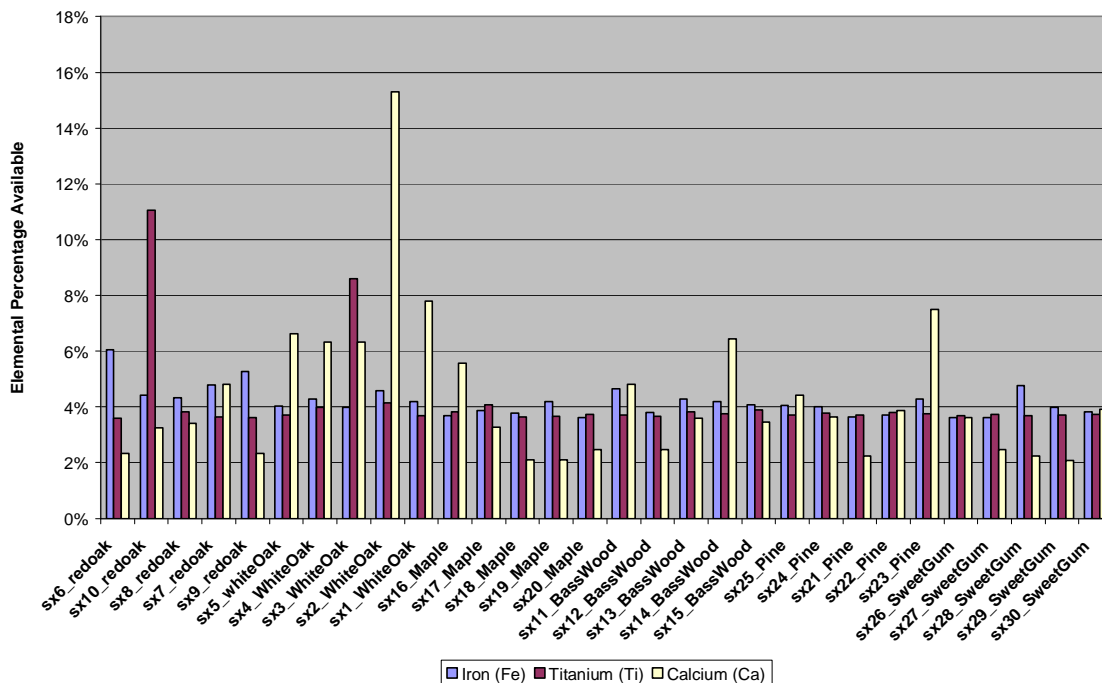
XRF Elemental Analysis of Unburned Woods



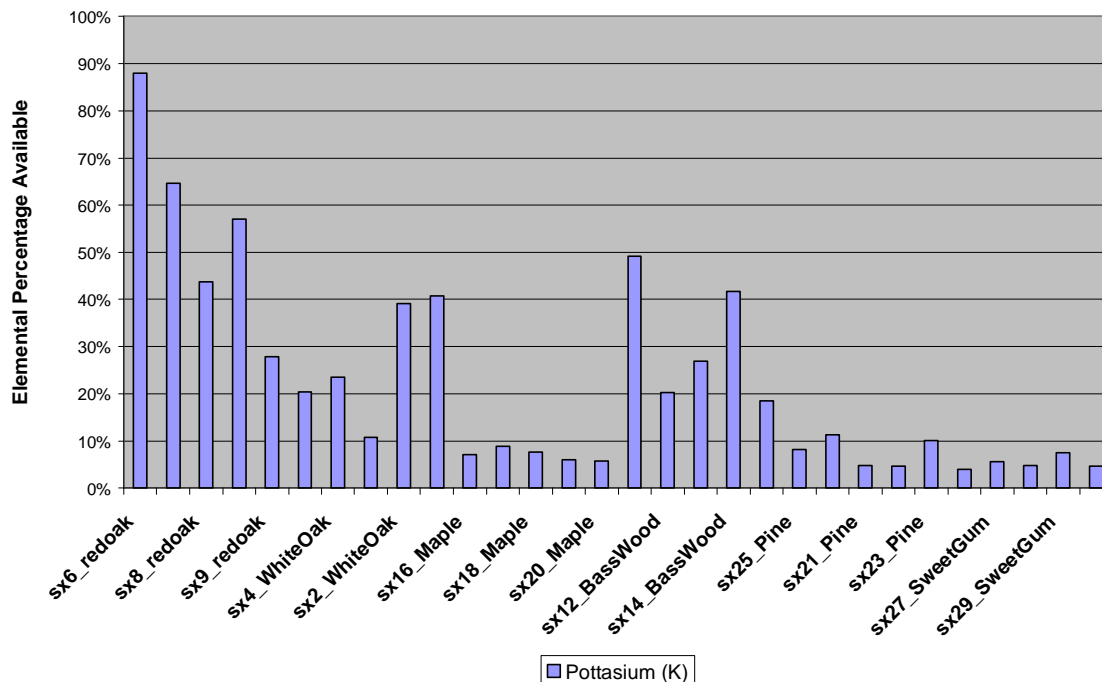
XRF Elemental Analysis for Unburned Woods: Potassium (K) & Calcium (Ca)



XRF Elemental Analysis Wood Soots



XRF Elemental Analysis on Wood Soots



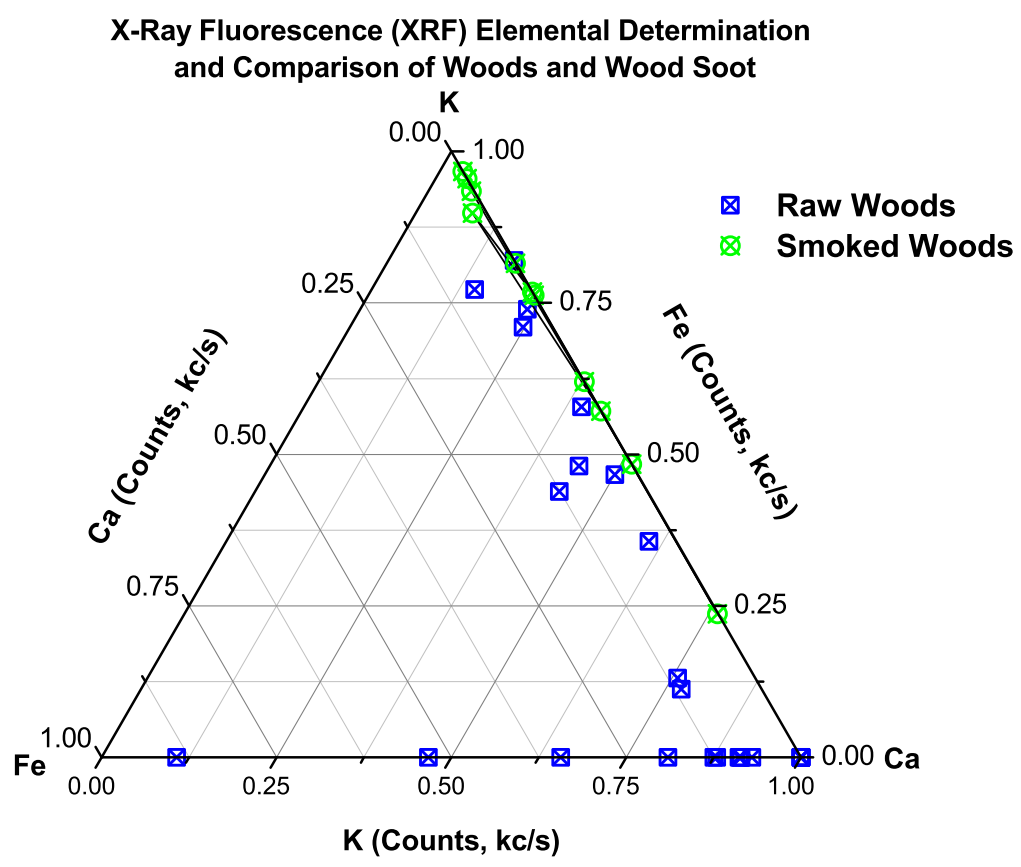


Figure 32 Triangular plots of XRF data on Unburned and Burned woods showing high concentrations of potassium (K) and calcium (Ca). Before being burned woods are high in calcium and have trace amounts of Iron. After combustion, wood smoke contains high concentrations of potassium and calcium, with barely any iron.

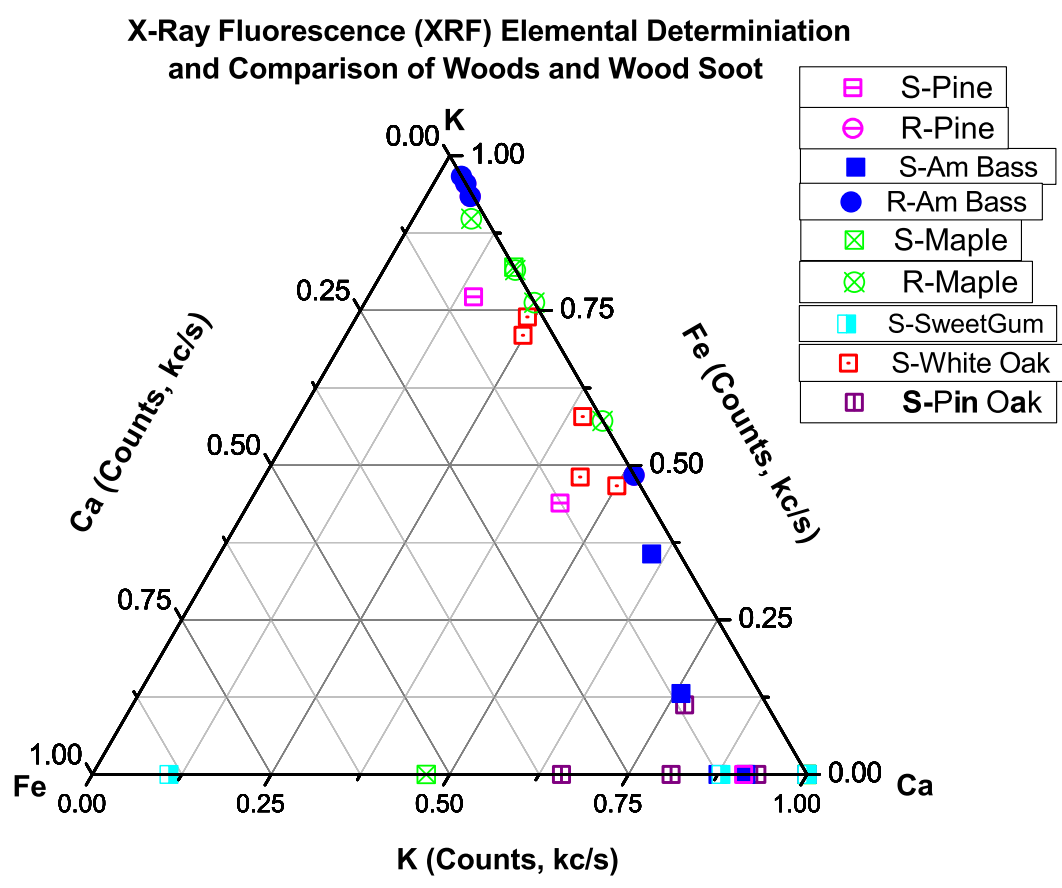


Figure 33 Triangular plot of XRF data for specific Unburned and Burned woods, with a focus on K, Ca, Fe. Here we have a distinction of elemental concentrations of K, Ca, and Fe by wood species. Most woods contain K concentrations higher than 75% after combustion.

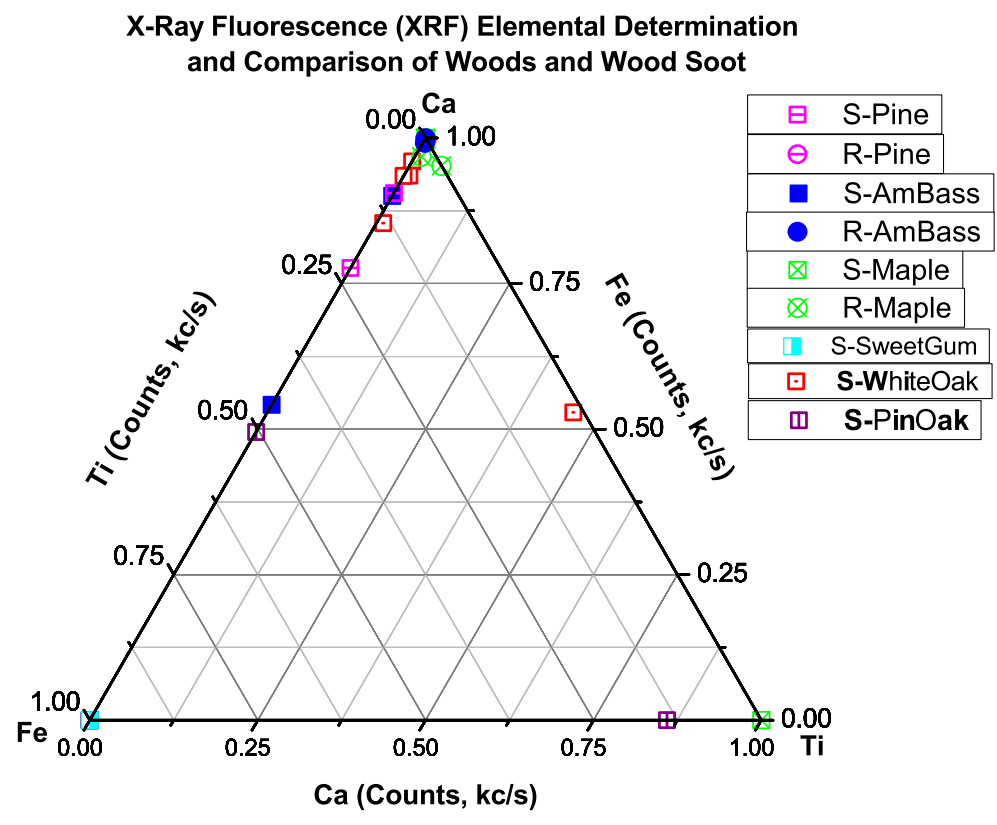


Figure 34 Triangular plot of XRF data for specific Unburned and Burned woods, with a focus on Ti, Ca, Fe. Here we have a distinction of elemental concentrations of Ti, Ca, and Fe by wood species. Concentrations of Ca seem to remain at a constant high throughout the combustion process.

Comparison of Elemental Ratios for XRF samples

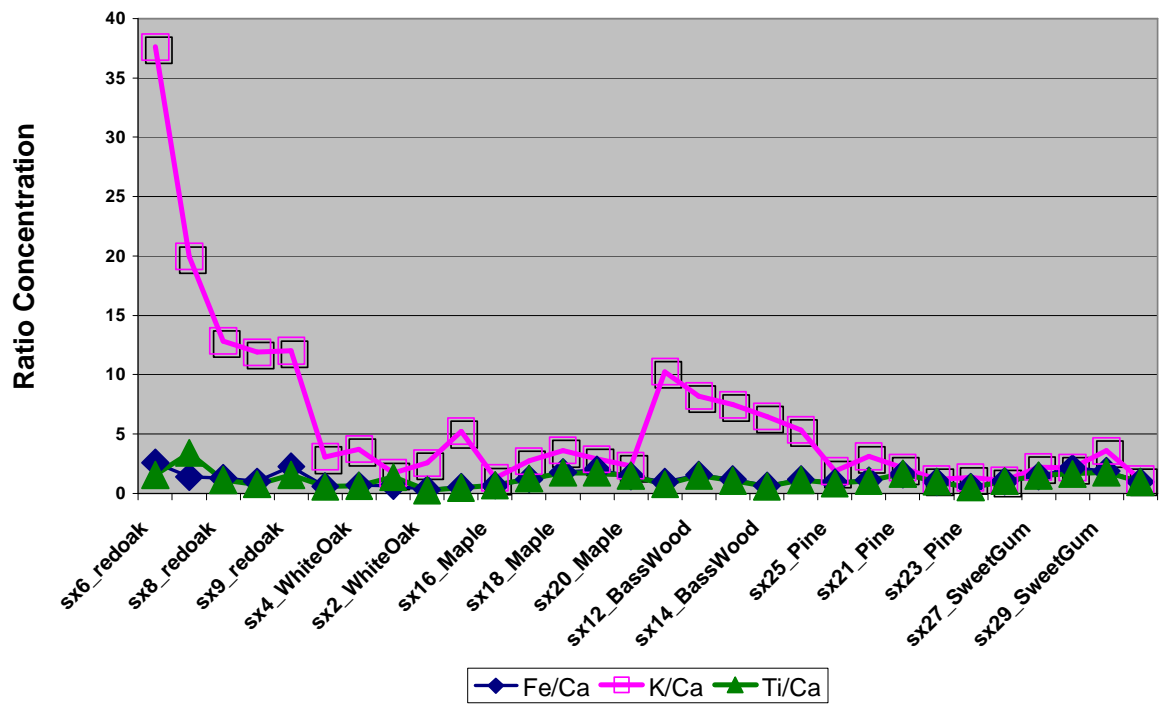


Figure 35 Comparison of elemental ratios for Fe/Ca, K/Ca and Ti/Ca find a higher K/Ca throughout the smoke samples indicating a possible tracer ratio for biomass burning events. The highest K/Ca ratios occur in Red Oak and American Basswoods, both deciduous tree species.

Appendix D Statistical Comparison of Deciduous & Coniferous Trees

Oneway: Deciduous vs. Coniferous Fingerprint Region (400-900 wavenumbers)

Descriptives

Wavenumber

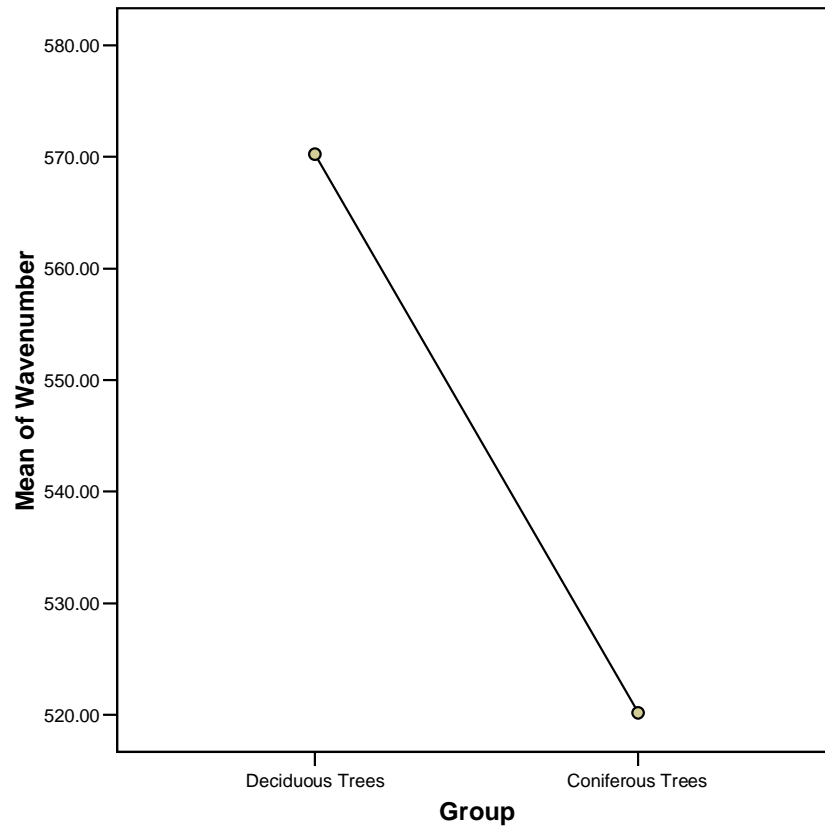
	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1 Deciduous Trees	80	570.2239	136.93977	15.31033	539.7494	600.6983	406.91	875.52
2 Coniferous Trees	64	520.2086	116.34649	14.54331	491.1461	549.2711	404.98	892.88
Total	144	547.9949	130.17446	10.84787	526.5520	569.4378	404.98	892.88

ANOVA

Wavenumber

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	88943.231	1	88943.231	5.411	.021
Within Groups	2334247.383	142	16438.362		
Total	2423190.613	143			

Means Plots



Oneway: Deciduous vs. Coniferous Full Spectrum Peaks (400-4000 wavenumbers)

Descriptives

Wavenumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1Deciduous Trees	752	2421.85	1245.18	45.41	2332.71	2510.99	406.91	3970.71
2 Coniferous Trees	189	2125.57	1817.11	132.18	1864.83	2386.30	406.91	7975.23
Total	941	2362.34	1383.19	45.09	2273.85	2450.83	406.91	7975.23

Test of Homogeneity of Variances

Wavenumber

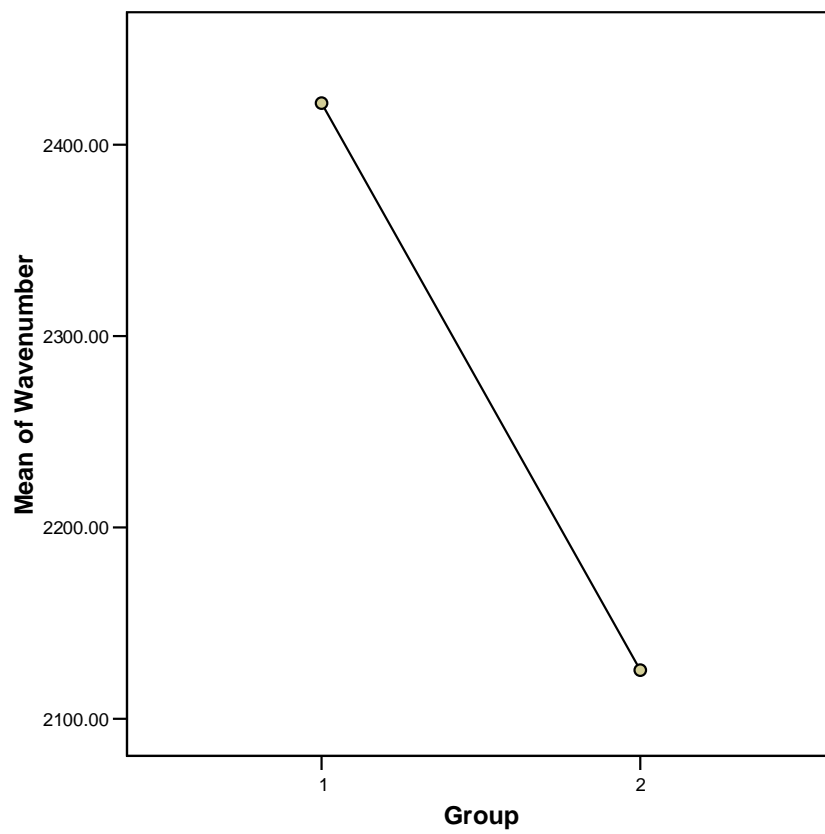
Levene Statistic	df1	df2	Sig.
32.256	1	939	.000

ANOVA

Wavenumber

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	13259109.758	1	13259109.758	6.974	.008
Within Groups	1785161825.289	939	1901130.804		
Total	1798420935.047	940			

Means Plots



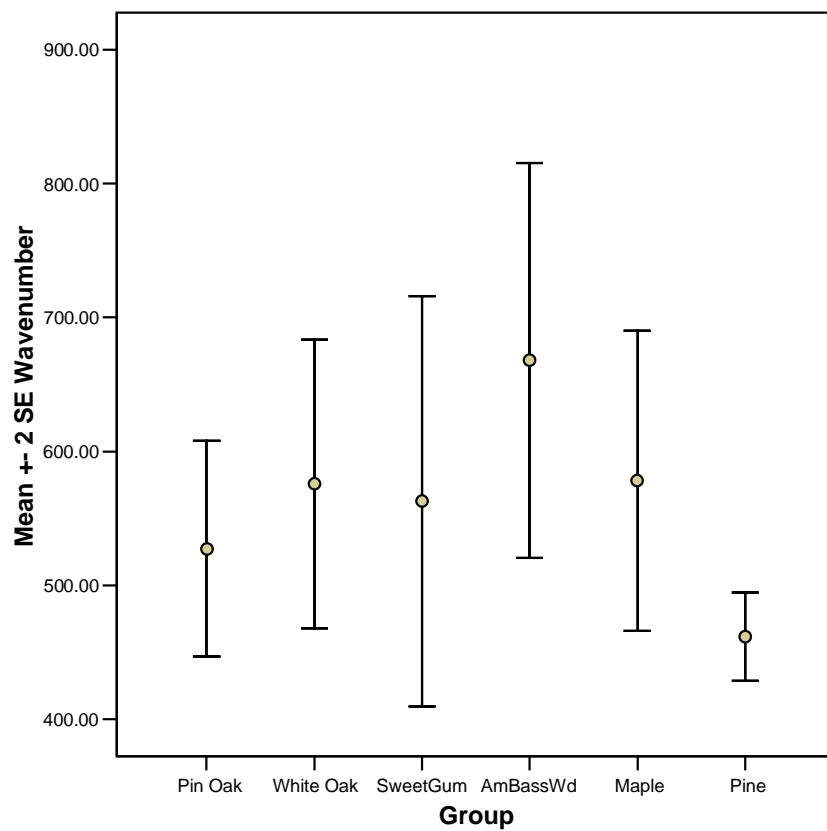
Appendix E

Statistical Comparison of: All Greenwood & All Lumber Fingerprint Regions (400-900cm-1)

Table 1: of fingerprint regions for all greenwoods

Wood Names	Group	Wave number (cm-1)	Wood Names	Group	Wave number (cm-1)	Wood Names	Group	Wave number (cm-1)
PinOak	1	418.50	WhiteOak	2	410.76	Sweetum	3	418.50
PinOak	1	435.85	WhiteOak	2	426.19	Sweetum	3	439.71
PinOak	1	443.57	WhiteOak	2	439.69	Sweetum	3	457.07
PinOak	1	457.07	WhiteOak	2	464.76	Sweetum	3	472.50
PinOak	1	472.50	WhiteOak	2	561.18	Sweetum	3	713.57
PinOak	1	484.07	WhiteOak	2	588.18	Sweetum	3	875.57
PinOak	1	501.43	WhiteOak	2	669.18			
PinOak	1	518.78	WhiteOak	2	746.32			
PinOak	1	526.50	WhiteOak	2	875.52			
PinOak	1	669.21						
PinOak	1	873.64						
Wood Names	Group	Wave number (cm-1)	Wood Names	Group	Wave number (cm-1)	Wood Names	Group	Wave number (cm-1)
AmBsswd	4	451.28	Maple	5	418.50	Pine	6	418.50
AmBsswd	4	576.64	Maple	5	457.07	Pine	6	443.57
AmBsswd	4	667.28	Maple	5	472.50	Pine	6	457.07
AmBsswd	4	769.50	Maple	5	501.43	Pine	6	472.50
AmBsswd	4	875.57	Maple	5	516.85	Pine	6	516.85
			Maple	5	669.21			
			Maple	5	713.57			
			Maple	5	875.57			

Graph 1: Error for All Greenwood fingerprint regions



Oneway: Comparing All Greenwood Fingerprint Regions

Descriptives

Wavenumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	11	527.3745	133.35953	40.20941	437.7824	616.9667	418.50	873.64
2	9	575.7533	161.42844	53.80948	451.6684	699.8382	410.76	875.52
3	6	562.8200	187.54371	76.56440	366.0049	759.6351	418.50	875.57
4	5	668.0540	164.85013	73.72322	463.3655	872.7425	451.28	875.57
5	8	578.0875	158.58445	56.06807	445.5076	710.6674	418.50	875.57
6	5	461.6980	36.65561	16.39289	416.1840	507.2120	418.50	516.85
Total	44	559.8473	150.62697	22.70787	514.0525	605.6421	410.76	875.57

Test of Homogeneity of Variances

Wavenumber

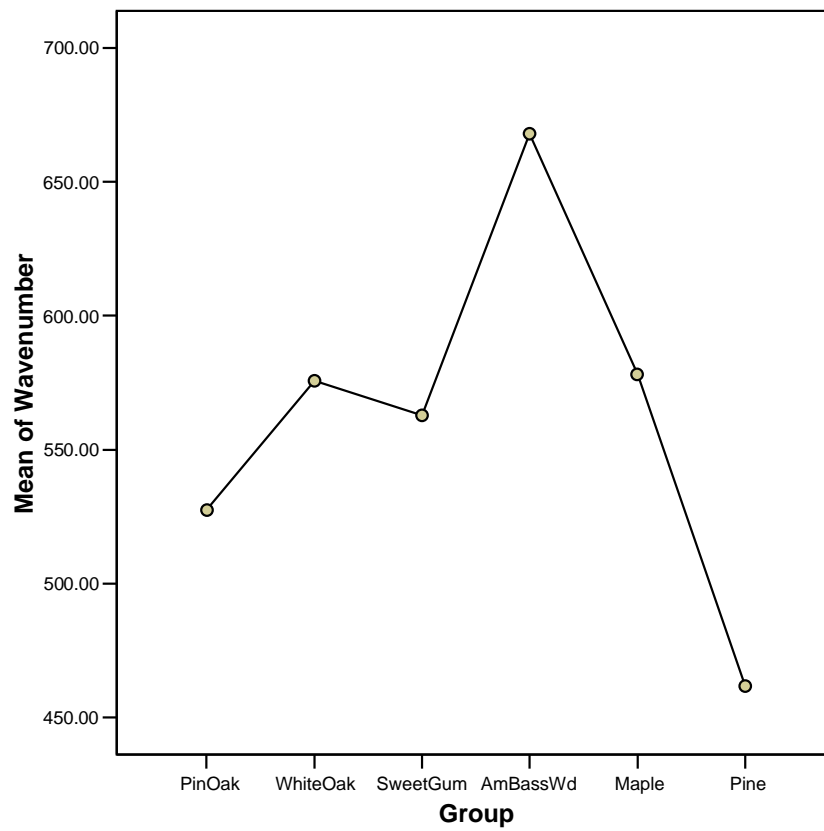
Levene Statistic	df1	df2	Sig.
1.746	5	38	.148

ANOVA

Wavenumber

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	123300.83 1	5	24660.166	1.099	.377
Within Groups	852303.99 3	38	22429.052		
Total	975604.82 4	43			

Means Plots: Comparing All Greenwood Fingerprint means



Oneway: Greenwood (Full Spectral Peaks: 400-4000 wavenumbers)

Descriptives: Greenwood

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	104	2483.8091	1170.22424	114.74993	2256.2297	2711.3886	410.76	3949.50
2	26	1826.4962	1371.65986	269.00463	1272.4707	2380.5216	418.50	3853.27
3	30	2131.3187	1317.93508	240.62092	1639.1936	2623.4437	418.50	3853.27
4	37	2470.2268	1248.75207	205.29358	2053.8721	2886.5814	474.43	3897.62
5	30	1987.7050	1264.11905	230.79551	1515.6752	2459.7348	418.50	3853.27
6	17	1990.9565	1277.30476	309.79191	1334.2270	2647.6860	418.50	3853.27
Total	244	2273.0345	1254.92170	80.33813	2114.7865	2431.2825	410.76	3949.50

ANOVA

Wavenumber					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	15640889.671	5	3128177.934	2.028	.075
Within Groups	367042427.366	238	1542195.073		
Total	382683317.037	243			

Means Plots: Greenwoods (Full Spectral Peaks: 400-4000 wavenumbers)

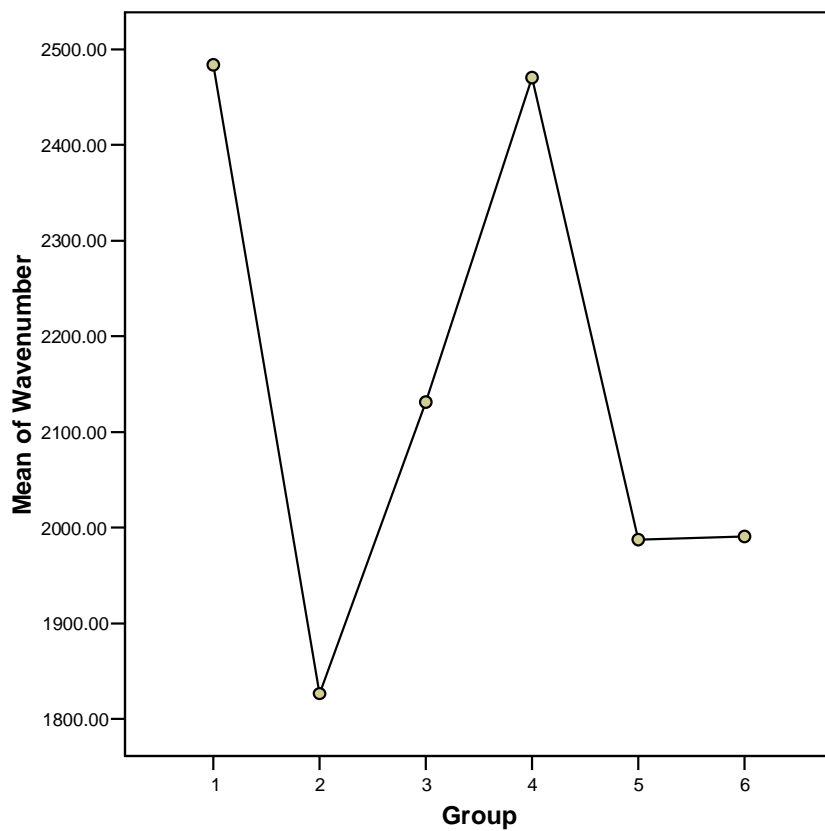
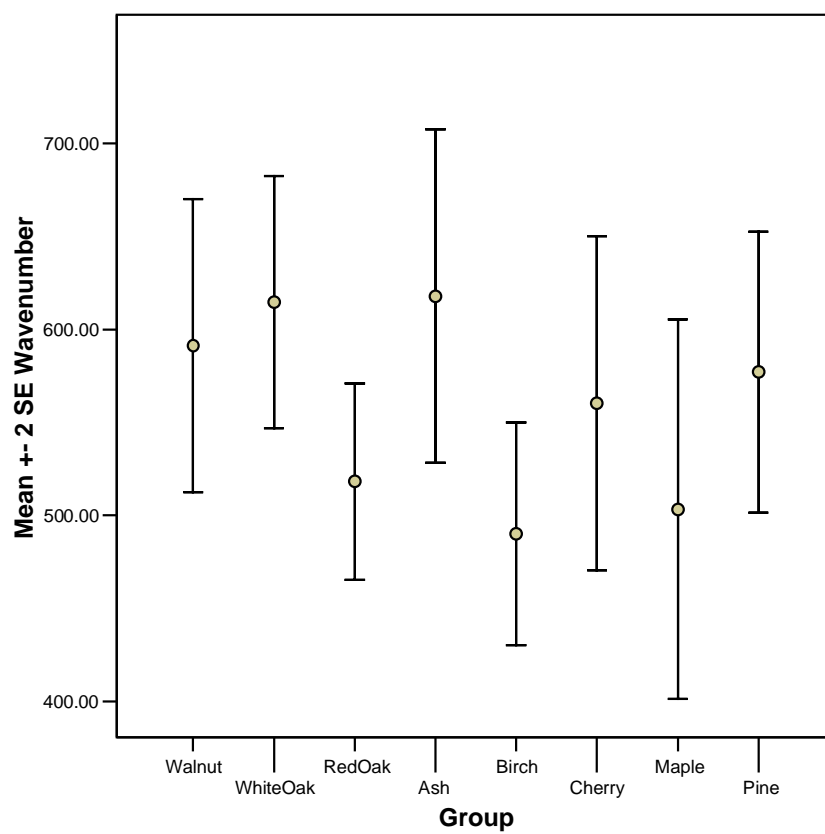


Table 2: Fingerprint Regions for All Lumber

Lumber Name	Group	Wave number (cm-1)	Lumber Name	Group	Wave number (cm-1)	Lumber Name	Group	Wave number (cm-1)
Walnut	1	410.76	WhiteOak	2	412.69	RedOak	3	406.91
Walnut	1	424.26	WhiteOak	2	426.19	RedOak	3	422.33
Walnut	1	458.98	WhiteOak	2	441.62	RedOak	3	433.91
Walnut	1	476.33	WhiteOak	2	458.98	RedOak	3	457.05
Walnut	1	487.9	WhiteOak	2	489.83	RedOak	3	476.33
Walnut	1	563.11	WhiteOak	2	509.12	RedOak	3	482.12
Walnut	1	588.18	WhiteOak	2	563.11	RedOak	3	495.62
Walnut	1	607.47	WhiteOak	2	588.18	RedOak	3	541.9
Walnut	1	620.97	WhiteOak	2	607.47	RedOak	3	565.04
Walnut	1	671.11	WhiteOak	2	620.97	RedOak	3	592.04
Walnut	1	744.39	WhiteOak	2	636.39	RedOak	3	667.25
Walnut	1	757.89	WhiteOak	2	659.54	RedOak	3	678.82
Walnut	1	875.52	WhiteOak	2	671.11			
			WhiteOak	2	711.6			
			WhiteOak	2	723.18			
			WhiteOak	2	819.6			
			WhiteOak	2	850.45			
			WhiteOak	2	875.52			
Lumber Name	Group	Wave number (cm-1)	Lumber Name	Group	Wave number (cm-1)	Lumber Name	Group	Wave number (cm-1)
Ash	4	406.91	Birch	5	406.91	Cherry	6	406.91
Ash	4	424.26	Birch	5	412.69	Cherry	6	422.33
Ash	4	433.91	Birch	5	420.41	Cherry	6	430.05
Ash	4	458.98	Birch	5	430.05	Cherry	6	487.9
Ash	4	563.11	Birch	5	441.62	Cherry	6	538.04
Ash	4	586.25	Birch	5	447.4	Cherry	6	561.18
Ash	4	607.47	Birch	5	482.12	Cherry	6	588.18
Ash	4	620.97	Birch	5	574.68	Cherry	6	624.82
Ash	4	671.11	Birch	5	619.04	Cherry	6	669.18
Ash	4	738.6	Birch	5	667.25	Cherry	6	875.52
Ash	4	806.1						
Ash	4	840.81						
Ash	4	875.52						

Table 2: Fingerprint Regions for All Lumber

Lumber Name	Group	Wave number (cm-1)	Lumber Name	Group	Wave number (cm-1)
Maple	7	414.62	Pine	8	404.98
Maple	7	422.33	Pine	8	422.33
Maple	7	433.91	Pine	8	433.91
Maple	7	576.61	Pine	8	457.05
Maple	7	669.18	Pine	8	476.33
			Pine	8	495.62
			Pine	8	522.61
			Pine	8	538.04
			Pine	8	563.11
			Pine	8	588.18
			Pine	8	649.89
			Pine	8	680.75
			Pine	8	732.82
			Pine	8	800.31
			Pine	8	892.88

Graph: Error of All Lumber Fingerprint Regions

Oneway: For All Lumber Fingerprint Regions

Descriptives

Wavenumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	13	591.2977	142.06832	39.40266	505.4467	677.1487	410.76	875.52
2	18	614.7528	144.13134	33.97208	543.0779	686.4276	412.69	875.52
3	12	518.2767	91.55624	26.43001	460.1046	576.4487	406.91	678.82
4	13	618.0000	161.79175	44.87296	520.2302	715.7698	406.91	875.52
5	10	490.2170	94.73598	29.95815	422.4470	557.9870	406.91	667.25
6	10	560.4110	141.98037	44.89813	458.8444	661.9776	406.91	875.52
7	5	503.3300	114.15536	51.05183	361.5874	645.0726	414.62	669.18
8	15	577.2540	146.36821	37.79211	496.1980	658.3100	404.98	892.88
Total	96	569.6613	137.93661	14.07810	541.7127	597.6098	404.98	892.88

Test of Homogeneity of Variances

Wavenumber

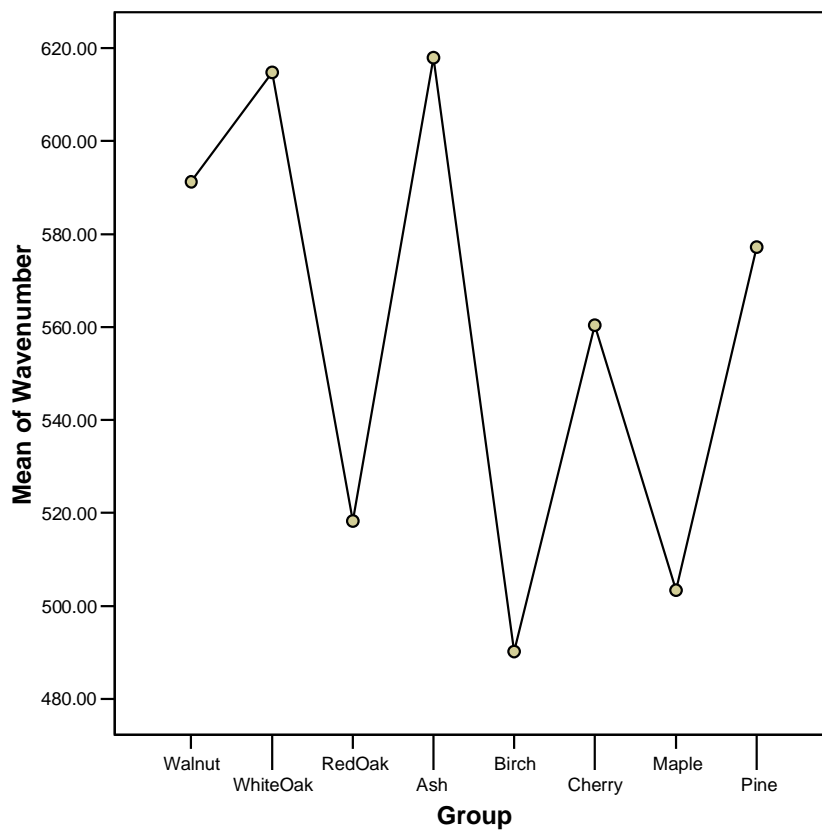
Levene Statistic	df1	df2	Sig.
.771	7	88	.613

ANOVA

Wavenumber

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	191578.427	7	27368.347	1.490	.181
Within Groups	1615939.941	88	18362.954		
Total	1807518.368	95			

Means Plots: For All Lumber Fingerprint Regions



Oneway: Lumber: (Full Spectral Peaks: 400-4000 wavenumbers)

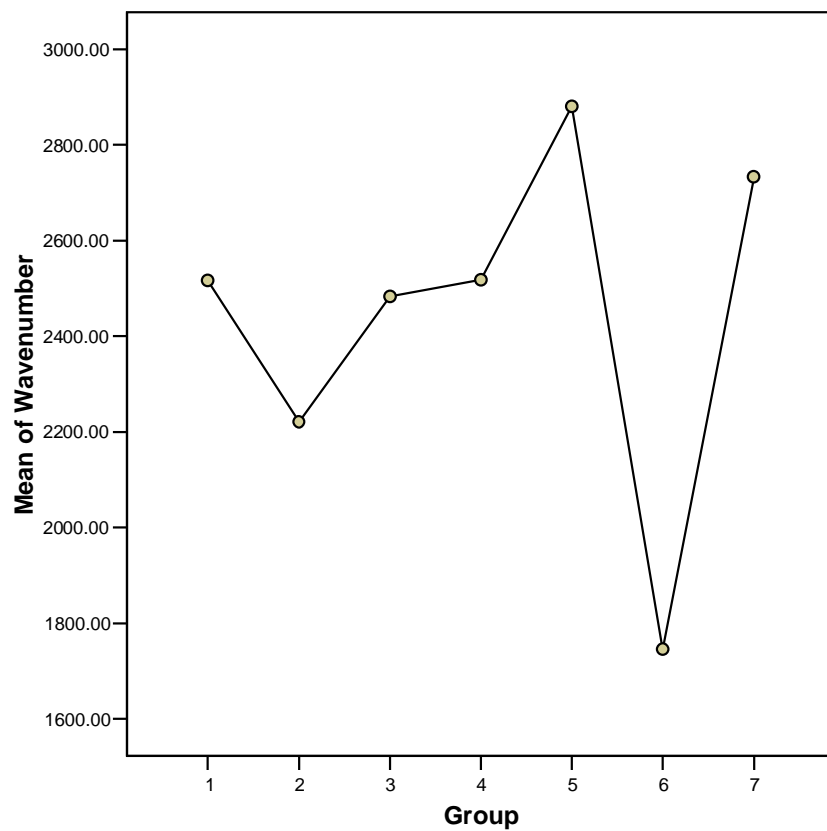
Descriptives: Lumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	63	2517.047 1	1343.65354	169.2844 3	2178.6524	2855.4419	410.76	3918.64
2	88	2221.724 7	1261.47706	134.4739 1	1954.4432	2489.0061	408.83	3939.86
3	104	2483.809 1	1170.22424	114.7499 3	2256.2297	2711.3886	410.76	3949.50
4	89	2517.775 7	1147.26161	121.6094 9	2276.1024	2759.4490	406.91	3943.71
5	53	2880.474 3	1231.39352	169.1449 1	2541.0602	3219.8884	414.62	3970.71
6	39	1745.410 5	1273.33061	203.8960 8	1332.6445	2158.1765	422.33	3907.07
7	89	2733.027 3	1142.85477	121.1423 6	2492.2823	2973.7723	410.76	3930.22
Total	525	2477.065 7	1238.67467	54.06019	2370.8644	2583.2671	406.91	3970.71

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	41324002. 012	6	6887333.669	4.678	.000
Within Groups	762657029 .571	518	1472310.868		
Total	803981031 .582	524			

Means Plots: Lumber



Oneway: Lumber vs. Greenwood (Full Spectral Peaks: 400-4000 wavenumbers)

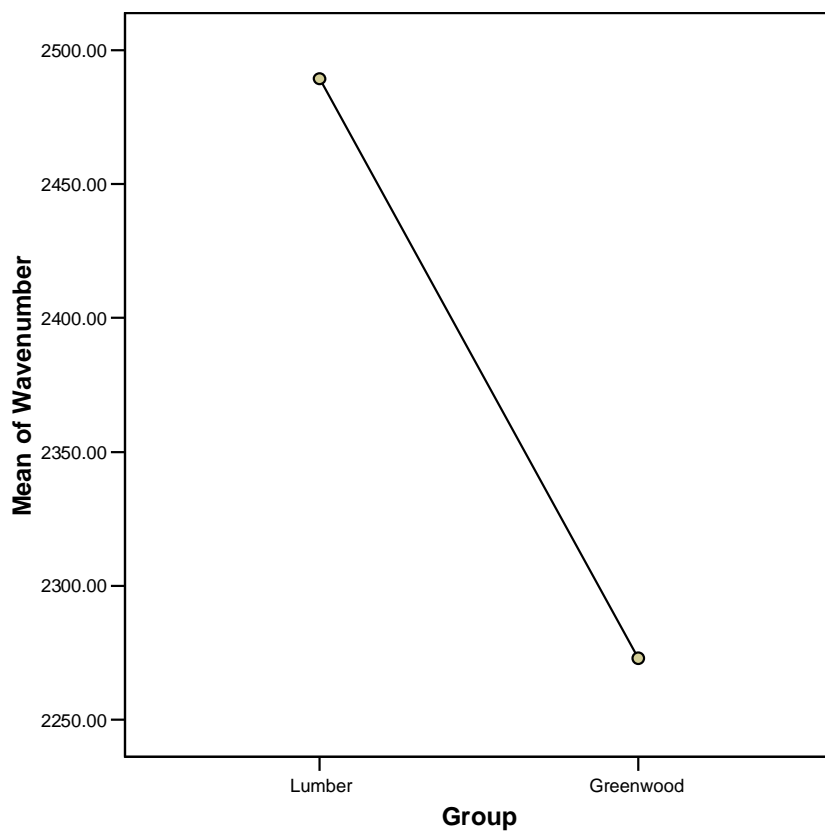
Descriptives: Lumber vs. Greenwood

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
					1 Lumber	601		
2 Greenwood	244	2273.03	1254.92	80.34	2114.79	2431.28	410.76	3949.50
Total	845	2426.89	1248.08	42.94	2342.61	2511.16	406.91	3970.71

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8120413.103	1	8120413.103	5.239	.022
Within Groups	1306589965.369	843	1549928.785		
Total	1314710378.472	844			

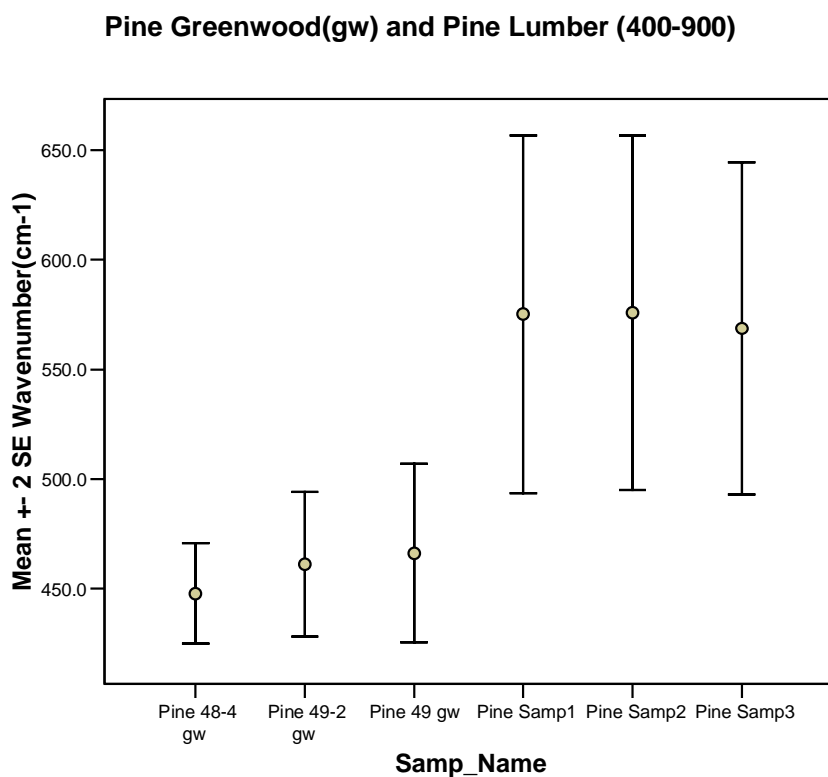
Means Plots: Lumber vs. Greenwood (Full Spectral Peaks: 400-4000 wavenumbers)



Appendix F

Statistical Comparison of Single Sample Sets for Greenwoods

Graph: Error Bars for Pine Greenwood (gw) and Pine Lumber (400-900)



Oneway: Pine Greenwood(gw) and Pine Lumber (400-900)

Descriptives

Wavenumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1 Pine GW	13	458.702	32.5451	9.0264	439.035	478.368	418.5	516.9
2 Pine Lumber	34	573.151	129.3014	22.1750	528.036	618.267	406.9	808.0
Total	47	541.495	122.2628	17.8339	505.597	577.393	406.9	808.0

Test of Homogeneity of Variances

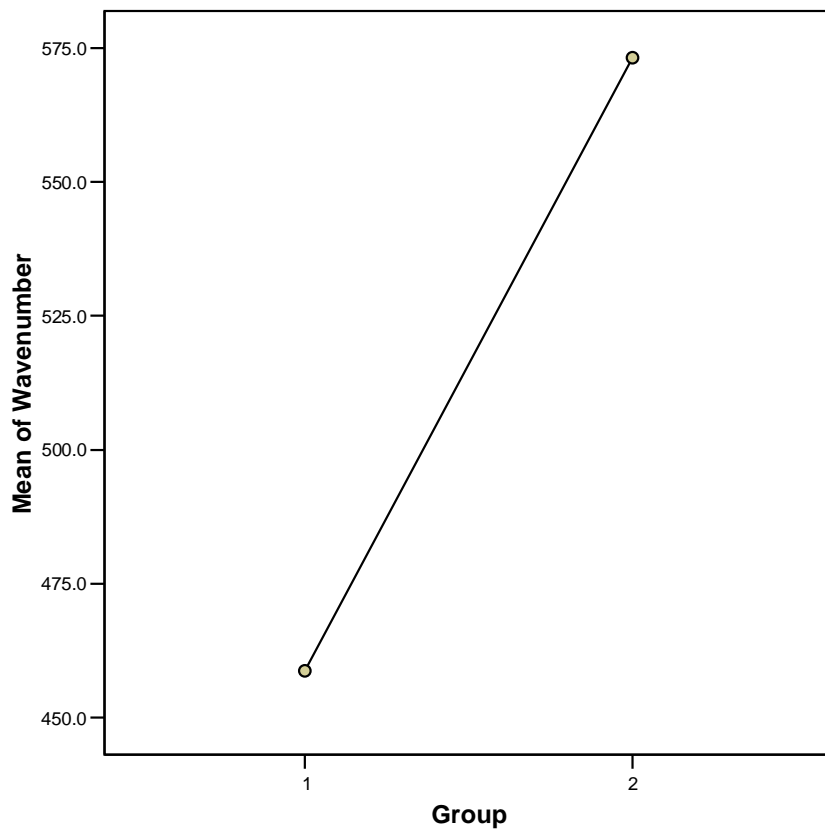
Wavenumber

Levene Statistic	df1	df2	Sig.
17.303	1	45	.000

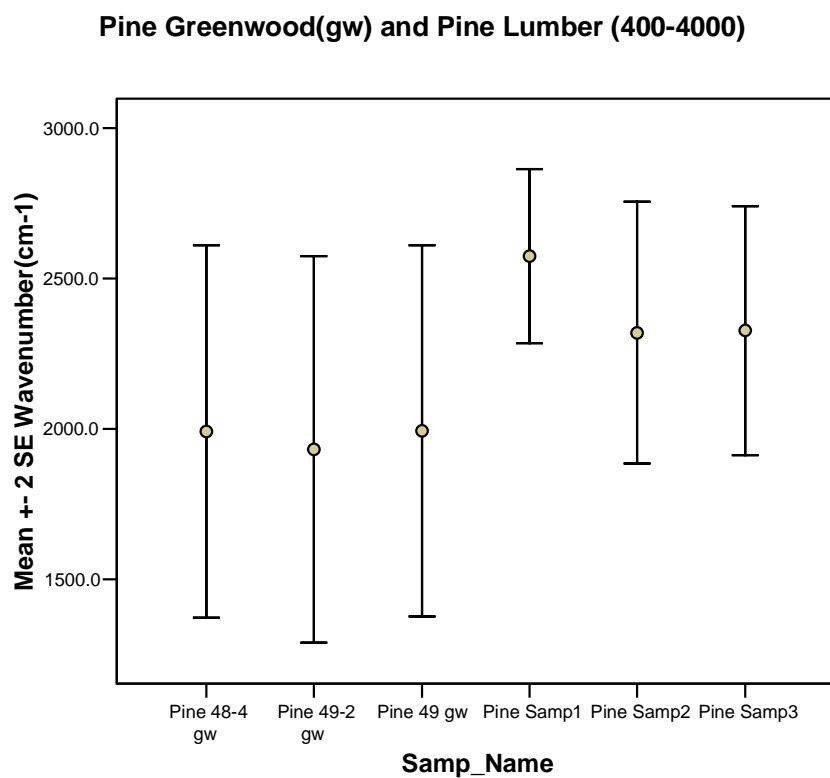
ANOVA

Wavenumber

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	123184.337	1	123184.337	9.821	.003
Within Groups	564432.387	45	12542.942		
Total	687616.724	46			

Means Plots: Pine Greenwood (gw) and Pine Lumber (400-900)

Graph: Error Bars for Pine Greenwood(gw) and Pine Lumber (400-4000)



Oneway: Pine Greenwood(gw) and Pine Lumber (400-4000)

Descriptives

Wavenumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1 Pine GW	51	1971.746	1265.5327	177.2100	1615.810	2327.683	418.5	3853.3
2 Pine Lumber	160	2442.271	1319.5489	104.3195	2236.240	2648.301	406.9	3912.9
Total	211	2328.542	1319.2582	90.8215	2149.504	2507.581	406.9	3912.9

Test of Homogeneity of Variances

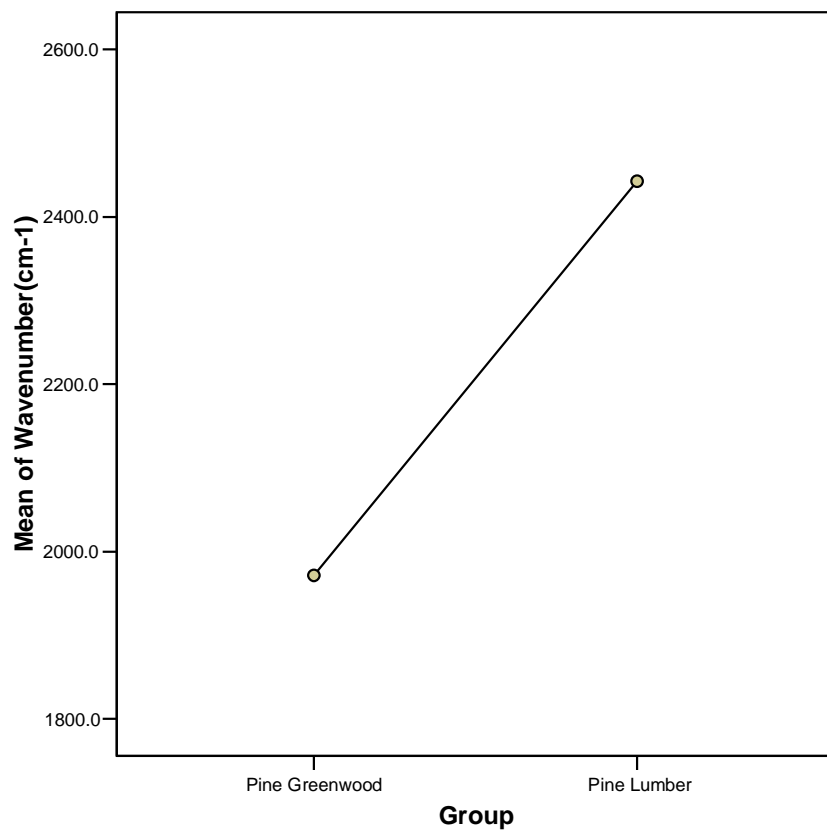
Wavenumber

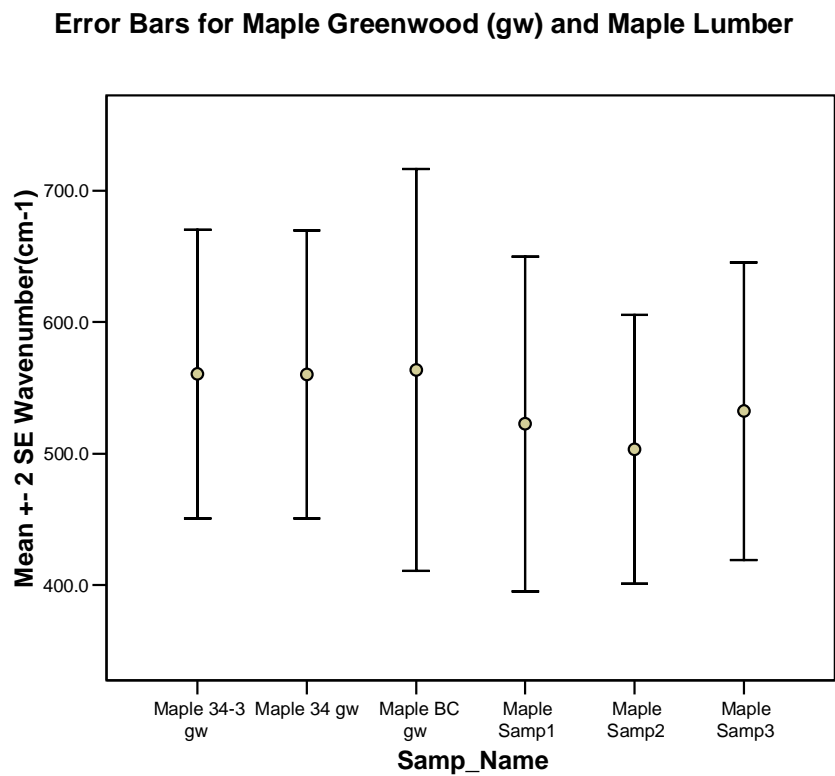
Levene Statistic	df1	df2	Sig.
3.862	1	209	.051

ANOVA

Wavenumber

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8561932.112	1	8561932.112	5.013	.026
Within Groups	356930917.864	209	1707803.435		
Total	365492849.976	210			

Means Plots: Pine Greenwood(gw) and Pine Lumber (400-4000)

Graph: Maple Greenwood(gw) and Maple Lumber (400-900)

Oneway: Maple Greenwood(gw) and Maple Lumber (400-900)

Descriptives

Wavenumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1 Maple GW	22	561.213	155.9172	33.2417	492.083	630.343	418.5	875.6
2 Maple Lumber	13	518.164	108.3174	30.0418	452.708	583.619	410.8	669.2
Total	35	545.223	140.0052	23.6652	497.130	593.317	410.8	875.6

Test of Homogeneity of Variances

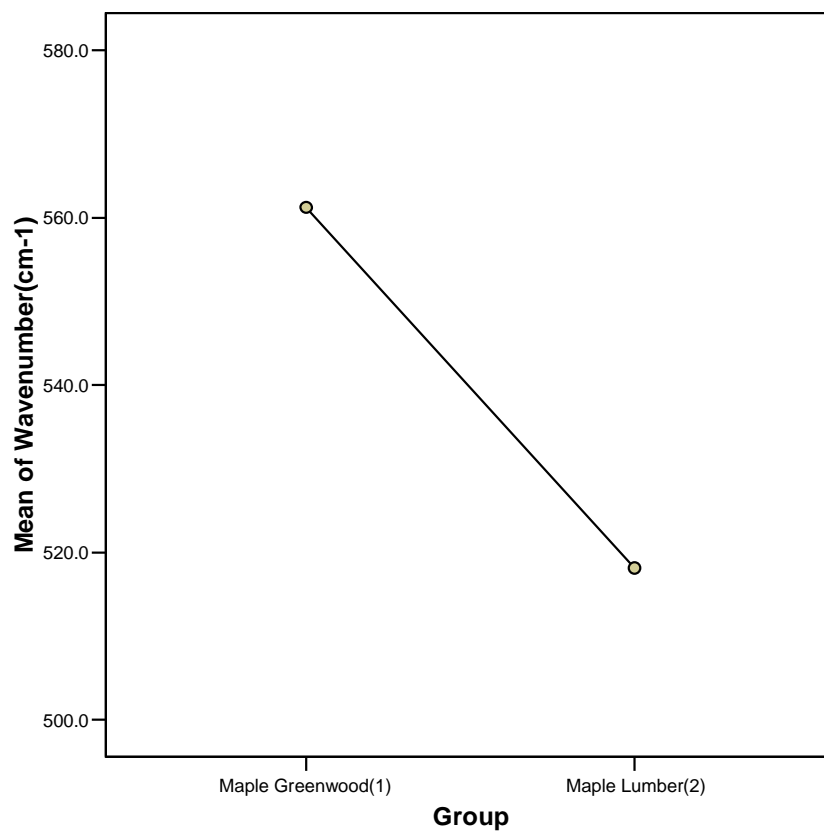
Wavenumber

Levene Statistic	df1	df2	Sig.
1.306	1	33	.261

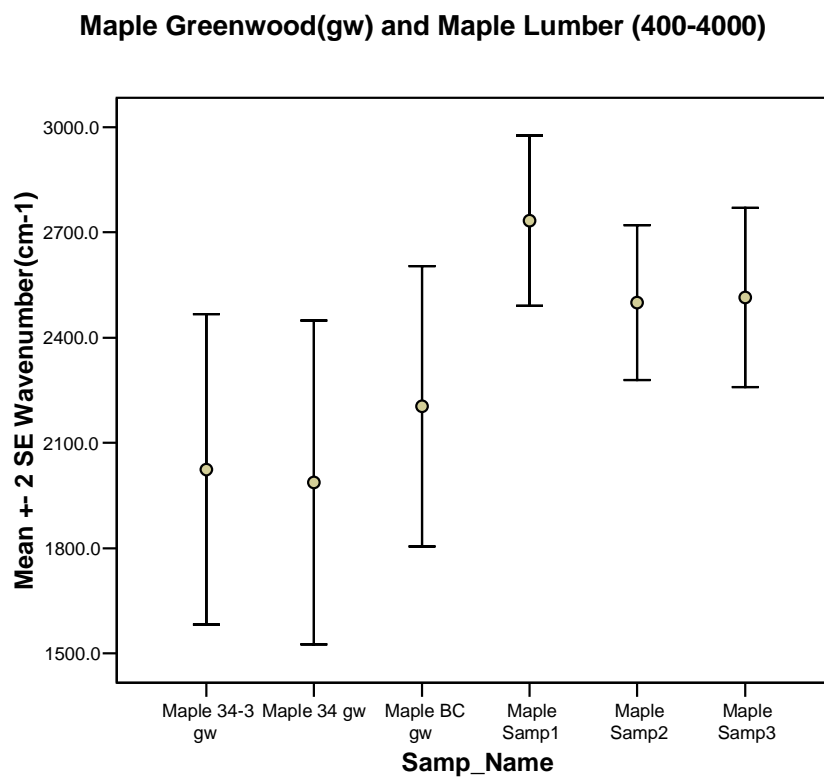
ANOVA

Wavenumber

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	15143.662	1	15143.662	.767	.387
Within Groups	651305.591	33	19736.533		
Total	666449.253	34			

Means Plots: Maple Greenwood(gw) and Maple Lumber (400-900)

Graph: Error Bars for Maple Greenwood(gw) and Maple Lumber (400-4000)



Oneway: Maple Greenwood(gw) and Maple Lumber (400-4000)

Descriptives

Wavenumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1 Maple GW	99	2080.412	1231.8384	123.8044	1834.726	2326.098	418.5	3853.3
2 Maple Lumber	274	2579.894	1137.2625	68.7045	2444.636	2715.152	410.8	3949.5
Total	373	2447.324	1182.2386	61.2140	2326.955	2567.693	410.8	3949.5

Test of Homogeneity of Variances

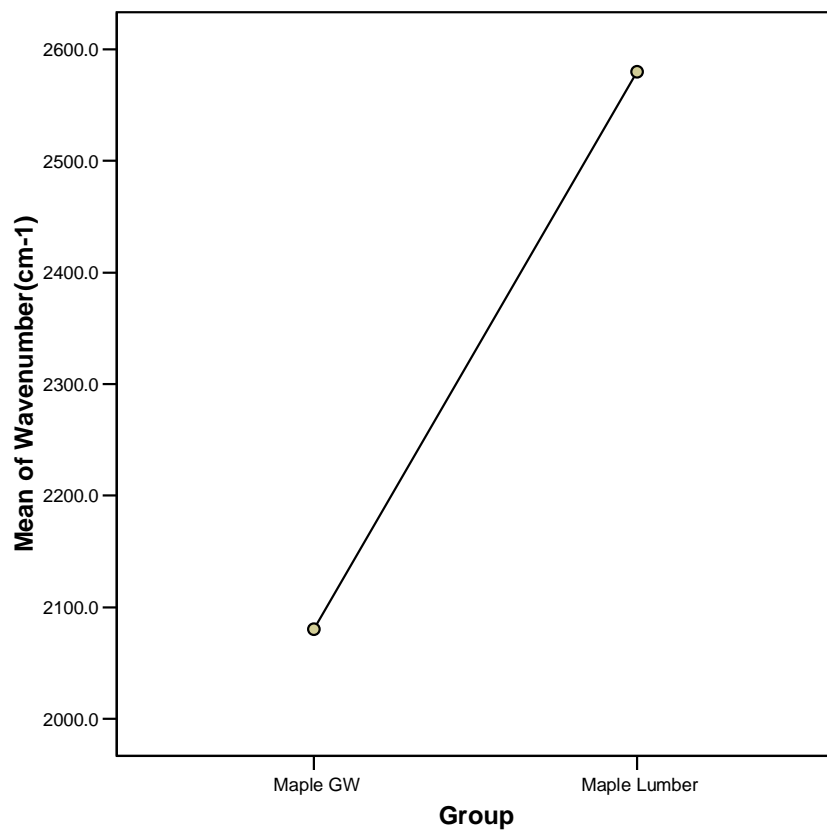
Wavenumber

Levene Statistic	df1	df2	Sig.
.093	1	371	.761

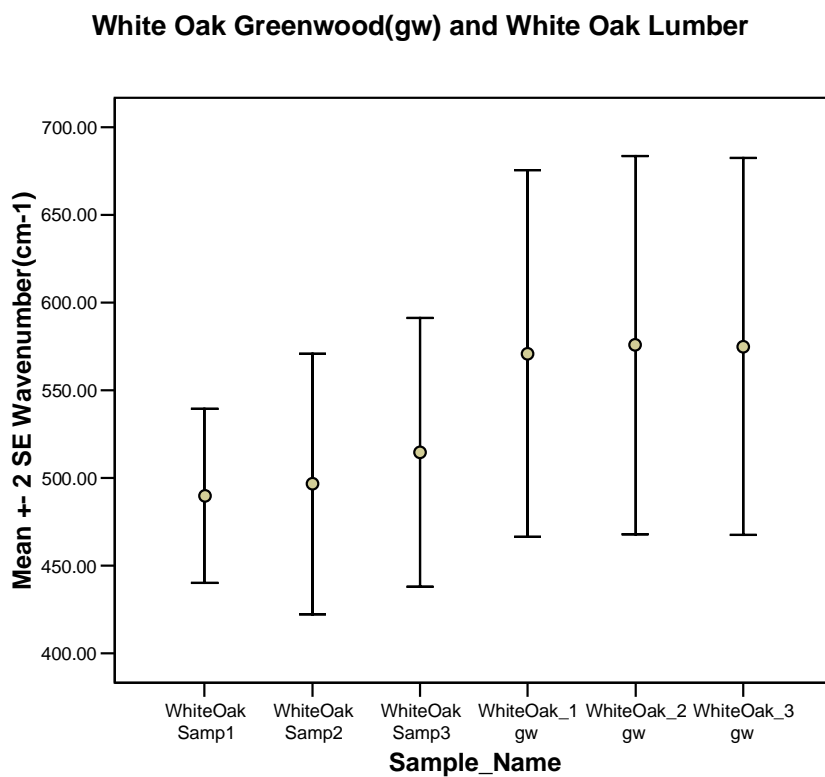
ANOVA

Wavenumber

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	18143307.188	1	18143307.188	13.414	.000
Within Groups	501796653.631	371	1352551.627		
Total	519939960.819	372			

Means Plots: Maple Greenwood(gw) and Maple Lumber (400-4000)

Graph: Error Bars for White Oak Greenwood(gw) and White Oak Lumber (400-900)



Oneway: White Oak Greenwood(gw) and White Oak Lumber (400-900)

Descriptives

Wavenumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1 WhiteOak GW	27	573.8252	153.49731	29.54057	513.1037	634.5467	410.76	875.52
2 White Oak Lumber	22	499.5768	84.30137	17.97311	462.1997	536.9540	408.83	669.21
Total	49	540.4892	131.39215	18.77031	502.7490	578.2294	408.83	875.52

Test of Homogeneity of Variances

Wavenumber

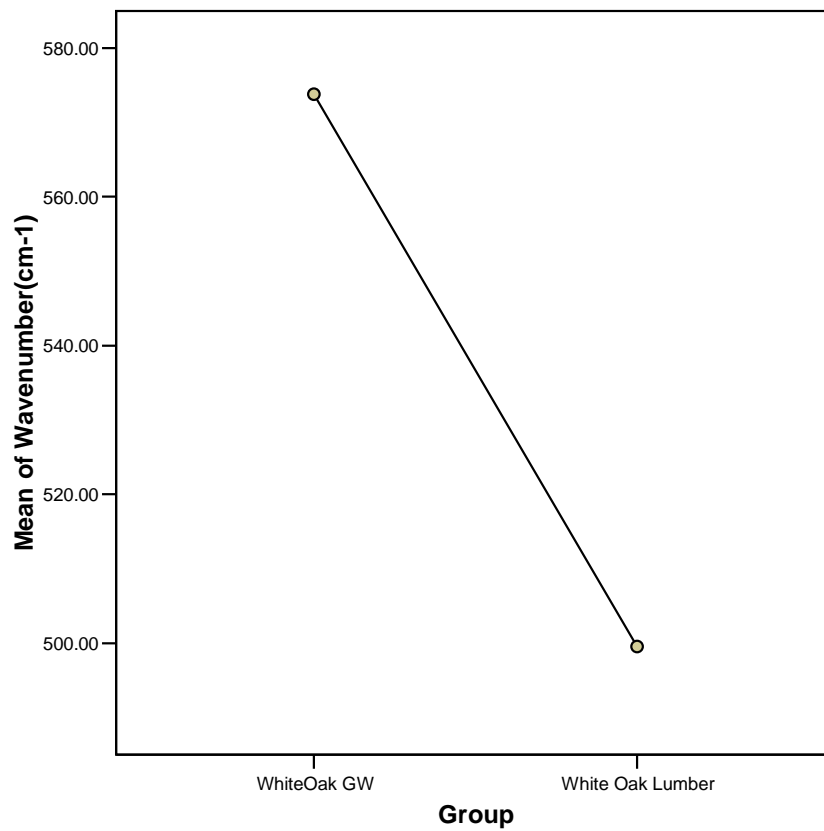
Levene Statistic	df1	df2	Sig.
8.658	1	47	.005

ANOVA

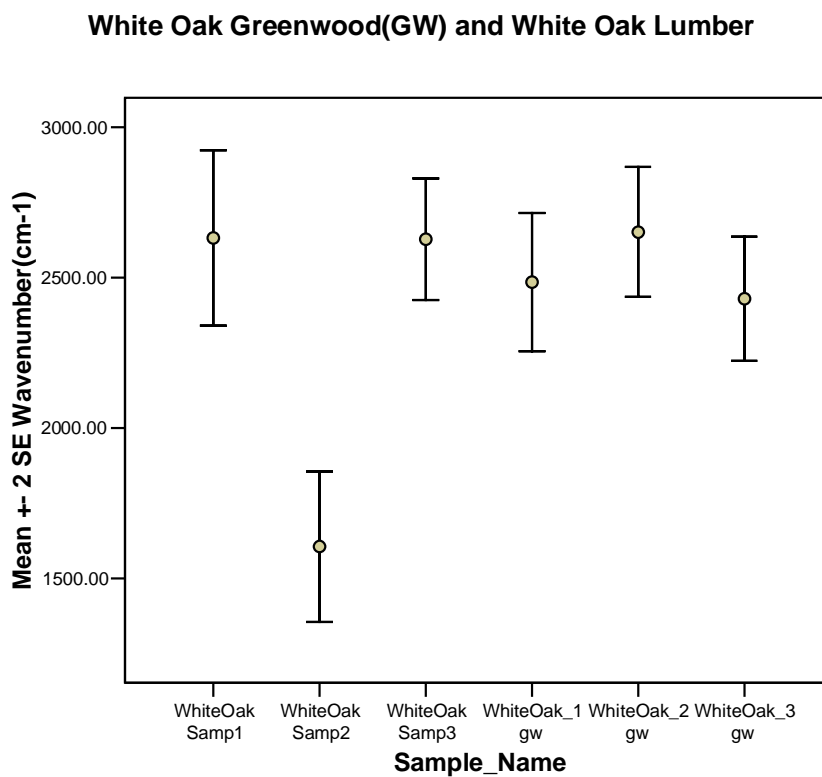
Wavenumber

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	66828.879	1	66828.879	4.123	.048
Within Groups	761838.152	47	16209.322		
Total	828667.031	48			

Means Plots: White Oak Greenwood(gw) and White Oak Lumber (400-900)



Graph: Error Bars for White Oak Greenwood(gw) and White Oak Lumber (400-4000)



Oneway: White Oak Greenwood(gw) and White Oak Lumber (400-4000)

Descriptives

Wavenumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1 WhiteOak GW	346	2523.5488	1162.10646	62.47523	2400.6686	2646.4291	410.76	3963.00
2 White Oak Lumber	242	2463.4939	1191.23324	76.57537	2312.6514	2614.3364	408.83	3949.50
Total	588	2498.8323	1173.54495	48.39618	2403.7816	2593.8831	408.83	3963.00

Test of Homogeneity of Variances

Wavenumber

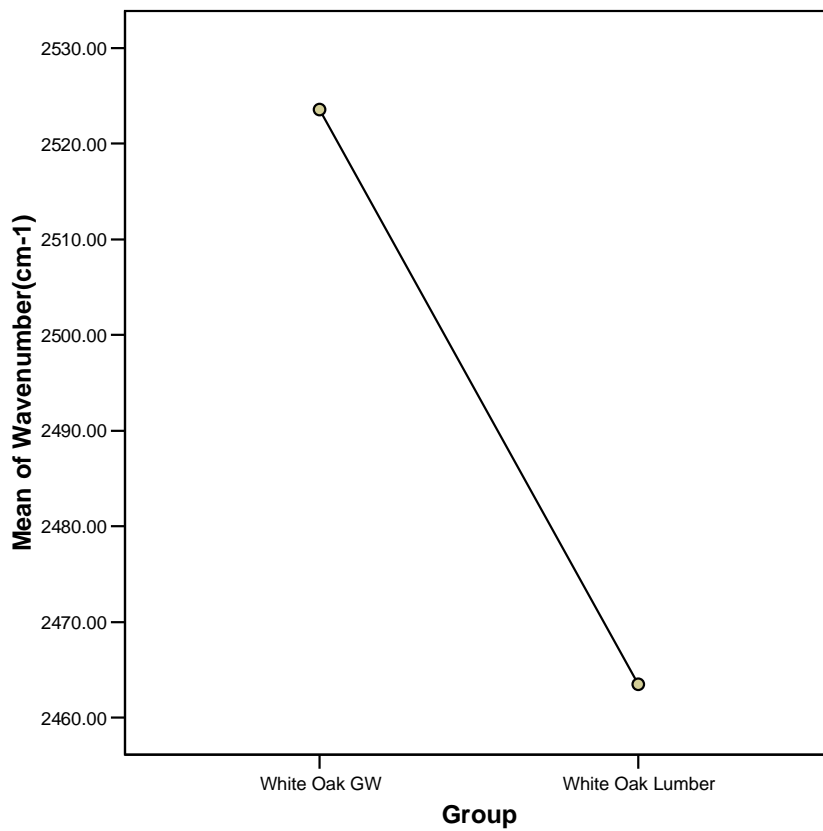
Levene Statistic	df1	df2	Sig.
.326	1	586	.568

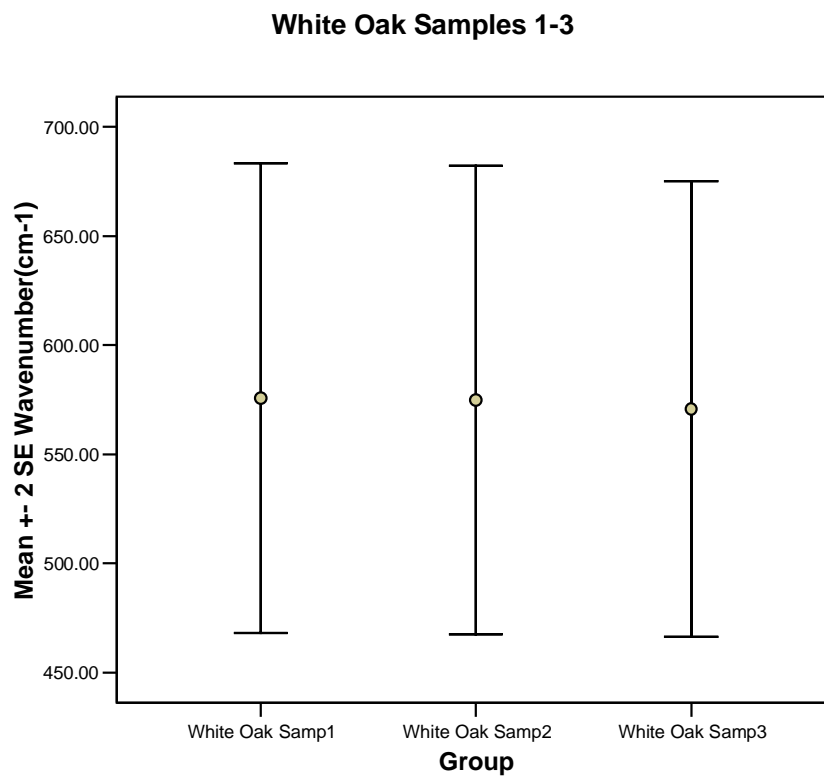
ANOVA

Wavenumber

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	513584.487	1	513584.487	.373	.542
Within Groups	807907368.272	586	1378681.516		
Total	808420952.760	587			

Means Plots: White Oak Greenwood (GW) and White Oak Lumber (400-4000)



Graph: White Oak Samples 1-3 (Greenwood) (400-900)

Oneway: White Oak Samples 1-3 (Greenwood) (400-900)
Descriptives

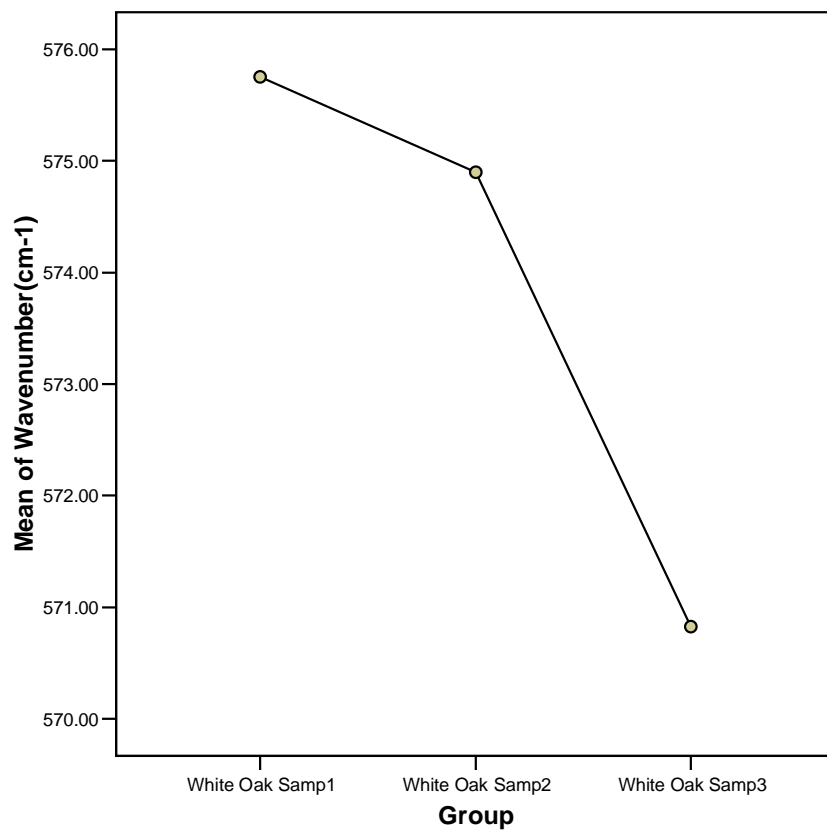
	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1 White Oak Samp1	9	575.7533	161.42844	53.80948	451.6684	699.8382	410.76	875.52
2 White Oak Samp2	9	574.8967	161.13118	53.71039	451.0403	698.7531	418.48	875.52
3 White Oak Samp3	9	570.8256	156.64173	52.21391	450.4201	691.2310	416.55	875.52
Total	27	573.8252	153.49731	29.54057	513.1037	634.5467	410.76	875.52

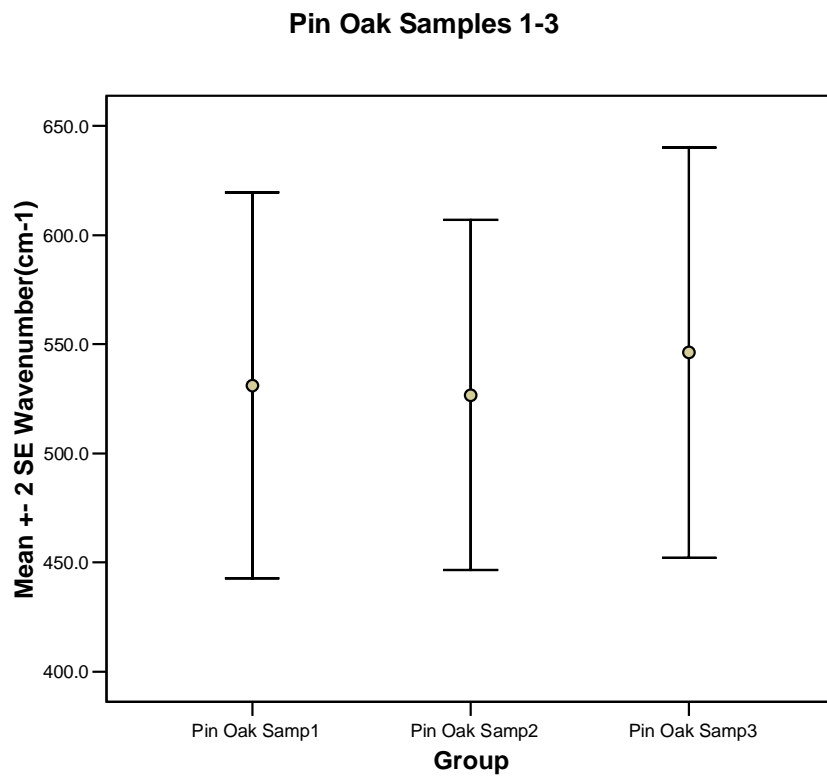
Test of Homogeneity of Variances

Wavenumber			
Levene Statistic	df1	df2	Sig.
.018	2	24	.983

ANOVA

Wavenumber					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	124.772	2	62.386	.002	.998
Within Groups	612472.243	24	25519.677		
Total	612597.016	26			

Means Plots: White Oak Samples 1-3 (Greenwood) (400-900)

Graph: Pin Oak Samples 1-3 (Greenwood) (400-900)

Oneway: Pin Oak Samples 1-3 (Greenwood) (400-900)

Descriptives

Wavenumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1 Pin Oak Samp1	10	531.126	139.9217	44.2471	431.032	631.220	418.5	873.6
2 Pin Oak Samp2	11	526.673	133.0580	40.1185	437.283	616.062	418.5	871.7
3 Pin Oak Samp3	9	546.213	140.9896	46.9965	437.839	654.588	418.5	875.6
Total	30	534.019	133.1693	24.3133	484.293	583.746	418.5	875.6

Test of Homogeneity of Variances

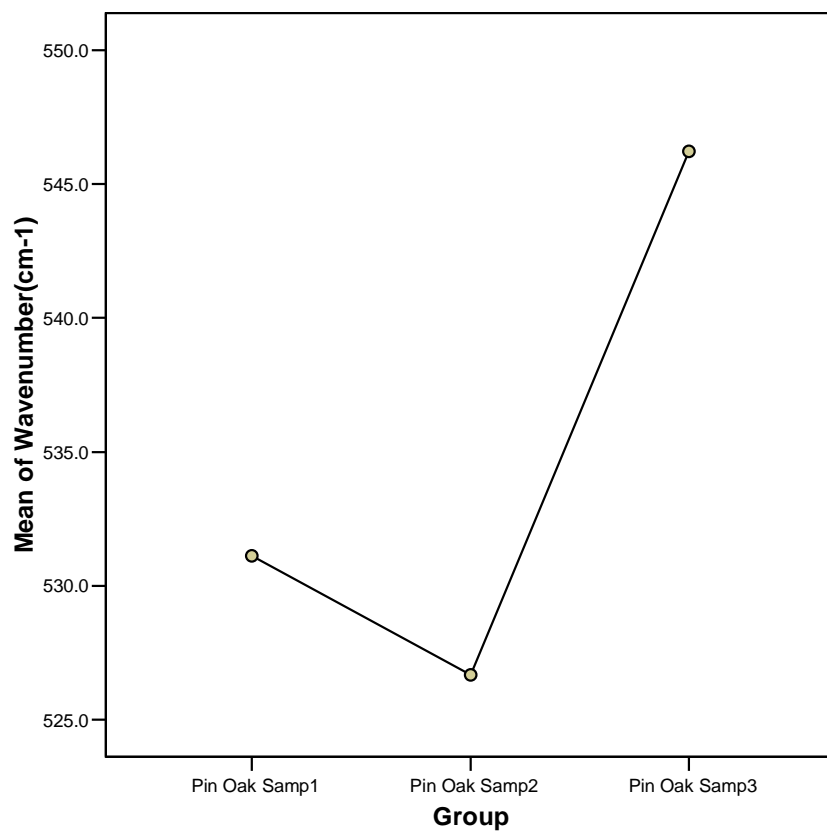
Wavenumber

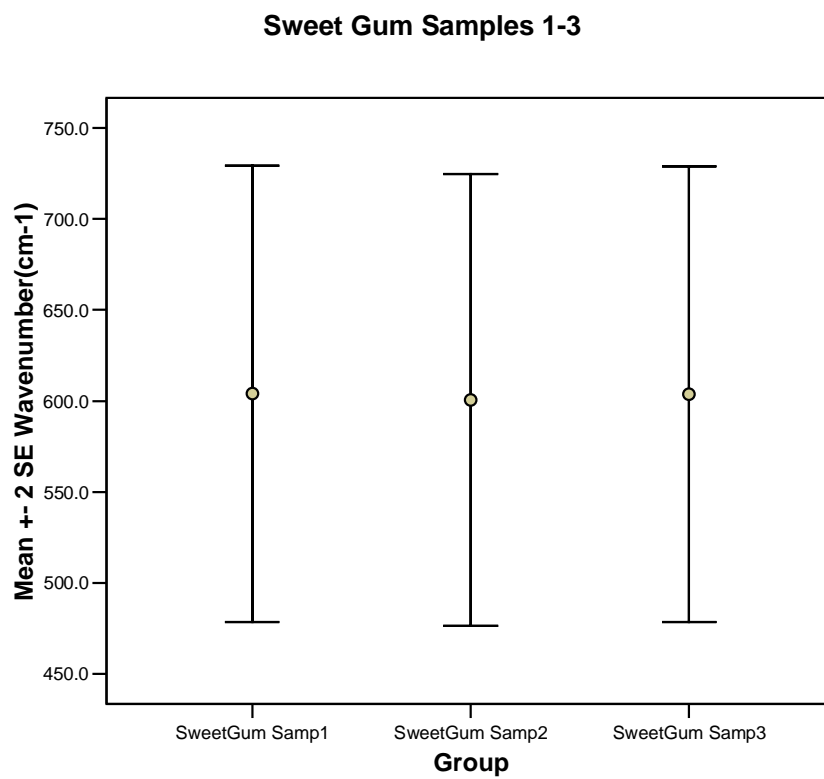
Levene Statistic	df1	df2	Sig.
.033	2	27	.967

ANOVA

Wavenumber

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2015.655	2	1007.828	.053	.948
Within Groups	512271.816	27	18973.030		
Total	514287.471	29			

Means Plots: Pin Oak Samples 1-3 (Greenwood) (400-900)

Graph: SweetGum Samples 1-3 (Greenwood) (400-900)

Oneway: SweetGum Samples 1-3 (Greenwood) (400-900)

Descriptives

Wavenumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1 SweetGum Samp1	8	603.883	177.4384	62.7339	455.540	752.225	418.5	875.6
2 SweetGum Samp2	8	600.506	175.8126	62.1591	453.523	747.489	418.5	875.6
3 SweetGum Samp3	8	603.641	177.3381	62.6985	455.383	751.900	418.5	875.6
Total	24	602.677	169.0073	34.4985	531.311	674.042	418.5	875.6

Test of Homogeneity of Variances

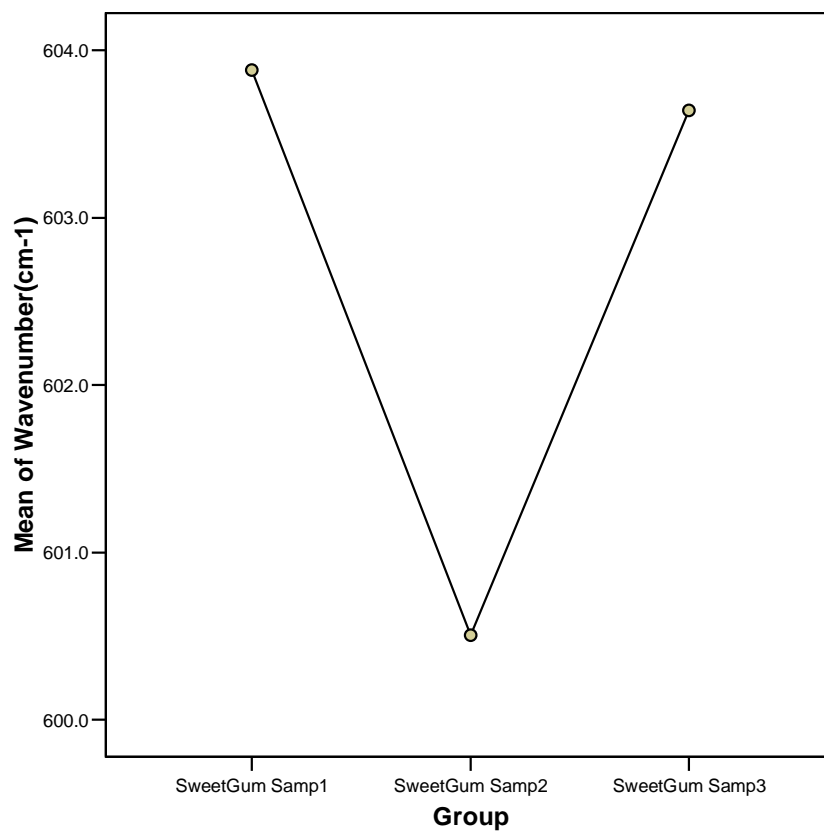
Wavenumber

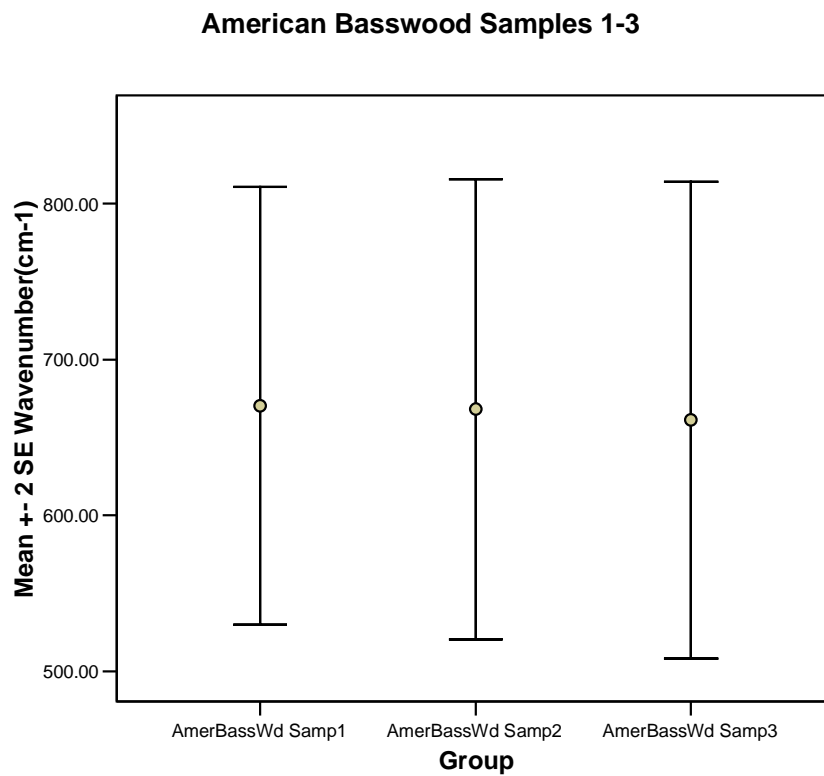
Levene Statistic	df1	df2	Sig.
.001	2	21	.999

ANOVA

Wavenumber

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	56.761	2	28.381	.001	.999
Within Groups	656902.671	21	31281.080		
Total	656959.432	23			

Means Plots: SweetGum Samples 1-3 (Greenwood) (400-900)

Graph: American Basswood Samples 1-3 (Greenwood) (400-900)

Oneway: American Bass Wood Samples 1-3 (Greenwood) (400-900)

Descriptives

Wavenumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1 AmBssWd Samp1	5	670.3680	157.11744	70.26505	475.2809	865.4551	474.43	881.35
2 AmBssWd Samp2	5	668.0540	164.85013	73.72322	463.3655	872.7425	451.28	875.57
3 AmBssWd Samp3	5	661.1100	170.88882	76.42380	448.9235	873.2965	447.43	873.64
Total	15	666.5107	152.24274	39.30891	582.2014	750.8199	447.43	881.35

Test of Homogeneity of Variances

Wavenumber

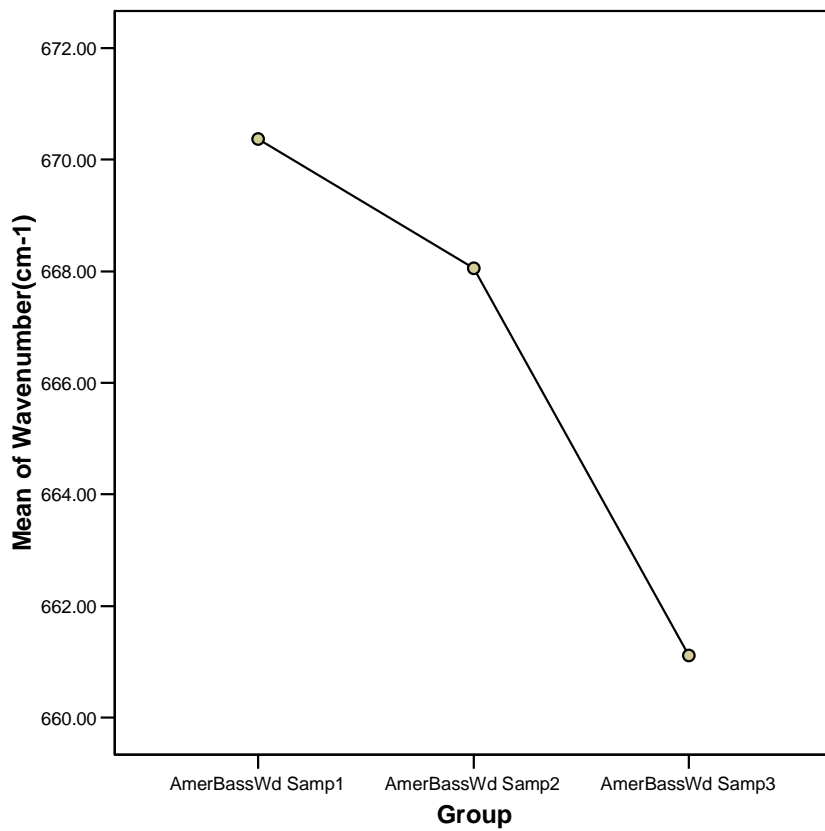
Levene Statistic	df1	df2	Sig.
.038	2	12	.962

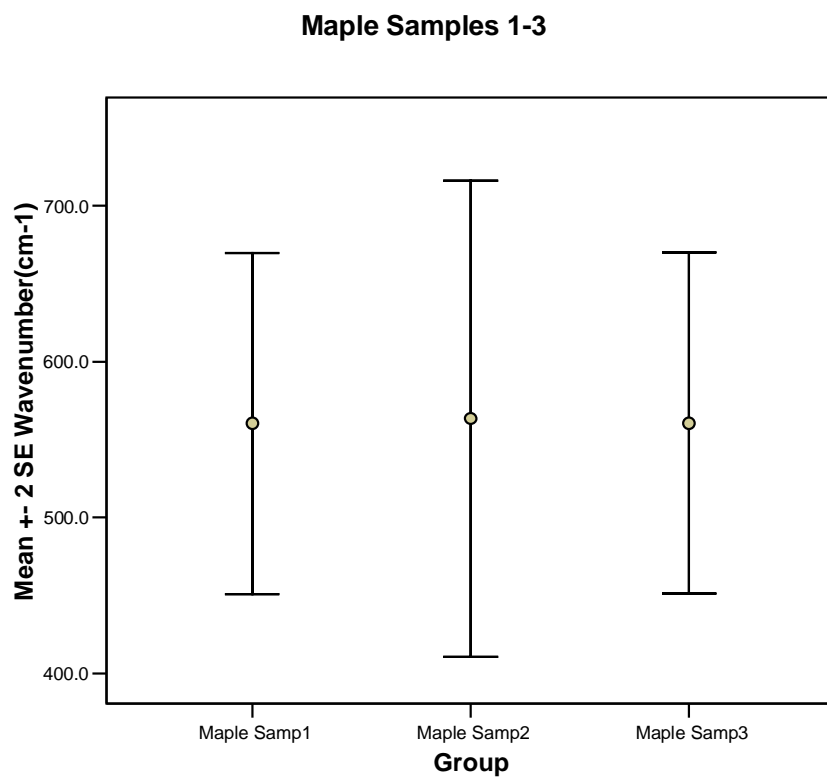
ANOVA

Wavenumber

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	232.140	2	116.070	.004	.996
Within Groups	324257.78	12	27021.482		
Total	324489.92	14			

Means Plots: American Bass Wood Samples 1-3 (Greenwood) (400-900)



Graph: Maple Wood Samples 1-3 (Greenwood) (400-900)

Oneway: Maple Wood Samples 1-3 (greenwood) (400-900)

Descriptives

Wavenumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1 Maple Samp1	8	560.249	154.8526	54.7487	430.789	689.709	418.5	875.6
2 Maple Samp2	6	563.463	187.0429	76.3599	367.174	759.753	418.5	875.6
3 Maple Samp3	8	560.490	154.7769	54.7219	431.093	689.887	418.5	875.6
Total	22	561.213	155.9172	33.2417	492.083	630.343	418.5	875.6

Test of Homogeneity of Variances

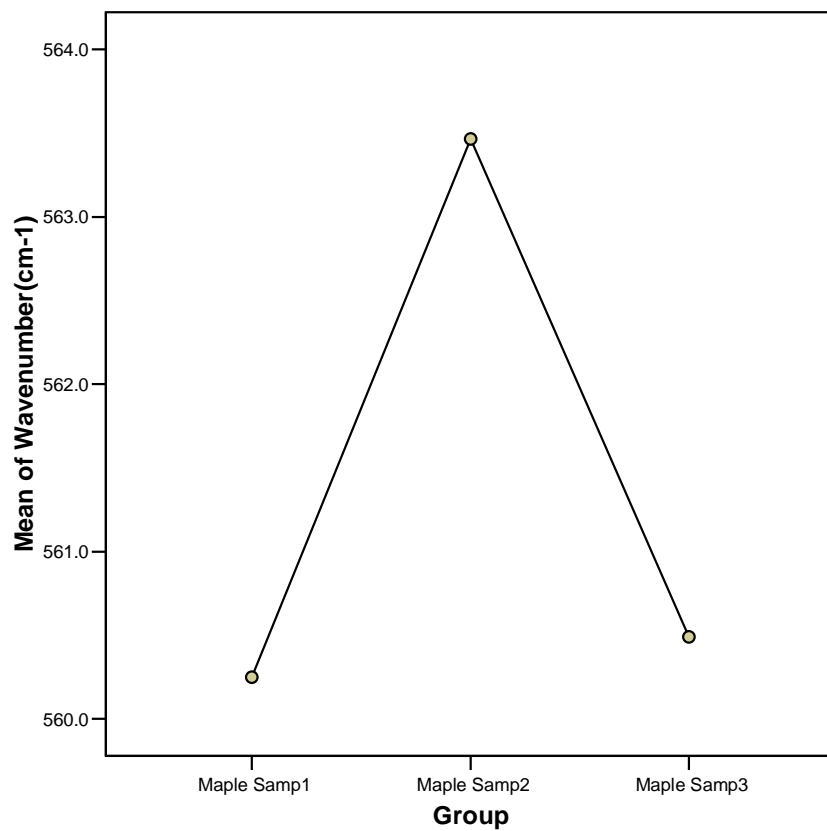
Wavenumber

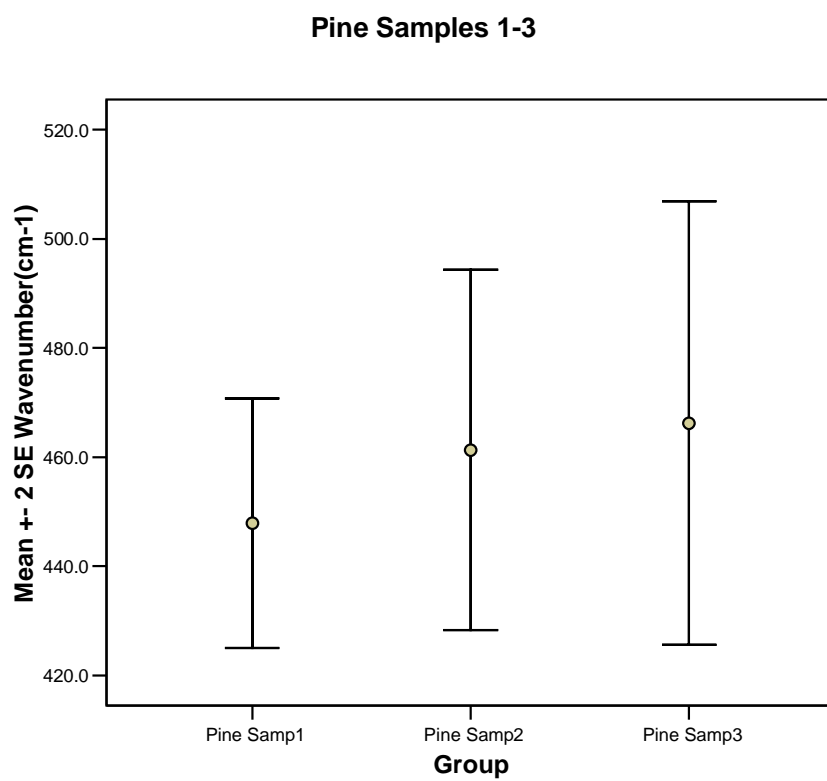
Levene Statistic	df1	df2	Sig.
.381	2	19	.688

ANOVA

Wavenumber

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	42.004	2	21.002	.001	.999
Within Groups	510471.726	19	26866.933		
Total	510513.730	21			

Means Plots:Maple Wood Samples 1-3 (greenwood) (400-900)

Graph: Pine Wood Samples 1-3 (greenwood) (400-900)

Oneway: Pine Wood Samples 1-3 (greenwood) (400-900)

Descriptives

Wavenumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1 Pine Samp1	4	447.910	22.8936	11.4468	411.481	484.339	418.5	472.5
2 Pine Samp2	5	461.312	36.9036	16.5038	415.490	507.134	418.5	516.9
3 Pine Samp3	4	466.230	40.6766	20.3383	401.504	530.956	418.5	516.9
Total	13	458.702	32.5451	9.0264	439.035	478.368	418.5	516.9

Test of Homogeneity of Variances

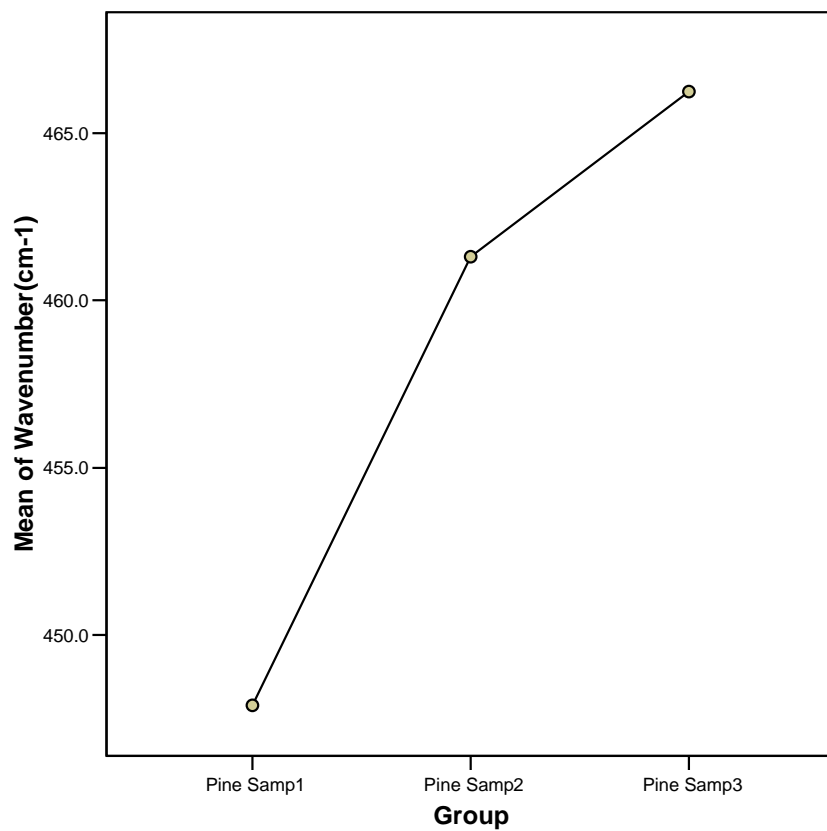
Wavenumber

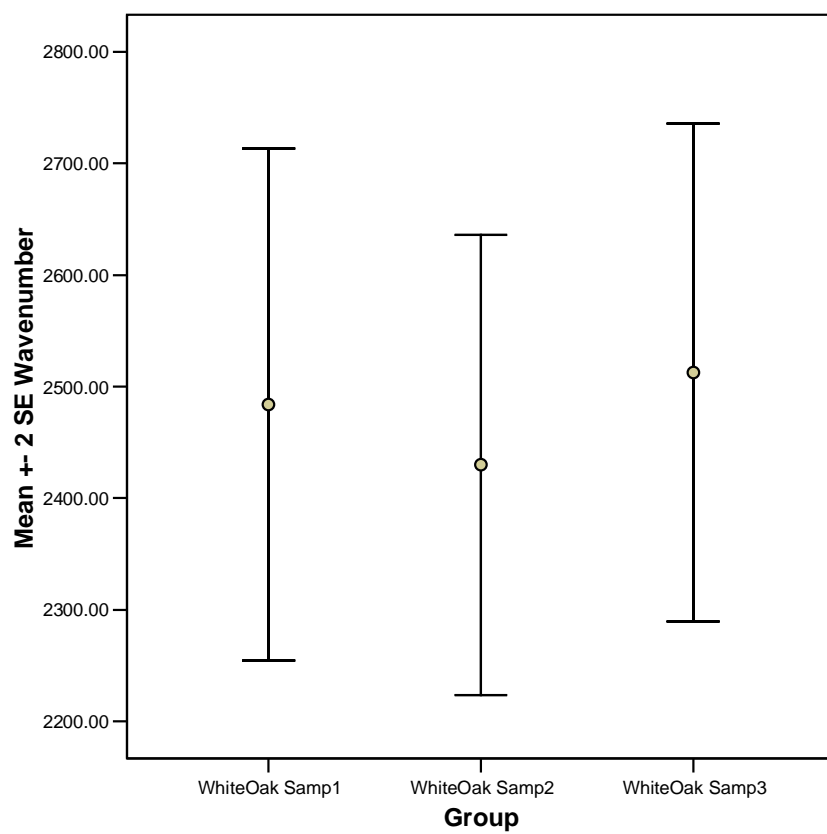
Levene Statistic	df1	df2	Sig.
.393	2	10	.685

ANOVA

Wavenumber

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	726.613	2	363.306	.303	.745
Within Groups	11983.603	10	1198.360		
Total	12710.216	12			

Means Plots: Pine Wood Samples 1-3 (greenwood) (400-900)

Graph: Greenwood WhiteOak Samp1-3 (400-4000)

Oneway: Greenwood WhiteOak Samp1-3 (400-4000)

Descriptives

Wavenumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	104	2483.8091	1170.22424	114.74993	2256.2297	2711.3886	410.76	3949.50
2	121	2429.8679	1133.03386	103.00308	2225.9289	2633.8068	418.48	3963.00
3	109	2512.7386	1164.57637	111.54619	2291.6347	2733.8425	416.55	3949.50
Total	334	2473.7086	1152.07812	63.03891	2349.7039	2597.7133	410.76	3963.00

Test of Homogeneity of Variances

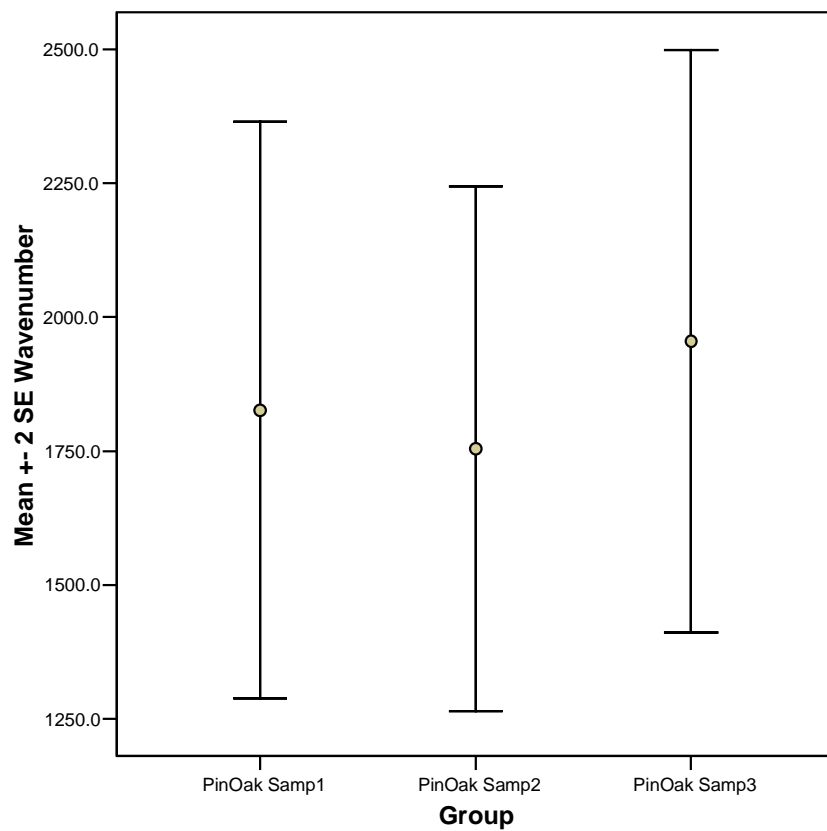
Wavenumber

Levene Statistic	df1	df2	Sig.
.559	2	331	.572

ANOVA

Wavenumber

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	409217.886	2	204608.943	.153	.858
Within Groups	441576354.335	331	1334067.536		
Total	441985572.221	333			

Graph: Greenwood PinOak Samp1-3 (400-4000)

Oneway: Greenwood PinOak Samp1-3 (400-4000)

Notes

Descriptives

Wavenumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	26	1826.496	1371.6599	269.0046	1272.471	2380.522	418.5	3853.3
2	29	1754.459	1319.0671	244.9446	1252.713	2256.205	418.5	3853.3
3	26	1955.265	1385.4694	271.7129	1395.662	2514.869	418.5	3853.3
Total	81	1842.038	1343.0595	149.2288	1545.064	2139.013	418.5	3853.3

Test of Homogeneity of Variances

Wavenumber

Levene Statistic	df1	df2	Sig.
.316	2	78	.730

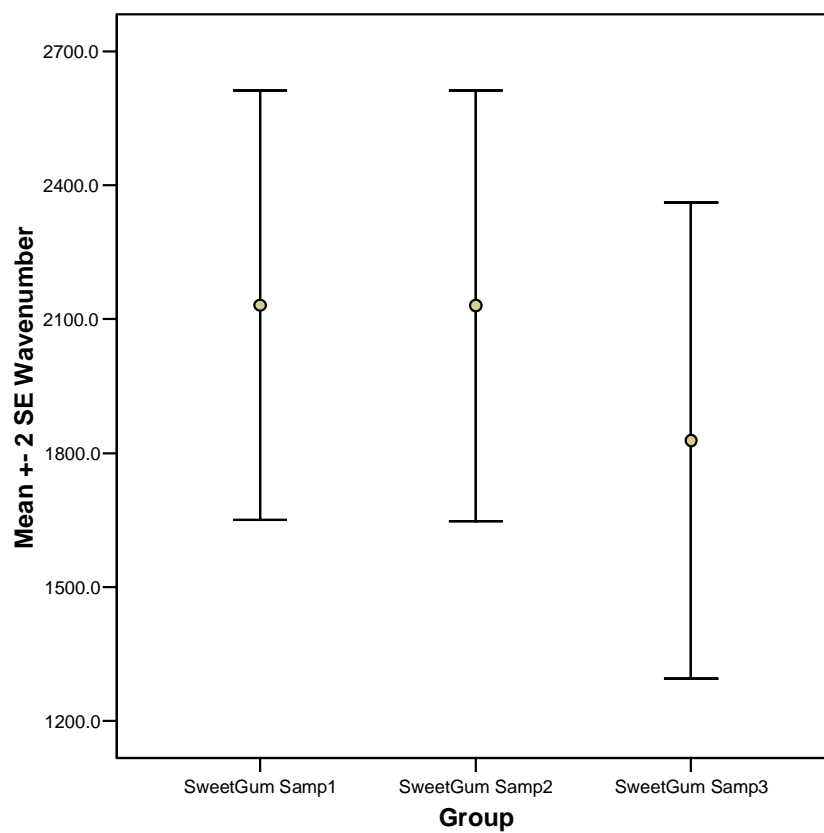
ANOVA

Wavenumber

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	562044.261	2	281022.130	.152	.859
Within Groups	143742671.954	78	1842854.769		
Total	144304716.215	80			

Graph: Greenwood SweetGum Samp1-3 (400-4000)

Notes



Oneway: Greenwood SweetGum Samp1-3 (400-4000)

Notes

Descriptives

Wavenumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	30	2131.319	1317.9351	240.6209	1639.194	2623.444	418.5	3853.3
2	30	2130.225	1321.6351	241.2965	1636.719	2623.732	418.5	3853.3
3	23	1828.193	1279.4717	266.7883	1274.908	2381.478	418.5	3859.1
Total	83	2046.925	1299.9240	142.6852	1763.079	2330.771	418.5	3859.1

Test of Homogeneity of Variances

Wavenumber

Levene Statistic	df1	df2	Sig.
.285	2	80	.753

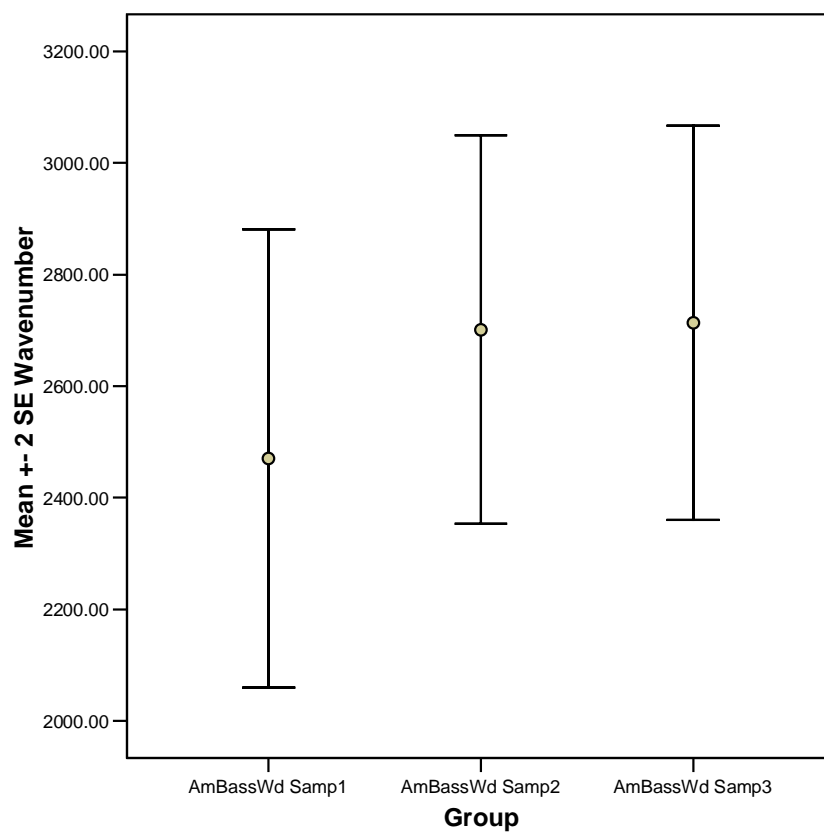
ANOVA

Wavenumber

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1522241.478	2	761120.739	.444	.643
Within Groups	137041548.388	80	1713019.355		
Total	138563789.866	82			

Graph: Greenwood AmBassWd Samp1-3 (400-4000)

Notes



Oneway:: Greenwood AmBassWd Samp1-3 (400-4000)

Notes

Descriptives

Wavenumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	37	2470.2268	1248.75207	205.29358	2053.8721	2886.5814	474.43	3897.62
2	49	2701.2855	1218.55194	174.07885	2351.2765	3051.2945	451.28	3897.62
3	48	2713.7279	1223.00879	176.52611	2358.6032	3068.8527	447.43	3889.91
Total	134	2641.9427	1223.89315	105.72826	2432.8163	2851.0691	447.43	3897.62

Test of Homogeneity of Variances

Wavenumber

Levene Statistic	df1	df2	Sig.
.027	2	131	.974

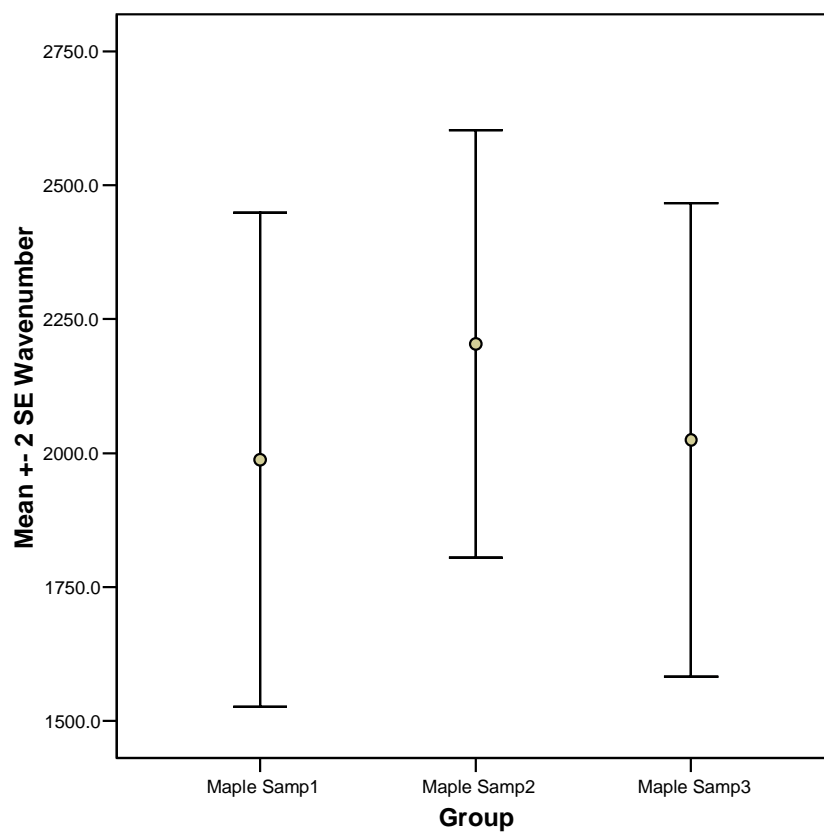
ANOVA

Wavenumber

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1510902.030	2	755451.015	.501	.607
Within Groups	197711719.368	131	1509249.766		
Total	199222621.398	133			

Graph: Greenwood Maple Samp1-3 (400-4000)

Notes



Oneway: Greenwood Maple Samp1-3 (400-4000)

Notes

Descriptives

Wavenumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	30	1987.705	1264.1191	230.7955	1515.675	2459.735	418.5	3853.3
2	37	2203.825	1213.3409	199.4720	1799.277	2608.373	418.5	3853.3
3	32	2024.629	1250.1071	220.9898	1573.917	2475.341	418.5	3853.3
Total	99	2080.412	1231.8384	123.8044	1834.726	2326.098	418.5	3853.3

Test of Homogeneity of Variances

Wavenumber

Levene Statistic	df1	df2	Sig.
.002	2	96	.998

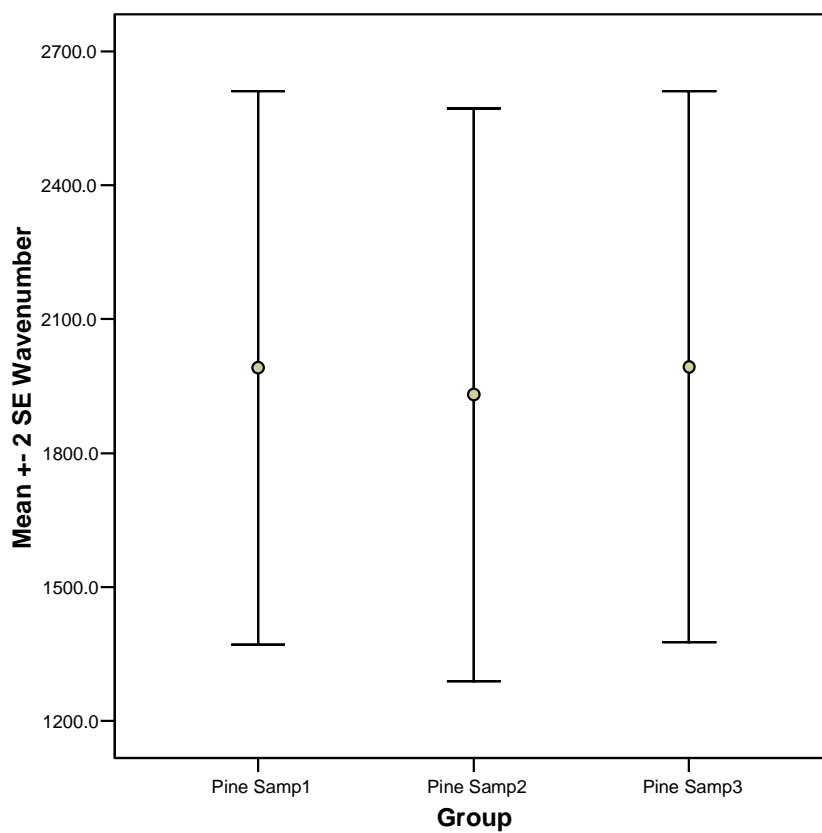
ANOVA

Wavenumber

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	920955.331	2	460477.665	.299	.742
Within Groups	147786772.367	96	1539445.545		
Total	148707727.698	98			

Graph: Greenwood Pine Samp1-3 (400-4000)

Notes



Oneway: Greenwood Pine Samp1-3 (400-4000)

Notes

Descriptives

Wavenumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	17	1990.956	1277.3048	309.7919	1334.227	2647.686	418.5	3853.3
2	17	1930.944	1323.2600	320.9377	1250.587	2611.302	418.5	3853.3
3	17	1993.339	1272.6880	308.6722	1338.983	2647.695	418.5	3853.3
Total	51	1971.746	1265.5327	177.2100	1615.810	2327.683	418.5	3853.3

Test of Homogeneity of Variances

Wavenumber

Levene Statistic	df1	df2	Sig.
.025	2	48	.976

ANOVA

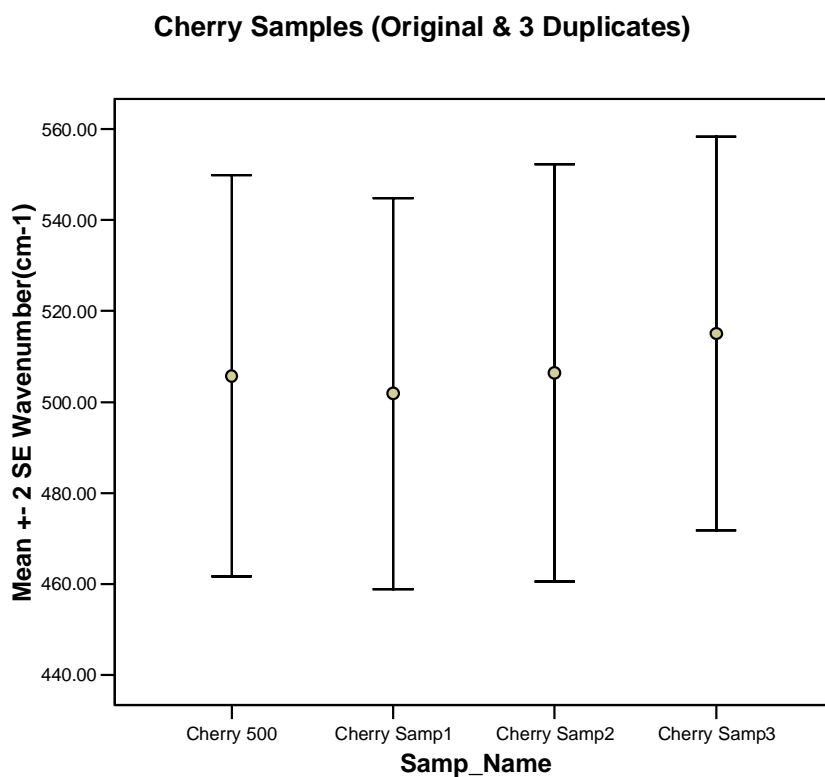
Wavenumber

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	42501.459	2	21250.729	.013	.987
Within Groups	80036145.152	48	1667419.691		
Total	80078646.611	50			

Appendix G

Statistical Comparison of Single Sample Sets for Lumbers

Graph: Cherry Wood Samples 1-4 Lumber (400-900)



Oneway: Cherry Wood Samples 1-4 Lumber (400-900)

Descriptives

Wavenumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
					1 Cherry Orig	12			505.7408	76.50154	22.08409	457.1341	554.3476	410.76	669.18
2 Cherry Samp1	13	501.8469	77.61500	21.52653	454.9446	548.7492	410.76	665.32
3 Cherry Samp2	12	506.3842	79.44194	22.93291	455.9092	556.8592	410.76	669.18
4 Cherry Samp3	12	515.0633	75.04710	21.66423	467.3807	562.7460	420.41	669.18
Total	49	507.1484	74.88718	10.69817	485.6383	528.6585	410.76	669.18

Test of Homogeneity of Variances

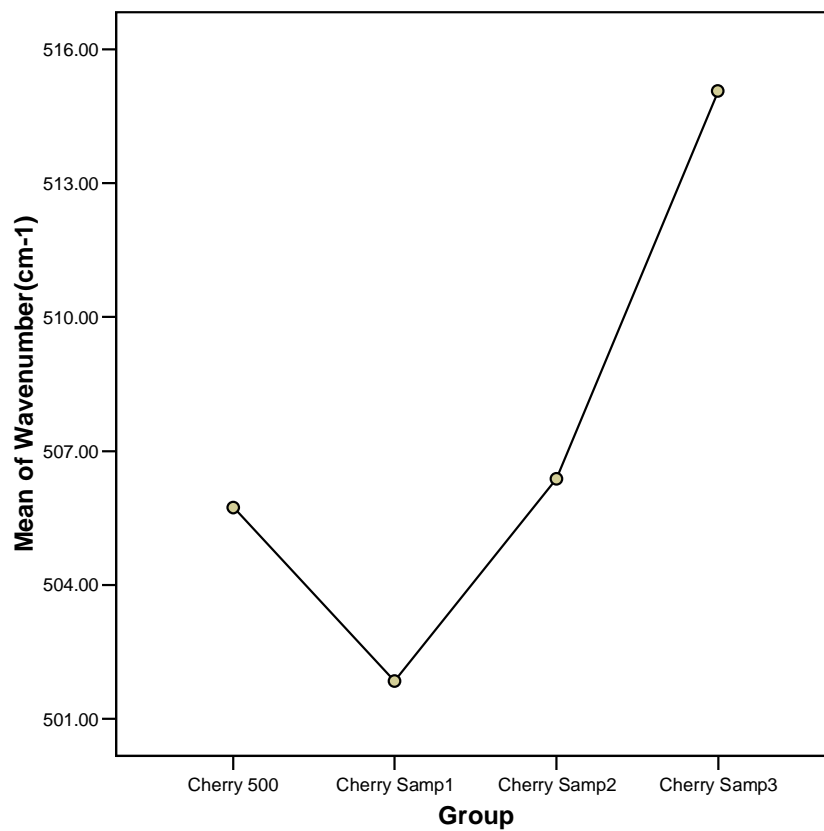
Wavenumber

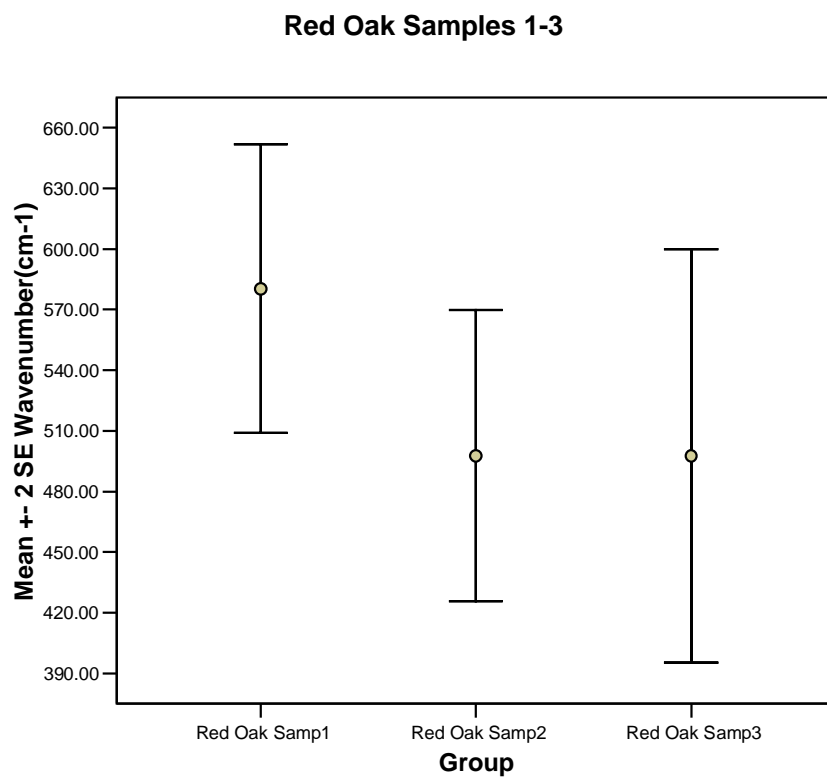
Levene Statistic	df1	df2	Sig.
.013	3	45	.998

ANOVA

Wavenumber

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1147.911	3	382.637	.064	.978
Within Groups	268040.375	45	5956.453		
Total	269188.286	48			

Means Plots: Cherry Wood Samples 1-4 Lumber (400-900)

Graph: Red Oak Wood Samples 1-3 Lumber (400-900)

Oneway: Red Oak Wood Samples 1-3 (Lumber) (400-900)

Descriptives

Wavenumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1 RedOak Samp1	17	580.3541	147.38237	35.74548	504.5771	656.1311	408.83	900.59
2 RedOak Samp2	9	497.7589	107.96534	35.98845	414.7694	580.7484	406.91	669.18
3 RedOak Samp3	5	497.5440	114.33409	51.13176	355.5795	639.5085	404.98	669.18
Total	31	543.0184	134.85288	24.22029	493.5540	592.4828	404.98	900.59

Test of Homogeneity of Variances

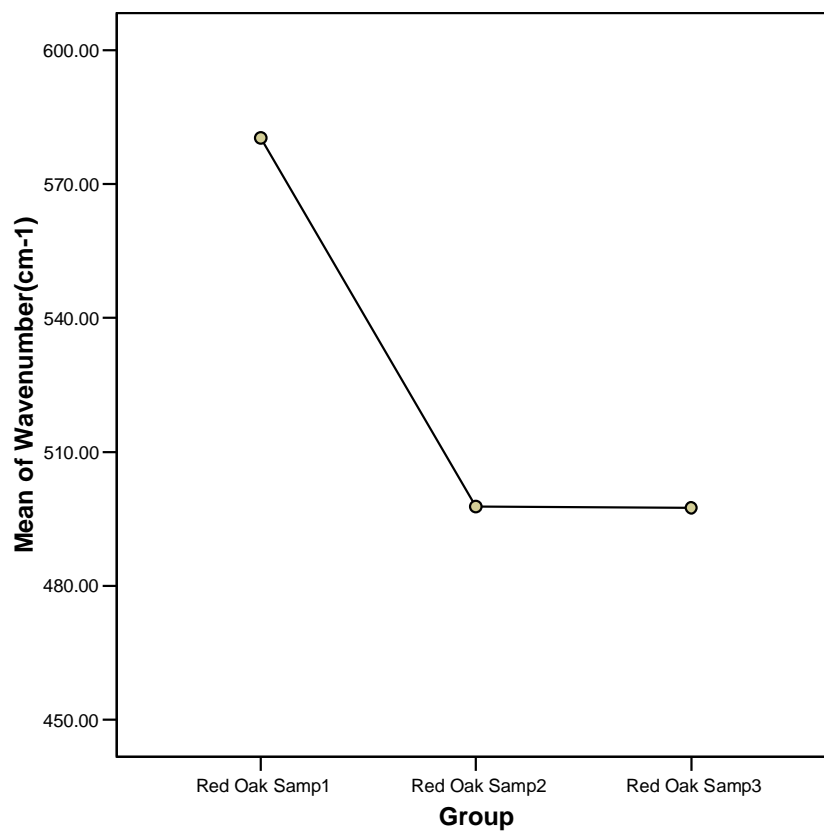
Wavenumber

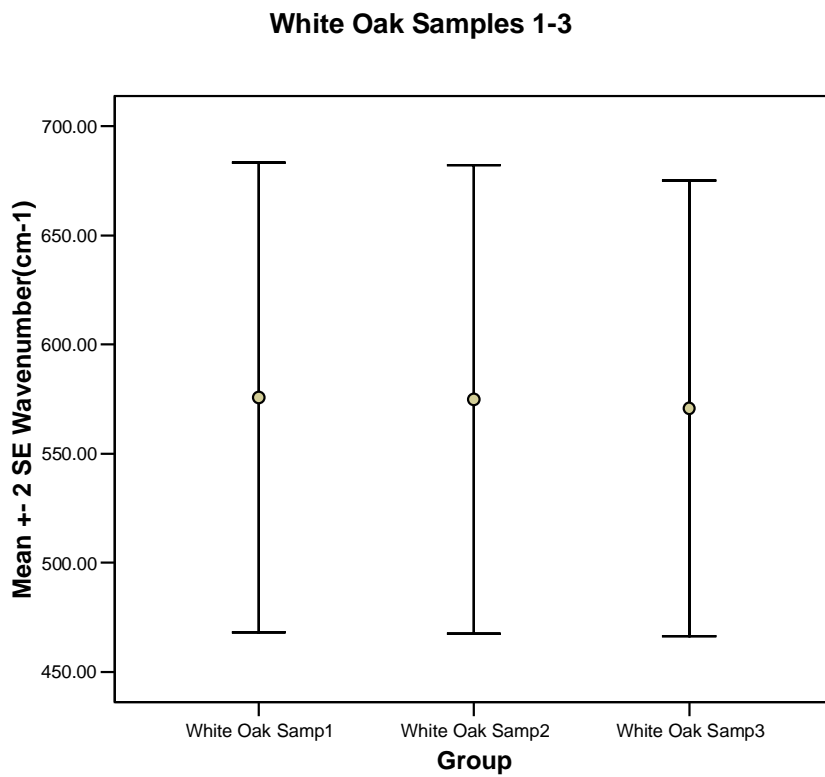
Levene Statistic	df1	df2	Sig.
.442	2	28	.647

ANOVA

Wavenumber

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	52472.664	2	26236.332	1.490	.243
Within Groups	493086.280	28	17610.224		
Total	545558.945	30			

Means Plots: Red Oak Wood Samples 1-3 (Lumber) (400-900)

Graph: White Oak Wood Samples 1-3 (Lumber) (400-900)

Oneway: White Oak Wood Samples 1-3 (Lumber) (400-900)

Descriptives

Wavenumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1 WhiteOak Samp1	9	575.7533	161.42844	53.80948	451.6684	699.8382	410.76	875.52
2 WhiteOak Samp2	9	574.8967	161.13118	53.71039	451.0403	698.7531	418.48	875.52
3 WhiteOak Samp3	9	570.8256	156.64173	52.21391	450.4201	691.2310	416.55	875.52
Total	27	573.8252	153.49731	29.54057	513.1037	634.5467	410.76	875.52

Test of Homogeneity of Variances

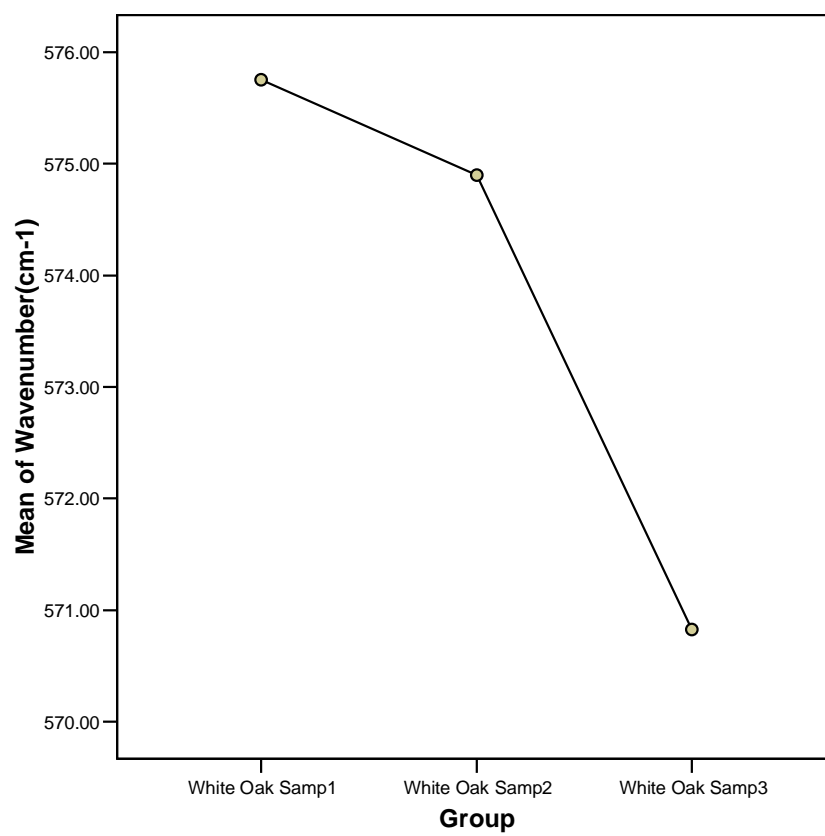
Wavenumber

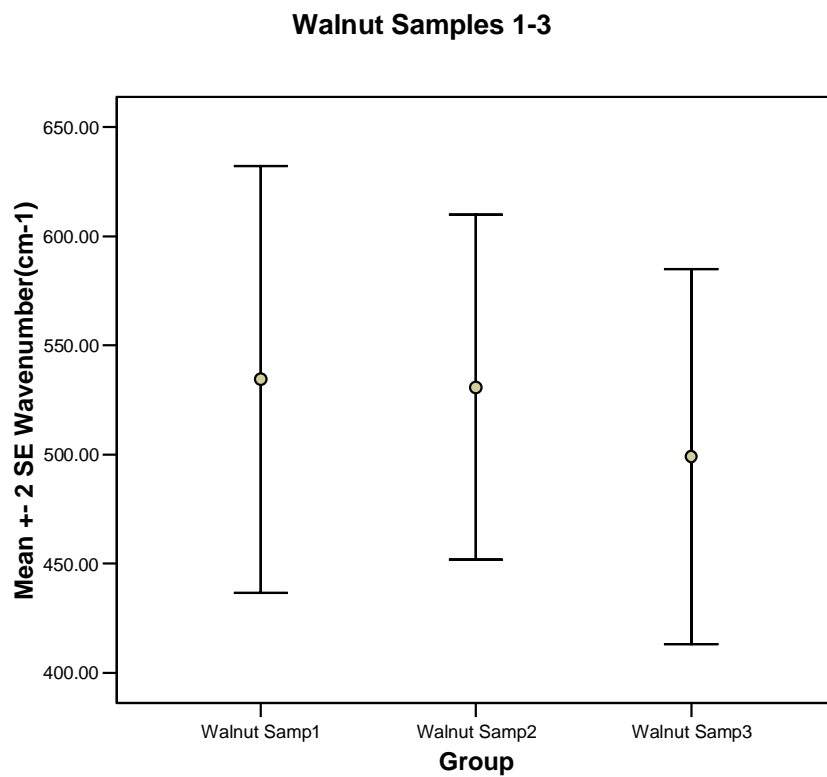
Levene Statistic	df1	df2	Sig.
.018	2	24	.983

ANOVA

Wavenumber

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	124.772	2	62.386	.002	.998
Within Groups	612472.243	24	25519.677		
Total	612597.016	26			

Means Plots: White Oak Wood Samples 1-3 (Lumber) (400-900)

Graph: Walnut Wood Samples 1-3 (Lumber) (400-900)

Oneway: Walnut Wood Samples 1-3 (Lumber) (400-900)

Descriptives

Wavenumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
					1 Walnut Samp1	6			534.5067	119.75281	48.88888	408.8338	660.1795	406.91	669.18
2 Walnut Samp2	8	530.8100	111.74105	39.50643	437.3921	624.2279	410.76	671.11
3 Walnut Samp3	6	499.1517	105.20621	42.95026	388.7445	609.5588	406.91	669.18
Total	20	522.4215	107.39401	24.01403	472.1596	572.6834	406.91	671.11

Test of Homogeneity of Variances

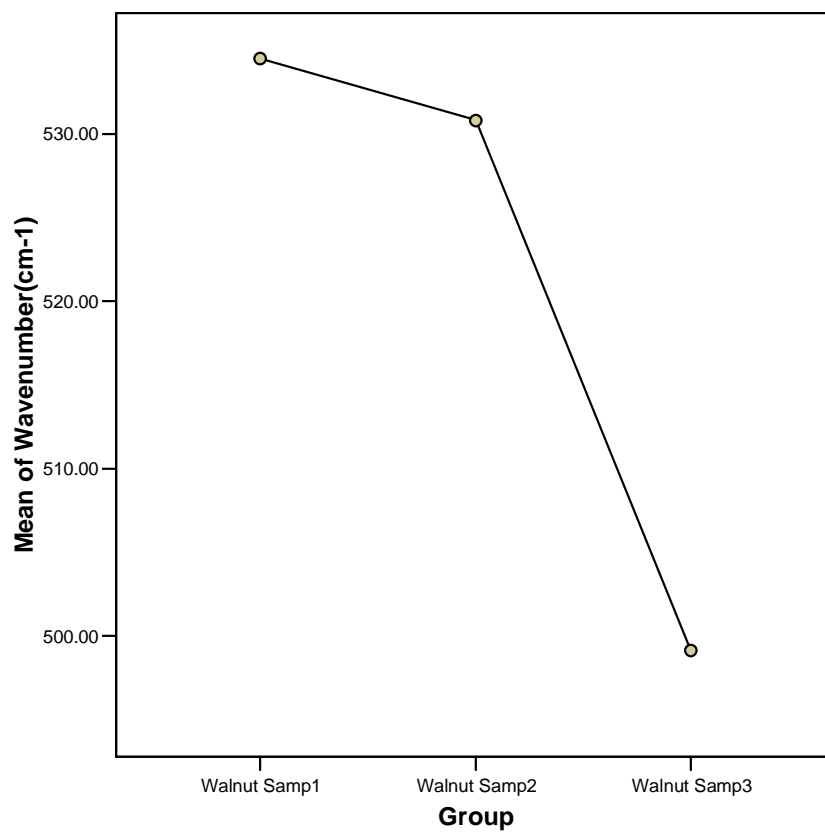
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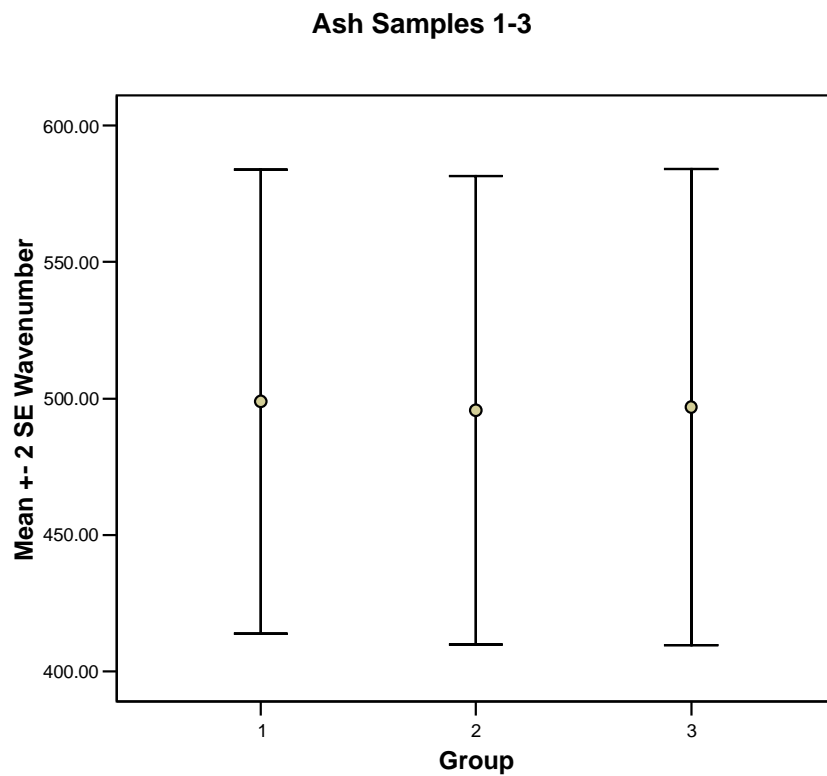
Levene Statistic	df1	df2	Sig.
.450	2	17	.645

ANOVA

Wavenumber

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4688.154	2	2344.077	.186	.832
Within Groups	214447.837	17	12614.579		
Total	219135.991	19			

Means Plots: Walnut Wood Samples 1-3 (Lumber) (400-900)

Graph: Ash Wood Samples 1-3 (Lumber) (400-900)

Oneway: Ash Wood Samples 1-3 (Lumber) (400-900)

Descriptives

Wavenumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1 Ash Samp1	6	498.8300	104.14194	42.51577	389.5397	608.1203	414.62	669.18
2 Ash Samp2	6	495.6167	105.13740	42.92217	385.2817	605.9516	406.91	665.32
3 Ash Samp3	6	496.9033	106.87655	43.63217	384.7433	609.0634	406.91	671.11
Total	18	497.1167	99.00727	23.33624	447.8815	546.3518	406.91	671.11

Test of Homogeneity of Variances

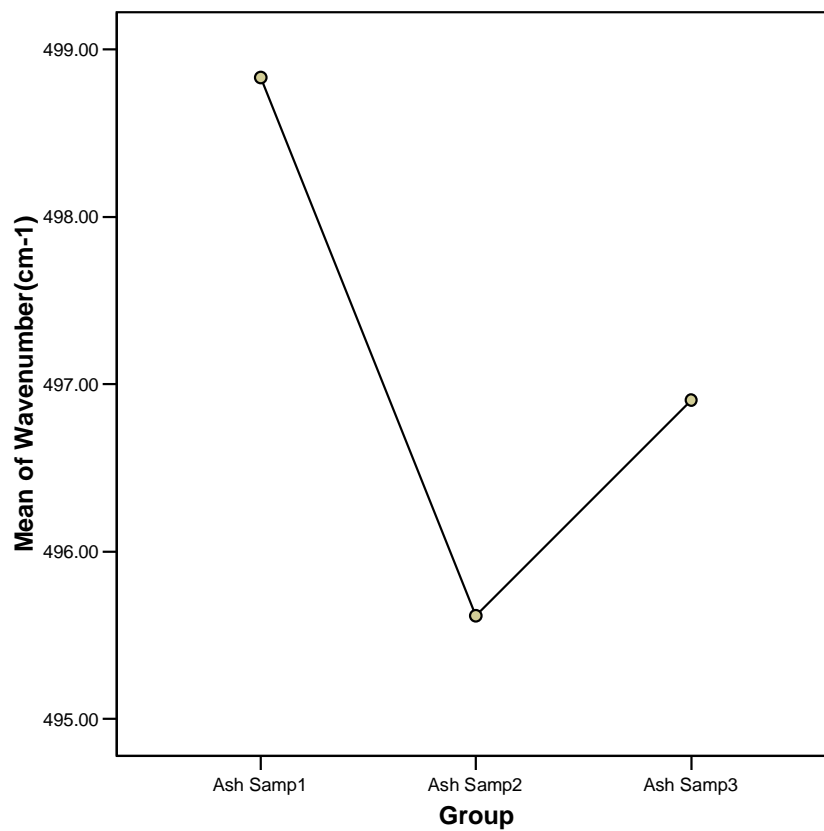
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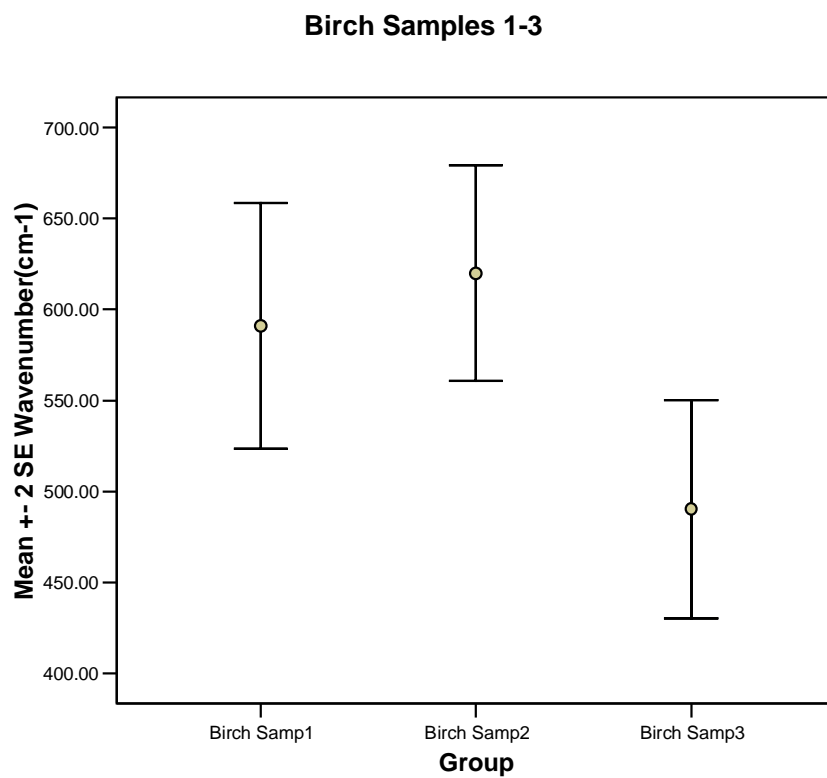
Levene Statistic	df1	df2	Sig.
.003	2	15	.997

ANOVA

Wavenumber

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	31.386	2	15.693	.001	.999
Within Groups	166610.073	15	11107.338		
Total	166641.459	17			

Means Plots: Ash Wood Samples 1-3 (Lumber) (400-900)

Graph: Birch Wood Samples 1-3 (Lumber) (400-900)

Oneway: Birch Wood Samples 1-3 (Lumber) (400-900)

Descriptives

Wavenumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1 Birch Samp1	15	591.1400	130.84174	33.78319	518.6823	663.5977	422.33	865.88
2 Birch Samp2	21	619.9567	135.66824	29.60524	558.2012	681.7121	403.05	875.52
3 Birch Samp3	10	490.2170	94.73598	29.95815	422.4470	557.9870	406.91	667.25
Total	46	582.3557	133.69192	19.71180	542.6541	622.0573	403.05	875.52

Test of Homogeneity of Variances

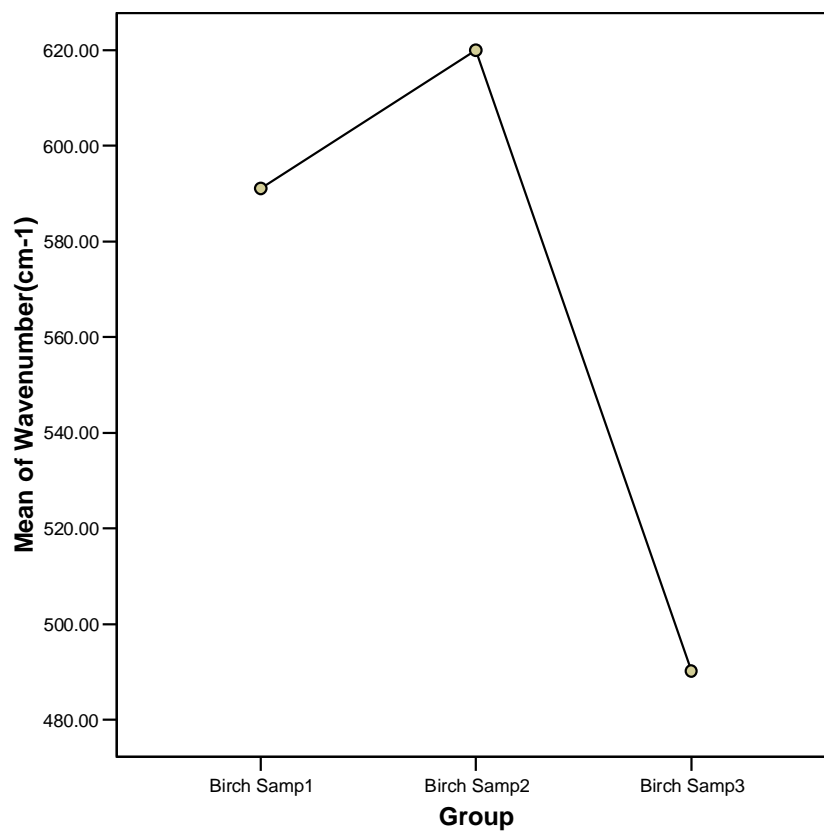
Wavenumber

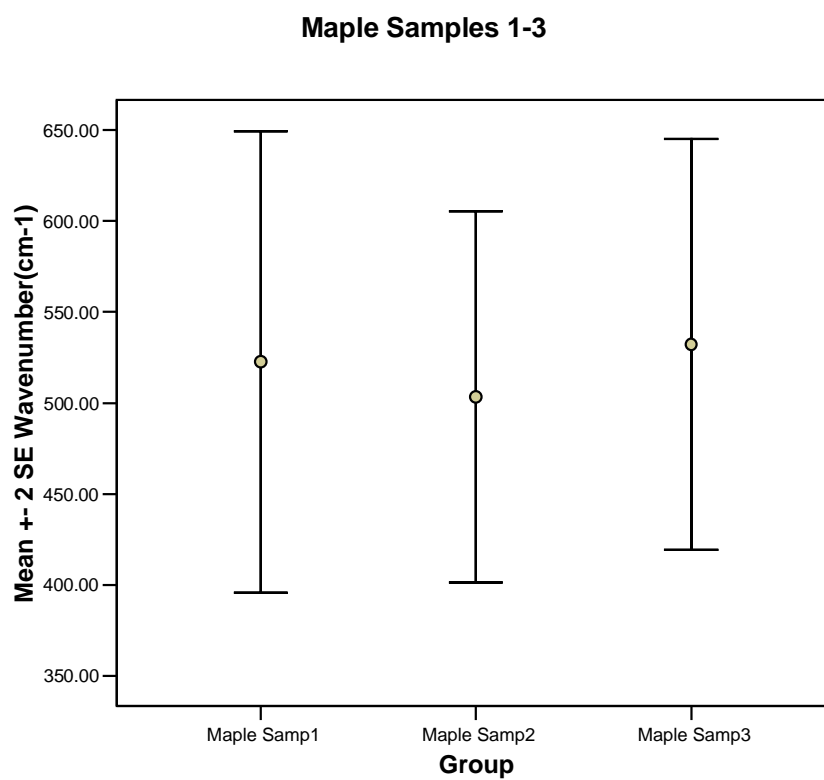
Levene Statistic	df1	df2	Sig.
1.000	2	43	.376

ANOVA

Wavenumber

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	115743.346	2	57871.673	3.614	.035
Within Groups	688565.446	43	16013.150		
Total	804308.792	45			

Means Plots: Birch Wood Samples 1-3 (Lumber) (400-900)

Graph: Maple Wood Samples 1-3 (Lumber) (400-900)

Oneway: Maple Wood Samples 1-3 (Lumber) (400-900)

Descriptives

Wavenumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1 Maple Samp1	4	522.6125	126.94972	63.47486	320.6072	724.6178	410.76	669.18
2 Maple Samp2	5	503.3300	114.15536	51.05183	361.5874	645.0726	414.62	669.18
3 Maple Samp3	4	532.2575	113.05380	56.52690	352.3637	712.1513	422.33	669.18
Total	13	518.1638	108.31738	30.04184	452.7083	583.6194	410.76	669.18

Test of Homogeneity of Variances

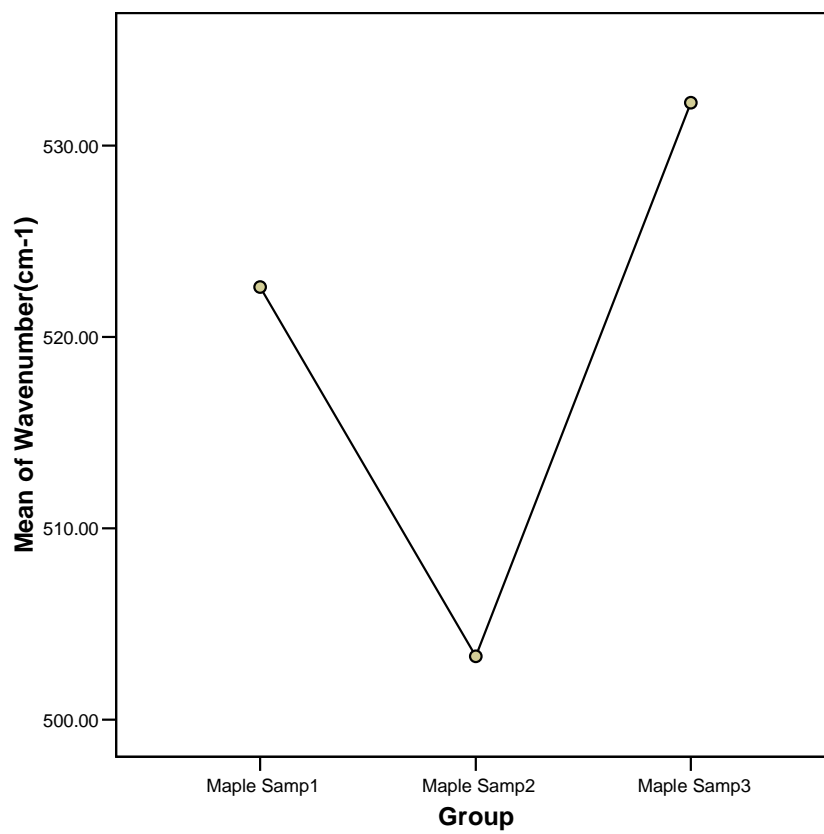
Wavenumber

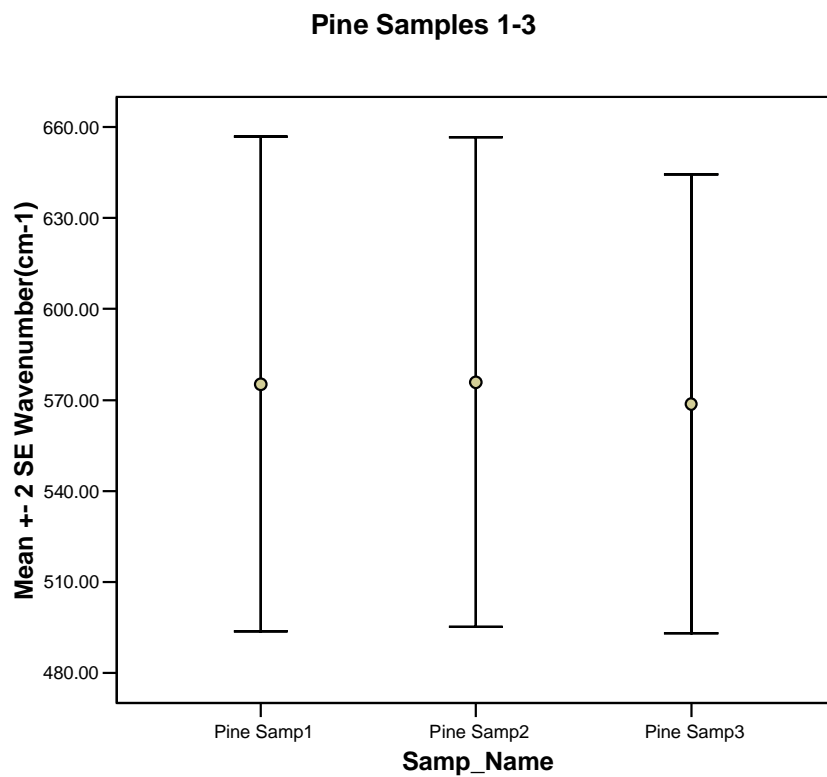
Levene Statistic	df1	df2	Sig.
.155	2	10	.858

ANOVA

Wavenumber

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1973.901	2	986.951	.071	.932
Within Groups	138817.960	10	13881.796		
Total	140791.862	12			

Means Plots: Maple Wood Samples 1-3 (Lumber) (400-900)

Graph: Pine Wood Samples 1-3 (Lumber) (400-900)

Oneway: Pine Wood Samples 1-3 (Lumber) (400-900)

Descriptives

Wavenumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1 Pine Samp1	11	575.2100	135.34199	40.80715	484.2860	666.1340	406.91	806.10
2 Pine Samp2	11	575.9091	133.96516	40.39202	485.9101	665.9081	408.83	802.24
3 Pine Samp3	12	568.7367	130.98120	37.81102	485.5152	651.9582	408.83	808.03
Total	34	573.1515	129.30141	22.17501	528.0361	618.2669	406.91	808.03

Test of Homogeneity of Variances

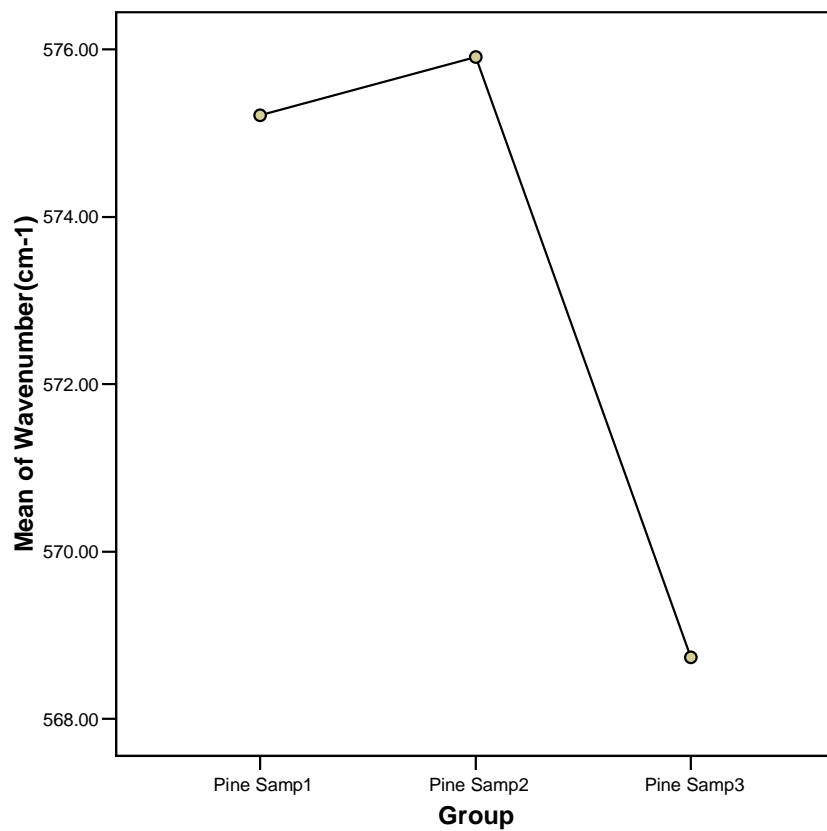
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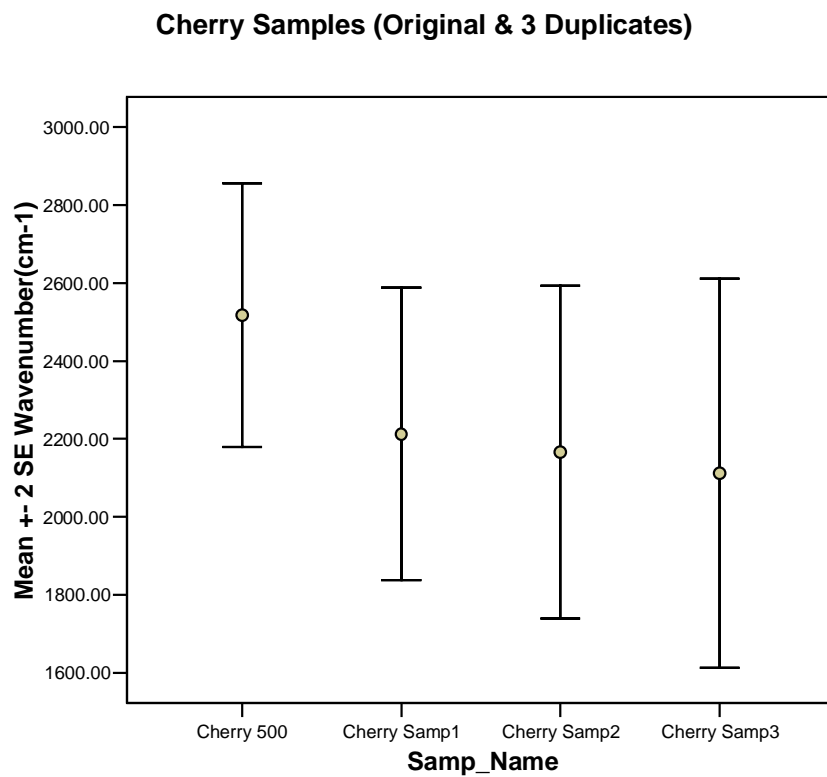
Levene Statistic	df1	df2	Sig.
.002	2	31	.998

ANOVA

Wavenumber

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	364.148	2	182.074	.010	.990
Within Groups	551358.023	31	17785.743		
Total	551722.171	33			

Means Plots: Pine Wood Samples 1-3 (Lumber) (400-900)

Graph: Cherry Wood Samples 1-4 Lumber (400-4000)

Oneway: Cherry Wood Samples 1-4 Lumber (400-4000)

Descriptives

Wavenumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1 Cherry Orig.	63	2517.0471	1343.65354	169.28443	2178.6524	2855.4419	410.76	3918.64
2 Cherry Samp1	51	2212.8212	1342.65251	188.00896	1835.1941	2590.4483	410.76	3905.15
3 Cherry Samp2	41	2166.0917	1369.28845	213.84693	1733.8909	2598.2925	410.76	3905.15
4 Cherry Samp3	33	2112.5485	1434.00881	249.62889	1604.0711	2621.0259	420.41	3905.15
Total	188	2286.9772	1364.35032	99.50547	2090.6796	2483.2747	410.76	3918.64

Test of Homogeneity of Variances

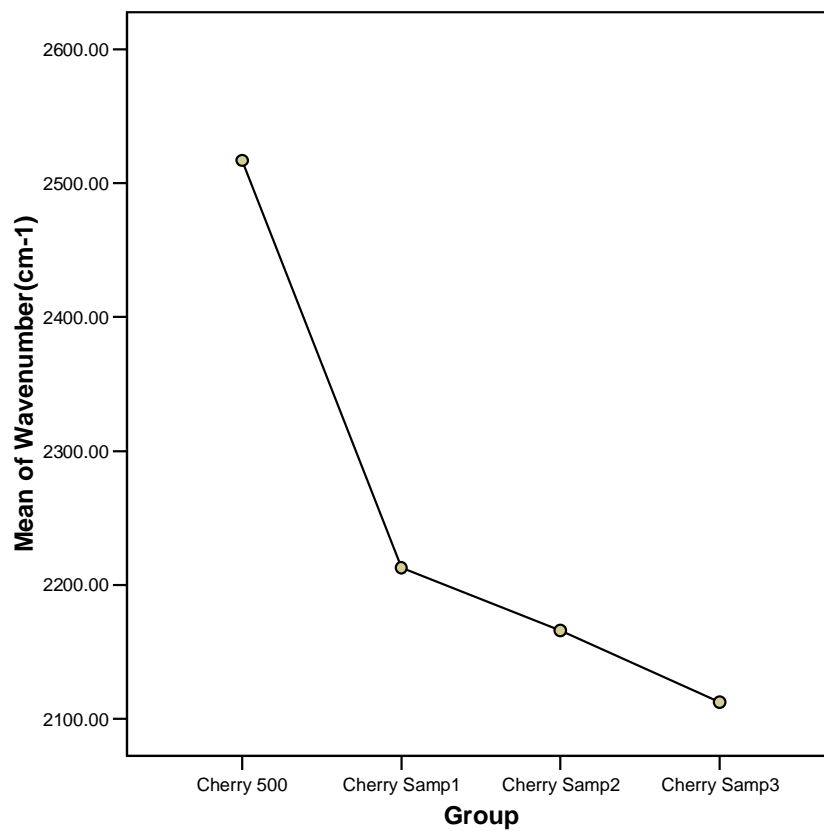
Wavenumber

Levene Statistic	df1	df2	Sig.
.254	3	184	.859

ANOVA

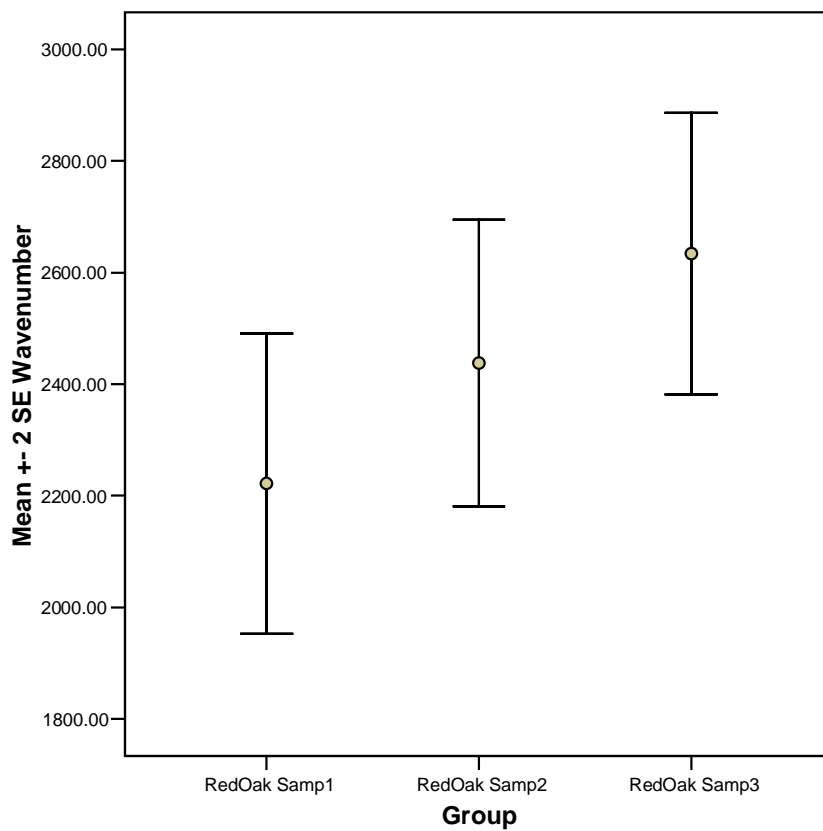
Wavenumber

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5218364.985	3	1739454.995	.933	.426
Within Groups	342873121.531	184	1863440.878		
Total	348091486.516	187			

Means Plots: Cherry Wood Samples 1-4 Lumber (400-4000)

Graph: Lumber RedOak Samp1-3 (400-4000)

Notes



Oneway: Lumber RedOak Samp1-3 (400-4000)

Notes

Descriptives

Wavenumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	88	2221.7247	1261.47706	134.47391	1954.4432	2489.0061	408.83	3939.86
2	88	2437.7132	1205.06709	128.46058	2182.3839	2693.0425	406.91	3943.71
3	86	2633.7248	1171.11717	126.28481	2382.6367	2884.8128	404.98	3930.22
Total	262	2429.5071	1220.44538	75.39937	2281.0386	2577.9756	404.98	3943.71

Test of Homogeneity of Variances

Wavenumber

Levene Statistic	df1	df2	Sig.
.055	2	259	.946

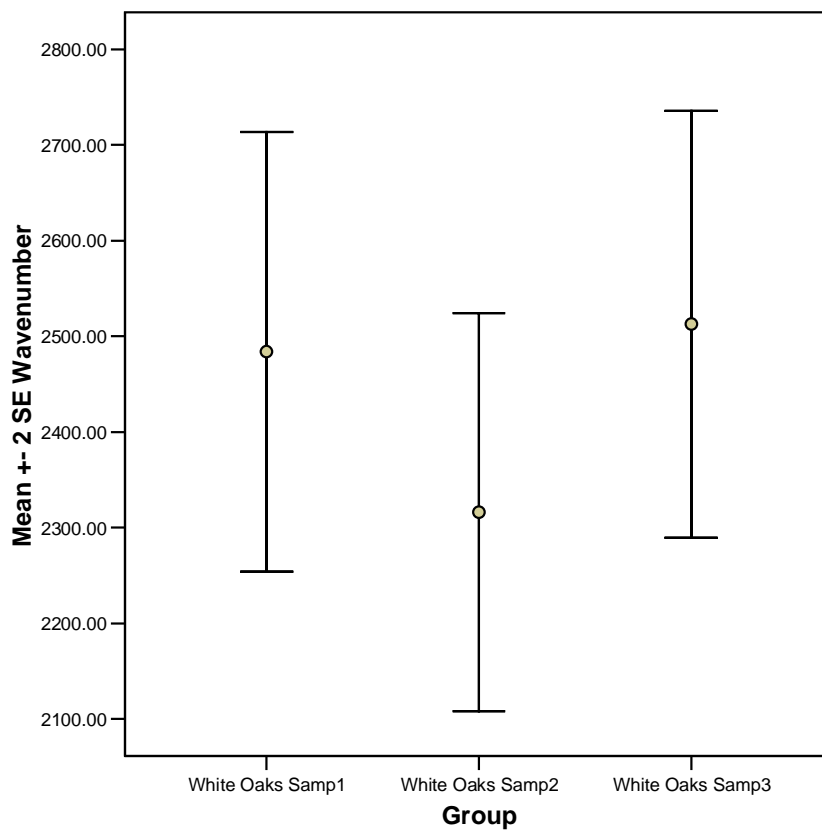
ANOVA

Wavenumber

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	7391815.252	2	3695907.626	2.510	.083
Within Groups	381364275.306	259	1472448.939		
Total	388756090.559	261			

Graph: Lumber White Oaks Samp1-3 (400-4000)

Notes



Oneway: Lumber White Oaks Samp1-3 (400-4000)

Notes

Descriptives

Wavenumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	104	2483.8091	1170.22424	114.74993	2256.2297	2711.3886	410.76	3949.50
2	112	2316.3121	1100.87513	104.02292	2110.1838	2522.4405	418.48	3932.14
3	109	2512.7386	1164.57637	111.54619	2291.6347	2733.8425	416.55	3949.50
Total	325	2435.7896	1144.67670	63.49524	2310.8746	2560.7046	410.76	3949.50

Test of Homogeneity of Variances

Wavenumber

Levene Statistic	df1	df2	Sig.
2.506	2	322	.083

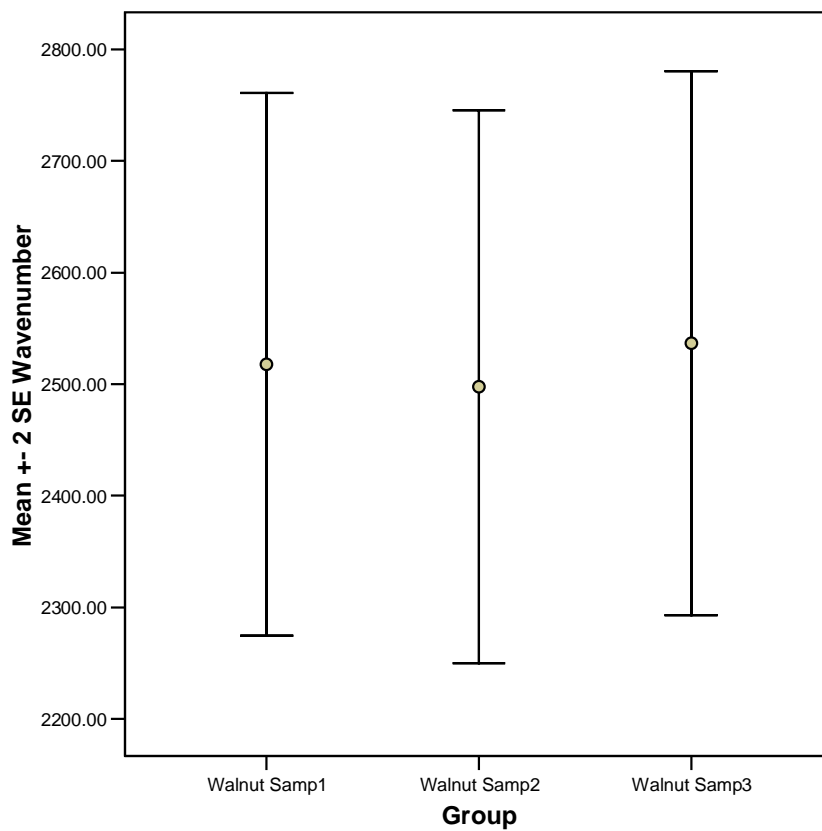
ANOVA

Wavenumber

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2484001.301	2	1242000.650	.948	.389
Within Groups	422048258.347	322	1310708.877		
Total	424532259.648	324			

Graph: Lumber Walnut Samp1-3 (400-4000)

Notes



Oneway: Lumber Walnut Samp1-3 (400-4000)

Notes

Descriptives

Wavenumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	89	2517.7757	1147.26161	121.60949	2276.1024	2759.4490	406.91	3943.71
2	91	2497.6185	1181.60323	123.86567	2251.5377	2743.6992	410.76	3943.71
3	91	2536.9085	1163.06031	121.92185	2294.6894	2779.1275	406.91	3943.71
Total	271	2517.4317	1159.97646	70.46355	2378.7038	2656.1596	406.91	3943.71

Test of Homogeneity of Variances

Wavenumber

Levene Statistic	df1	df2	Sig.
.151	2	268	.860

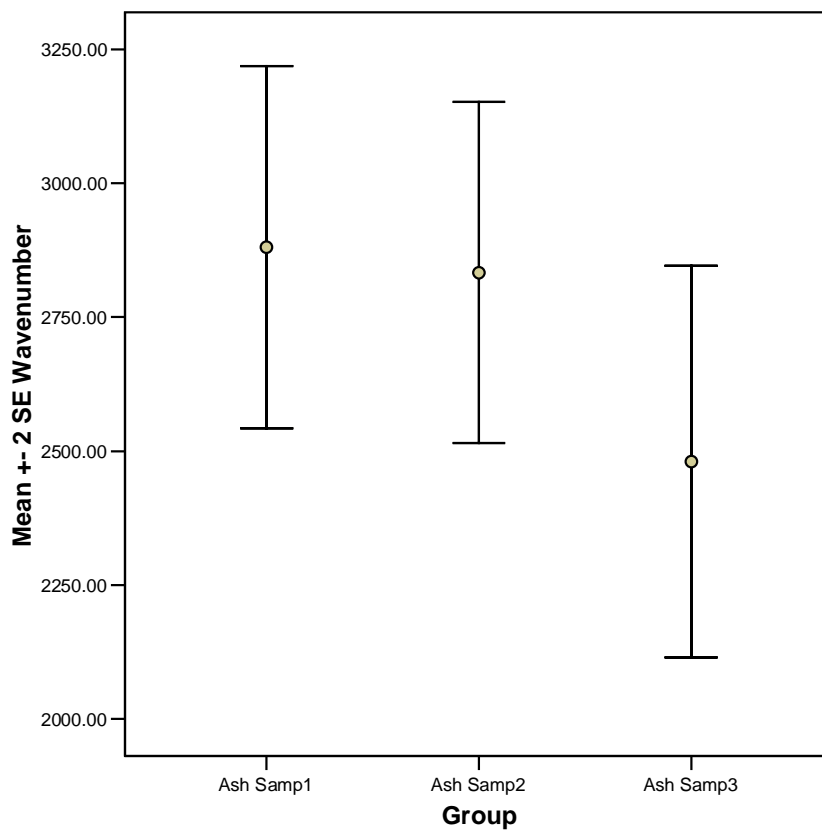
ANOVA

Wavenumber

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	70254.222	2	35127.111	.026	.974
Within Groups	363227000.371	268	1355324.628		
Total	363297254.593	270			

Graph: Lumber Ash Samp1-3 (400-4000)

Notes



Oneway: Lumber Ash Samp1-3 (400-4000)

Notes

Descriptives

Wavenumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	53	2880.4743	1231.39352	169.14491	2541.0602	3219.8884	414.62	3970.71
2	58	2833.4167	1213.53772	159.34531	2514.3332	3152.5002	406.91	3988.07
3	46	2480.5122	1238.60142	182.62182	2112.6930	2848.3314	406.91	3934.07
Total	157	2745.9036	1231.19564	98.26011	2551.8117	2939.9956	406.91	3988.07

Test of Homogeneity of Variances

Wavenumber

Levene Statistic	df1	df2	Sig.
.059	2	154	.943

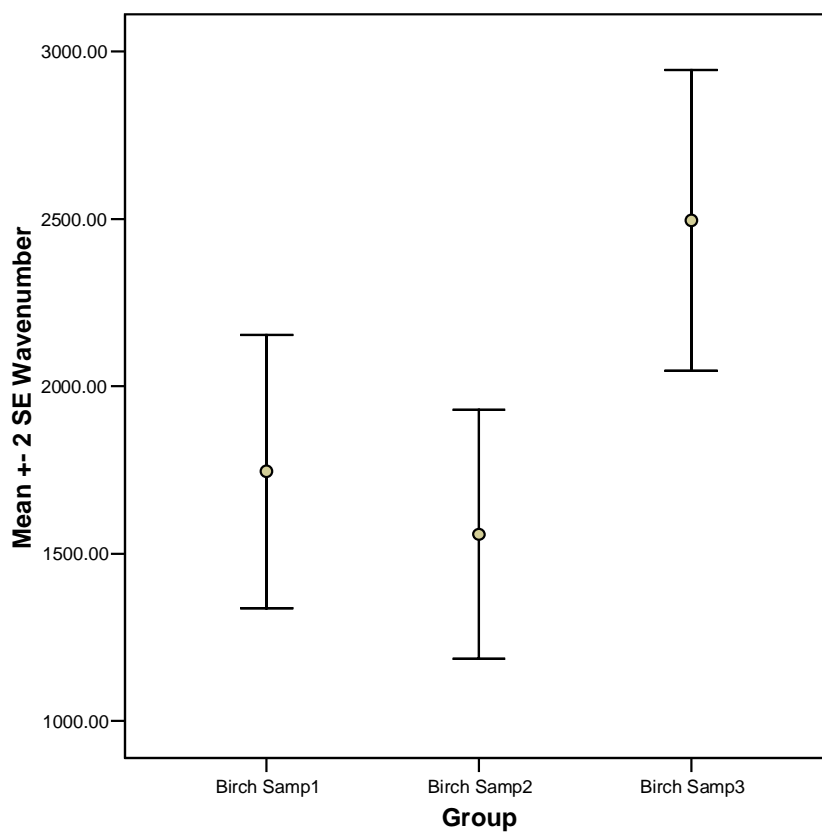
ANOVA

Wavenumber

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4643887.786	2	2321943.893	1.542	.217
Within Groups	231827573.239	154	1505373.852		
Total	236471461.025	156			

Graph: Lumber Birch Samp1-3 (400-4000)

Notes



Oneway: Lumber Birch Samp1-3 (400-4000)

Notes

Descriptives

Wavenumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	39	1745.4105	1273.33061	203.89608	1332.6445	2158.1765	422.33	3907.07
2	43	1557.4835	1221.08605	186.21388	1181.6887	1933.2783	403.05	3897.43
3	40	2494.8092	1420.37638	224.58122	2040.5508	2949.0677	406.91	3895.50
Total	122	1924.8784	1357.47280	122.89981	1681.5658	2168.1910	403.05	3907.07

Test of Homogeneity of Variances

Wavenumber

Levene Statistic	df1	df2	Sig.
3.502	2	119	.033

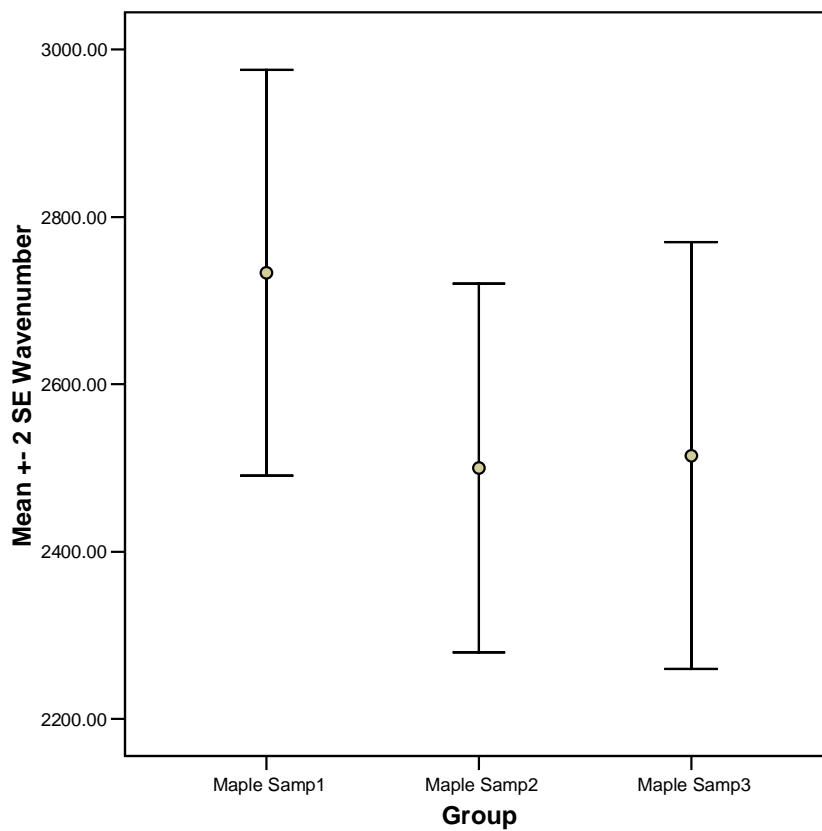
ANOVA

Wavenumber

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	20053085.037	2	10026542.518	5.880	.004
Within Groups	202917534.066	119	1705189.362		
Total	222970619.102	121			

Graph: Lumber Maple Samp1-3 (400-4000)

Notes



Oneway: Lumber Maple Samp1-3 (400-4000)

Notes

Descriptives

Wavenumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	89	2733.0273	1142.85477	121.14236	2492.2823	2973.7723	410.76	3930.22
2	105	2499.8070	1128.51348	110.13164	2281.4119	2718.2022	414.62	3949.50
3	80	2514.6481	1139.62649	127.41412	2261.0367	2768.2596	422.33	3943.71
Total	274	2579.8942	1137.26252	68.70454	2444.6362	2715.1523	410.76	3949.50

Test of Homogeneity of Variances

Wavenumber

Levene Statistic	df1	df2	Sig.
.134	2	271	.874

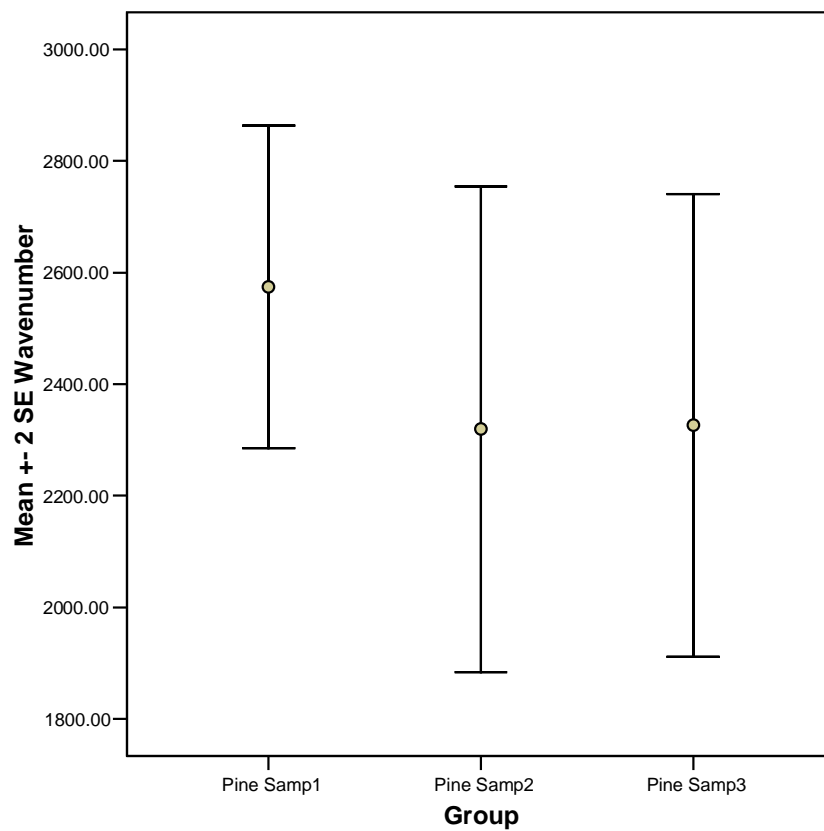
ANOVA

Wavenumber

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3101056.496	2	1550528.248	1.201	.303
Within Groups	349987869.437	271	1291468.153		
Total	353088925.933	273			

Graph: Lumber Pine Samp1-3 (400-4000)

Notes



Oneway: Lumber Pine Samp1-3 (400-4000)

Notes

Descriptives

Wavenumber

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	76	2574.1988	1261.21235	144.67098	2285.9994	2862.3982	406.91	3912.86
2	40	2319.3670	1376.56186	217.65354	1879.1212	2759.6128	408.83	3905.15
3	44	2326.1257	1373.59236	207.07684	1908.5154	2743.7359	408.83	3905.15
Total	160	2442.2707	1319.54888	104.31950	2236.2401	2648.3014	406.91	3912.86

Test of Homogeneity of Variances

Wavenumber

Levene Statistic	df1	df2	Sig.
.620	2	157	.539

ANOVA

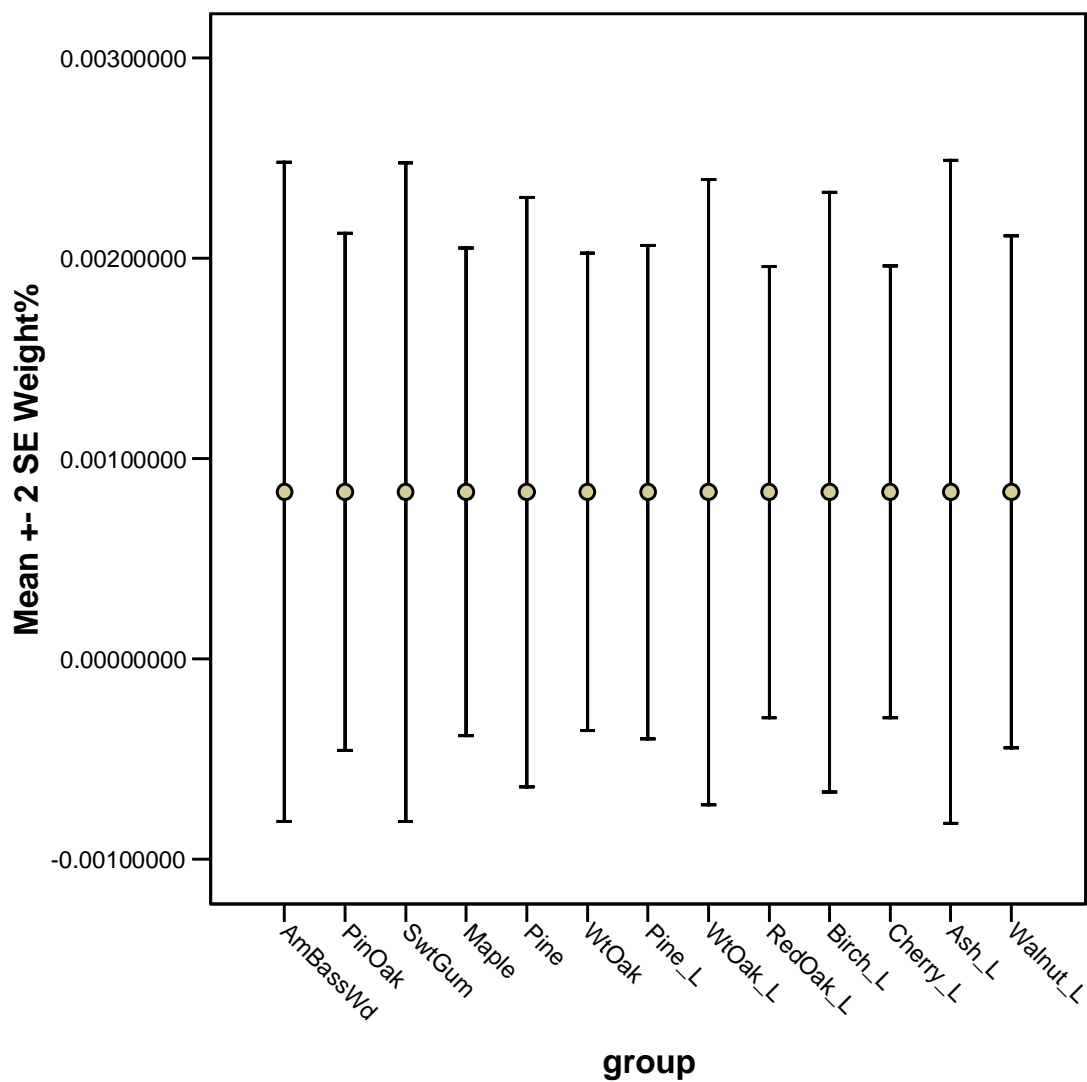
Wavenumber

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2520540.158	2	1260270.079	.721	.488
Within Groups	274331731.095	157	1747335.867		
Total	276852271.253	159			

Appendix H

Statistical Analysis of SEM/EDS Results

Graph: Error for All Carbon Coated Woods



Oneway:SEM Elemental Wt% Comparison for All Carbon Coated Woods

Descriptives

Weight%

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1AmBsWd	12	.0008333	.00284940	.00082255	-.0009770	.0026437	.00000	.00988
2PinOak	12	.0008333	.00223559	.00064536	-.0005870	.0022537	.00000	.00776
3SwtGum	12	.0008333	.00284887	.00082239	-.0009767	.0026434	.00000	.00987
4Maple	12	.0008333	.00210867	.00060872	-.0005064	.0021731	.00000	.00691
5Pine	12	.0008333	.00254729	.00073534	-.0007851	.0024518	.00000	.00890
6WtOak	12	.0008333	.00206457	.00059599	-.0004784	.0021451	.00000	.00724
7Pine_L	12	.0008333	.00213353	.00061589	-.0005222	.0021889	.00000	.00745
8WtOak_L	12	.0008333	.00270314	.00078033	-.0008841	.0025508	.00000	.00941
9RedOak_L	12	.0008333	.00195038	.00056302	-.0004058	.0020725	.00000	.00689
10Birch_L	12	.0008333	.00259341	.00074865	-.0008144	.0024811	.00000	.00906
11Cherry_L	12	.0008333	.00195366	.00056397	-.0004079	.0020746	.00000	.00642
12Ash_L	12	.0008333	.00286777	.00082785	-.0009887	.0026554	.00000	.00993
13Walnut_L	12	.0008334	.00221367	.00063903	-.0005730	.0022399	.00000	.00755
Total	156	.0008333	.00231874	.00018564	-.0004666	.0012000	.00000	.00993

Test of Homogeneity of Variances

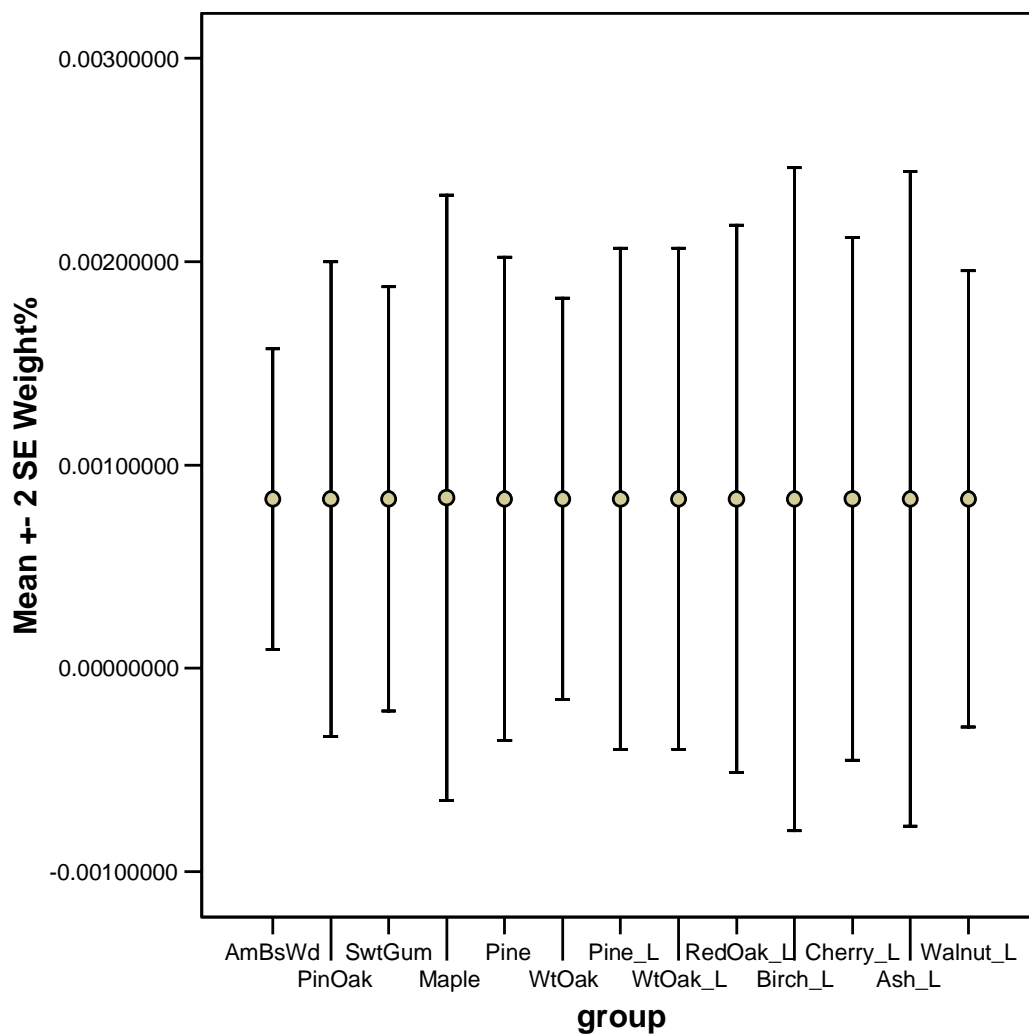
Weight%

Levene Statistic	df1	df2	Sig.
.053	12	143	1.000

ANOVA

Weight%

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	.000	12	.000	.00001	1.000
Within Groups	.001	143	.000		
Total	.001	155			

Graph: Error for All Gold Coated Woods

Oneway: Elemental Weight % Comparison of All Gold Coated Woods

Descriptives

Weight%

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1AmBsWd	12	.0008333	.00128146	.00036992	.0000191	.0016475	.00000	.00388
2PinOak	12	.0008333	.00202256	.00058386	-	.0021184	.00000	.00696
3SwtGum	12	.0008333	.00180773	.00052184	-	.0019819	.00000	.00630
4Maple	12	.0008333	.00257941	.00074461	-	.0024783	.00000	.00899
5Pine	12	.0008333	.00205771	.00059401	-	.0021407	.00000	.00727
6WtOak	12	.0008333	.00170998	.00049363	-	.0019198	.00000	.00605
7Pine_L	12	.0008333	.00213689	.00061686	-	.0021910	.00000	.00745
8WtOak_L	12	.0008333	.00213611	.00061664	-	.0021905	.00000	.00729
9RdOak_L	12	.0008333	.00233033	.00067270	-	.0023139	.00000	.00803
10Brch_L	12	.0008333	.00282516	.00081555	-	.0026283	.00000	.00980
11Cherry_L	12	.0008333	.00223003	.00064375	-	.0022505	.00000	.00779
12Ash_L	12	.0008333	.00278810	.00080485	-	.0026044	.00000	.00968
13Wlnut_L	12	.0008333	.00194320	.00056095	-	.0020679	.00000	.00684
Total	156	.0008333	.00209552	.00016777	.0005023	.0011652	.00000	.00980

Test of Homogeneity of Variances

Weight%

Levene Statistic	df1	df2	Sig.
.104	12	143	1.000

ANOVA

Weight%

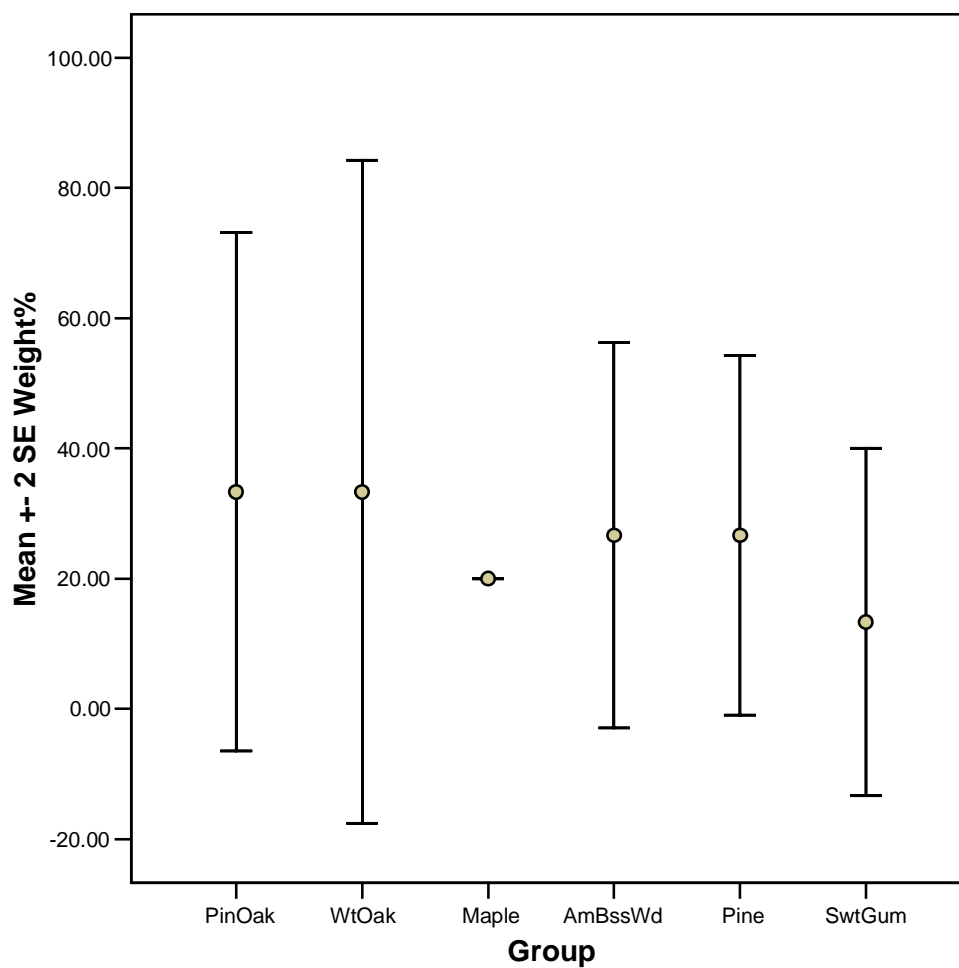
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.000	12	.000	.00001	1.000
Within Groups	.001	143	.000		
Total	.001	155			

Appendix I

Statistical Analysis of XRF Results

Graph: Error for XRF Burned Greenwood Results (Ti, Ca, Fe)

Notes



Oneway: Comparison of XRF Elemental (Ti, Ca, Fe) Results for Burned Greenwoods

Notes

Descriptives

Weight%

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1PinOak	3	33.3333	34.4678	19.9000	-52.2895	118.9561	9.9036	72.9106
2WtOak	3	33.3333	44.1256	25.4759	-76.2807	142.9473	6.2676	84.2514
3Maple	3	20.0000	.0000	.0000	20.0000	20.0000	20.0000	20.0000
4AmBss Wd	3	26.6667	25.6478	14.8078	-37.0461	90.3795	.0000	51.1570
5Pine	3	26.6667	23.9526	13.8290	-32.8349	86.1682	.0000	46.3556
6SwtGu m	3	13.3333	23.0940	13.3333	-44.0354	70.7020	.0000	40.0000
Total	18	25.5556	25.1010	5.9164	13.0731	38.0380	.0000	84.2514

Test of Homogeneity of Variances

Weight%

Levene Statistic	df1	df2	Sig.
3.285	5	12	.042

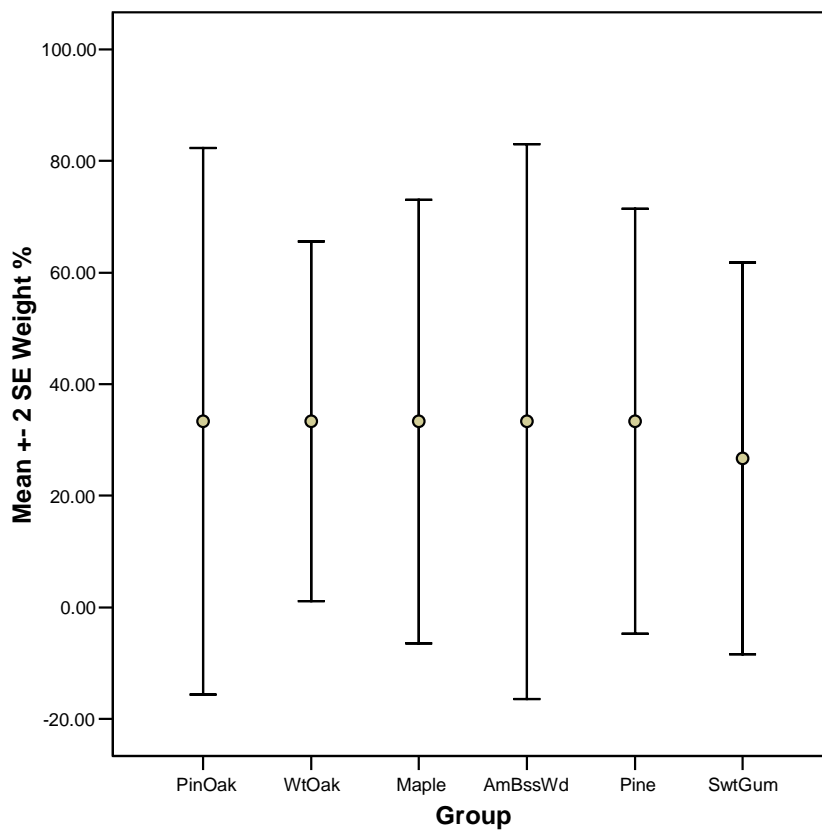
ANOVA

Weight%

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	911.111	5	182.222	.223	.946
Within Groups	9799.939	12	816.662		
Total	10711.050	17			

Graph:: Error for XRF Burned Greenwood Results (K, Ca, Fe)

Notes



Oneway: Comparison of XRF Elemental (K, Ca, Fe) Results for Burned Greenwoods

Notes

Descriptives

Weight %

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1PinOak	3	33.3333	42.3991	24.4791	-71.9918	138.6584	2.2548	81.6335
2WtOak	3	33.3333	27.9220	16.1208	-36.0288	102.6954	3.9558	59.5268
3Maple	3	33.3333	34.4190	19.8718	-52.1681	118.8348	10.6590	72.9383
4AmBssWd	3	33.3333	43.0638	24.8629	-73.6431	140.3098	7.2140	83.0376
5Pine	3	33.3333	32.9398	19.0178	-48.4937	115.1604	5.9107	69.8708
6SwtGum	3	26.6667	30.3769	17.5381	-48.7938	102.1271	.0000	59.7338
Total	18	32.2222	30.0584	7.0848	17.2745	47.1699	.0000	83.0376

Test of Homogeneity of Variances

Weight %

Levene Statistic	df1	df2	Sig.
.452	5	12	.804

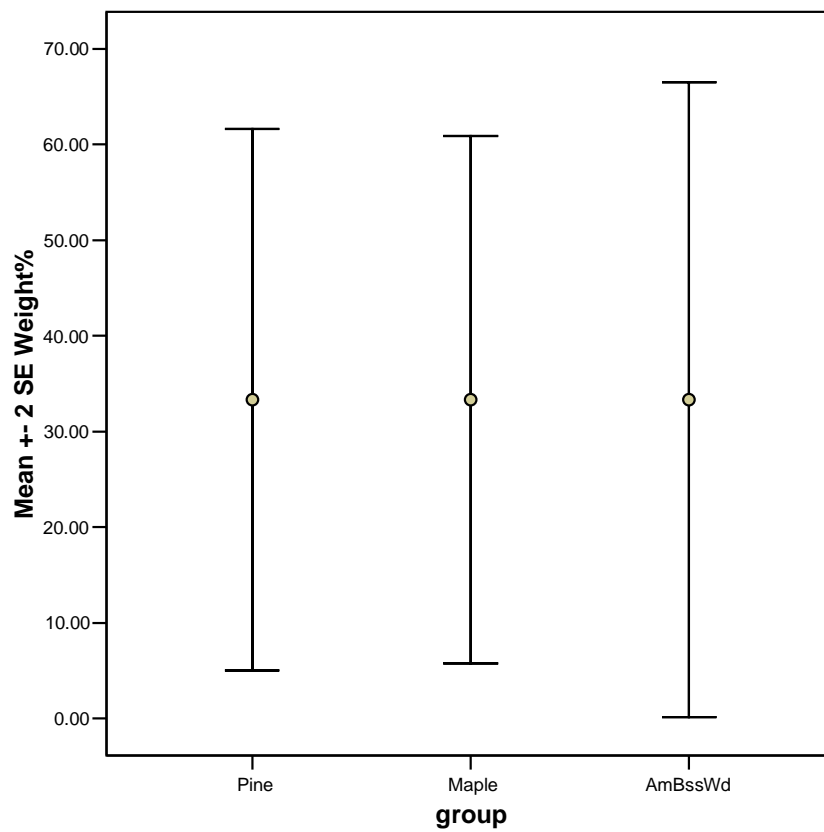
ANOVA

Weight %

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	111.111	5	22.222	.017	1.000
Within Groups	15248.530	12	1270.711		
Total	15359.641	17			

Graph: Error for XRF Unburned Greenwood Results (Ti, Ca, Fe)

Notes



Oneway: Comparison of XRF Elemental (Ti, Ca, Fe) Results for Unburned Greenwoods

Notes

Descriptives

Weight%

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1Pine	12	33.3333	49.0424	14.1573	2.1733	64.4934	.0000	100.0000
2Maple	12	33.3333	47.7493	13.7840	2.9949	63.6718	.0000	100.0000
3AmBs sWd	9	33.3333	49.7618	16.5873	-4.9169	71.5836	.0000	99.9551
Total	33	33.3333	47.2184	8.2197	16.5904	50.0763	.0000	100.0000

Test of Homogeneity of Variances

Weight%

Levene Statistic	df1	df2	Sig.
.020	2	30	.980

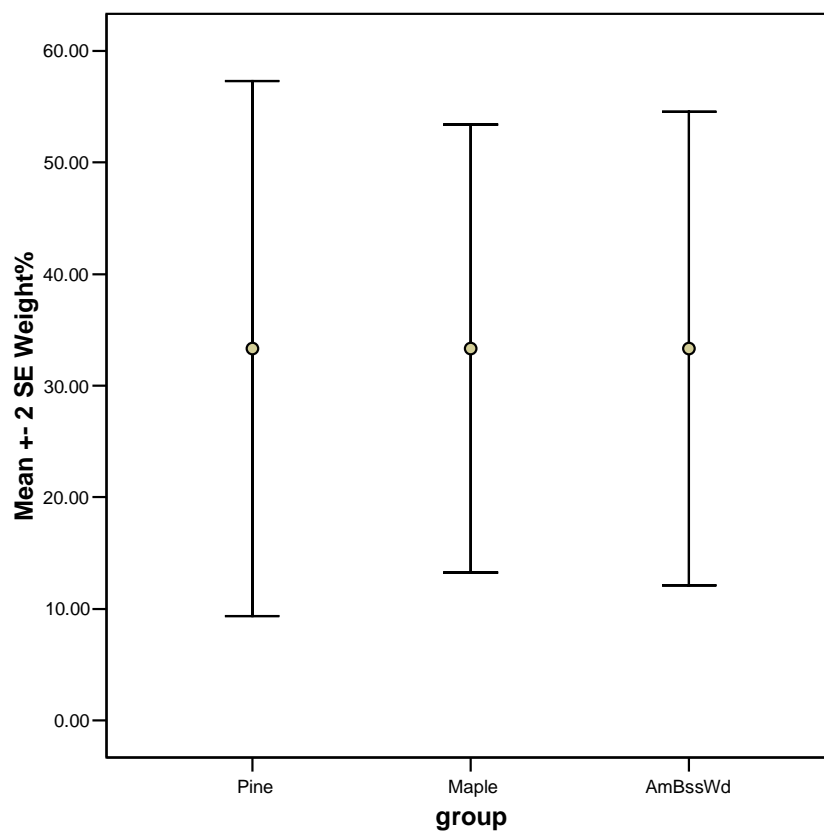
ANOVA

Weight%

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.000	2	.000	.00001	1.000
Within Groups	71346.548	30	2378.218		
Total	71346.548	32			

Graph: Error for XRF Unburned Greenwood Results (K, Ca, Fe)

Notes



Oneway: Comparison of XRF Elemental (K, Ca, Fe) Results for Unburned Greenwoods

Notes

Descriptives

Weight%

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1Pine	12	33.3333	41.4951	11.9786	6.9686	59.6981	.0000	96.6958
2Maple	12	33.3333	34.7450	10.0300	11.2574	55.4092	.0000	89.8541
3AmBs sWd	9	33.3333	31.7976	10.5992	8.8916	57.7751	.0000	76.7837
Total	33	33.3333	35.4913	6.1782	20.7487	45.9180	.0000	96.6958

Test of Homogeneity of Variances

Weight%

Levene Statistic	df1	df2	Sig.
1.144	2	30	.332

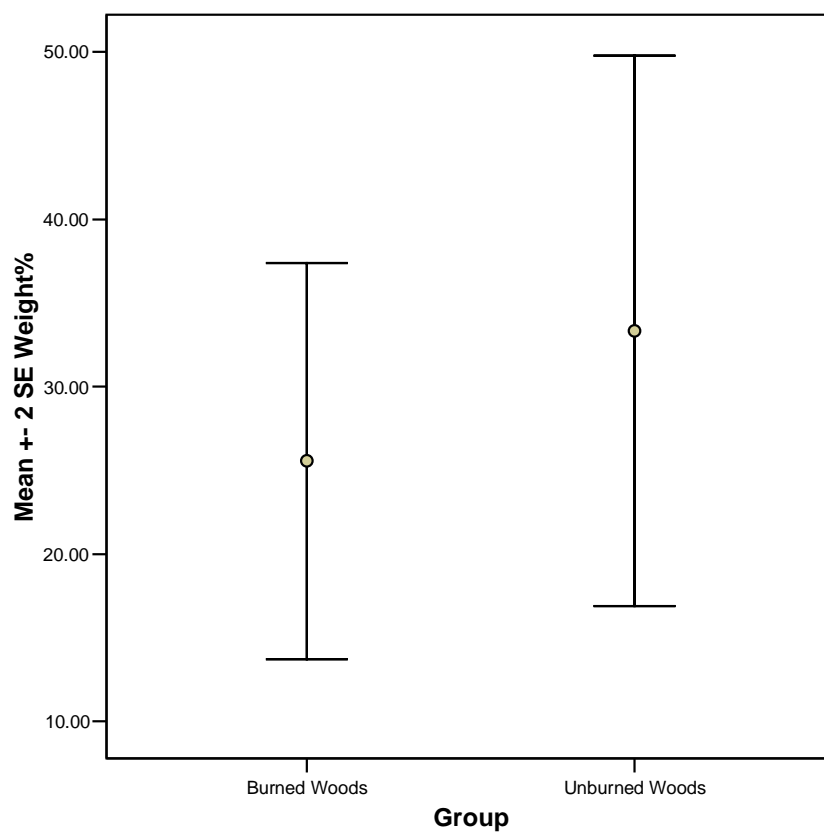
ANOVA

Weight%

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.000	2	.000	.000	1.000
Within Groups	40308.288	30	1343.610		
Total	40308.288	32			

Graph: Error for XRF Burned & Unburned Greenwood Results (Ti, Ca, Fe)

Notes



Oneway: Comparison of XRF Elemental (Ti, Ca, Fe) Results for Burned & Unburned Greenwoods

Notes

Descriptives

Weight%

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1Burned	18	25.5556	25.1010	5.9164	13.0731	38.0380	.0000	84.2514
2Unburned	33	33.3333	47.2184	8.2197	16.5904	50.0763	.0000	100.000
Total	51	30.5882	40.6847	5.6970	19.1455	42.0310	.0000	100.000

Test of Homogeneity of Variances

Weight%

Levene Statistic	df1	df2	Sig.
28.325	1	49	.000

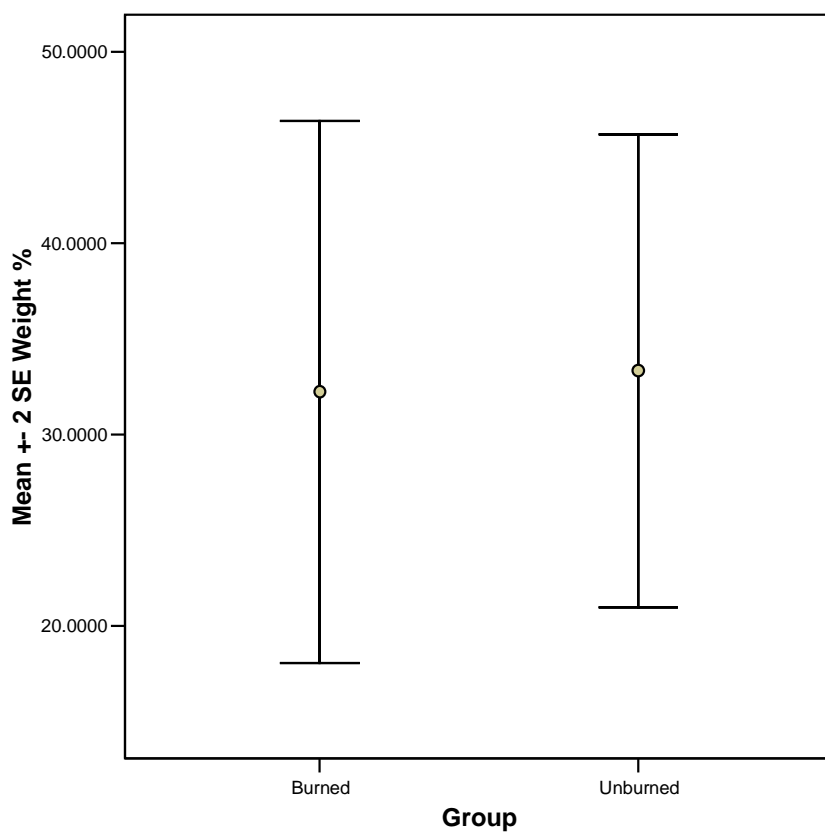
ANOVA

Weight%

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	704.575	1	704.575	.421	.520
Within Groups	82057.598	49	1674.645		
Total	82762.173	50			

Graph: Error for XRF Burned & Unburned Greenwood Results (K, Ca, Fe)

Notes



Oneway: Comparison of XRF Elemental (K, Ca, Fe) Results for Burned & Unburned Greenwoods

Notes

Descriptives

Weight %

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1Burned	18	32.2222	30.0584	7.0848	17.2745	47.1699	.0000	83.0376
2Unburned	33	33.3333	35.4913	6.1782	20.7487	45.9180	.0000	96.6958
Total	51	32.9412	33.3713	4.6729	23.5553	42.3270	.0000	96.6958

Test of Homogeneity of Variances

Weight %

Levene Statistic	df1	df2	Sig.
1.417	1	49	.240

ANOVA

Weight %

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	14.379	1	14.379	.013	.911
Within Groups	55667.929	49	1136.080		
Total	55682.308	50			

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