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Characterization of Kendex® 0834 (Heavy Resins) & Kendex® 0897 (Light Resins)

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CHARACTERIZATION OF KENDEX® 0834 (HEAVY RESINS) &
KENDEX® 0897 (LIGHT RESINS)

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by
Victor L Correa Rodriguez

2014

Dedication

I dedicate this work firstly to my mother. It was her support and encouragement that helped me to achieve what I am and have done up to this day. I also dedicate this work to my best friends Ediemyr Rosado and Jason Sierra for their moral support and for always being there for me when no one else could.

CHARACTERIZATION OF KENDEX® 0834 (HEAVY RESINS) & KENDEX® 0897
(LIGHT RESINS)

by

VICTOR L CORREA RODRÍGUEZ B.S

THESIS

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Abstract

Characterization of crude oil and some of its refined products has always been a challenge in the refining industry. This is mainly due to the high molecular complexity of crude oil. In this research, Heavy and Light Resins extracted from Penn Grade crude oil were analyzed with a wide variety of techniques, ranging from X-Ray Diffraction, Electron Microscopy, Fourier Transformed Infrared, C-13 Nuclear Magnetic Resonance, and chromatographic methods. An asphaltene extraction protocol was performed on both products. Only the Heavy Resin sample yielded a low amount of asphaltene. Results show that both Resins have a high degree of carbon branching, very little aromatic compounds and low concentration of heteroatoms such as N, S and O. X-Ray analysis shows the presence of different types of metals, mainly iron, in solution in the form of particles. These particles were observed under a High Resolution Electron Microscope and a thermodynamic analysis was performed on the asphaltene extracted.

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Chapter 1: Introduction

1.1. Historical Background of Crude Oil

The crude oil refining industry has an extensive history in most parts of the world; both old and new. It often considers itself mature and has experienced many huge developments, forever affecting the way we view and utilize energy. Energy sources and technology change over time and each is influenced by the other. In the United States during the 1850s wood was the biggest source of energy. By the 1900s coal use predominated over wood. By the 1950s, oil overtook coal as more people owned cars and rail transport shifted from coal to petrol (Figure 1.1)¹. From 1950 onwards, the introduction and growth of hydroelectric power, nuclear energy and natural gas are ever increasing at a fast rate (Figure 2.1).

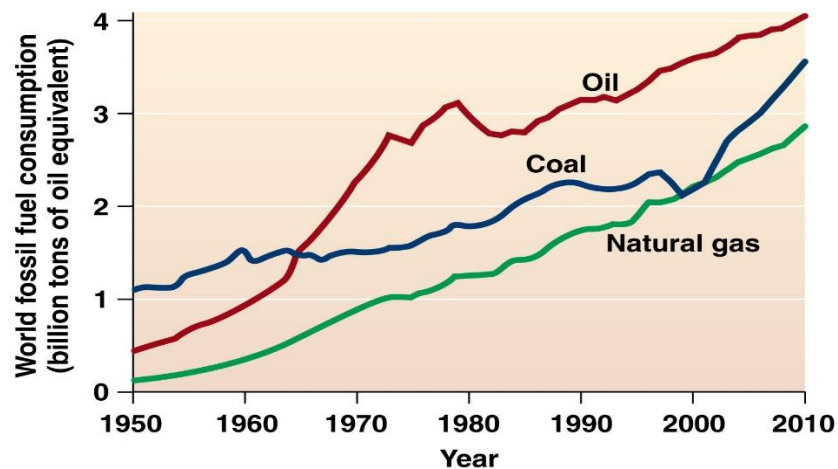


Figure 1.1: Global consumption of oil, coal and natural gas.¹

Changes in energy technology are driven mostly by economic and environmental needs. The burning of fossil fuels not only has limited options for applications, mostly concerning fuel-economy, but it also increases emissions of greenhouse gasses. To this

day, a very promising alternative energy source is hydrogen production²⁻³, solar energy⁴, etc.

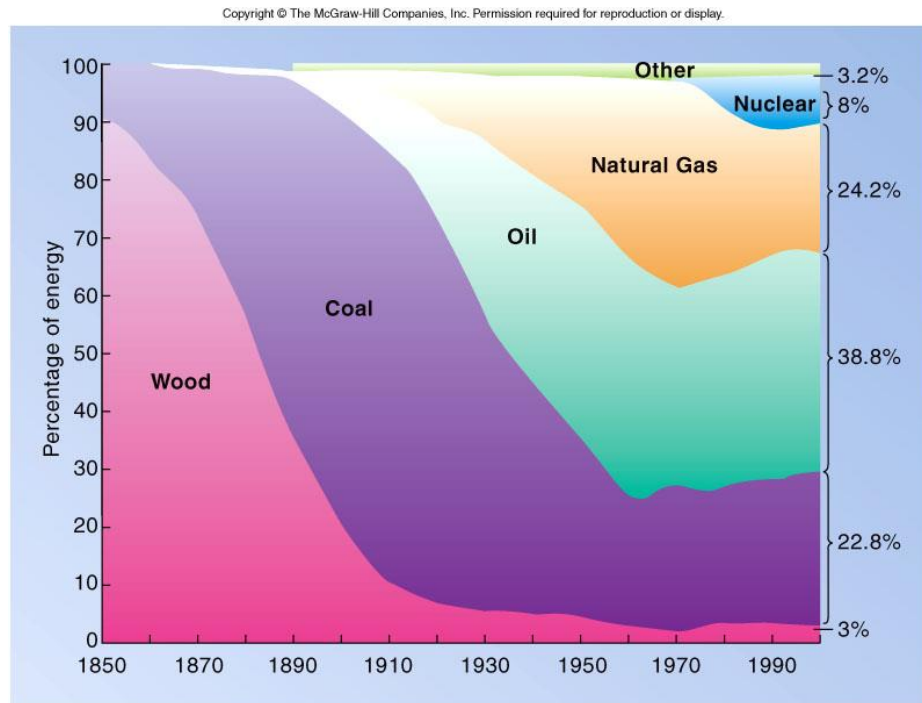


Figure 1.2: Historical analysis of the dependence of non-renewable energy sources in percentages since 1850¹.

Although the refining process has evolved considerably, characterization of crude oil has always remained a challenge. Crude oil moves a large portion of the world's economy with the increase of technological advancements and rising number of developing countries. It is a necessity to mass produce refined products of crude oils. However, raw crude oil cannot be used in the form it is extracted. It needs to be refined into separate products. Depending on the boiling temperature and pressure, oil constituents can be separated by volatilizing⁵. Short carbon chains evaporate and condensate, whereas heavy oils with longer carbon chains are separated from lighter oils.

An immensely large number of products can be derived from the refining of crude oil. Some of these products, to enumerate a few consist of parafilms, naphtha, waxes, plastics; a wide variety of fabrics, engine oils, lubricants, asphalt, and diesel and gasoline fuel for various types of motors⁶.

This research is focused on the characterization of the Kendex® 0834 (Heavy Resins) & Kendex® 0897 (Light Resins). Both products are from the American Refining Group® (ARG) located in Bradford, Pennsylvania. It is the oldest refinery in the US, established in 1881. It currently produces more than 11,000 Barrels (42 US gallons a barrel or 159 L) of crude oil per day⁷, making it one of the largest refineries in the US. ARG crude is commonly converted into high quality waxes, lubricant based oils, gasoline and fuels and other specialty products, most of which are available domestically.

1.2. Asphaltenes and Resins: Structure, properties and applications

Characterization has always been a challenge in the crude oil industry due to the complexity of the molecular arrangements⁸. Crude oil can be roughly separated into four main components: Saturates, Aromatics, Resins and Asphaltenes (SARA)⁹. SARA analysis is performed by separating these main components via chromatographic methods. This research is focused on the resinous fraction of Pennsylvania Grade crude oil. Asphaltenes will also be analyzed in this research due to their presence on the resin products. These molecules are a class component of hydrocarbons, organized as aromatic rings with alkane branching (figure 1.3). They usually have heteroatoms such as sulfur or nitrogen. Asphaltenes typically organize themselves in layers, much like graphite¹⁰. They have some commercial uses; mainly for road construction and waterproofing. The main

reason for the interest in these hydrocarbons is due to the impact they have on the refining process. They are typically treated as by-products that are undesirable in lighter oils. Heavy oils contain the greatest asphaltene concentrations, while lighter oils have lower amounts⁸. In the heavy crude oil fractions such as the Heavy Resin sample discussed in this research, asphaltenes are stable and precipitate well. They can be easily removed from solution by various conventional methods, some of which will be discussed further on in the methodology of this work.

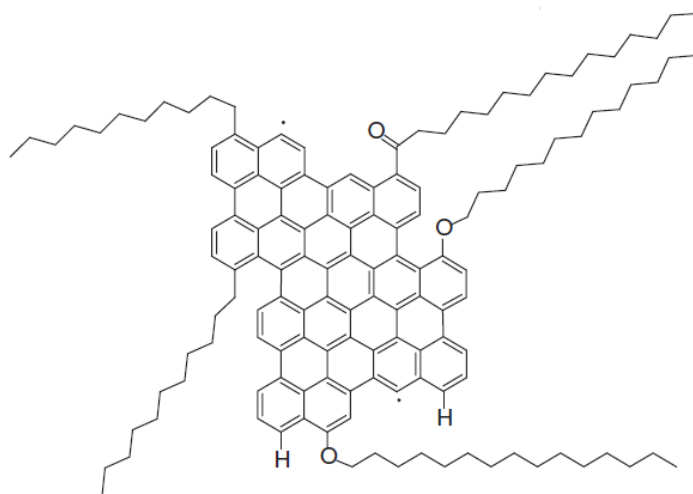


Figure 1.3: Representative figure of an asphaltene molecule¹¹.

A higher degree of aromatic carbon can be appreciated when compared to resin molecules (figure 1.4). It is also noteworthy to mention the lack of branching carbon structures in when compared to resin molecules¹². Resins are another form of hydrocarbon compounds but have a higher degree of alkane branching and less aromatic carbon (figure 1.4). They may also exhibit the presence of the same heteroatoms in

asphaltenes. Figure 1.4 is a characterization analysis from Brazilian petroleum performed by Coelho et al, 2006, using mainly Infrared techniques and computational modeling.

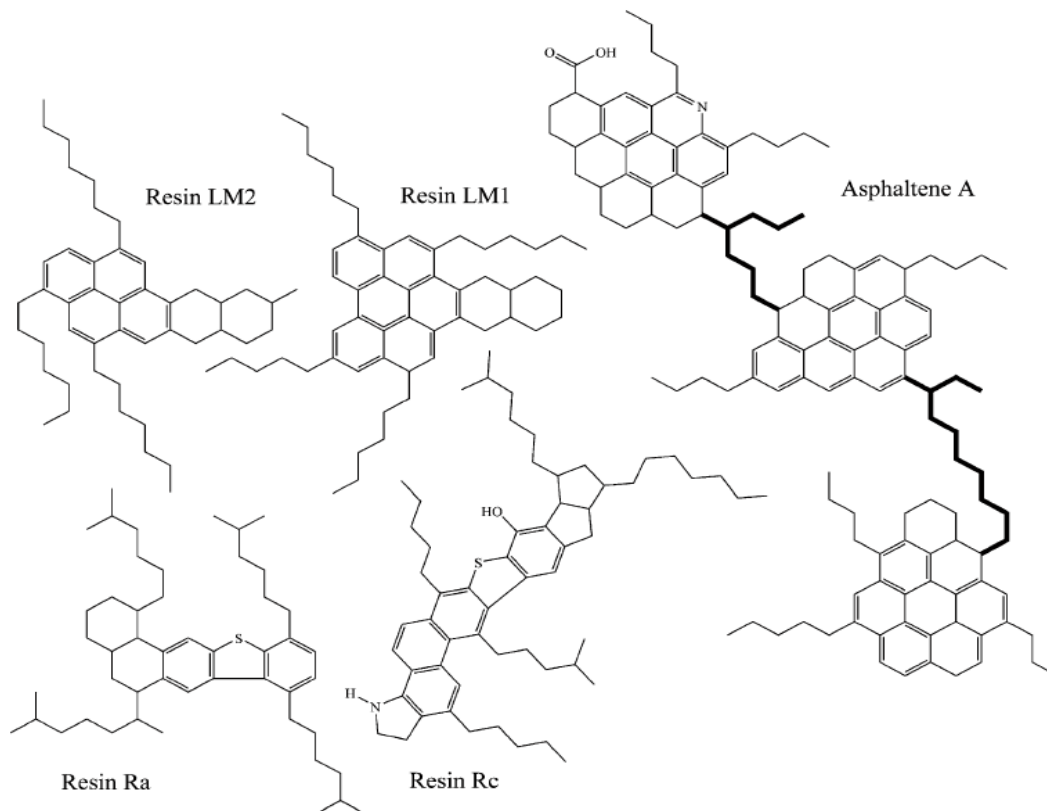


Figure 1.4: Analysis of Brazilian crude performed by Coelho et al, 2006

The distinction between asphaltene and resin molecules is apparent. Asphaltenes display a larger degree of aromatic compounds and a higher molecular weight. Aside from examining the hydrocarbon structures, many studies have been done on the inorganic portion of crude oils¹³. Mainly metals in solution which have the tendency to interact with these hydrocarbon structures.

1.3. The Refining and Extraction Process

Given the vast complexity of crude oil, the process of refining is not limited to one procedure alone. Most refineries have standards in order to “de-resin” and “de-

asphalt” crude oils; that is to remove the resinous viscous portion, leaving a lighter oil that will be further refined. Though not depicted in full detail, the basic schematic that ARG employs to refine the crude is as follows:

1. The Crude Unit provides the feedstock to the ROSE Unit
2. Distillation occurs in the Crude Unit. Products are stored in storage tanks.
3. The main purpose of the ROSE Unit is to remove the heavy carbonaceous components using propane at selected temperatures and pressure, depending on the feed.
4. Propane is recycled in the form of super critical fluid and is re-used for further processes.

A schematic representation of the ROSE Unit is shown in figure 1.5 with the respective steps mentioned above.

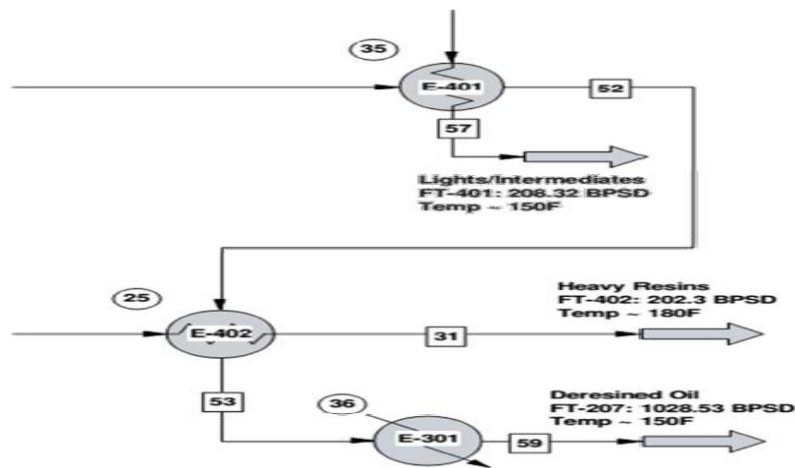


Figure 1.5: Diagram of refining process. Courtesy of the American Refining Group [].

1.4. Possible Applications of Resins

As previously mentioned, crude oil displays a very wide molecular variety, making its characterization very challenging. In this section, some types of molecular structures of interest will be discussed in order to propose some possible applications for them based on the properties that they possess. The first group of molecules that will be discussed in this work are resin molecules. The molecular structures of resins resemble those of asphaltenes¹³. They are both carbon and hydrogen based molecules with aromatic groups and alkane branches. It is not uncommon for these molecules to have heteroatoms such as sulfur and nitrogen¹⁴. Both asphaltenes and resins are responsible for giving the crude oil its black tacky color¹⁵. They are typically stacked together in the form of layers, much like graphite¹¹. One way to differentiate one from the other is that asphaltenes do not dissolve in paraffinic solvents (n-heptane/n-pentane/petroleum ether etc.), whereas resins do dissolve¹⁶. Asphaltenes are present as colloids in the crude oil, while resins are dissolved. ARG distributes both Heavy and Light Resin for applications such as metalworking fluids and as viscosity builders¹⁷. The main goal of this research is to characterize both products in order for the refinery to produce quality lubricants.

Chapter 2: Methods and Characterization

2.1. Characterization

This section describes the work done regarding the characterization of the Kendex® 0834 (Heavy Resins) & Kendex® 0897 (Light Resins). Both products are from the American Refining Group® (ARG) and are produced in the crude oil refining process. These resins are both Penn-Grade resins which are extracted by the process mentioned in section 1.2 of the first chapter in this work. A conclusive analysis of the products will be presented based on FT-IR, C-13 NMR, XRD, XRF, SARA, and asphaltene extraction with heptane and pentane fractioning. A functionalization of the Light Resin was performed via saponification with NaOH and results are demonstrated by Fourier Transformed Infrared (FT-IR). Lastly, the asphaltene fraction extracted from the Heavy Resin was subjected to a High Resolution Transmission Electron Microscopy (HRTEM) analysis. This analysis includes Energy Dispersive Spectrometry (EDS) and a thermodynamic analysis of the asphaltene sample.

2.1.1. X-Ray Diffraction

An X-Ray Diffraction (XRD) analysis was performed on both Light Resin and Heavy Resin samples. XRD is a widely used technique but it is mostly employed to determine the structure of a crystal. Although resins are not crystals, but amorphous, meaning randomly arranged structures, this technique is effective in determining the presence of metal crystals in solution within the resins. It is also useful to compare the diffraction pattern of both resins in order to determine if they share some similarities. The advantage of using XRD is that it provides accurate results and it is also a non-destructive

technique and sample preparation is easy. For this research, the XRD analysis was performed with an X-ray diffractometer (Cu-K α (λ = 0.154nm)) in the Department of Metallurgical and Materials Engineering at UTEP. The analysis was carried out on both Light and Heavy Resins.

2.1.2. Extraction of asphaltenes with pentane & heptane from the the Kendex® 0834 (Heavy Resins) & Kendex® 0897 (Light Resins)

A standard extraction of asphaltenes was performed on both products using heptane and pentane as solvents¹². This procedure consists in preparing a dilution of 1:40 (w:v) by dissolving 100g of the resin being analyzed to a final volume of 4L of solution. The solvents employed for this analysis were heptane and pentane. These are commonly used as standard extraction solvents because asphaltenes are insoluble in them. The molar weight of asphaltenes is dependent on the molar weight of the solvent[]. Pentane yields asphaltene molecules with a lower molecular weight, and thus yields a larger quantity than heptane. The solution was stirred using a magnetic Teflon stirrer for 24 hours covered with aluminum foil. The solution was then filtered through a Whatman 40 filter paper (125mm). The resulting solid was then weighted and a w/w % was calculated to determine the yield.

2.1.3. X-Ray Fluorescence Analysis (XRF)

XRF is a non-destructive technique employed to determine the elements present at the surface of a material. XRF works by irradiating the sample with X-rays that ionize the sample and it, in turn emits a characteristic X-ray photon. It is not reliable to determine the carbon/nitrogen ratio or the carbon content of the resins or any element

with a Z value lower than 6 due to the lack of electrons in these elements. It is especially efficient in determining metals in the sample. The determination of metals in the resins is of great importance¹⁷, for example, to know more about the geological background of the extraction site¹⁷ and to know if there is any type of contamination during the fracking and refining procedure. It is also of great interest to chemists and engineers who want to make products such as parafilms, waxes and plastics from the resins. These metals tend to poison catalysts and therefore they affect further reactions. According to previous reports on crude oil characterization, the most commonly observed metals are Nickel, Molybdenum, Vanadium and Iron, amongst a few others¹⁷. Some could be present in the form of particles or in the form of porphyrins¹⁸.

2.1.4. Fourier Transformed Infrared Analysis (FTIR)

FTIR is a widely employed technique in the field of organic chemistry and biochemistry. It is useful to determine functional groups in an organic sample. The sample is irradiated with infrared light and the functional groups present in the sample will vibrate, twist or bend at a specific wavelength, depending on the group. Common organic groups that are expected, according to previous reports are methyl, CH₂, C=C and aromatics. The wavelength ranged from 4,000cm⁻¹ to 650cm⁻¹. The FTIR analysis was performed in the Department of Chemistry at UTEP.

2.1.5. C-13 Nuclear Magnetic Resonance (C13-NMR):

A C-13 NMR analysis was performed on both samples. The purpose of this technique is that it is very accurate in determining the different types of carbon in the

different molecules and their relative abundance. Samples were dissolved in deuterated chloroform until solution was completely opaque. Due to technical issues, the Heavy Resin and the solid extracted with pentane could not be analyzed. This was due to the lack of solubility in the selected solvent.

2.1.6. Saturates, Aromatics, Resins and Asphaltene (SARA) Analysis

Both Heavy and Light Resins were subjected to a Saturates (S), Aromatics (A), Resins (R) and Asphaltene (A) analysis which consists basically on a chromatographic analysis. This is a very common procedure used widely in the crude oil characterization field. The samples were sent to the University of Calgary, Alberta, Canada for this analysis.

2.1.7. HRTEM Analysis Sample Preparation

HRTEM is a widely employed technique in materials science due to the large amount of information it can produce. It works similar to a light microscope, but instead of using light, it uses electrons that are transmitted through a very thin sample. Because electrons have a very small DeBroglie wavelength, this microscope has significantly high resolution. This technique can provide compositional and crystallographic information (if equipped).

Four samples were prepared by conventional Heptane extracted method [(99.8%purity, Toluene (99.9%purity)]. A mixture of sample (Fractionated 300°C, 400°C and 500°C) and toluene was performed in a separation column. The eluting fraction was concentrated and mixed with *n*-heptane to allow precipitation of insoluble components. The resulting precipitates were dissolved again in toluene, until the solution changed its

color from black to brown, allowing reduction of the amount of resins. One drop of brown solution was deposited onto a Cu/formvar Silicon 200-mesh grid and left to dry in an argon atmosphere. The products of the three prepared solutions (300°C, 400°C, 500°C) was observed first using an Scanning Transmission Electron Microscope (STEM) in order to determine their chemical composition by Energy Dispersive Scattering (EDS) and morphological structure.

The heating experiment was performed using a High Resolution Transmission Electron at operational voltage of 200kV and beam dosage of 6.2 μ A using Cu/Silicon formvar 200-mesh grid. Then using sample of crude (non-heat treated) was subjected to heat treatment using a Gatan Heating Stage sample probe, in order to observe thermodynamic behavior in-situ as a function of temperature, in the range of 300°C < T < 600°C, with a ramp rate of 300°C/sec as described in figure 1. All images were captured on a Gatan CCD camera.

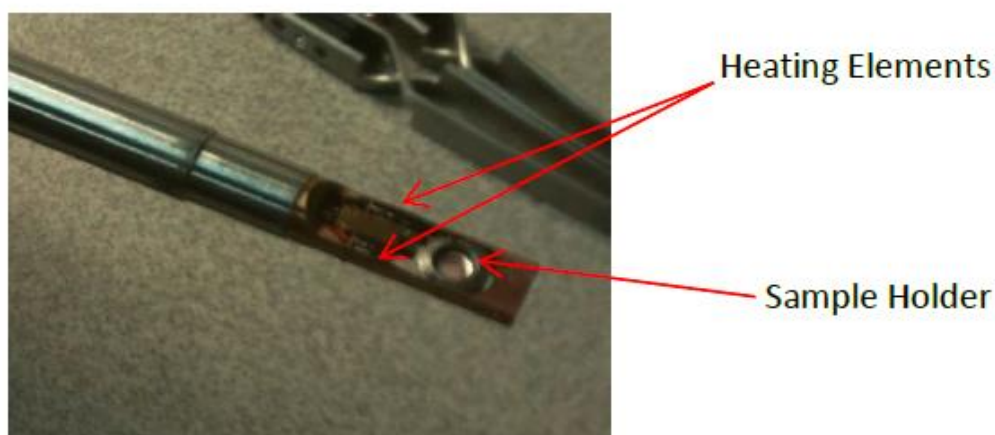


Figure 2.1: HRTEM sample holder and heating elements.

2.1.8. Functionalization via Saponification

Kendex® 0897 (Light Resins) were saturated with NaOH at room temperature and according to IR results, OH groups can be added to the products successfully.

The procedure to add functional groups is done in the same fashion as soap is made via saponification. NaOH pellets are dissolved in a 1:1 (v/v) mixture of distilled water and ethanol. Then a 1:1 mixture of Light Resins and NaOH are brought together and allowed to mix at room temperature by magnetic stirring. The color of the resin changes with longer exposures of about a day or two. Adding functional groups to the resins may prove to be useful to make polymers such as epoxy which is ideal for the production of high viscosity lubricants.

Chapter 3: Results

3.1. Characterization Results and Discussion

3.1.1. X-Ray Diffraction

The samples were mounted on an epoxy sample holder without any type of special treatment. The angle of diffraction ranged from 5-80 degrees on the 2-Theta scale for both samples. XRD analysis shows that both resins have a clearly different composition. The Light Resin (Figure 3.1) showed very obvious peaks at 21° and 23° both of which correspond very well with Iron Sulfide crystal planes discussed in the figure below.

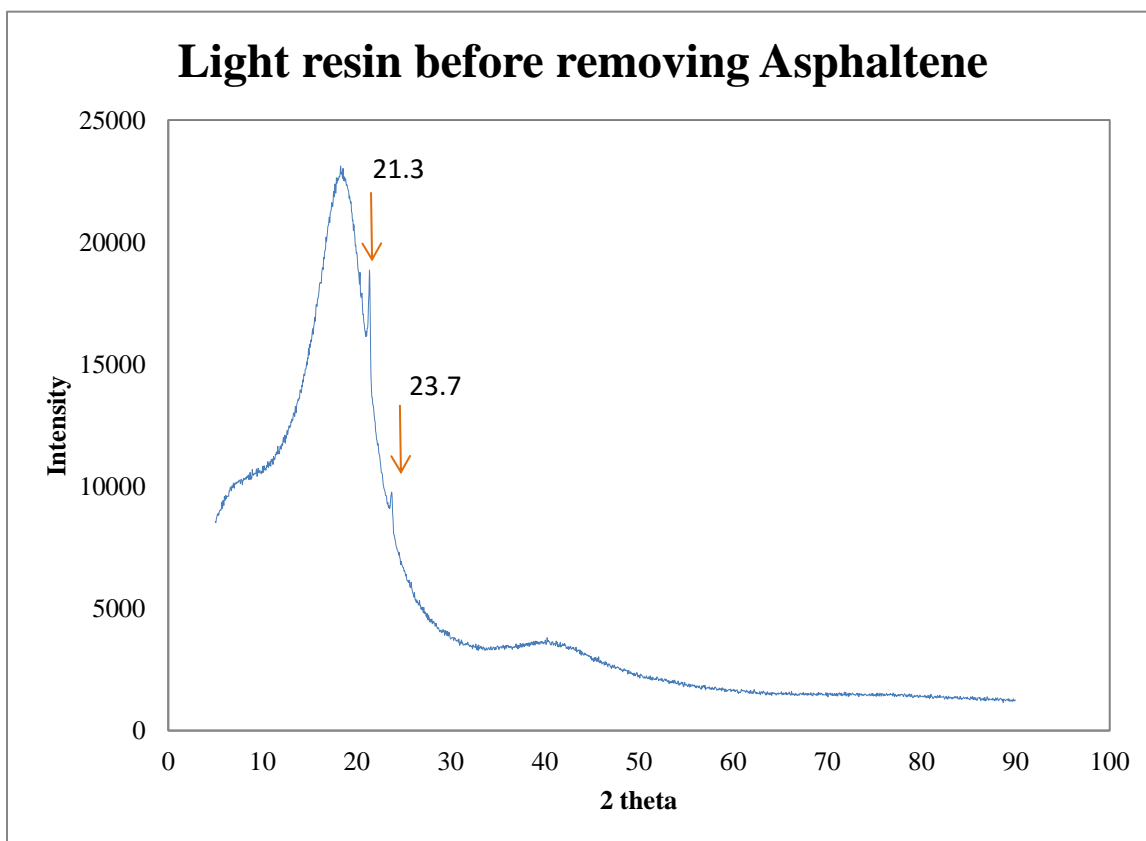


Figure 3.1: XRD pattern of Light Resin sample. Two obvious peaks are present. According to the EVA database they correspond to iron crystals.

The Heavy Resin (Figure 3.2) sample showed no obvious peaks that revealed crystals structures. It can also be observed that both resins produced a similar XRD pattern. The main difference is that the highest intensity of the Light Resin is about 20° on the 2-Theta scale and the Heavy Resin has the highest intensity about 13° on the 2-Theta scale.

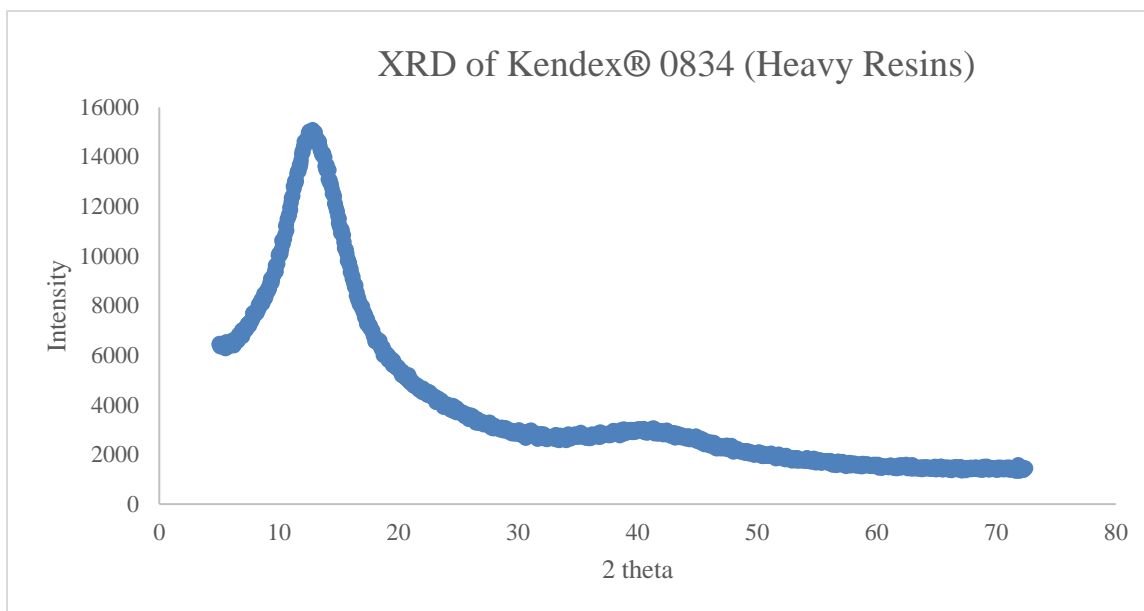


Figure 3.2: Heavy Resin XRD pattern shows no obvious peaks and a maxima at 13° in the 2-Theta scale.

A comparison was made to show the differences between both products (Figure 3.3). In the comparison, the XRD analysis of the Heavy Resin after the removal of asphaltenes with pentane is included. The most obvious result is that the highest intensity peak of the Heavy Resin shifts to the right and seems to fit with the Light Resin sample. The main difference is in the intensity, which may tell us more about the spacing between the molecules present in the samples.

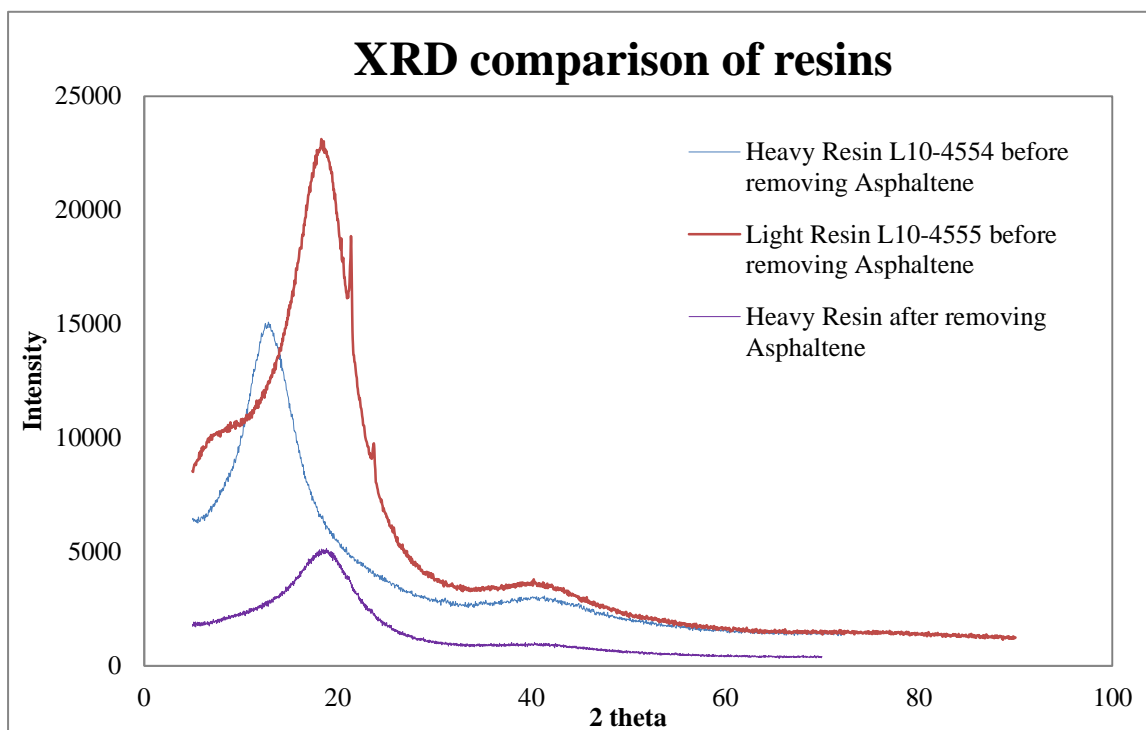


Figure 3.3: Comparison of XRD patterns of Heavy Resin (blue), Light Resin (red) and Heavy Resin after removal of asphaltenes.

From Figure 3.3, once the asphalt content of the heavy resin sample is removed, a striking similarity between the Light Resin and Heavy Resin is apparent. The maxima peak shifts to the right and is located at 18° on the 2-Theta scale. This may be due to the fact that, since there are no asphaltenes, the stacking of the molecules no longer affects the diffraction pattern. There are only resins and saturates in the heavy resin sample, making it similar to the Light Resin. No peaks are obvious once the asphaltenes are extracted. A possible de-metallization may have occurred when the extraction took place and the metals are present on the solid extracted. This is further corroborated with the XRD pattern of the asphaltenes extracted, which displays a wide array of peaks (figure 3.5).

3.1.2. Extraction of asphaltenes with pentane & heptane from the the Kendex® 0834 (Heavy Resins) & Kendex® 0897 (Light Resins)

Both products yielded no asphaltenes when using heptane as a solvent. However, when using pentane on the the Kendex® 0834 (Heavy Resins), there was a 0.8% yield of asphaltenes. The solid product was a black and very light powder as shown in Figure 3.4. There was a 0% yield from the extraction of the Kendex® 0897 (Light Resins).



Figure 3.4: Asphaltene sample extracted from the Heavy Resin.

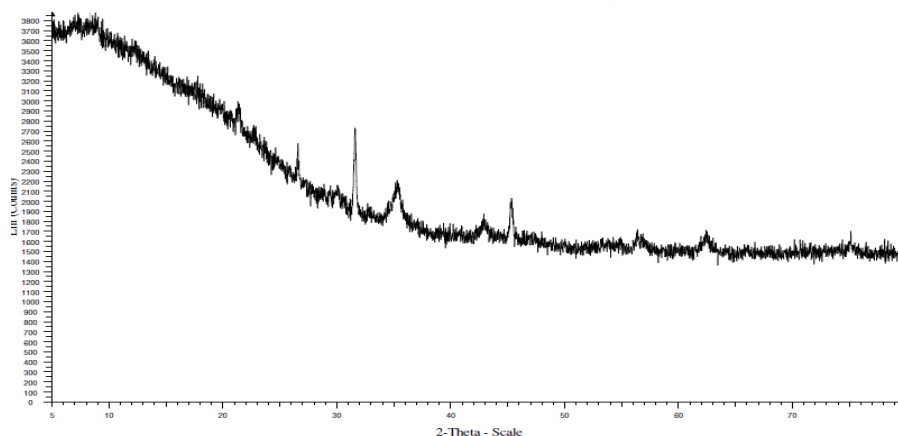


Figure 3.5: XRD pattern of extracted asphaltene.

3.1.3. X-Ray Fluorescence Analysis (XRF)

The solid phase extracted as explained previously was pelleted and submitted to X-Ray Fluorescence (XRF) analysis. In Figure 3.5, the spectra is shown. The large peak

at about 6 keV in the “energy” axis corresponds to Iron. Table 1 summarizes the list of most common metals present in the sample. Sulfur is included on the table and it can be clearly seen that it is in a low relative concentration.

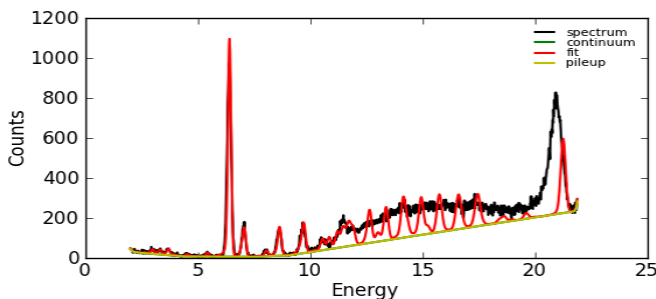


Figure 3.6: XRF spectra of pelleted solid fraction extracted from the Heavy Resin with pentane.

Table 1: List of elements measured by XRF. Iron has the highest relative concentration.

Element	Group (shell)	Fit Area	Sigma
S	K	2.84E+01	1.72E+01
Fe	K	1.12E+04	9.91E+01
Zn	K	1.63E+03	4.29E+01
Br	K	1.10E+03	5.49E+01
Rb	K	1.99E+03	6.51E+01
Sr	K	2.59E+03	7.70E+01
Zr	K	1.45E+03	8.93E+01
Nb	K	2.67E+03	7.81E+01
Mo	K	2.76E+03	7.98E+01
Au	L	3.38E+03	7.99E+01
Pb	L	1.37E+03	7.27E+01
Bi	L	1.29E+03	6.10E+01
Rn	L	2.78E+03	9.79E+01

From the XRF analysis it is observable that many of the metal elements present in the sample are in accordance with previous reports²⁰ regarding the extraction and characterization of metals in crudes.

3.1.4. Fourier Transformed Infrared Analysis

Both Kendex® 0834 (Heavy Resins) & Kendex® 0897 (Light Resins) were analyzed by FTIR and results are shown on figure 3.7.

FT-IR results show that there are very little to no heteroatoms such as N, O and S in the functional groups in both Kendex® 0834 (Heavy Resins) & Kendex® 0897 (Light Resins). Almost everything is hydrocarbons and very little presence of aromatic compounds.

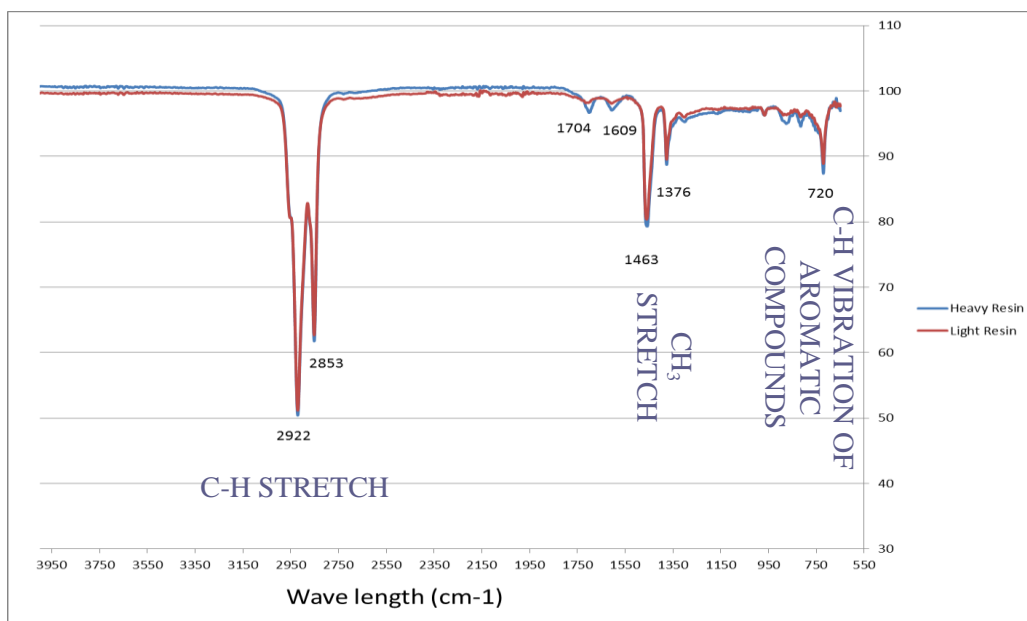


Figure 3.7: FT-IR spectra of Heavy Resin (blue) and Light Resin (red). A clear similarity exists between both products regarding their functional groups.

3.1.5. C-13 Nuclear Magnetic Resonance (C13-NMR):

The light resin, exhibited prominent peaks that corresponded to branched carbon structures which are common in light resins. Another notable aspect was the lack of carbon species that had oxygen functional groups. This might explain why the Infrared Analysis previously performed showed less prominent peaks when compared to the heavy resin.

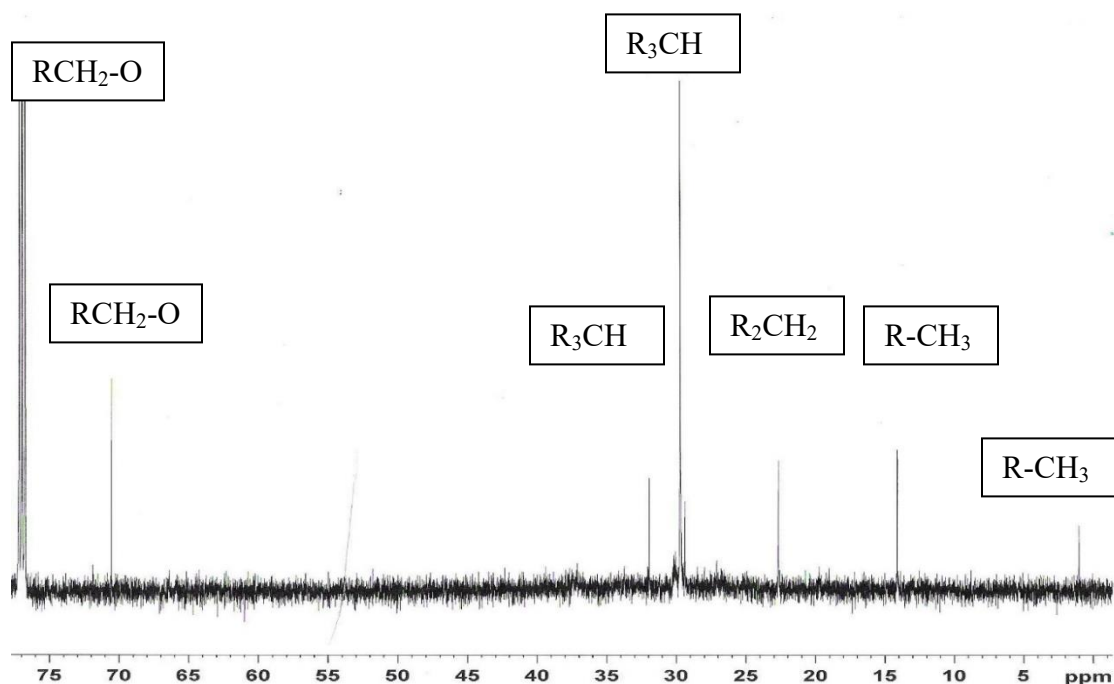


Figure 3.8: C-13 NMR of Light Resin

3.1.6. Saturates, Aromatics, Resins and Asphaltene (SARA) Analysis

Results show, as indicated on table 2, that the Light Resin has a very high percentage of saturated species of carbon compounds. The Light Resin sample also exhibits a considerable amount of aromatic species and resin species and no asphaltene. This correlates with the asphaltene extraction results performed on the Light Resin, where no asphaltenes were extracted with either pentane or heptane. As for the Heavy

Resin Sample, the most commonly observed group of molecules are aromatic compounds. This result could very easily explain why the Heavy Resin sample is much denser than the Light Resin. Another result that correlated well with the previous extraction process was the concentration of asphaltene. The SARA analysis for the Heavy Resin revealed a 0.4% w:v fraction of asphaltene. The previous extraction performed yielded 0.8% asphaltene. American Refining Group reported an asphaltene percentage of about 0.6-1%. Given the nature of these samples, it is not unusual to see a slight deviation of different species. The extraction protocol was performed several times after viewing these results and on every occasion the same percentage of asphaltenes was obtained.

Table 2: SARA analysis of Light Resin. No asphaltenes are present, which goes in accordance with the extraction previously performed.

Sample	Saturates (%)	Aromatics (%)	Resins (%)	Asphaltenes (C7)
Light Resin Kendex 0897	76.5	19.1	4.4	0

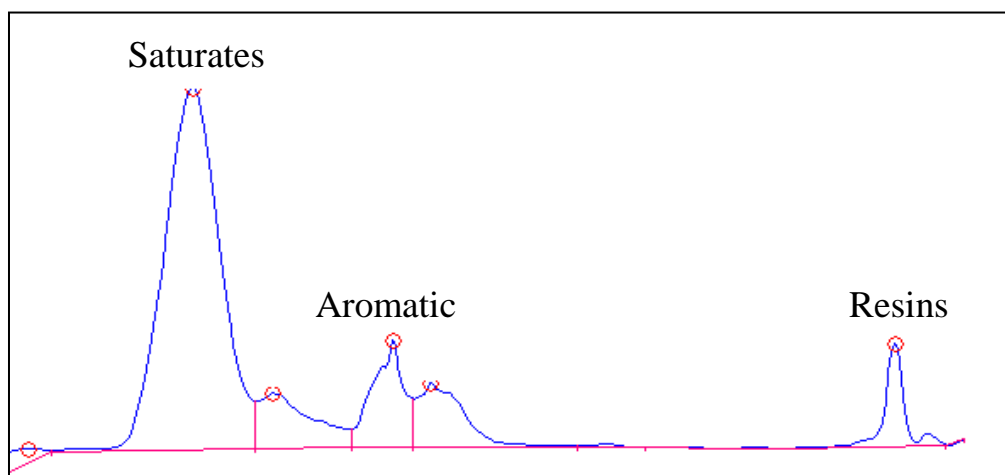


Figure 3.9: SARA analysis of Light Resin.

There is an obvious presence of aromatic groups in the sample. The higher concentration of saturates may explain why the Light Resin sample has a lower viscosity than the Heavy Resin.

Table 3: SARA analysis of Heavy Resin.

Sample	Saturates (%)	Aromatics (%)	Resins (%)	Asphaltenes (C7)
Heavy Resin Kendex 0897	24.2	58.9	16.5	0.4

It can be observed that there is less than 1% asphalt in the sample which goes in accordance with previous data obtained.

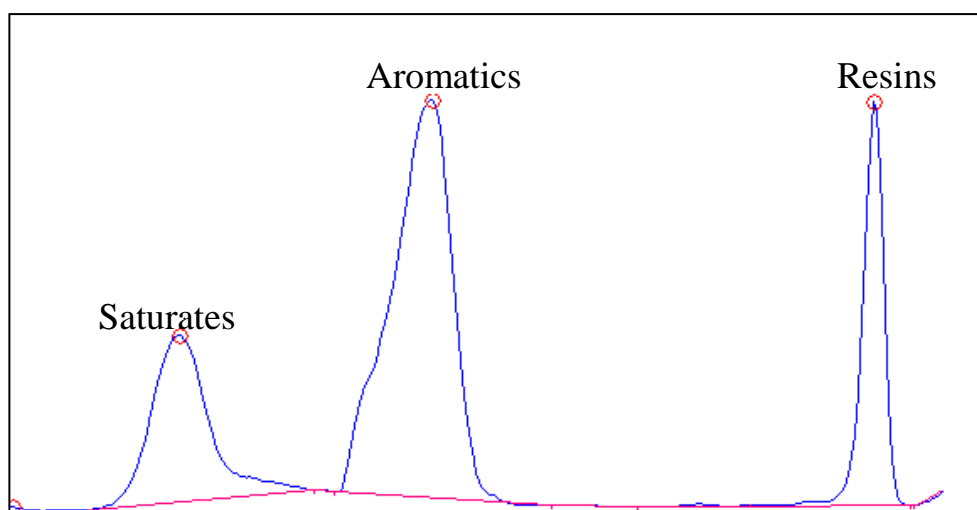


Figure 3.10: SARA analysis of Heavy Resin.

A lower concentration of saturates is observed in contrast to the relative concentration of aromatics.

3.1.7. HRTEM Analysis

In figure 3.11 & 3.12, the formation of clusters corresponding to asphaltene can be clearly seen. Morphological changes and clustering start to appear at 300°C. Searching for more elements observed on the samples, it was possible to determine the formation of

metal nanoparticles, as presented on figure 10. The crystallographic planes were determined and the particle size measured. Figure 3.13, presents the morphological structure. The most common element present was Carbon, peak reflect a low quantity as compared with Aluminum and Copper, which are present in large quantity on the sample holder and are therefore not considered in the analysis. Al and Cu are not considered in the analysis due to their presence in the sample holder. Carbon is the most prominent element and oxygen can also be seen but in a much lower amount.

3.1.8. Functionalization via Saponification

A visible change is appreciated on the product itself; changing to a light brown color comparable to caramel and particularly smells of plastic.

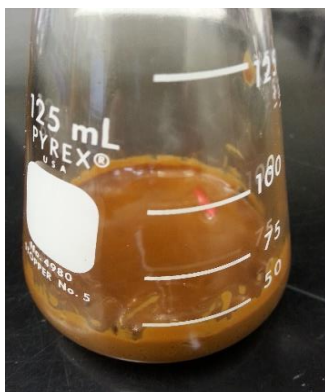


Figure 3.15: Light Resin sample after saponification in excess NaOH. There is an obvious color change in the product, due to oxidation of resins.

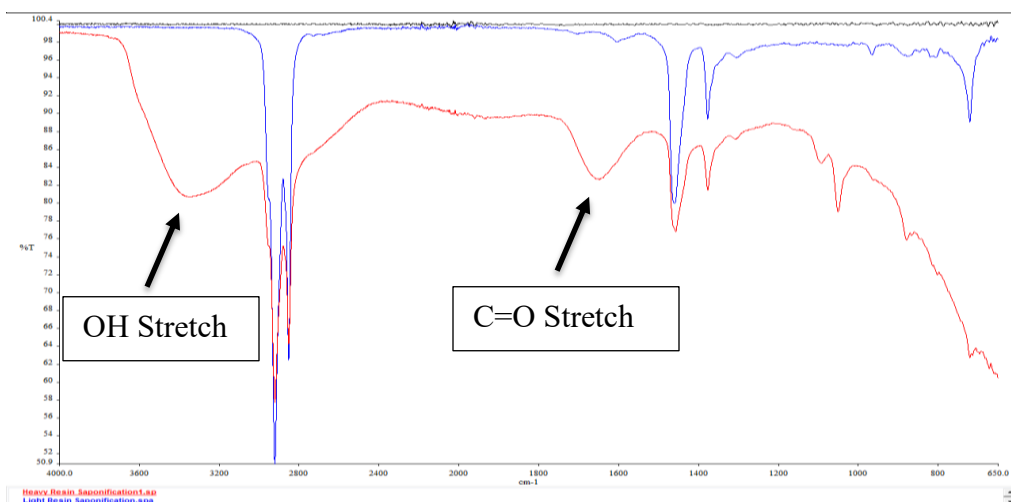


Figure 3.16: FT-IR analysis of Light Resin after saponification.

It can be clearly seen that OH and C=O functional groups have been added to the product. This result signifies that the resin products can be further modified to change their physical and chemical properties to make them more viscous and improve lubricating capacity by increasing polymerization and reducing branching.

Chapter 4: Conclusions

Both Light & Heavy Resins were characterized with the available instrumentation at UTEP. The results indicate that both resins are very similar to one another. The Heavy Resin is denser due to the small asphaltene portion that was extracted. Once that fraction is extracted, the Heavy Resin behaves exactly in the same manner as the Light Resin. XRF analysis shows the metals present in the asphaltene fraction. De-Metallization experiments have been carried out with H_3PO_4 but the Heavy resin yielded no asphaltenes this time.

FT-IR shows that there are not any heteroatoms such as O, N or S containing groups on both samples. C-13 NMR and Proton NMR show that this is in agreement and that there are almost no aromatics in the Light Resins sample. This is also confirmed in the SARA analysis. The Heavy Resin does have aromatic molecules and less saturates. This concludes that both products are mostly a wide variety of alkane hydrocarbons with some degree of branching.

Three samples of heptane extracted were investigated using HRTEM techniques. Images reveal high texture and clustering stacking (in agreement with powder X-Ray diffraction) for sample processed at 500°C , in this characteristic sample the formation of metal nanoparticles as observed on imaging.

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Curriculum Vita

Víctor Correa was born in January 19, 1991 to María del los A. Rodríguez Matías and Víctor Correa Padilla. He graduated with a High School degree from the Inmaculada Concepción at San Juan, Puerto Rico and continued to attend to his studies at the Universidad Metropolitana of San Juan, Puerto Rico majoring in Cell & Molecular Biology. As early as a freshman he acquired the Honors in Science Award given to those students who demonstrate satisfactory and competitive academic progress. He has participated in several internships as an undergraduate both in the US mainland and internationally. On his first internship at the University of Texas at El Paso he managed to publish two peer-reviewed papers while on his sophomore year. In the AGMUS 2010 Symposium he won Best Oral Presenter. He was a recipient of the INBRE scholarship. He was awarded with the Honors in Science Medal at graduation. He graduated with a Bachelors in Science in Cell & Molecular Biology with a minor in Chemistry. He was accepted at the University of Texas at El Paso to pursue graduate studies in the field of Materials Science & Engineering. He is a member of the Alpha Sigma Mu (ASM) Society and is now working on the biological response of interconnected Ti-6Al-4V foam constructs for biomedical implants. His thesis is titled “*Commercial Heavy and Light Resins: Characterization of Physical-Chemical Properties*” under the guidance of Dr. R. Chianelli and Dr. M. Ramos.