Polyesters From Chemically Modified Oil of Renewable Source

O.F. Osagie, Oriji A.B

1 Department of Chemistry, Rivers State University of Science and Technology P.M.B 5080 Port Harcourt, Rivers State, Nigeria.
2 Department of Petroleum and Gas Engineering, University Of Port Harcourt, Port Harcourt, Nigeria.

Abstract: Rubber seeds, agricultural wastes without any known nutritional value, were blended to obtain oil. The oil was employed in the production of polyesters (alkyd resins) using alcoholysis method. The rubber seed oil (RSO) and its alkyl resins were characterized and evaluated by standard methods for their physicochemical properties, drying schedule and chemical endurance. RSO had an iodine value of 99.40, saponification values of 202.36, acid value of 22.16, viscosity of 25.72 free fatty acid of 11.20 and golden yellow colour. Also, the RSO prepared polyesters have coating properties whose values are comparable to those of commercial polyesters. It is therefore recommended that the oil obtained from the seeds of natural rubber (agricultural waste) be exploited in Nigeria for the production of environmentally friendly polyesters in order to optimize its application in non pigmented surface coating.

Keywords: Wastes, Rubber seeds, Environmentally friendly, Renewable source, polyesters

I. Introduction

Agricultural raw materials are known to be environmentally friendly, biodegradable, low cost and readily available. (Bakare et al.2006). The use of these material resources in many applications has attracted the attention of many researchers due to their potentials to substitute petrochemical derivatives. Plant oils and animal fats belong to such agricultural resources with enormous applications. The world production of plant oils and animal fats rose from 58.4 million tons in 1980 to 114.5 million tons in 2000.

The development in organic chemistry, due to better and improved analytical equipment, has made it possible to perform comprehensive examination of chemical composition, the structure, and the property of natural products like vegetable oils. Modification and application of improved consumer-based products has continuously evolved. (Carracher and Sperling 1983). This gradual increase in various applications of fats and oils has triggered the expansion of planted areas of these crops. Recently, cultivation by means of genetic engineering to develop high oleic acid soy bean and rapeseed oil as well as new oil seeds, is continuously being investigated and develop to meet growing demands (Warwel et al. 2001).

In Nigeria, vegetable oil dependent industries rely mostly on imported oils like linseed and soybean oil which are very expensive. The locally available oils like palm oil, palm kernel oil, groundnut oil and coconut oil are in short supply. (Akintayo et al.2002).

Nigeria has the potential of producing over 13,000 tons of rubber seed oil annually. But to the best of our knowledge, rubber seed oil has no commercial value in Nigeria. Though previous research studies have shown that rubber seed oil is a potential raw material for alkyls resins used as binders for surface coatings. (Joseph et al. 2003).

The use of petroleum based monomers in manufacturing of petroleum based products is expected to decline in coming years because of the continuous rise in petroleum products and the high rate of oil depletion of known oil reserves. This coupled with strict governmental legislation all over the world on environmental protection against degradation, has inspired the investigation of renewable natural resources as a viable alternative. (Aigbodion et al. 2003). Because of this, plants and animals oils have long been identified as possible substitute for petrochemical derivatives in the production of polymers and Bio diesel.

To meet the increasing demands for these renewable agricultural raw materials, great attention has been shifted to chemical industries as it offer a large number of possible applications. The use of modern bio-technique and genetic approaches has proved successful for boiled plants such as rapeseed, walnut and soil bean. (Ogunyi and Njikang 2000).

This modern universal approach for changing the amount and composition of the stored oil has enable the optimization of the resources for different specific applications, also, underused and used seed such as rubber seed, (agricultural waste), African locust bean seed and jathropha seed have continuously been sourced for non edible applications.

Rubber seed oil (RSO), an agricultural by product, abundantly available in Nigeria and rich in unsaturated hydrocarbons, is an excellent starting material for many products. An estimation of potential production, based on a world planted area of 9.37 million hectares and an average production rate of rubber seed of 287kg/ha/year is over 1.08 million tons of rubber seed oil per annum. This figure is expected to increase substantially with the expansion of natural rubber production. (Ikuhoria et al. 2004). Although rubber seed oil is a potential raw material for the production of commercially valuable alkyl resin, the processing of polymers and the production of biodiesel.

Despite the production potential of alkyl resin from rubber seed oil, the produced resins are usually dark and this limits its application in non pigmented coatings. Chemical transformation of vegetable oils to fatty acid alkyl esters called transesterification or alcholysis is one of the methods of modifying the quality of vegetable oils. Various components of vegetable oils which are glycerol esters of fatty acids and various amounts of solubilised impurities such as pigments, vitamins, sterols, phospholipids etc, which are capable of compromising the quality of the finished alkyl resins. Ester of rubber seed oil (RSO) would preclude some of these undesirable effects. (Ogunyi and Njikang 2000)

Polyesters are defined as the product of polycondensation reaction between a polybasic acid and polyhydric alcohol modified with a monobasic fatty acids or drying oil with suitable catalyst at controlled temperature (Aigbodion et al., 2000). The oils that are mostly employed for alkyl resin synthesis are linseed, soybean, castor and tall oils (Ogunyi and Njikang, 2000, Kildiran et al., 1996 and Majumder, 1999). These oils are largely imported to Nigeria for the formulation of coatings for metal cans used in packing of beverages, drugs, food etc. However, drying oils are available locally, which have remained untapped. These include rubber oil, soybean oil, walnut oil and tobacco oil (Adefarati, 1986). These drying oils owe their value as raw materials for decorative and protective coatings to their ability to polymerize or “dry” after they have been applied to surface to form tough, adherent, and impervious and abrasion resistance films. The advantages claimed in surface coating applications include excellent odour and heat bleach ability, good drying properties and more uniform
Polyesters From Chemically Modified Oil of Renewable Source

polymer structure (Kirk and Othmer, 1947).

The RSO is unique because of its relative abundance, level of unsaturation and possession of similar properties with linseed oil, which is traditionally employed in the manufacture of Alkyd Resins (Aigbodion, 1991). In addition, due to non use of RSO for edible purposes, it stands out as a veritable substitute for the linseed oil which is currently being imported into the country at a great cost.

However, doubts have been expressed about the sustained successful use of RSO for the large scale production of polyesters. Such doubts are attributed to fears that low percentage yield may result from the sourcing of oil from the rubber seed. Against this backdrop, many works had been conducted to verify the sustainability of RSO in the manufacture of alkyd resin. As a further step in this direction, this work attempts to contribute to the pool of scientific knowledge for the possible application of RSO in the production of alkyd Resin at industrial scale.

It is expected that the successful application of RSO as good substitute for linseed oil and other edible oils in the manufacture of alkyd resins will conserve the nation’s foreign exchange and lessen the pressure on the demand for edible oils. This will ultimately translate to low prices for the edible oils and other associated products derivable from them.

II. Literature Review

Alkyd resins (polyesters) are often used in paints and varnishes industry. The alkyd resin is a prime candidate for surface coating materials. It is generally manufactured from phthalic anhydride, poly and drying oils. According to Formo et al. (1965), polyesters form the largest group of synthetic resins available to paint industries and it is widely used due to their low cost and versatility (Kirk and Othmer, 1947). In order to improve properties of alkyd resins, modification with various other materials is recommended. The other materials may be present in physical or chemical combination. The modification of polyesters with cellulose nitrate gives fast-drying, also, modification of alkyd resin with chlorinated rubber gives good fire-resistance. Alkyd resin is also used in coating application. Also they are compatible with most of the resin used on paint industries like rosin, epoxy, phenolic resin, amino resin, polyurethanes etc. Alkyd resins are used in both clear and fire resistant. Alkyd resin. As a further step in this direction, this work attempts to contribute to the pool of scientific knowledge for the possible application of RSO in the production of alkyd Resin at industrial scale.

III. Sources and Composition of Rubber Seed Oil (RSO)

Rubber seed oil is the oil obtained from the seed of rubber trees. The oil is unsaturated and comprises mainly of oleic, linoleic and linolenic acids. The function of oils and fats in alkyd is to provide the site for free radicals cro

<table>
<thead>
<tr>
<th>Oil source/Seed</th>
<th>OC (%)</th>
<th>AV (mgKOH/g)</th>
<th>SV (mgKOH/g)</th>
<th>IV (g12/100 g)</th>
<th>SG (dimensiolnless)</th>
<th>RI (mm2/s)</th>
<th>V (%)</th>
<th>HV (MJ/kg)</th>
<th>FFA (mgKOH/g)</th>
<th>Reference/source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moringa</td>
<td>40.39</td>
<td>NR</td>
<td>186.67</td>
<td>69.45</td>
<td>1.4608</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>0.40</td>
<td>Anwar &amp;Bhanger (2003).</td>
</tr>
<tr>
<td>C. pepo Cashew nut</td>
<td>41.59</td>
<td>0.39</td>
<td>190.69</td>
<td>104.36</td>
<td>0.915</td>
<td>1.4662</td>
<td>93.65cp</td>
<td>NR</td>
<td>0.39</td>
<td>Duhan, (2012).</td>
</tr>
<tr>
<td>Flated rubber Black benseed C. maxima Agusi</td>
<td>43.69</td>
<td>0.53</td>
<td>185.20</td>
<td>105.12</td>
<td>0.913</td>
<td>1.4656</td>
<td>48.09cp</td>
<td>NR</td>
<td>0.27</td>
<td>Mabaleha, Mitei&amp;Yeboah (2007).</td>
</tr>
<tr>
<td>Desert melon Rubber seed</td>
<td>28.0</td>
<td>2.5</td>
<td>182.1</td>
<td>124.0</td>
<td>0.954</td>
<td>1.468</td>
<td>NR</td>
<td>NR</td>
<td>0.5854</td>
<td>Mabaleha, Mitei&amp;Yeboah (2007).</td>
</tr>
<tr>
<td>Source: Bwade et al; 2013.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Where OC= Oil Content, AV= Acid Value, SV= Saponification Value, IV= Iodine value, SG= Specific gravity, RI= Refractive index, FFA= Free fatty acid and HV= heating value
V. Purification of Oil

Crude fats and oils are obtained directly from the extraction of the oil seed. Crude fats and oils contain varying substances that may influence undesirable flavour, colour, or keeping quality of the oil. These substances are removed through a series of purification and processing steps.

1.5.1 Degumming

Degumming is defined as the treatment of additives that are used for the removal of waxes, phosphates, and other impurities in oil. The process of degumming converts the phosphatides to the hydrated gums that are highly insoluble in oil and are quickly separated as the sludge. For the crude lecithin processing, all the hydrated gums are completely vacuum dried. In this process, phosphoric acid and water are added at the temperatures of 60°C (140°F).

1.5.2 Alkali Refining

Alkali refining involves the reaction of free fatty acids in oil with alkaline solution such as caustic soda and potassium hydroxide. In alkali refining, alkaline solution is used to neutralize the free fatty acid present in the oil.

1.5.3 Bleaching

Bleaching is the process of removing colour pigments and metal ions from oil. The purpose of bleaching (or decolorizing) is to reduce the levels of pigments such as carotenoids and chlorophyll, but it also further removes residues of phosphatides, soaps, traces of metals, oxidation products, and proteins. These trace components interfere with further processing. They reduce the quality of the final product and are removed by adsorption with activated clay and silica.

VI. Classification of Alkyd Resin

There are several types of alkyds. One classification is into oxidizing and nonoxidizing types. Oxidizing alkyds cross-link by the same mechanism as drying oils. Nonoxidizing alkyds are used as polymeric plasticizers or as hydroxy-functional resins, which are cross-linked by melamine–formaldehyde (MF), by urea–formaldehyde (UF) resins, or by isocyanate cross-linkers. A second classification is based on the ratio of monobasic fatty acids to dibasic acids utilized in their preparation (oil lengths). Oil length is the amount of fatty acid present in the resins (in percentage). Alkyds are short oil if fatty acid percentage is less than 45%, medium oil if fatty acid percentage is between 45-55% and long oil if fatty acid percentage is greater than 55% (Prane and Joseph, 2002).

VII. Aim of the Study

This research work is anchored on the following aims and objectives:

- To partially refine rubber seed oil, synthesize alkyd resins
- To determine the physicochemical properties and chemical resistance of the RSO prepared alkyd resins

Experimental

2.1 Collection of Samples

The Rubber (Hevea brasiliensis) seeds were obtained from a rubber plantation at Omagwa Town in Ikwere Local Government Area of Rivers State, Nigeria. Other reagents used for the study was obtained from laboratory in the Department of Chemistry, Rivers State University of Science and Technology.

2.2 Preparation of rubber seed oil

The shells was removed from the rubber seed, cleaned and dried under the sun for a day. The kernel was later dried to constant weight in the oven for three hours at 35°C to ensure that water and moisture were removed. 1000g of the kernel was immediately grounded using mortar and pestle into a paste in order to weaken and rupture the cell. The paste was stored in a labeled airtight container for oil extraction. n-hexane was added to the paste in the container and mix for oil extraction. The mixture was filter using a filter paper to separate the paste from the oil. The extracted oil was put in an evaporating dish for 24 hours to evaporate the n-hexane. The oil was later put in an oven at 60°C for another 24 hours to remove any remaining n-hexane. Finally, the oil was collected and stored in a label airtight container for further used.

2.3 Degumming of rubber seed oil

300g of crude rubber seed oil was weighed. 100ml of acetic acid was then mixed with the weighed crude rubber seed oil in a 500ml beaker. The mixture was stirred and allowed to settle in a separating funnel over-night and finally, the gums were separated from the rubber seed oil and thereafter washed with water and dried.

2.4 Physico-chemical characterization of crude and degummed rubber seed oil

Saponification Value

2g of RSO was dissolved into a 25ml ethanolic potassium hydroxide solution in 250ml round bottom flask with a reflux condenser. The flask was heated in a steam bath and occasionally swirled to effect saponification as the solution starts to boil, the heating was effected for 30mins, after heating: the soap solution formed was titrated with standard. 0.5m hydrochloric acid using phenolphthalein as indicator. A blank titration was also done in the same manner. The saponification value (S,V) was expressed as:

\[
S,V = \frac{(56.1M \times V)}{W}
\]

Where:

- \( M \) = Molarity of hydrochloric acid
- \( W \) = Weight of samples in grammes used
- \( U \) = Volume in ml of hydrochloric acid titrated in blank and
Iodine Value

The sample under determination was weighed and dissolved in 25ml of carbon tetrachloride and agitated thoroughly and then allowed to stand for about 30 mins in dark. 100ml of distilled water and 20ml 10% (w/v) potassium iodide was added to the mixture and filtered with 0.1M standard sodium thiosulphate using 0.5% (w/v) starch solution as indicator. Blank solution was also carried out in similar manner. The iodine value (IV) was calculated as follows:

\[ IV = \frac{b - a \times M x 12.69}{W} \]

Where

- \( M \) = Molarity of standard sodium thiosulphate
- \( W \) = Weight of sample in grams used
- \( b \) = Volume in ml of sodium thiosulphate titrated in blank
- \( a \) = Volume in ml of sodium titrated in test.

Acid Value

2g of the RSO was dissolved in 50ml of neutralized solvent of equal volume of diethyl ether and absolute ethanol. The resultant solution was titrated with 0.1M KOH solution using phenolphalein as indicator. The acid value was calculated using the expression:

\[ \text{Acid Value (AV)} = \frac{(V \times M \times 56.1 \times 0.142)}{2 W} \]

Where

- \( V \) = Volume of titrant (KOH) in ml
- \( M \) = Molarity of standard KOH
- \( W \) = Weight of grams of samples

Refractive Index

It was determined using refractometer, in the determination of refractive index, the prison of a refractometer was cleaned using soft paper and acetone after which 5 drops of the RSO were placed on it. The prison was closed firmly and the lamp was swung against it. The switch button at the back of the instrument was used to adjust the alignment mark until the centre mark was aligned on the cross hair and the reading was taken.

Colour

The colour of both crude rubber seed oil and the degummed rubber seed oil samples were determined by the physical eye identification.

Specific gravity

The specific gravity (SG) of both samples was obtained by using a 25ml capacity density bottle at 20\(^0\)C. The SG was calculated as the ratio of the weight of equal volume of the samples to that of water equal temperature i.e. SG

\[ \text{SG} = \frac{W_s}{W_w} \]

Where
- \( W_s \) = Weight of samples (CRSO and DRSO)
- \( W_w \) = Weight of distilled water

2.5 Preparation of Rubber seed oil based Polyesters (Alkyd resins)

RSO was reacted with glycerol at a temperature range of 230-250\(^0\)C in a three-necked flask, fitted with motorized stirrer, nitrogen gas inlet, a dean and stark trap carrying a water condenser. Alcoholysis was complete when one part of the reaction mixture dissolved in three parts of anhydrous methanol and formed a clear solution. The reaction temperature was cooled to about 180\(^0\)C and then phthalic anhydride and xylene was introduced to the flask. The reaction temperature was elevated and then monitored to completion by determination of the acid value periodically, until it dropped to below 7.

2.6 Recipe for Alkyd formulation

The recipe for alkyd resins formulation is presented in table 2.1 below.

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>RSO (g)</td>
<td>151.13</td>
</tr>
<tr>
<td>Glycerol (g)</td>
<td>60</td>
</tr>
<tr>
<td>Phthalic anhydride (g)</td>
<td>90.13</td>
</tr>
<tr>
<td>Calcium Oxide (g)</td>
<td>0.5</td>
</tr>
<tr>
<td>Oil length (%)</td>
<td>50 (medium)</td>
</tr>
</tbody>
</table>

2.7 Physico-chemical analysis of polyesters samples

The physico-chemical properties of alkyd resins prepare was determined using ASTM standard methods (ASTM D 1639-90, (1994), AOAC, (1997). Similar procedure was used for the determination of physicochemical parameter of the oil.
2.8 Drying Schedule of the RSO

The drying schedule was achieved by applying thin spread of the polyesters on clear glass panel and dried at room temperature. The drying process was monitored in terms of the time of set-to-touch, surface-dry and dry-through.

2.9 Chemical Endurance

The chemical endurance was determined using ASTM (D 1308-67) standard test method at room temperature. The resistance of the films to different solvent media (water, brine, KOH, HCl) was determined.

VIII. Results

Table 3.1: Physico-chemical properties of Refined and Crude rubber seed oil (RSO)

<table>
<thead>
<tr>
<th>Properties/parameters</th>
<th>Crude RSO</th>
<th>Refined RSO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td>Light brown</td>
<td>Golden yellow</td>
</tr>
<tr>
<td>Acid value (mgKOH/g)</td>
<td>22.40</td>
<td>22.16</td>
</tr>
<tr>
<td>Saponification Value (mgKOH/g)</td>
<td>202.62</td>
<td>202.36</td>
</tr>
<tr>
<td>Iodine Value (gI2/100g)</td>
<td>99.40</td>
<td>98.42</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>0.900</td>
<td>0.889</td>
</tr>
<tr>
<td>Viscosity (Stokes)</td>
<td>26.84</td>
<td>25.72</td>
</tr>
<tr>
<td>Free fatty acid (mgKOH/g)</td>
<td>11.70</td>
<td>11.20</td>
</tr>
<tr>
<td>Refractive index</td>
<td>1.47</td>
<td>1.46</td>
</tr>
</tbody>
</table>

Table 3.2: Physico-chemical properties of the finished Polyesters

<table>
<thead>
<tr>
<th>Properties/parameters</th>
<th>Alkyd resins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td>Dark brown</td>
</tr>
<tr>
<td>Specific gravity (S.G)</td>
<td>0.935</td>
</tr>
<tr>
<td>Acid value</td>
<td>5.97</td>
</tr>
<tr>
<td>Saponification value (S.V)</td>
<td>283.20</td>
</tr>
<tr>
<td>Iodine value</td>
<td>89.60</td>
</tr>
<tr>
<td>Refractive index</td>
<td>1.604</td>
</tr>
<tr>
<td>Free fatty acid</td>
<td>3.00</td>
</tr>
</tbody>
</table>

Table 3.3: Drying schedule for formulated alkyd resin

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Medium Alkyd Resin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set to touch (mins)</td>
<td>45</td>
</tr>
<tr>
<td>Surface dry (min)</td>
<td>140</td>
</tr>
<tr>
<td>Dry through (min)</td>
<td>660</td>
</tr>
</tbody>
</table>

Table 3.4: Chemical Endurance of polyesters film

<table>
<thead>
<tr>
<th>Solvent Media</th>
<th>Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkali (0.1MKOH)</td>
<td>Film was removed</td>
</tr>
<tr>
<td>Acid (0.1HCl)</td>
<td>Film was not removed</td>
</tr>
<tr>
<td>Brine (5% w/w NaCl)</td>
<td>Film was not removed</td>
</tr>
<tr>
<td>Water (Cold)</td>
<td>Film was not removed</td>
</tr>
</tbody>
</table>

IX. Discussion

The refractive index of 1.467 obtained in this study falls within the standard value for refractive index of organic oil which is between 1.3 – 1.6 (Kovo and Bawa, 2007). The value is also in the range found for common oils such as castor seed (1.47), butyrospermiumparkii (1.453), sterculiasetegera (1.465), blighiasapida (1.449) and shear butter oils (1.60) (Asuquo et al, 2010; Kyari, 2008). Refractive index is an indication of the level of saturation of the oil.

The viscosity value (25.72 stoke) obtained for RSO is higher than those of other oils e.g. castor oil (13.02 stoke), shear butter oil (17.78 stoke) and lower than crambe oil (27.20 stoke) (Asuquo et al, 2010).

The specific gravity of RSO was found to be 0.900 indicating that the oil is less dense than water. This value is quite comparable to the linseed oil, which is recommended standard in the production of alkyd resin. Also, the value seems to indicate that no heavy element is present in the oil (Aigbodion and Bakare, 2005). The value seems to indicate that no heavy element is present in the oil (Aigbodion and Bakare, 2005). The specific gravity obtained for RSO in this study is similar to those of other oils e.g. shea butter oil (0.92) and castor seed oil (0.96) (Asuquo, 2008). Refractive index is an indication of the level of saturation of the oil.

The viscosity value (25.72 stoke) obtained for RSO is higher than those of other oils e.g. castor oil (13.02 stoke), shear butter oil (17.78 stoke) and lower than crambe oil (27.20 stoke) (Asuquo et al, 2010).

The specific gravity of RSO was found to be 0.900 indicating that the oil is less dense than water. This value is quite comparable to the linseed oil, which is recommended standard in the production of alkyd resin. Also, the value seems to indicate that no heavy element is present in the oil (Aigbodion and Bakare, 2005). The specific gravity obtained for RSO in this study is similar to those of other oils e.g. shea butter oil (0.92) and castor seed oil (0.96) (Asuquo, 2008).

Peroxide value of 15.2 was obtained for RSO in this study. Peroxide value is an indication of deterioration of oils. Oils with higher peroxide values are more unsaturated than those with lower peroxide values. More unsaturated oils are known to absorb more oxygen and develop higher peroxide values, and oils with higher peroxide values are prone to rancidity (Asuquo, 2008). Therefore, the oil in this study may not be suitable for consumption since it has a peroxide value above 10.

The saponification value (202.36) in table 3.1 obtained for RSO in this study is above those of common oils such as soybean (189 – 195), peanut (187 – 196) and cotton seed oil (189 – 198) (Codex, 1993) which suggest that the oil has high lauric acid content. The lauric acid content and the saponification value of oil serve as important parameters in determining the suitability of oil in soap making and alkyd production. The saponification value obtained for RSO in this study (Table 3.1) projects the oil as good in alkyd synthesis. The saponification value obtained for RSO in this study is also in the range of 203 reported for RSO obtained from (RRIN) Edo State Nigeria and 182.12 ± 0.27 reported for Malaysian rubber seed oil (Abdullah and Salimon, 2009).

From the results in Table 3.1, crude RSO has a light brown colour similar to the dark colour reported for RSO obtained from the rubber research institute of Nigeria (Aigbodion and Bakare, 2005). This indicates that in its natural form, RSO is only suitable in applications where bright color is not the major consideration e.g. pigmented coatings.

The iodine value of 99.40 (table 3.1) obtained for RSO in this study is lower than 136 and 135.79±0.33 reported by
Rubber seed oil was used in the preparation of alkyd resin. Generally, there are increase in the values of acid value, saponification value and iodine value for the alkyd resin when compared to that of RSO. RSO seems to be more promising in the production of alkyd resin as indicated by physico-chemical analysis of the finished alkyd resin. The alkyd resin films have properties that will make it to be highly resistant to acid, brine, and water. Therefore, it can be useful in formulation of non-polluting coatings. However, it has its short coming which is poor resistance to alkali.

X. Conclusion

References

**Polyesters From Chemically Modified Oil of Renewable Source**


Polyesters From Chemically Modified Oil of Renewable Source


