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Extraction, Characterization of African Pear (*Dacryodes Edulis*) Oil and its Application in Synthesis and Evaluation of Surface Coating Driers

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Abstract: *The fatty composition of African pear oil (APO) revealed that the oil is rich in saturated fatty acids, having palmitic acid (44.31%), stearic acid (8.07%), and oleic acid (42.45%) as the most abundant saturated and unsaturated fatty acids respectively. It iodine value was determine as 45.050 $gI_2/100g$ which classified it as non-drying oil. The synthesis of surface coating driers was carried out by precipitation method using APO, palm kernel oil (PKO), sodium hydroxide, lead (II) trioxonitrate (V), cobalt (II) chloride hexahydrate and anhydrous calcium chloride. The colour of lead, cobalt and calcium driers of APO and PKO were found to be yellow, purple and white respectively. The specific gravity of PKO driers were greater than those of APO driers. The prepared driers and the commercial driers were used separately in the formulation of white gloss alkyd paints and the properties of APO driers were found to be better than those of PKO driers and were also found to be comparable with commercial samples.*

Keywords: *African pear oil; Alkyd resin; Coatings; Fatty acid composition; Palm kernel oil; Precipitation; Surface coating drier*

1. Introduction

Dacryodes edulis is cultivated in large quantity in South- Eastern Nigeria and other African countries like Cameroon, Sierra Leone, Uganda, Malaysia, Liberia, and Zaire. There are two varieties of *Dacryodes edulis* in Nigeria- *D.e.var. edulis* and *D.e.var. parvicarpa* (Isaac and Ekpa, 2009). The fruits and seeds of this plant have been found to contain reasonable amounts of oil (Ikhuoria and Maliki, 2007; Arisa and Lazarus, 2008). African pear oil contains the following acids: palmitic acid (9.06%), stearic acid (15.46%), oleic acid (26.63%) and linoleic acid (30.85%) (Ikhuoria and Maliki, 2007).Umoti and Okyi (1987) gave the fatty acid composition and the range of fatty acids in African pear oil as follows: palmitic acid 47.89% (35 – 65%), oleic acid 31.25% (16 – 35%) and linoleic acid 17.5% (14 – 27%). The physicochemical properties of African pear oil determined by Ikhuoria and Maliki (2007) are average melting point (80 ^{0}C), refractive index (1.456), viscosity (0.33 poise), free fatty acid (1.100%), saponification value (143.760 mgKOH/g), iodine value (44.079 $gI_2/100g$), acid value (15.280 mgKOH/g), ester value (128.480) and unsaponifiable matter (53.920%). On the other hand, Umoti and Okyi (1987) determined saponification value, iodine value and specific gravity of APO as 201.4 mgKOH/g, 59.6 $gI_2/100g$ and 0.9 respectively.

Adequate development of this oil could contribute to the nation's demand for vegetable oils for surface coatings and other industrial applications.

However, the composition of pigmented coating products can be grouped into pigments (primary pigments and extender pigments); binders; solvents (organic solvents and water) and lastly additives. Additives are materials that are included in small quantities to modify some property of the coating (Ekpa and Isaac, 2008). Additives used in surface coatings include driers, anti – skinning agents, wetting agents, anti – microbial agents, anti – foaming agents and thickening agents (Ekpa, 2008). The additive of interest in this research is drier (or metallic soap). Driers belong to a class of soap, they are added to both gloss, and water reducible alkyd paints to accelerate drying. They also increase drying process in other coating products like varnish. They are available as liquids, solids and pastes. It catalyzes the decomposition of peroxides and hydro peroxides formed by the action of atmospheric oxygen on binders like alkyd resins. This promotes the formation of radicals, and polymerization of the binder is thus initiated and accelerated. Martinson and Sisler (1987) defined driers as materials added to paint formulations to facilitate the oxidation of oils. Ekpa (1996) and Ekpa and Isaac (2008) defined metallic soaps as group of compounds in which the acid hydrogen or the cation in a long chain monobasic acid has been replaced by a metal of the alkaline earth or heavy metals series. Hein (1998) defines drier for coatings as a metal carboxylate, which catalyzes, performs or promotes the cross-linking of resin polymer or drying oils. These soaps are substantially water insoluble but soluble in organic solvents. This characteristic of insolubility in water differentiates them from ordinary soaps of sodium and potassium. In addition, their solubility in organic solvents account for their wide applications in a variety of products.

The application of *Dacryodes edulis* oil in production of surface coating driers has not been reported elsewhere. In view of the partial and anticipated shift in the source of feed-stocks in chemical industry from non-renewable petroleum resources to renewable environmentally benign agricultural resources, it is important that more avenues be exploited for production of biocompatibility, biodegradable and low toxicity surface coating products. Hence, this research is aimed at widening the knowledge of fatty acid composition of *Dacryodes edulis* oil, and evaluating its potential application in synthesis of surface coating driers (lead, cobalt and calcium driers). We also report on the production and evaluation of surface coating driers from palm kernel oil and it properties compared with that of African pear oil. This will help to diversify the uses of this oils thereby increasing earnings for local farmers as well as encouraging cultivation of *Dacryodes edulis* plant.

2. EXPERIMENTAL

2.1. Materials

Ripe fruits of African pear (*D. e. var. edulis*) and PKO respectively were purchased from Akpan Andem market, Uyo. Analytical grade lead (II) trioxonitrate (V) (BDH, Egland), cobalt (II) chloride hexahydrate (BDH, England) and anhydrous calcium chloride (BDH, England) were obtained from commercial sources and used in the preparation of surface coating driers. On the other hand, technical grade titanium (IV) oxide, calcium trioxocarbonate (IV), toluene and alkyd resin were obtained from commercial sources and used in the preparation of alkyd gloss paint. In addition, standard octoate driers were bought from the open market to serve as control.

2.2. Extraction of Oil and Determination of Fatty Acid Composition

The African pear fruits were washed thoroughly with distilled water and split open with a sharp stainless knife to remove the seed from the pulp. The prepared pulp sample was dried at a temperature of 70 ^{0}C in a Gallenkamp hot air oven model OV 160 for 48 hrs. The dried sample was grounded into uniform powder using a Corona traditional grain mill REF 121 (100 μm mesh size). The oil was obtained by Soxhlet extraction of the milled sample using petroleum ether as the solvent. The extracted oil was referred to as African pear oil.

The fatty acid composition of APO was determined by GC–MS analysis using the procedure described elsewhere (Ekpa and Isaac, 2013).

2.3. Physicochemical Properties

APO was analysed for its physicochemical properties viz: acid value, iodine value, saponification value, free fatty acid, specific gravity and color using standard methods (ASTM D 1959-85; ASTM D 1980-85).

2.4. Preparation of APO and PKO Metallic Soaps of Lead, Cobalt and Calcium

The metallic soaps of APO and PKO were prepared by the precipitation method as modified by Ekpa (2008). It involves two stages – the saponification reaction between triglyceride oils (APO and PKO) and sodium hydroxide (NaOH), followed by double decomposition reaction in which sodium in the soap is replaced by the heavier lead, cobalt, and calcium metals respectively. The alkali soap process was the same for the lead, cobalt and calcium driers.

The concentration of the alkali used was determined by manipulating the saponification value of the oils and its saponification equivalent, and carefully increasing the concentration of the hydroxide until a good yield was obtained. Similarly, the concentrations of the metal salts were also varied until a reasonable yield was obtained in the double decomposition step.

2.5. Preparation of APO and PKO Alkali Soap

20 g of APO was weighed into three 250 cm^3 beakers labelled A, B and C. Similarly, 20 g of PKO was weighed into three 250 cm^3 beakers labelled D, E and F. These oil samples were then heated for about 3 – 5 mins to evaporate little quantities of water present and then, were allowed to cool. A 0.7 $moldm^{-3}$ solution of NaOH (prepared by dissolving 28 g of NaOH in 100 cm^3 of distilled water) was added to the oil samples respectively with adequate stirring for few minutes. The samples were then left overnight to solidify to form solid soaps. The solid soaps were separated from the lye, washed with cold distilled water to remove any excess alkali.

2.6. Preparation of APO and PKO Lead Soap

The soap obtained from beaker A which weighed 44.130 g was put into 400 cm^3 beaker and 25 cm^3 of hot water ca 80 ^{0}C was then used to dissolve this soap to increase the surface area for reaction. 0.5 $moldm^{-3}$ solution of lead (II) trioxonitrate (V) (prepared by dissolving 45.5 g of $Pb(NO_3)_2$ in 250 cm^3 of water) was added to the dissolved soap with constant stirring. The metallic soap, which precipitated was filtered, washed with distilled water and dried in a desiccator in which silica gel was used as the drying agent until all the water was precluded. The procedure described above was repeated using PKO soap (which weighed 43.130 g) obtained from beaker D to produce PKO lead soap. The soaps were standardized to required metal content by dissolving in white spirit.

2.7. Preparation of APO and PKO Cobalt Soap

The soap obtained from beaker B, which weighed 44.676 g was put into a 400 cm^3 beaker. 20 cm^3 of hot water ca 80 ^{0}C was then used to dissolve this soap to form a solution of it. 0.5 $moldm^{-3}$ solution of cobalt (II) chloride hexahydrate (prepared by dissolving 29.75 g of $CoCl_2.6H_2O$ in 250 cm^3 of water) was added to the dissolved soap with constant stirring resulting in the formation of a precipitate. The precipitate of cobalt soap was filtered with muslin cloth, washed with distilled water and dried in a desiccator.

The metal soap was then standardized to required metal content by dissolving it in white spirit. The procedure described above was repeated using the soap obtained from beaker E to produce palm kernel oil cobalt soap. The weight of PKO alkali soap from beaker E was 45.113 g.

2.8. Preparation of APO and PKO Calcium Soap

The procedure for the preparation of APO and PKO calcium soap were similar to those described in lead and cobalt soaps. The mass of alkali soap from beakers C and F were 40.133 g and 37.076 g respectively, while the concentration of the metal salt (calcium chloride) was 1.0 $moldm^{-3}$ (prepared by dissolving 29.65 g of anhydrous calcium chloride in 250 cm^3 of distilled water). The precipitate obtained was filtered, washed with distilled water and dried in a desiccator. The soap was standardized to required metal content by dissolving in white spirit.

2.9. Evaluation of African Pear Oil and Palm Kernel Oil Driers

To evaluate the performance properties of APO and PKO driers, the procedure described in our previous studies (Isaac and Ekpa, 2013; Ekpa and Isaac, 2013) was used in the preparation of alkyd gloss paint with APO and PKO cobalt, lead, and calcium driers. The cobalt drier act as primary drier (catalytic or surface or top drier), while the lead and calcium driers act as secondary drier (cross-linking or through or polymerization drier) and coordination drier (auxiliary or promoter drier) respectively. The standard octoate cobalt, lead and calcium driers were also used in the preparation of the alkyd gloss paints to serve as control. The colour, specific gravity, solid content, adhesion, flexibility, durability, drying schedules, hardness property of the two sets of alkyd gloss paints samples were determined using the methods described elsewhere (Ogunniyi and Odetoye, 2008; Odetoye *et al.*, 2010; Isaac and Ekpa, 2013).

3. RESULTS AND DISCUSSION

3.1. Extraction and Fatty Acid Profile of African Pear Oil

African pear (*D. e. var. edulis*) extract was liquid at room temperature. This implies that it could be classified as oil. The percentage oil yield of the APO was 58.23 % and fall within the range reported by Umoti and Okyi (1987). Umoti and Okyi (1987) gave the range of oil yield of African pear oil extracted by solvent extraction as 40 – 65% depending on the maturity of the fruits, while the range of yield obtained by press extraction was given as 25 – 49 %. It has been established that the oil content of African pear (*D. edulis*) varies from species to species (Isaac and Ekpa, 2009).

The total unsaturated and saturated fatty acids in APO were observed to be 47.62 % and 52.38 % respectively. The most abundant unsaturated fatty acid present was oleic acid (42.45 %), while the least abundant unsaturated acid was linoleic acid (5.17 %). On the other hand, the most and the least abundant saturated fatty acids present were palmitic acid (44.31 %) and stearic acid (8.07 %) respectively (Table 1).

Table 1. *Fatty acid composition of African pear oil*[a]

Fatty acid	No. of carbon	Weight (%)
Palmitic acid	16	44.31
Stearic acid	18	8.07
Oleic acid	18	42.45
Linoleic acid	18	5.17

[a] Total unsaturated fatty acids = 47.62 %; total saturated fatty acids = 52.38 %

The amounts of unsaturated and saturated fatty acids as reported in the present work are close to those reported by Umoti and Okyi (1987) (48.75 % and 51.25 %). Nonetheless, the results of present work differ from those of Ikhuoria and Maliki (2007), who have reported 57.48 % of unsaturated and 24.57 % of saturated fatty acids in APO. The slight difference in the amounts of different fatty acids as shown in Table 1 may be due to different species of African pear (*D. e. var. edulis*) used in the studies, different environmental or geographical conditions and the maturity level of the fruit.

3.2. Physicochemical Properties of APO and PKO

The colour of APO obtained in this research by solvent extraction was green, while that of PKO was yellow. However, colour is a useful characteristic of oil and an important parameter commonly employed in quality grading of oils and their sales appeal (Payne, 1967), but it is not necessarily the major determinant of the potential end-use in industrial applications (Ekpa and Isaac, 2013). For example, in the preparation surface coating driers, the colour of the triglyceride oil posed little or no effect on the final product (metallic soap). Rather, the colour of the final product is determined by the oxidation state of the cation present in the metallic soap.

The specific gravity of APO (0.900) and PKO (0.919) (Table 2) were found to be comparable with those of known vegetable oils of commercial interest. Guner *et al.* (2006) gave the specific gravity of the following commercial oils as follows: sunflower oil (0.916-0.923), soybean oil (0.917 – 0.924), linseed oil (0.925-0.932). The specific gravity of rubber seed oil was observed to be 0.919 (Aigbodion and Pillai, 2001), while Okieimen and Aigbodion (1997) determined it as

0.926. Umoti and Okyi (1987) determined the specific gravity of APO as 0.900 which is the same as the value determined in this research.

Acid value (AV) and free fatty acid (FFA) of oil are used as an indicator for edibility of oil and suitability for use in the paint industry (Akubugwo *et al*., 2008). The AV of APO and PKO were observed to be 7.854 mgKOH/g and 21.123 mgKOH/g (Table 2) respectively. The high acid value in PKO could be an indication of possible deterioration of the oil and susceptibility to fungal degradation. Fungal attack is well known to cause modification in the chemical composition of fats and oils due to possible enzyme hydrolysis leading to increase in acidity (Ikhuoria and Maliki, 2007). This explains why the acid value of PKO purchased from the open market for used in this research as a precursor for synthesis of metallic soap has such high acid value. This high acid value may be attributed to fungal attack due to prolonged storage of the oil. The acid value of APO obtained in this research is less than the value (15.280 mgKOH/g) reported in the literature by Ikhuoria and Maliki (2007).

Saponification value is used in checking adulteration of the oil (Akubugwo *et al*., 2008). Generally, the saponification value of APO (227.205 mgKOH/g) and PKO (242.633 mgKOH/g) (Table 2) were relatively high. This high saponification value in the oil samples suggests that they are normal triglycerides. In addition, it is an indication that the fatty acids of the oils are of low molecular weight and less fatty acids in the chemical bound state. The saponification value of APO obtained in this research is higher than the value (201.400 mgKOH/g) reported in the literature (Umoti and Okyi, 1987), while that of PKO fall within the range of 242 – 255 mgKOH/g reported in the literature (Woollat, 1985).

One of the most dominant parameters affecting the fatty acid and oil properties is the degree of unsaturation. The iodine value gives an indication of the degree of unsaturation of the oils. Triglyceride oils are divided into three groups depending on their iodine values: drying, semi-drying and non-drying oils. The iodine value of a drying oil is higher than 130. This value is between 90 and 130 for semi-drying oils. If the iodine value is smaller than 90, oil is called non-drying oil (Guner *et al.*, 2006).

The level of unsaturation measured by iodine value is one of the most important properties of triglyceride oils that determine its industrial applications. The iodine value of African pear oil obtained in this study (45.050 gI_2/100g) (Table 2) shows a low level of unsaturation in African pear oil. Ikhuoria and Maliki (2007) determined the iodine value of African pear to be 44.079 gI_2/100g, while Umoti and Okyi (1987) determined it as 59.600 gI_2/100g. The iodine value obtained in this research collaborates with the percentage unsaturated fatty acid earlier determined as 47.62 %. On the other hand, the iodine value of PKO obtained in this study was very low (14.213 gI_2/100g) and fall within the range of 14 – 21 gI_2/100g reported in the literature (Woollat, 1985). This shows that the oil consists mainly of esters of saturated fatty acids. This could be one of the reasons, it tends to solidify or exist as fat at room temperature. The low iodine values of APO and PKO when compared with other oils like cocoa butter, coconut oil, and palm oil, means that the oil can be used as plasticizers and lubricants, hence, their application in this research as a precursor for the production of surface coating driers. The slight differences observed among the physicochemical parameters of the APO under investigation and the literature report may be due to different species of African pear (*D. e. var. edulis*) as well as level of maturity of African pear fruits used in this study or due to different environmental or geographical conditions.

3.3. Physicochemical Properties of African Pear and Palm Kernel Oils Driers

Another interesting area in this research is the use of African pear oil as a precursor for synthesis and evaluation of surface coating driers whose properties compare in its entire ramification with the standard octoate driers. This has not been reported elsewhere, and it is one of the contributions of this research to knowledge in the area of surface coating research. The mass of heavy metal soaps of PKO and APO are greater than the mass of sodium soaps of the two oils. The mass of heavy metal soaps of both oils also increases from calcium through cobalt to lead. This observation may be due to the difference in the masses of sodium soaps used in the preparation of the different metallic soaps. In addition, the atomic masses of the metals increase from calcium through cobalt to lead.

The difference in the metal percentages on standardization may be explained based on solubility of the metal soaps, as they have to be dissolved to a point of proper fluidity, and manufacturer's discretion to suit reproducible computational requirements such as similar to provisions given by standard drier manufacturers. However, this need for similarity is usually readily sacrificed when adequate solubility of the drier solid (100 % non – volatile) in mineral spirits is required, as reflected in the case of the lead drier (21 %) instead of between 55– 60 %(non –volatile) with the octoates and naphthenates. This implies that the non – volatile content can be adjusted to give the same metal percentages for all the drier types. The metal content in the 100 % precipitate obtained is different for the metals. This immediately is attributed to the difference in the molecular masses of the metals, which is the basis of the calculation of the metal percentage. The difference in specific gravity of the metallic soaps may be attributed to the molecular masses of the metals and the fatty acids present in APO and PKO. The specific gravity of PKO metallic soaps are greater than those of APO metallic soaps (Tables 3 and 4). This shows the influence of fatty acids on the specific gravity of the metallic soaps and it is believed that specific gravity increases with decrease in total fatty acids present in the oil. The total fatty acids in PKO were 216.168 g (Woollat, 1985) and that of APO was 280.142 g (Ikhuoria and Maliki, 2007). In this research, the total fatty acid of APO is 270.538 g. The specific gravity of the metallic soaps of PKO and APO follows the trend: lead soap greater than cobalt soap, greater than calcium soap as the molecular masses of the metals decreases.

The difference in the colour of the metal soaps may be due to the metal oxidation state, which for lead and cobalt, suggest the presence of unpaired electrons which may lead to electronic transitions due to selective absorption of electromagnetic radiation in the visible region. However, like most calcium compounds in the +2 state, a white is notice, which in the case of PKO and APO calcium soaps, which were white in colour (Table 3) is due to energetic absorptions as a result of a metal – anion charge transfer. The colour of APO cobalt soap, as well as PKO cobalt soap were purple and light purple respectively (Tables 3 and 4) signifying the existence of cobalt in the +2 state in both driers. On the other hand, the colour of lead soaps of PKO and APO were yellow.

The metal soaps of PKO and APO showed appreciable solubility in white spirit. This was attributed to the presence of the long hydrocarbon chains in the fatty acids of APO and PKO, which is invariably aliphatic as in white spirit.

The non – volatile percentage is discretionary, hence, the variations noticed is as well suits solubility requirements and reproducibility of results. The specific gravity results of PKO soaps compare favourably with those of the standard driers. The specific gravity of APO soaps also compares favourably with the standard driers. This suggests better complexing strength of the cobalt and calcium metals to the fatty acid anions. Lead soap also showed good complexing strength and good solubility thus, even when reduced to such a low non – volatile percentage (%) it gives an appreciably good specific gravity.

Table 2. *Some physicochemical properties of African Pear Oil*

Properties	Result		Literature	
	PKO	APO	[2]	[3]
Colour	Yellow	Green	-	-
Specific gravity (at 28^{0}C)	0.919	0.900	-	0.9
Acid value (mgKOH/g)	21.123	7.854	15.280	-
Free fatty acid (% oleic acid)	-	3.948	1.100	-
Free fatty acid (% lauric acid)	7.530	-	-	-
Saponification value (mgKOH/g)	242.633	227.205	143.76	201.400
Iodine value (gI_2/100g)	14.213	45.050	44.079	59.600

Table 3. *Weight of sodium soaps, heavy metal soaps and the properties of the metallic soaps of APO.*

Properties	Lead	Cobalt	Calcium
Alkali metal soap	**A**	**B**	**C**
Mass of alkali soap (g)	44.130	44.676	40.133
Mass of heavy metal soap (g)	77.184	71.452	46.942
Metal %	5.684	5.735	3.878
Non- volatile %	21.000	60.000	58.000
Specific gravity	1.085	1.0600	0.916
Colour (initial)	Yellow	Purple	White
Colour (final)	Yellow	Purple	White

3.4. Evaluation of Performance Characteristics of APO and PKO Driers in the Production of Surface Coatings

The driers manufactured from APO, PKO were used in the formulation of white gloss alkyd paints following the recipe in (Ekpa and Isaac, 2013), and the following physicochemical properties were evaluated: colour, solid content, specific gravity, adhesion, flexibility and durability using standard methods (Isaac and Ekpa, 2013).

It is observed from Table 5 that the colour of paint samples from PKO and APO driers compares favourably with the colour of paint sample prepared from standard driers. With the exception of adhesion of PKO drier- based paint sample to glass surface, all other properties of PKO and APO driers based paint samples compare favourably with the standard drier alkyd paint sample. The adhesion of PKO drier – based paint sample was improved on other surfaces like wood and plastered wall. That of APO drier was excellent on these surfaces.

The paint samples formulated from palm kernel oil and African pear oil driers were also examined in terms of the times of set – to – touch and dry – through. This is a very important consideration in coating formulation, as coated surfaces may need to dry so that they can be put into service immediately after the coating has been supplied. The set – to–touch time as well as dry – through time of the paint samples depends on the amount of sunlight, volume of air and temperature of drying. It would be assumed that the anions of the driers (palm kernel and African pear oils) are responsible for the differences in the drying schedule of paint samples observed in Table 6. The faster drying properties of paint samples with African pear oil driers may be attributed to elevated level of unsaturation in African pear oil compared to palm kernel oil, which is a lauric acid. This observation indicates that anion part of the drier also plays a vital role in the drying properties of the driers.

Pencil hardness test (scratch and gouge) of paint samples prepared from palm kernel oil and African pear oil driers was examined. Paint samples from APO driers give a harder film than paint sample from PKO driers (Table 7). This difference in hardness may again be due to the unsaturated nature of the oils, which in this case is greater in African pear oil than in palm kernel oil. This enhances auto – oxidation and cross linking leading to the formation of a tough film in African pear oil driers alkyd paint sample.

4. Conclusion

The iodine value of African pear oil shows that the oil is non-drying oil. The oil extracted from fruits of African pear plant has been successfully converted to surface coating driers. The driers thus obtained gave good drying performance when used in the formulation of alkyd gloss paints. In addition, the physicochemical and performance characteristics of African pear oil driers were better than those of palm kernel oil driers and closely comparable with the commercial driers samples. Fatty acid composition of oils also affects the specific gravity of metallic soaps obtained thereof

Table 4. *Weight of sodium soaps, heavy metal soaps and the properties of the metallic soaps of palm kernel oil (PKO).*

Properties	**Lead**	**Cobalt**	**Calcium**
Alkali metal soap	**D**	**E**	**F**
Mass of alkali soap (g)	43.130	45.113	37.076
Mass of heavy metal soap (g)	73.938	65.947	39.237
Metal %	6.825	7.234	4.933
Non- volatile %	21.000	60.000	58.000
Specific gravity	1.031	1.011	0.911
Colour (initial)	Yellow	Purple	White
Colour (final)	Yellow	Light purple	White

Table 5. *Performance properties of paint samples formulated from PKO and APO driers.*

Quality tests	**PKO drier based paints**	**APO drier based paints**	**Octoate drier based paints**
Colour	Brilliant white	Brilliant white	Brilliant white
Specific gravity	1.17	1.15	1.14
Solid content(%)	63.70	64.43	65.01
Adhesion	Good	Excellent	Excellent
Flexibility	Excellent	Excellent	Excellent
Durability	Good	Excellent	Excellent

Table 6. *Outdoor and indoor drying schedule of paint samples formulated from PKO and APO driers.*

Paint sample	**Indoor drying schedule**		**Outdoor drying schedule**	
	Set-to-touch time (min)	**Dry-through time (min)**	**Set-to-touch time (min)**	**Dry-through time (min)**
Palm kernel oil drier based alkyd paint	15	480	13	440
African pear oil drier based alkyd paint	12	420	09	370
Standard alkyd paint (SAP)	10	420	06	360

Table 7. *Hardness tests of paint samples prepared from PKO and APO driers.*

Paint sample	**Pencil hardness**	
	Scratch	**Gouge**
Palm kernel oil drier based alkyd paint	4H	5H
African pear oil drier based alkyd paint	5H	6H
Standard alkyd paint	5H	6H

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References

Aigbodion, A. I., Pillai, C. K., 2001. Synthesis and molecular weight characterization of rubber seed oil-modified alkyd resins. J. Appl. Polym. Sci. 79, 2431 – 2438.

Akubugwo, I. E., Chinyere, G. C., Ugbogu, A. E., 2008. Comparative studies on oils from some common plat seeds in Nigeria. Pakistan J. Nutrition. 7(4), 570-573.

Arisa, N. U., Lazarus, A., 2008. Production and refining of Dacryodes edulis "native pear" seeds oil. African J. Biotech. 7 (9), 1344-1346.

Ekpa, O. D., 1996. The use of metallic soaps from palm and kernel oils in the formulation of soybean oil-based paints. West African J. Bio. Appl. Chem. 41, 28-33.

Ekpa, O. D., 2008. Entrepreneurial chemistry: A chemist's approach to wealth creation in a depressed economy. 43rd Inaugural lecture, university of Calabar. Pp. 60.

Ekpa, O. D., Isaac, I. O., 2008. The use of metallic soaps from cottonseed oil and soybean oil-based alkyd resins in paint production. New Era Res. J. Engr., Sci. Tech. 1(3&4), 1-14.

Ekpa, O. D., Isaac, I. O., 2013. Fatty acid composition of melon (Colocynthis vulgaris Shrad) seed oil and its application in synthesis and evaluation of alkyd resins. IOSR J. Appl. Chem. 4(4), 30-41.

Guner, F. S., Yusuf, Y., Erciyes, A. T., 2006. Polymers from triglyceride oils. Prog. Org. Coat. 31, 633 – 670.

Hein, W. R., 1998. Driers for water-borne coatings. J. Coat. Tech. 70 (886), 19-22.

Ikhuoria, E. U., Maliki, M., 2007. Characterization of avocado pear (Persea americana) and Africa pear (Dacryodes edulis) extracts. African J. Biotech. 7, 950-954.

Isaac, I. O., Ekpa, O. D., 2009. Minerals and anti-nutrients in two varieties of African pear (Dacryodes edulis). J. Food Tech. 7(4), 106 – 110.

Isaac, I. O., Ekpa, O. D., 2013. Fatty acid composition of cottonseed oil and its application in production and evaluation of biopolymers. American J. Polym. Sci. 3(2), 13-22.

Martinson, C. R., Sisler, C. W., 1987. Concise encyclopaedia of science and technology. 2nd edition. McGraw-Hill Inc. pp. 531.

Odetoye, T. E., Ogunniyi, D. S., Olatunji, G. A., 2010. Preparation and evaluation of Jatropha curcas Linneaus seed oil alkyd resins. Ind. Crops & Products. 32, 225 – 230.

Ogunniyi, D. S., Odetoye, T. E., 2008. Preparation and evaluation of tobacco seed oil-modified alkyd resins. Bioresource & Tech. 99,1300 – 1304.

Okieimen, F. E., Aigbodion, A. I., 1997. Studies in molecular weight determination of rubber seed oil alkyds. Ind. Crops & Products. 6, 155 – 161.

Payne, H. F., 1967. Organic coating technology. Vol. II. John Wiley & Sons Inc., New York. Pp. 678.

Umoti, U., Okyi, D. A., 1987. Characteristics and composition of oil and cake of African pear. J. Sci., Food Agr. 38, 67 – 72.

Woollatt, E., 1985. The manufacture of soaps, other detergents and glycerine. John Wiley & Sons, New York. Pp. 473.