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A Comparative Analysis Of Activated Carbons From African Teak (Iroko) Wood And Coconut Shell In Palm Oil Bleaching

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Abstract — This study compares the effectiveness of activated carbons from the African Teak/Iroko wood (Milicia excelsia) and coconut shell as adsorbents in Crude Palm Oil (CPO) bleaching. This was done in order to source for local agro-waste substitutes for the imported Fuller's earth. The materials were activated using analytical grade $CaCl_2$ in 25% solution at a temperature of 109^{O}C in a laboratory hot air oven. The obtained activated carbon samples were subjected to proximate analysis to ascertain their percentage ash, moisture, volatile matter and fixed carbon contents. The CPO to be analysed was degummed, neutralized and further bleached using 2g, 4g, 6g, 8g, 10g, 12g and 14g of the adsorbent samples at a temperature of 130^{O}C after which the obtained oils were analysed and results plotted. It was observed that the bleached oil samples generally had reduced specific gravity, opacity, color, and free fatty acid (FFA) compared to the CPO. It was also observed that the opacity, color, and FFA reduced as the adsorbent dosage increased. Conversely, the percentage color reduction and the percentage FFA reduction increased with adsorbent dosage. Overall, the oil samples bleached with activated carbon from the African Teak/Iroko wood exhibited more desirable properties than the ones bleached with the coconut shell activated carbon.

Keywords — Palm oil; activated carbon; bleaching; Free Fatty Acids; coconut shell.

I. INTRODUCTION

Palm oil is a vegetable oil extracted from the mesocarp of the fruits of the Oil Palm tree (*Elaeis guineensis*) [1]. It is very important because it finds application in the food, energy, biofuels, cosmetics and general manufacturing industries [2]. Palm oil is one of the cheapest and most abundant vegetable oil in the world [3]. Palm oil is different from Palm kernel oil (PKO), in that Palm kernel oil (PKO) is gotten from the kernels of the oil Palm fruit. The tree from which both oils are obtained, the Oil Palm tree (*Elaeis guineensis*), is currently grown in over 11 million hectares of land worldwide [2]. Due to its abundance in nature, it can meet the demand for vegetable oils in the world market.

Over the years, there has been a rapid growth in the palm oil industry due to the extensive use of processed palm oil in many countries in the world. Indonesia alone produced 43 million tons of crude palm oil (CPO) in 2019 [4]. In Malaysia, the oil palm industry contributes 5 – 7% of the country's gross domestic product (GDP) [5]. Both countries are the largest producers of palm oil accounting for 85% of the total palm oil production in the word [1]. Palm oil is also produced in large quantities in other parts of the world. Nigeria is one country where palm oil is consumed in large volumes because of its importance in the preparation of traditional dishes. The Crude Palm Oil (CPO) is used in Nigeria for the cooking of soups, stews, African salad and also in frying [6].

The range of application of CPO is limited as a result of its color coupled with the high level of Free Fatty Acids (FFA), metal ions, gums, triglycerides, impurities, and other unsuitable properties it contains [3]. Components such as tocoprenols, tocopherols, carotenes, sterols, phospholipids, phytosterols, and metals account for about 1% of CPO [9]. The reddish color is due to color pigments (carotenoids) in addition to tocoprenols, tocopherols, and sterols, while the high fat content is due to triglycerides,

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diglycerides and fatty acids it has [7]. This led to the need to refine CPO to make it clearer in color and reduce its fat content which in turn would increase its area of application and acceptance by consumers [3].

Industrially, CPO undergoes refining to convert the dark-red oil to a light-colored product. This good grade oil can be used in a wide range of areas such as in the production of margarine, shortenings, soaps, biscuits, amongst other products. Refining of CPO includes the 4 major processes of degumming, neutralization, deodorization and bleaching [8]. Bleaching is the most important process in the refining of CPO because it determines its final quality [9]. It is in this process that the pigments responsible for CPO coloration are removed [10]. However, it has to be monitored to make sure the final product to be obtained at the end of the process is of good grade [4].

Adsorptive bleaching turned out to be most preferred over convectional heat treatment and chemical bleaching because it is cheaper and causes less harm to the environment [11]. Crude Palm Oil can be refined using adsorbents (such as clay, charcoal, carbon, etc) that have been activated either thermally or by the use of acid activating agents [12]. Adsorbents are usually solid materials produced to have highly porous structures to create larger internal surfaces which would allow effective percolation of diffusing molecules in the fluid phase [13]. Activation has been shown to improve the adsorptive ability of adsorbents [14]. With the aid of adsorbents, color pigments that have been dissociated alongside other impurities would be removed from the oil without tampering with the essential chemical contents, leaving a refined oil that is fit for usage or storage [12].

The current adsorbent used in industrial bleaching of CPO in Nigeria is the imported bentonite clay (Fuller's earth) [15]. This adsorbent has some attendant health, environmental, and economic problems. Acid-treated Fuller's earth release fumes that can harm workers and equipment involved in the refining process [8]. A little dose of the acids may pass into the oil and cause liver and stomach disorders when consumed. Also, spent Fuller's earth causes environmental pollution if not properly taken care of [3]. The imported bentonite clay is expensive and requires extra cost for environmental neutralization after use [16]. These add to the overall cost of production which increases the price of the finished product.

The above situation led to the search for a suitable local substituent for the imported bentonite clay (Fuller's earth) amongst researchers in Nigeria [15]. There clamour for the use of locally-sourced agro-waste is on the rise owing to their availability and carbon content [16]. Salawudeen et al. [17] studied the impact of inorganic-acid treated local clays in CPO bleaching. It was discovered that hydrochloric acid (HCl) performed better than sulphuric acid (H2SO4) in bleaching. Their research also showed that bleaching capacity increased with increase in acid concentration. Nnam et al. [9] also investigated the bleaching efficiency of acid-activated Kaolin clay from Ebonyi State, Nigeria. The authors discovered that bleaching efficiency increased with increasing acid concentration, contact time, temperature, and adsorbent dosage. These substitutes, being clays, are non-renewable and still had potentials to cause environmental degradation [18].

However, Ogbuagu & Ikpeama [19] compared the bleaching powers of Fuller's earth, Kaolin, charcoal and activated carbon. Their study showed that all the adsorbents used reduced the free fatty acid (FFA), peroxide value (PV), content, and unsaponifiable matter content. The researchers also discovered that Fuller's earth performed better than the rest in color reduction but activated carbon performed best in the removal of xanthophylls (Y-Band) from the CPO sample. Sriatun et al. [20] also investigated the ability of activated carbon from teak wood in CPO bleaching and discovered them to be effective but dependent on activator type. Alhassan et al. [7] used activated rice husk ash to bleach CPO and found it to be effective in the bleaching process and for chromophore deactivation. These show that activated carbon can be used in palm oil bleaching and it can be sourced from local and cheap materials in Nigeria which are even considered as wastes in some quarters.

In this research, the effect of activated carbon from two sources, African Teak/Iroko wood (Milicia excelsia) and coconut shell, in CPO bleaching was studied. The results obtained herein will be analyzed with the aim of developing a ready and suitable substitute for bentonite clay in CPO bleaching.

II. MATERIALS AND METHODS

2.1 Materials Used

The CPO, African Teak/Iroko wood, and coconut shells used in this study were obtained from Nkwoala market in Eziama, Ngor-Okpala Local government area of Imo state, Nigeria. Other reagents such as $CaCl_2$ (Calcium Chloride), food grade Phosphoric acid (H_3PO_4), Phenolphthalein, Sodium Hydroxide (NaOH), Ethanol (C_2H_5OH), and Distilled Water were purchased from De Blessed Chemical store in Aba, Nigeria.

2.2 Material Preparation

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2.2.1 Preparation of Activating Agent

The activating agent used in the course of this work is 25 wt% (weight percentage) solution of 1.5M $CaCl_2$ (Calcium Chloride). It was chosen because of it was readily available and also safe. 2.5 liters of aqueous $CaCl_2$ (Calcium Chloride) was mixed with 7.5 liters of water making it 3 parts of water to 1 part of $CaCl_2$.

2.2.2 Preparation of Adsorbents

The African Teak (Iroko) wood was made into a charcoal by burning in open air for 3 hours. The wood charcoal was crushed to very fine sizes and sun-dried for a day. The fine-crushed wood charcoal was soaked in the activating agent for 30 minutes to form a paste which was then spread and allowed to dry for another 30 minutes. Then it was rinsed with clean water and allowed to dry again. The dried paste was then charged into the laboratory hot air oven to bake for 30 minutes at $109^{O}C$. The obtained activated carbon was stored in a plastic container for analyses.

Coconuts, gotten from the same location, were de-husked, and de-shelled to obtain the required material needed. The shells were then dried in the sun for one week for them to completely dry. Then they were cleaned to remove all fibers and dirt. The coconut shells were put into the muffle furnace to burn at a temperature of $316^{O}C$ for 3 hours. The coconut shells were then removed from the furnace and placed in a beaker containing 25wt% solution of $CaCl_2$ for 24 hours in a controlled atmosphere for better mixing after which the coconut shell charcoal was rinsed with water and allowed to drain for an hour in a tray. The coconut shell coals were then put into the laboratory hot air oven to bake for 3 hours at $109^{O}C$. After baking, the output is activated carbon that was then crushed and pulverized until they have gotten to the desired consistency after which they were kept in plastic containers and made ready for analysis.

2.2.3 Degumming and neutralization of the CPO

The Palm oil to be refined was degummed by the process described by Uzoh et al. [12]. 1 kg of the CPO was initially heated up to a temperature of $100^{o}C$ before treatment with a food grade phosphoric acid of about 0.1 % of oil weight (i.e, 1g) with acid concentration approximately 85%. Neutralization of the degummed oil followed suit by adding 150g of 2M NaOH. The mixture was subsequently stirred and heated to $75^{O}C$ for a period of 20 minutes so as.to break down the formed emulsions that will result. Two layers were formed after centrifuging, oil and soap. The soap stock was then filtered off and the bleached and neutralized oil kept for bleaching.

2.3 Proximate Analysis of the Activated Carbon samples from the two sources

2.3.1 Percentage Ash Content

10g of the activated carbon samples was taken in a crucible and its weight recorded. This is after the weight of the empty crucible must have been determined. The samples were then heated in a muffle furnace to $750^{O}C$ for 1.5hrs. The crucible was kept open during the heating process. After heating, the crucible was cooled in the desiccator and its weight measured again and recorded.

$$Percentage\ ash\ content = \frac{w_3 - w_1}{w_2 - w_1} x100 \quad (1)$$

Where: w_1 = weight of empty crucible (g); w_2 = weight of empty crucible and 10g of sample (g); w_3 = weight of crucible and sample after drying (g).

2.3.2 Percentage Moisture Content

The weight of an empty petri-dish was first determined. 5g each of the adsorbent samples was introduced and the weight was recorded. This sample was heated for 1.5 hours at a temperature of $110^{O}C$ in the laboratory hot air oven. After the required drying,

the sample was left to cool in a desiccator for 5 minutes and weighed again.

$$Percentage\ moisture\ content = \frac{w_6 - w_4}{w_5 - w_4} x100 \quad (2)$$

Where: w_4 = weight of empty petri-dish (g); w_5 = weight of empty petri-dish and 5g of adsorbent (g); w_6 = weight of petri-dish and sample after drying (g).

2.3.3 Percentage Volatile Matter

An empty crucible was weighed and recorded. 10g of the activated carbon sample was placed in it and weighed again. The filled crucible was placed in a furnace at a temperature of 950^{O}C for 7 minutes. The crucible was then taken out of the furnace and weighed to obtain the oven dry weight.

$$Percentage\ Volatile\ matter\ = \frac{w_9 - w_7}{w_8 - w_7} \quad (3)$$

Where: w_7 = weight of empty crucible (g); w_8 = weight of empty crucible and 10g of activated carbon sample (g); w_9 = weight of empty crucible and dried sample (i.e oven dry weight) (g).

2.3.4 Percentage Fixed Carbon

The percentage fixed carbon was evaluated by subtracting the percentage ash, moisture, and volatile content from 100 as shown in (4) below:

$$Percentage\ Fixed\ carbon = 100 - PAC - PMC - PVM \quad (4)$$

Where: PAC = percentage ash content; PMC = percentage moisture content; PVM = percentage volatile matter.

2.4 Bleaching of the degummed and neutralized oil using the activated carbon samples

The bleaching of the degummed and neutralized oil was done by the process described by Mustapha et al. [15]. 250 ml of the degummed and neutralized oil was poured into a beaker and 2g of the Iroko wood (*Milicia excelsia*) activated carbon that had passed through a sieve of mesh size 40µm was added. The mixture was heated to a temperature of 130^{o}C with constant stirring for 30 minutes. The process was repeated for 6 more doses of the adsorbent – 4g, 6g, 8g, 10g, 12g, and 14g.

The same procedure was followed in bleaching the degummed and neutralized oil using the coconut shell activated carbon.

2.5 Characterization of the bleached palm oil

2.5.1 Specific Gravity

A clean and dry relative density bottle with known weight was filled with distilled water, gently cleaned with a cotton wool and weighed again. The bottle was emptied and dried in an oven. After cooling, the bottle was filled with the bleached oil and weighed. The specific gravity was then calculated as:

$$S.G = \frac{\text{Weight of Oil } (w_{12} - w_{10})}{\text{Weight of water } (w_{11} - w_{10})} \quad (5)$$

Where: w_{10} = weight of empty relative density bottle (g); w_{11} = weight of relative density bottle and distilled water (g); w_{12} = weight of relative density bottle and bleached oil sample (g).

2.5.2 Percentage Color Reduction

The determination of the percentage color reduction of the bleached Palm Oil was carried out by the process described by Kamalu et al. [11]. Firstly, the crude palm oil was analysed in a spectrophotometer at a wavelength of 400nm to obtain the Transmittance. This transmittance was inverted to obtain the Opacity of the CPO. The bleached oil at the end of each experimental run was then observed in the spectrophotometer at the same wavelength of 400nm to obtain the Transmittance of the oil. The transmittance was inverted to obtain the Opacity of each bleached oil sample. The percentage color reduction was then obtained by the equation:

$$\text{Percentage Color reduction} = \frac{Q_0 - Q_i}{Q_0} \times 100 \quad (6)$$

Where: Q_O = opacity of CPO; Q_i = opacity of bleached palm oil.

2.5.3 Free Fatty Acid (FFA) Content

The weight of the conical flask was zeroed and 10g of the oil sample was taken. 50 mL of ethanol was poured into a beaker and three (3) drops of the indicator (phenolphthalein) was added. The degummed, neutralized and bleached oil was transferred into a conical flask bearing the sample and titrated with 0.1 M NaOH until a pale pink color did not disappear for 30 seconds. The acid value is obtained using (6) while the FFA content was determined from (7).

$$\text{Acid value} = \frac{V \times M \times g}{W}. \quad (7)$$

$$FFA = \frac{Acid\ Value}{2}. \quad (8)$$

Where: V = titre value of 0.1 M NaOH (mL); M = molarity of NaOH (i.e 0.1 mol/dm^3); g = Molecular weight of fatty acid (56.1 g/mol); W = weight of oil sample (i.e 10g); FFA = free fatty acid content (mg NaOH/g).

2.5.4 Percentage Free Fatty Acid Reduction

To obtain the percentage of free fatty acid reduced (% FFA Reduction), the free fatty acid value of the oil sample was subtracted from the free fatty acid value of the CPO divided by the free fatty acid of the Crude Palm Oil. This is to ascertain if there was actually a reduction in the amount of free fatty acid. Mathematically, this is given as:

$$\%\ \text{FFA Reduction} = \frac{f_O - f_i}{f_O} \times 100 \quad (9)$$

Where: f_O = FFA content of CPO (mg NaOH/g); f_i = FFA of bleached oil samples (mg NaOH/g).

III. RESULTS AND DISCUSSION

3.1 Results

The results from the proximate analyses and characterization of the activated carbon samples from *Milicia excelsa* (Iroko) wood and coconut shell are presented in Table 1 below.

TABLE I: Proximate Analysis of Activated carbon samples

Parameter	Iroko Wood Activated Carbon	Coconut Shell Activated Carbon
Percentage Ash content	5.42%	2.89%
Percentage Moisture content	7.32%	4.75%
Percentage Volatile matter	18.01%	13.45%
Percentage Fixed Carbon	69.25%	78.91%

Table 2 shows the results obtained from the characterization of CPO before degumming, neutralization, and bleaching.

TABLE II: Characterization of the CPO before bleaching

Parameter	Value
Specific gravity	0.9453
Transmittance	79.36
Opacity	0.0126
Free Fatty Acid content (FFA) (mg NaOH/g)	5.55

After successfully bleaching the Crude palm oil (CPO) with varying adsorbent doses from 2g – 14g, the obtained results from analyses were also tabulated.

TABLE III: Specific gravity of the oil samples bleached using Activated carbon samples

Activated carbon dose (g)	Specific gravity of bleached oil	
	Oil bleached with Iroko wood activated carbon	**Oil bleached with coconut shell activated carbon**
2	0.9151	0.9376
4	0.9120	0.9506
6	0.9113	0.9806
8	0.9287	0.9285
10	0.9000	0.9253
12	0.8956	0.9153
14	0.8899	0.9136

TABLE IV: Transmittance of the oil samples bleached using the activated carbon samples

Activated carbon dose (g)	Transmittance of bleached oil samples	
	Oil bleached with Iroko wood activated carbon	**Oil bleached with coconut shell activated carbon**
2	142.1	92.1
4	144.2	103.4
6	150.1	109.8
8	162.5	109.1
10	159.9	119.3
12	180.2	126.7
14	188.0	133.7

TABLE V: Opacity of the oil samples bleached using Activated carbon samples

Activated carbon dose (g)	Opacity of bleached oil samples	
	Oil bleached with Iroko wood activated carbon	**Oil bleached with coconut shell activated carbon**
2	0.0070	0.0108
4	0.0069	0.0097
6	0.0067	0.0091

8	0.0062	0.0092
10	0.0063	0.0084
12	0.0055	0.0079
14	0.0053	0.0075

TABLE VI: Percentage Color Reduction of the oil samples bleached using Activated carbon samples

Activated carbon dose (g)	Percentage Color reduction (%)	
	Oil bleached with Iroko wood activated carbon	**Oil bleached with coconut shell activated carbon**
2	44.44	14.29
4	45.24	23.02
6	46.83	27.78
8	50.79	26.98
10	50.00	33.33
12	56.35	37.30
14	57.94	40.48

TABLE VII: Free Fatty Acid (FFA) content of the oil samples bleached using Activated carbon samples

Activated carbon dose (g)	Free fatty acid (FFA) (mg NaOH/g)	
	Oil bleached with Iroko wood activated carbon	**Oil bleached with coconut shell activated carbon**
2	5.53	5.44
4	5.46	5.42
6	3.47	4.25
8	3.73	4.16
10	2.56	3.89
12	2.44	2.56
14	1.21	1.87

TABLE IX: Percentage FFA reduction of the oil bleached using Activated carbon samples

Activated carbon dose (g)	% Free fatty acid (FFA) Reduction	
	Oil bleached with Iroko wood activated carbon	**Oil bleached with coconut shell activated carbon**
2	0.36	1.98
4	1.62	2.34
6	34.78	23.42
8	32.79	25.04
10	53.87	29.91
12	75.68	53.87
14	78.20	66.31

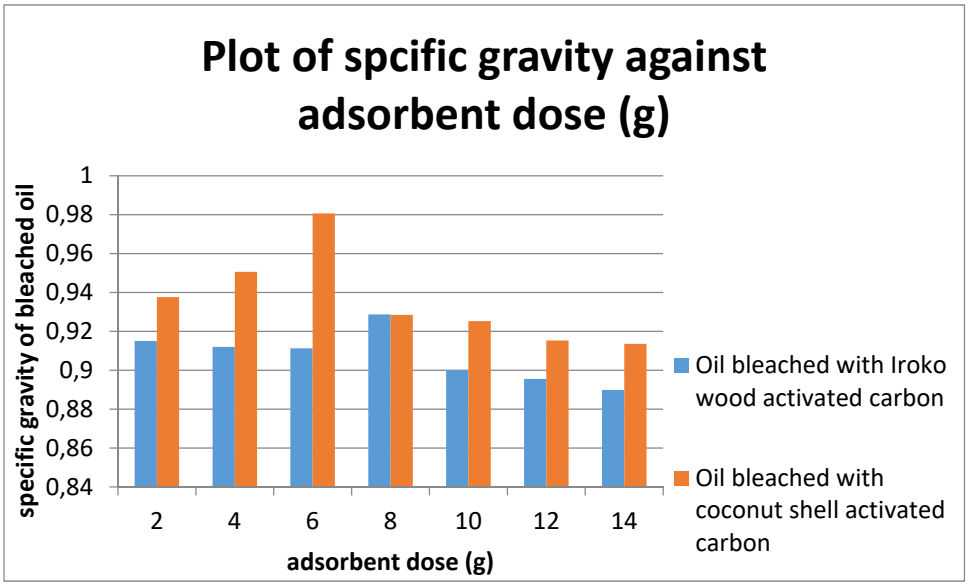

Fig. 1: Plot of Specific gravity against adsorbent dose (g)

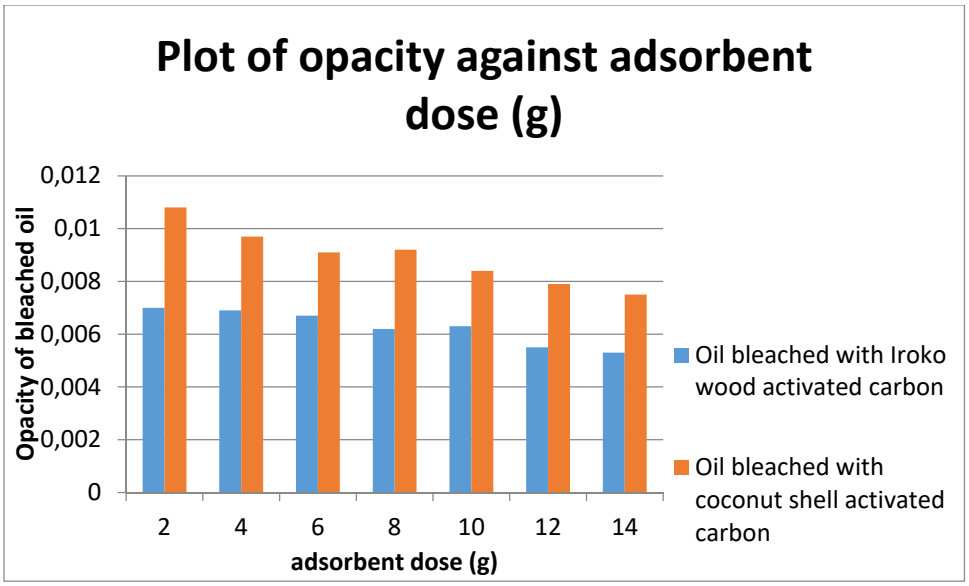

Fig. 2: Plot of Opacity against adsorbent dose (g)

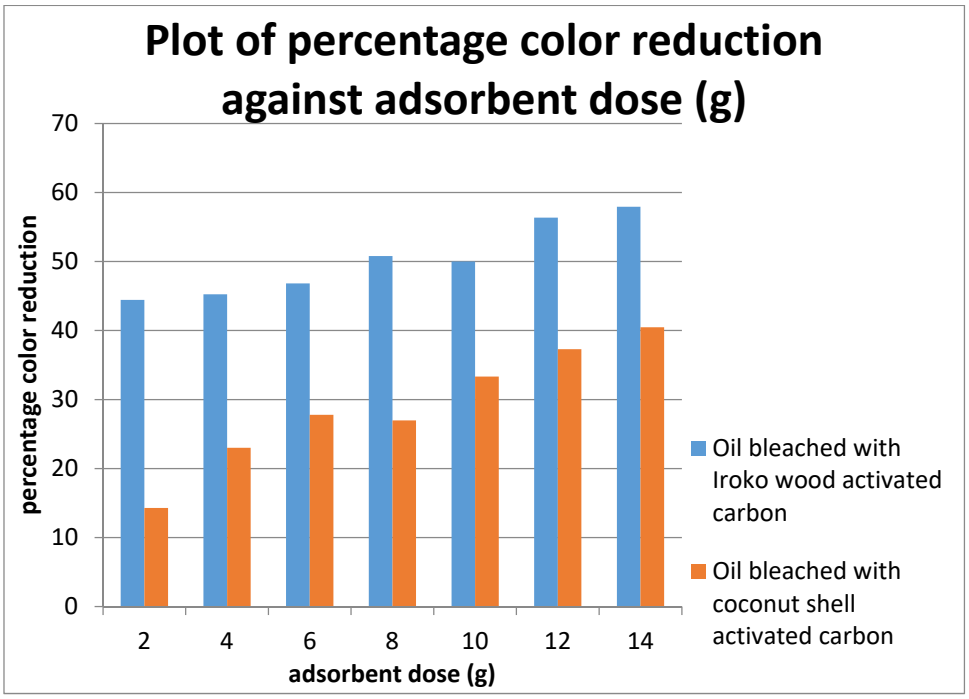

Fig. 3: Plot of Percentage color reduction against adsorbent dose (g)

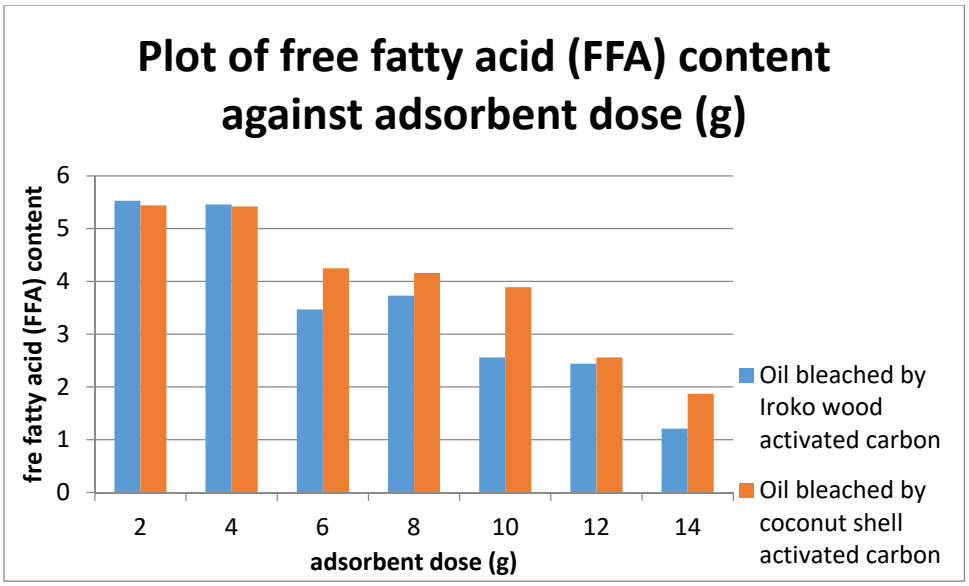

Fig. 4: Plot of Free Fatty Acid (FFA) content against adsorbent dose (g)

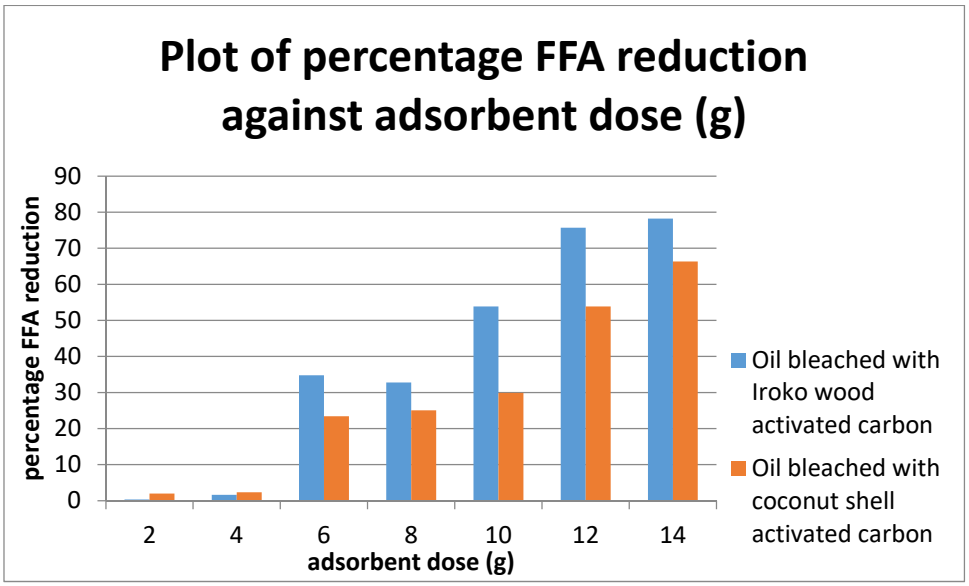

Fig. 5: Plot of Percentage Free Fatty Acid (FFA) reduction against adsorbent dose (g)

3.2 Discussion

3.2.1 Proximate Analysis of the activated carbon samples

From the proximate analysis done on the activated carbon samples from African Teak/Iroko wood and coconut shell (as presented in Table 1), it was observed that the activated carbon from the Iroko wood had higher ash and volatile matter contents (5.42% and 18.01% respectively), and lower amounts of moisture and fixed carbon contents (7.32% and 69.25% respectively). Conversely, the activated carbon obtained from the coconut shell had lower ash and volatile matter contents (2.89% and 13.45% respectively) and higher moisture and fixed carbon contents (4.75% and 78.91%).

Ash is the part of a material that is non-carbon or that consist of other mineral additives which may be undesirable as they increase in concentration during the activation process [14]. High amount of ash in adsorbents is undesirable since it may interfere in the adsorptive capacity of the adsorbent [13]. Also, higher amounts of moisture content and fixed carbon contents are desired in

adsorbents [20]. Since the activated carbon obtained from both sources are low in ash contents and high in moisture and fixed carbon contents, it is therefore expected that they perform well in the CPO bleaching process.

3.2.2 Effect of adsorbent type and dosage on the specific gravities of bleached oil samples

The values for the specific gravity of the oil samples bleached with varying amounts of adsorbents are tabulated in Table 3. From this table, we observe that the specific gravity for each oil sample was lower than that of CPO which is 0.9453 (as shown in Table 2). The obtained specific gravities are in-line with the normal specific gravity of quality vegetable oil which is between 0.85 – 0.95.

From the plot in Figure 1, the oils bleached with the Iroko wood activated carbon had lesser specific gravity than the ones bleached with the coconut shell activated carbon. Their specific gravity decreased steadily as the adsorbent dosage increased, except for a slight increase when 8g of sample was used. One the other hand, the specific gravity of the oils bleached with the coconut shell activated carbon increased as the adsorbent dosage increased from 2g – 6g and started decreasing progressively.

Generally, scenarios show that the activated carbons have adsorbed some fats off the oils as their specific gravities were below that of CPO. Specific gravity is an indication of the weight of a material and in oils, is an indication of the heaviness or amount of soluble fats enmeshed in them [6]. Thus the oils bleached with the Iroko wood (*Milicia excelsa*) activated carbon supposedly has less soluble fats than that of the bleached with the coconut shell activated carbon.

3.2.3 Effect of adsorbent type and dosage on the opacities of the bleached oil samples

Opacity is the reciprocal of transmittance. It is an indication of the resistance to the flow of light offered by oils while transmittance is the degree to which oils allow light to pass through them [11]. Opacity analysis can be used to determine the amount of color (carotenes and other pigments induced) removed from the oil sample [15].

The transmittances of the bleached oil are presented in Table 4. The results were inverted to get their opacities as presented in Table 5. From the table, it was observed that the opacity decreased progressively as the adsorbent dosage increased from 2g – 14g and they were all lesser to the opacity of the CPO which was obtained as 0.0126 (as shown in Table 2). This indicates that CPOs, which initially had lesser ability to allow the free flow of light due to their carotene, carotenoids, xanthophyll contents, can be turned into clean and clear oils by activated carbon adsorption.

From the plot in figure 2, we observe that the opacity of the oil bleached with the Iroko wood (*Milicia excelsa*) activated carbon is lesser than that bleached with the coconut shell activated carbon. This means that the oils bleached with the Iroko wood activated carbon can transmit more light than those bleached with the coconut shell activated carbon.

3.2.4 Effect of adsorbent type and dosage on percentage color reduction

From Table 6, we observe that the oil samples bleached with both types of activated carbons reduced in colors when compared to the CPO. The reduction in color generally increased as the activated carbon dosage increases showing that an increase in the activated carbon dosage increases the percentage color reduction.

From the plot in figure 3, the plot for the percentage color reduction for the oil bleached with the wood activated carbon increased more in color reduction compared to what was observed for the oil bleached with coconut shell activated carbon. This shows that Iroko wood activated carbons have more power to remove the carotene and color pigments from the oil than coconut shell activated carbons.

3.2.5 Effect of adsorbent type and dosage on FFA content

The FFA content of the crude palm oil was obtained as 5.55 mg NaOH/g and according to the results in Table 7, the value reduced progressively as the amount of the activated carbon increases from 2g – 14g. This is an indication of the effectiveness of activated carbons in the bleaching of crude palm oil. It also proofs that larger adsorbent doses have more active sites which can go into adsorption in line with the observation of Lieimkuehler [14].

From the plot of figure 4, oil bleached with coconut shell activated carbon had more fatty acid content than the oils bleached with the Iroko wood activated carbon. Thus the oils bleached with the coconut shell activated carbons retained more fat than those bleached with the wood activated carbon.

3.2.6 Effect of adsorbent type and dosage on percentage FFA reduction

There were reductions in the free fatty acid contents of the oils as can be seen from table 8, this is linked with the free fatty acid content of the oil and once again proves that the activated carbons have the power to remove some measure of the fats from CPO samples.

However, from the plot in figure 5, the oils bleached with the wood activated carbon achieved more percentage reduction, 20% higher, than that bleached with the coconut shell activated carbon. Thus, we can say that the wood activated carbon has higher free fatty acid (FFA) removal capacity than the coconut shell activated carbon.

IV. CONCLUSIONS

Activated carbon was produced from two sources: African Teak/Iroko (*Milicia excelsa*) wood and coconut shell and used to bleach crude palm oil (CPO). Proximate analysis of the samples showed they have excellent adsorptive properties which became evident in the bleaching process. However, the one from coconut shell has more fixed carbon content, more moisture content and less ash content. Crude oil samples bleached with the Iroko wood activated carbon had more desirable properties than the ones bleached with the coconut shell activated carbon. This shows that activated carbon from the two sources (most especially the African Teak/Iroko) can be worked on to develop a ready material to use in palm oil industry in Nigeria. It was also observed that these desirable qualities increased as the adsorbent dosage increased. In further studies, one should investigate the effect of activating agent, bleaching time, and temperature in the use of these adsorbent in CPO bleaching.

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