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Caustic Activation of Local Clays for Palm Oil Bleaching

C.A. Okwara and E.C. Osoka
Department of Chemical Engineering, Federal University of Technology,
P.M.B. 1526, Owerri, Imo State, Nigeria

Abstract: Local clay samples were obtained and activated for use in palm oil bleaching. The clay samples: Kaolin (from Mbano in Imo State), Bentonite (from Ohaozara in Ebonyi State) and Fuller's earth (from Bauchi in Bauchi State) were activated at 80-85°C for 35 to 40 min, using caustic soda (NaOH) at concentrations of 1M, 2M, 3M and 4M, respectively. The alkali-activated clays were then tested on palm oil of 7.68% FFA, 0.9 moisture and volatile content and 67.95 colour. The bleaching was done at about 150°C within 20 min and a Lovibond (two cell) tintometer was used to measure the extent of bleaching in terms of percentage colour reduction. The percentage colour reduction of the bleached palm oil was modelled against alkali concentration used in clay activation for the three samples. The results obtained reveal that, within the range of the experimental data, the percentage colour reduction for Kaolin and Fuller's earth can be adequately modelled using a third order polynomial with correlation coefficients of unity respectively, while that of Bentonite can be modelled using a logarithmic function with a correlation coefficient of 0.9866. Based on the models, Kaolin and Fuller's earth gave the best results when activated with 3M and 2.9M NaOH solutions respectively-giving percentage colour reductions of 76.38 and 80.69% respectively-while optimum performance for Bentonite was after activation with 1M NaOH solution, which gave 78.66% colour reduction.

Key words: Adsorption, alkali, bleaching, kaolin, bentonite, palm oil, fuller's earth

INTRODUCTION

Oils in their raw form contain impurities such as, organic pigments, oxidation metals, trace metals and traces of soaps. For oils to be used effectively, in most industrial processes, these impurities in them have to be extensively removed. The refining of these oils, especially palm oil, through adsorptive bleaching, remains inevitable in the oil refining industry[1,2].

Bleaching is designed solely to remove pigments like carotenoids, oxidation products, trace metals and trace soaps from the oil. Adsorptive bleaching is the most efficient form of bleaching in which various adsorbents like carbon, silica gel, activated alumina and activated clays are used. The amount of adsorbent required for any given bleaching operation will depend on the nature and activity of the adsorbent, the variety of oil and the colour of the oil to be used[3,1].

Adsorption occurs when molecules diffusing in the fluid phase are held for a period of time by forces emanating from an adjacent surface[4]. Physical adsorption is achieved as a result of intermolecular forces of attraction between molecules of solid and the substances adsorbed. It is readily reversible and it is a result of vander waal forces[5].

Adsorptive bleaching using activated clay is based on the ability of these clays to preferentially concentrate specific substances (impurities) from solutions unto their surfaces, after activation treatment has been done on the clay material[4]. Bleaching earth (clay) can be defined as a decolourising agent that will change the tint of any coloured oil to a lighter shade by changing the basic colour units in the oil, without altering the chemical properties of the oil www.fullersearth.com,[6].

The widely used bleaching earth is the Fuller's earth which is imported into the country, however, Nigeria is widely blessed with numerous clay mineral deposits, some of these are already being used for the production of ceramics, bricks and pottery, but its potential for the production of bleaching earth has not been fully exploited.

Corresponding Author: Okwara, C.A., Department of Chemical Engineering, Federal University of Technology, P.M.B. 1526, Owerri, Imo State, Nigeria

Studies have shown that Nigerian clays used in bleaching of palm oil as a substitute for imported Fuller's earth, give comparable performance when subjected to activation[7].

Activation using acid or alkali treatment increases the surface area of clays and also generates a system of fine pores for optimum results. This is as a result of the removal of alkali metals, alkali earth metals, iron and aluminium from the clay mineral. While acid activation removes the alkali metals, alkali earth metals, iron and aluminium from the clay mineral, alkali activation of clays brings about the dissolution of the silica lattice and promotes adsorption[8,9].

Acid activation has been extensively used to produce most of the available bleaching earths, unlike alkali activation[10,11]. This study views the alkali activation of some local clay samples as a substitute.

MATERIALS AND METHODS

Activation of clay samples: The bleaching earths were gotten from Mbano in Imo State (Kaolin), Ohaozara in Ebonyi State (Bentonite) and Bauchi in Bauchi State (Fuller's earth).

The apparatus used were: Weighing balance, mortar and pestle, 0.1 mm sieve mesh, electric oven, filter medium.

The reagents used were: Clay samples, sodium hydroxide (1M, 2M, 3M and 4M), water.

The clays were ground using a mortar and pestle to reduce to a fine powder and the particles that passed through a 0.1mm sieve mesh were activated.

Four concentrations of sodium hydroxide solution, namely, 1M, 2M, 3M and 4M were prepared. For activation at each concentration, 60 g of the clay was mixed with 5mls of alkali and the mixture subjected to a temperature of 80-85°C for 35-40 min in an electric oven. The slurry formed was decanted, washed with water to reduce the alkali concentration, filtered and dried overnight at 90-95°C.

The dried lump was pulverized and 2 g of the particle that passed through a 0.1 mm sieve shaker were used for the bleaching.

Bleaching operation: The palm oil was obtained from an oil mill at Umuagwo in Ohaji local government area of Imo state, Nigeria.

The palm oil was tested for free fatty acid, moisture and volatile contents and degummed. The apparatus used were: Conical flask, filter medium, magnetic stirrer and magnetic stirrer regulator hot plate, weighing balance. The reagents used were: Palm oil (degummed and neutralised), activated clay samples.

100 grams of the degummed and neutralised oil was weighed out into a 500 mL conical flask and heated to a temperature of 90-95°C using a heater. For each bleaching operation 2g of the activated clay was added to the oil, the mixture was continuously stirred using a magnetic stirrer and heated to 150°C for 20 min using the magnetic stirrer regulator hot plate.

The mixture was then filtered and the oil dried by putting it into a conical flask and exposing it to oven temperature of 90-100°C until all moisture was evaporated. This was to avoid rancidity. The Lovibond (two cell) tintometer was used on both the crude and bleached samples to obtain the colour reduction of the bleached oil samples.

RESULTS

Original colour of crude oil: 59Y+17.9R: Where Y and R are yellow and red readings, with coefficient values of 1 and 0.5, respectively, giving the original colour of crude oil as 67.95.

$$\%\,\text{colouredution} = \frac{\text{Crude sample cocour} - \text{bleached sample colour}}{\text{Crude sample colour}} \text{x} 100\% \quad (1)$$

The values in Table 1 was read off directly from the Lovibond (two cell) tintometer. The codes (Y and R) have been previously defined. Table 2 was obtained from Table I by substituting the coefficient values of 1 and 0.5 for Y and R, respectively to give the colour value of the bleached palm oil in numerical terms.

The values in Table 3 were obtained from the values in Table 2 by using Eq. (1) to calculate the percentage colour reduction of the bleached palm oil (the colour of the crude oil sample had been given as 67.95).

Table 1: Lovibond colour results for activated clay samples at different alkali concentrations

Kaolin	Fuller's earth	Bentonite	Alkali concentration
20Y±16.4R	30Y±7R	10Y±9R	1M
17Y±14R	15Y±3.8R	15Y±10.9R	2M
15Y±2.1R	12.5Y±2R	17Y±12.5R	3M
30Y±7R	15Y±2.3R	23.8Y±7R	4M

Table 2: Colour value of bleached palm oil for clay samples at different concentrations

Activated kaolin	Activated fuller's earth	Activated bentonite	Alkali concentration
28.20	33.50	14.50	1M
24.00	16.90	20.45	2M
16.05	13.50	23.25	3M
33.50	16.15	27.30	4M

Table 3: Percentage (%) colour reduction of palm oil for the three activated clays

Activated Kaolin	Activated Fuller's earth	Activated Bentonite	Alkali concentration
58.50%	50.70%	78.66%	1M
64.68%	75.13%	69.90%	2M
76.38%	80.13%	65.78%	3M
50.70%	76.23%	59.82%	4M

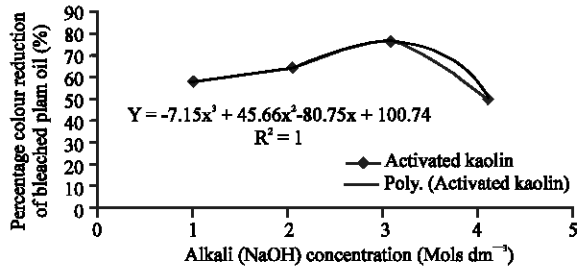

Fig. 1: Model equation for oil bleached using activated kaolin

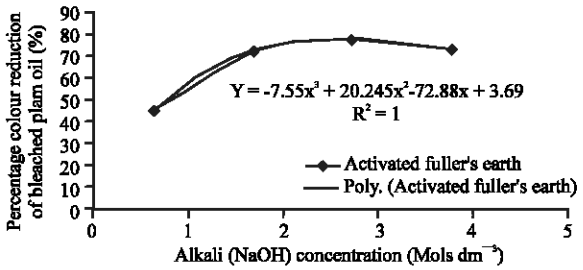

Fig. 2: Model equation for oil bleached using activated fuller's earth

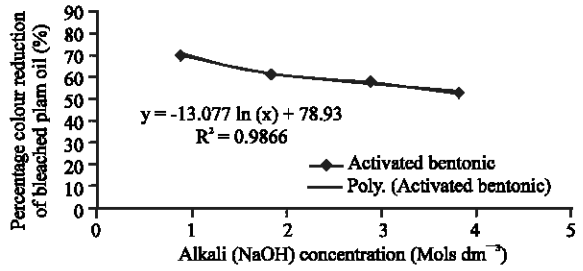

Fig. 3: Model equation for oil bleached using activated bentonite

The data from Table 3 was fitted to a model to obtain a relationship between percentage colour reduction and the concentration of alkali used in clay activation for the four samples. The models and plots appear on Fig. 1, 2 and 3 for activated Kaolin, Fuller's earth and Bentonite, respectively.

Activated Kaolin and Fuller's earth had the best fit with third order p olynomials, while activated Bentonite was best fitted with a logarithmic model. All models and correlation coefficients appear in Fig. 1-3. These results are comparable to those of acid activated Fuller's earth, which falls between 75 and 80% by Arumughan *et al.*,[1], thus giving credence to the study.

DISCUSSION

Table 3 shows the percentage colour reduction of palm oil achieved by the activated clay samples when activated with different concentrations of sodium hydroxide (Alkali). Kaolin shows an increase in adsorption activity as the concentration of alkali used in activation increases up to 3M and then it begins to drop in activity. Fuller's earth also follows a similar trend to Kaolin. Bentonite shows a continuous drop in adsorption activity as the concentration of alkali used in its activation increases, it thus has its best activity when activated with 1M solution of sodium hydroxide (NaOH).

Figure 1 to 3 are plots revealing model equations for the adsorption activity of the various activated clay samples as the concentration of alkali used in activation is varied from 1M to 4M.

The adsorption activities of activated Kaolin and Fuller's earth, within the range of experimental data, were adequately modelled using third order polynomials with regression coefficients of unity, respectively.

The adsorption activity of activated Bentonite was adequately modelled, within the range of experimental data, using a logarithmic plot with a regression coefficient of 0.9866. Based on the models the optimum adsorption activities for activated Kaolin and Fuller's earth were 76.38 and 80.70% palm oil colour reduction after activation with 3M and 2.9M NaOH solutions, respectively.

Activated Bentonite has its optimum adsorption activity (78.66% colour reduction) after activation with 1M NaOH. Based on the model and plot it would seem that its adsorption activity increased as the concentration of alkali used for activation decreased. This may not be indefinite as the model gives poor predictions at very low alkali concentrations.

Thus, in consideration of the optimums, Activated Fuller's earth (from Bauchi) gave the best adsorption activity, followed by activated Bentonite and finally Kaolin.

CONCLUSION

Local clay samples from within the country can be activated using different concentrations-2.9M, 3M and 1M for Fuller's earth, Kaolin and Bentonite respectively-of sodium hydroxide (NaOH), to obtain bleaching earth of very good quality.

The optimum adsorption activities of 80.70, 78.66 and 76.38% for activated Fuller's earth, Bentonite and Kaolin, respectively all fall within the range of 75-80% expected of acid activated (imported) Fuller's earth.

In consideration of the difference in cost of imported Fuller's earth, which was reported to be about N1500 per Kg, in comparison to Kaolin and Bentonite that sell for about N9 and N5 per kg respectively[8]. Activation of our local clays is a very viable project.

Alkali activation is recommended to aid further reduction in cost of activation as the cost of sodium hydroxide (NaOH) is much less than that of sulphuric acid (H_2SO_4), which sells for about 150% the price of sodium hydroxide per kilogram.

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