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Research Article

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Overview on the Effect of Particle Size on the Performance of Wood Based Adsorbent

Ikenyiri PN and Ukpaka CP*

Department of Chemical/Petrochemical Engineering, Rivers State University of Science and Technology Nkpolu, PMB 5080, Port Harcourt, Nigeria

Abstract

Oil spill is common to oil producing nations of the world. Various researches have been carried out. However, most of the materials used for oil spill clean-up are non-biodegradable and require expensive treatment to become an adsorbent. In this study, adsorptive capacities of cost effective raw hard and semi-hardwood particle sizes were investigated and compared. Semi-hard wood of various particle sizes was found to have better adsorptive capacities. Maximum uptake of the oil by both adsorbents occurred at 180 and 240 minutes for all the observations made. The maximum uptake also occurred in smaller particle sizes for all results. This study recommends that further research be done on the use of modified smaller particle size of semi-hardwood sawdust so as to increase its potential as a low-cost adsorbent in oil spill clean-up.

Keywords: Particle size; Performance; Oil spill; Crystal grain; Wood; Adsorbents

Introduction

The particle size of a material influences many of its properties and can indicate the quality of the material and its performance. Whether for stability in suspension, reactivity, appearance, viscosity, flow, packing density, texture and flavor or many other characteristics, the particle size of a material is a very important component in understanding how your product performs. Particle Size analysis can be as simple as measuring the diameter of a sphere, or measuring the amount of material that will pass through a mesh of a specified size. It can also be a very complex analysis examining the shape of the particles, its texture, and the distribution range of the various particle sizes. The information you need will determine which type of testing techniques to employ [1].

Effect of particle size is a complex phenomenon associated with significant change in physical and chemical properties of substance due to direct reduction of the particles (grains, crystallites), the contribution of the interface to system properties and due to particle size being commensurate with the physical parameters of length dimension [2-6]. Size effects are observed with the reduction in size of structural elements, particles, crystallites and grain below a certain threshold. Such effect occur at the average size of crystal grain of less than 100 nm and is more clearly observed at the grain size below 10 nm [7-9]. The specific surface area is increased as the particle size becomes small. The specific surface area is also increased if the particle has pores [10]. The specific surface area is important for the industrial process and chemical reaction. Even with the same material that has the same weight and volume, the surface activity and adsorption volume are changed according to the specific surface area. So it is important to measure the specific surface area to evaluate the activity and adsorption capacity of materials. (e.g., catalysis and adsorbent) [11-17].

The process of adsorption involves separation of a substance from one phase accompanied by its accumulation or concentration at the surface of another. The adsorbing phase is the adsorbent and the material concentrated or adsorbed at the surface of the phase is the adsorbate [18]. Adsorption can perform many separations which are practically by convectional techniques such as distillation, absorption and even membrane – based system. Adsorption phenomena are operative in most natural, physical, biological and chemical system and adsorption operations employing solids such as saw dust and synthetic applications and for purification of waters and wastewater or oil spillage [19]. The process of adsorption involves separation of a substance from one phase accompanied by its accumulation or concentration at the surface of another. The adsorbing phase is the adsorbent and the material concentrated or adsorbed at the surface of the phase is the adsorbate [20]. On the basis of type of force of attraction existing between adsorbate and adsorbent, adsorption can be classified into two type; physical adsorption or chemical adsorption.

An oil spill occurs when liquid petroleum is released into the environment by vehicle vessel or pipeline. As oil spill, it float on water and prevents sunlight to pass through it, this makes it difficult for plant and sea animal to survive, and oil spill can prove fetal for plant, animal and human life. The substance is so toxic that it can cause massive loss of specie that live the sea (There are also an environmental effect, economic effect caused by this oil spillage. In environment effect, it kills the animal in the water or near threshore. In the case of economic effect, it brings loss of refined petroleum, and gas available for use when oil spill occur various materials are used for its clean-up. Materials such as booms, sorbents, etc. was employed for clean-up of oil spills. For this study, adsorbent material from wood was used to investigate its functionality as a clean-up material. Recently, available agricultural by products have being used as adsorbents and some had shown tremendous success. Hence in this work will be made to investigate the performance of these adsorbent with respect to their particle size. Since the particle size of these materials play a major role in its performance as an adsorbent. The end of the study will indicate the appropriate particle size of good adsorbent. The significance of this research is to study the particle size as well as the performance of these adsorbents in an oil spill situation. The research will also involve determining the adsorption capacity with

***Corresponding author:** Ukpaka CP, Department of Chemical/Petrochemical Engineering, Rivers State University of Science and Technology Nkpolu, PMB 5080, Port Harcourt, Nigeria, Tel: 2349038858167; E-mail: chukwuemeka24@yahoo.com

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respect to the various particle size of the selected sample. The aim of this research is to study the effect of particle sizes on the performance of wood-based adsorbent [21].

Objective of the research includes: to determine the effect of particle size on the use of wood based adsorbent, to determine the absorption capacity of known absorbent with respect to different particle size, to compare this study with respect to time of adsorption capacity and to use the data obtain to ascertain the appropriate particle size was selected as a good adsorbent. The scope of this study is streamlined to the effect of particle size on the capacity of the adsorbent and to investigate the influence of particle size on the performance of the various type of selected adsorbent for this study.

Materials and Methods

Materials

The equipment/materials used for this investigation includes: standard laboratory coat, selected adsorbent (sawdust) which include iroko sawdust (hard wood) and palm tree sawdust (semi-hardwood), crude oil (Bonny light), tap water (underground water), sieve, working table, electronic weighing balance, desiccator, conical flask, stop watch, viscometer and pH meter.

Sample collection and preparation

The sawdust from hard wood (Iroko tree) was used for this research work and the samples were collected from saw-mill (timber) industry at Ilabuchi in Port Harcourt Rivers State, Nigeria. The semi hardwood (sawdust) from palm tree used for this study was collected from palm tree in area of River State university of Science and Technology, Port Harcourt, Rivers state of Nigeria. Underground water (tap water) was collected from the existing borehole in area of laboratory of Chemical/Petrochemical Engineering and transferred into the main laboratory for analysis. Crude oil was obtained from Port Harcourt Refinery, Eleme, in Rivers State of Nigeria.

The wood-based adsorbent (sawdust) were crushed and sieved to obtain difference particle sizes (0.8 mm, 1.4 mm and 3.5 mm). The particle size was washed with tap water to remove muddy materials and impurities and then dried in an electrical oven at 100 -110°C, the sawdust was then immersed in 2.0N of NaOH aqueous solution for 8 h. It was observed that a dark-red solution was generated during this treatment, which indicated the removal of lignin from the adsorbent material. Thereafter, it was washed several times with tap water to remove the lignin content and excess of NaOH. The sawdust was repeatedly washed with distilled water till no red coloration was observed. After washing, sawdust dried in an oven at 100 -110°C for 6 hours. It was then immersed in 0.2N H_2SO_4 for 8 hours to remove the traces of alkalinity and other impurities. The acid-treated sawdust was again thoroughly washed with tap water to remove the excess of H_2SO_4 and other coloring materials till the wash-found water was colourless. After the wash water became colourless, the treated sawdust adsorbent material was dried at 100 -110°C and stored in a desiccator for use as an adsorbent. Polyethylene material was introduced to prevent adsorption diffusing into the water environment, but only have contact with the crude and the sawdust adsorbent.

Experimental method

The following methods were carried out for this study: 200 ml of water at its room temperature was poured into a conical flask and the water was allowed for 30 minutes to attain its stability. A sample of Nigeria crude oil (bony light) was measured at constant volume of 10 ml and poured gently to avoid emulsion formation as well it was then allowed to spread for 15-20 minutes. The spreading of oil discharged in water was because of forces acting on it, such as gravitational force, viscosity and surface tension. A constant weight of 10 g of particle sized was obtained, and poured into the mixture as well the mixture was bowered with fan for more surface agitation. It was monitored at different range (60 min, 180 min, 120 min and 140 min) of time. It was then removed at time interval of 60 minutes and then weighed, the weight was recorded. The process was repeated for four times at constant weight of 10 g for each wood-based adsorbent using different particle sizes 0.8 mm, 1.4 mm and 3.5 mm. Weighing of the adsorbent before and after experiment help to determine the adsorption capacity of the material.

Measure of adsorption capacity

The formula below is used to determine the amount of oil adsorbed at a given period of time;

$$\text{Adsorption capacity } (AC) = \frac{A_{st} - A_0}{A_0} \quad (1)$$

Where, A_o is the initial weight of dry adsorbent and A_{st} is the weight of adsorbent after experiment.

Results

The results obtained from the research work are presented in Tables 1-7 and Figures 1-6.

Liquid	Density at room temperature 25°C	Viscosity at room temperature 25°C
Crude oil	0.832 g/ml	29.7700 centistoke

Where the characteristic of water surface area is 0.1455 N/mm

Table 1: Properties of Liquid Used in Experiment.

Time of adsorption (minutes)	Initial weight of adsorbent used (g)	Weight of adsorbent after Experiment (g)	Net weight of oil adsorbed (g)	Amount of Oil adsorbed by adsorbent (g)
60	10	32.20	22.20	2.22
120	10	47.20	37.20	3.72
180	10	70.20	60.20	6.02
240	10	80.00	70.00	7.00

Table 2: Adsorption Capacity of Crude Oil by Hardwood Sawdust Size (0.8 mm) at Constant Weight of 10 g at Difference Time Interval of 60 minutes.

Time of adsorption (minutes)	Initial weight of adsorbent used (g)	Weight of adsorbent after Experiment (g)	Net weight of oil adsorbed (g)	Amount of Oil adsorbed by adsorbent (g)
60	10	30.20	20.20	2.02
120	10	41.70	31.20	3.17
180	10	60.62	50.62	5.062
240	10	70.00	60.00	6.031

Table 3: Adsorption Capacity of Crude Oil by Hardwood Sawdust Size (1.40 mm) at Constant Weight of 10 g at Difference Time Interval of 60 minutes.

Time of adsorption (minutes)	Initial weight of adsorbent used (g)	Weight of adsorbent after Experiment (g)	Net weight of oil adsorbed (g)	Amount of Oil adsorbed by adsorbent (g)
60	10	25.25	15.25	1.52
120	10	37.18	27.18	2.71
180	10	43.19	33.19	3.32
240	10	59.00	49.00	4.9

Table 4: Adsorption Capacity of Crude Oil by Hardwood Sawdust Size (3.50 mm) at Constant Weight of 10 g at Difference Time Interval of 60 minutes.

Time of adsorption (minutes)	Initial weight of adsorbent used (g)	Weight of adsorbent after Experiment (g)	Net weight of oil adsorbed (g)	Amount of Oil adsorbed by adsorbent (g)
60	10	60.18	50.18	5.01
120	10	70.20	60.20	6.02
180	10	80.31	70.31	7.03
240	10	89.21	79.21	7.90

Table 5: Adsorption Capacity of Crude Oil by Semi-hardwood Sawdust Size (0.8 mm) at Constant Weight of 10 g at Difference Time Interval of 60 minutes.

Time of adsorption (minutes)	Initial weight of adsorbent used (g)	Weight of adsorbent after Experiment (g)	Net weight of oil adsorbed (g)	Amount of Oil adsorbed by adsorbent (g)
60	10	46.72	36.72	3.67
120	10	61.44	51.44	5.14
180	10	70.31	60.31	6.03
240	10	80.10	70.10	7.01

Table 6: Adsorption Capacity of Crude Oil by Semi-hardwood Sawdust Size (1.40 mm) at Constant Weight of 10 g at Difference Time Interval of 60 minutes.

Time of adsorption (minutes)	Initial weight of adsorbent used (g)	Weight of adsorbent after Experiment (g)	Net weight of oil adsorbed (g)	Amount of Oil adsorbed by adsorbent (g)
60	10	30.12	30.12	2.12
120	10	42.20	32.20	3.22
180	10	60.00	50.00	5.00
240	10	71.00	61.00	6.10

Table 7: Adsorption Capacity of Crude Oil by Semi-hardwood Sawdust size (3.50 mm) at Constant Weight of 10 g at Difference Time Interval of 60 minutes.

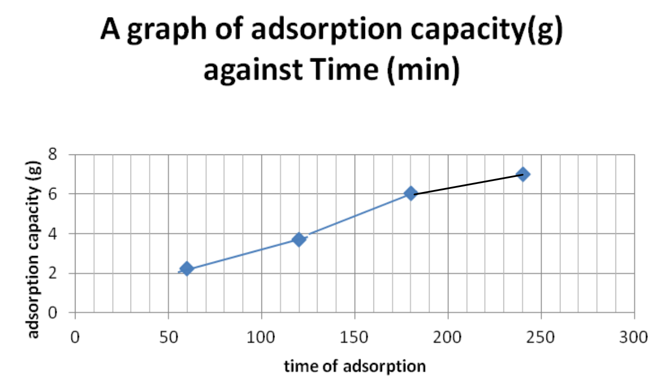

Figure 1: Effect of Contact Time on the Adsorption Capacity for 0.8 mm Sized Hardwood Sawdust.

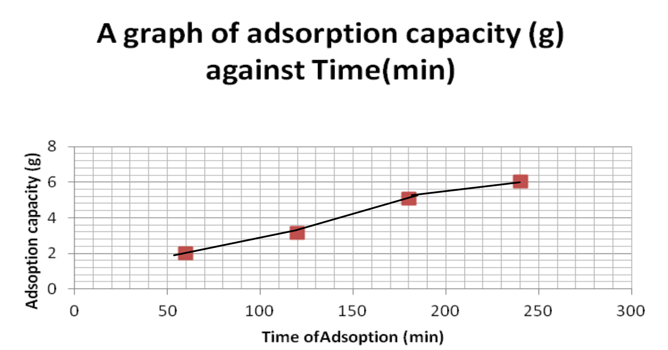

Figure 2: Effect of Contact Time on the Adsorption Capacity for 1.40 mm Sized Hardwood Sawdust.

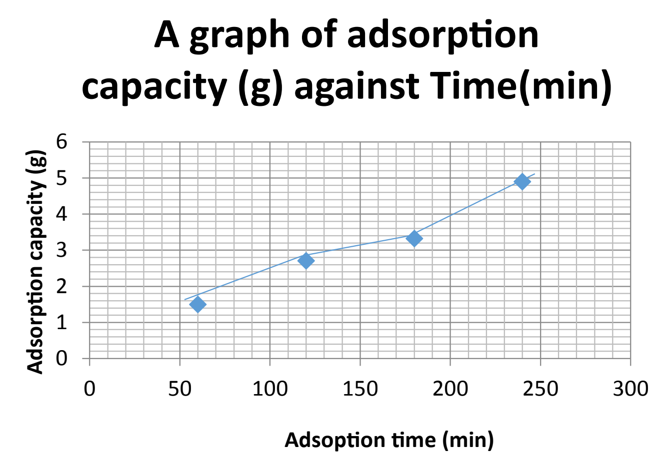

Figure 3: Effect of Contact Time on the Adsorption Capacity for 3.5 mm Sized Hardwood Sawdust.

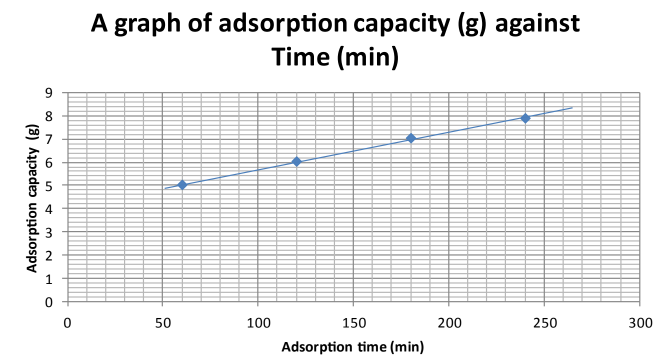

Figure 4: Effect of Contact Time on the Adsorption Capacity for 0.8 mm Sized Semi-Hardwood Sawdust.

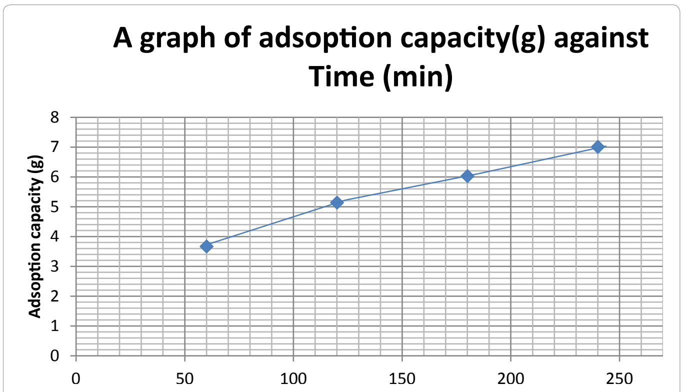

Figure 5: Effect of Contact Time on the Adsorption Capacity for 1.40 mm Sized Semi-Hardwood Sawdust.

Discussion

Effects of particle size

The following adsorbents were used in the research work which was classified into three different particles sizes (0.8 mm, 1.4 mm and 3.5 m). Adsorbent with largest surface areas (0.8 mm) was found to have adsorbed most crude oil than those with smaller surface areas (1.4 mm and 3.5 mm). This means that the higher the surface area, the higher the adsorption capacity, the lower the surface area the lower the adsorption

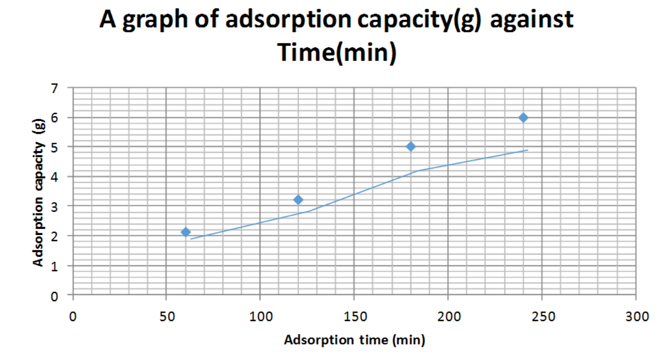

Figure 6: Effect of Contact Time on the Adsorption Capacity for 3.5 mm Sized Semi-Hardwood Sawdust.

capacity. Again, the semi-hand wood particle was found to have greater adsorption capacities than the corresponding hardwood particle of the same weight as result of difference in porosity of the adsorbents.

Effects of contact time

Tables 1-6 shows the various time intervals by which the adsorbents were remove from the solution between 60 to 240 minutes. The result shows that the maximum uptake (adsorption capacity) occurred at 240 minutes for both hardwood adsorbent and semi-hardwood adsorbents. The maximum uptake increases from 0 to 140 minutes, and as the contact time of the adsorbent with the oil increases, adsorption of the oil also increases until saturation point occurred. Here, the higher the surface area, the higher the rate of adsorption.

Conclusion

This research work concludes that the smaller particle sizes are more effective on the performances of wood-based adsorbent than corresponding larger particle sizes of both sawdust (semi-hardwood and hardwood). Again, the particle size of semi-hardwood is more effective in oil-water clean-up than the corresponding particle size of hardwood. This is attributed to its low density and high porosity. Maximum uptake (amount adsorbed) of the oil by both adsorbents occurred at 180 and 240 minutes for all the results. This study recommends that further research be done to investigate and modified on the use of smaller particle sizes and semi-hard wood to increase its performance as an adsorbent in oil spill clean-up.

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