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The Study of Super Hydrobobicity of Kapok Fibre and Its Performance

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Abstract: Nowadays, oil pollutant becomes more worst where it is causing damages to marine life. Therefore, this paper has approached for overcome the oil pollution, which is absorbed by kapok fibre. Kapok fibre is one of the natural fibre that has provides superhydrophobic-oliophilic characteristics. Kapok fibre also has penetrating hollow light structure and the waxy surface characteristics. This characteristics show that kapok fibre one of the best sorbent can be used to absorbs oil. 2 grams selective kapok fibre was used and sorption was measured in several oils that have different characteristics which is density and viscosity. Type of oil used in this study was cooking oil, lubricant oil, petroleum oil, two stroke lubricant oil, and diesel oil. The lubricant oil and two stroke lubricant oil represent the high viscosity and density, cooking oil represent for medium viscosity and density and petroleum oil and diesel oil represent low viscosity and density respectively. The highest volume oil sorption were lubricant oil. Kapok fibre has huge potential as an oil absorbent due to its excellent hydrophobicity-oleophilicity.

Keywords: Kapok Fiber, Hydrophobic-Oliophilic, Sorbent

1. Introduction

The oil pollutant, causing considerable damage to water,aquatic and marine ecosystem, and tourism, has been an essential contaminant in recent years in water. Various methods for oil extraction were suggested, such as in-situ burning from polluted areas [1], bioremediation [2], and the use of absorbing materials [3]. Consequently, oil sorption extraction is considered as the most efficient and cost-effective method in environmental conditions for a complete purification of spent oil. The material is a good oil-sorbent, easy to find, fast sorption, excellent sorption and good recyclability. Decent, different kinds of materials such as rice husk [4], cotton fibre [5], corn stalk [6], kapok fibre[7] and bagasse [8] have been developed as oil sorbents, including polyurethane foam [9], synthetic resins [10], cellulose aerogels [11], $CaCO_3$ powder [12] and natural fibre [13]. Most of the organic synthetic and mineral products have their disadvantages. For example, organic plastic such as polyurethane foams, have high oil supply capacity but are poorly biodegradability and expensive while powdered minerals such as $CaCO_3$, have

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low oil sorption capacity and poor buoyancy. On the other hand, refined materials and natural organic materials have good oil absorption because they are sustainable and degradable.

Kapok fibre is a kind of natural plant fibre produced from silk cotton tree fruits, having a low density, good bouyancy and extensive hollowness. These features give kapok fibre greater efficiency in sorption of oil than other materials [14]. The raw kapok fibre is hard to preserve oils efficiently because of its smooth surface. It was done by the sol-gel process, which shows strong oil retaining ability and water repellence for the oil or water environment, and was obtained by superhydrophobic kapok fibre with roughened surface [15]. Although some studies on oil sorption magnetic materials have been carried out, a few more information on the use of magnetically superhydrophobic kapok fibre for oil sorption have been accessible. Therefore, this paper intended to analyses the characteristic of kapok fibre with different oils.

In recent years, several of natural products have been used for the removal of oil spills, including rice husk [4], bagasse [8], corn stalk [6], kapok fibre [7] and cotton fibre [5]. It is because the natural material has typically a low hydrophobicity, a relatively low sorption potential and poor buoyancy. Selective water oil sorption was recently produced with many natural hydrophobic and superhydrophobic materials [16]. The outcome of corn straw will absorb various oils easily and float after sorption on the water surface, such as by acetylating hydroxyl groups onto corn straw, prepared Li et al. [16]. Oleic acid is used by Sathasivam et al., for modification of banana trunk fibre for the processing, in selective oil sorption in water sorting of hydrophobic sorbents [17]. Gan et al., obtained superhydrophobic magnetic sawdust by plunging $CoFe_2O_4$ into the sawdust surface with the aid of external magnets, which could strip oil from the water's surface and modify energy polysiloxane low surface layers chemically [17]. Dopamine self-polymerisation accompanied by hydrophobic silane modification was carried out in the previous study with superhydrophobic cotton fibre, and this generated fibre is much more able to absorb oil than raw cotton fibre [18]. Regardless of innovation in oil sorbents dependent on natural materials modified, it is extremely desirable for natural material based oil sorbents to be prepared using filtration methods with excellent stability and recyclability. Furthermore, it is still a big task to clean all oils with natural materials on the surface of water and with oil-in-water emulsions.

2. Materials and Methods

2.1 Materials

Raw kapok fibre was used as the medium of oil sorption. There fives oils that have been used in this studies which lubricant oil, cooking oil, petroleum oil, 2 stroke lubricant oil and diesel oil. All this all have their own properties such as density and viscosity.

2.2 Oil Sorption Capacity

Two grams of dried sample was weighed before and after immersed in the selected oils at room temperature. After 3 minutes, the sample and the mesh were taken out and drained for a few minutes [10]. Then , removed the excess oil from the bottom of the mesh using filter paper. To the determined the oil sorption capacity the sample was weighed before and after sorption. The sorption was calculated by following formula:

$$Q = \quad (Wt - Wi)/Wi \qquad Eq.1$$

Where Q represent sorbent oil capacity, measured in a gram of oil per gram sample, Wt represent the sorbent saturated mass (g), Wi represent the saturated sorbent weight (g). Both oil sorption capacities have been tested three times, using an average value [10].

In order to reach an average value all oil sorption capacity tests were performed three times. The emulsifier oil-in-water can be obtained with a vigorous stirring for 2 minutes, as shown in Figure 1, in the oil/water mixture (aqua phase) at a ratio of 1:1 to 1 oil. For a certain time, the emulsion containing the prepared fibre is agitated and the oil droplets have been absorbed from the milky emulsion to separate oil droplets from the emulsion [7].

2.3 Recyclability Test

In order to reach sorption saturation, super hydrophobic kapok fibre was plunging into oil and was then added to the sand core funnel. The fiber then drains for 5 minutes under vacuum to remove the remaining oil and dry it in the oven at 60 °C [12]. For the same time, the collected fibre will again be used. There were repeated sorption/desorption processes and observations of the contact angle of the water. The superhydrophobic fibre conjoint with the vacuum system allows massive amounts of oil to be separated continuously and collected within a short period. In particular, the fibre obtained will separate oil-in-water emulsions with a high separation rate.

2.4 The Separation Property of Oil/Water Emulsion

Several of surfactant free oil-in-water emulsions by mixing oil and water have been conducted to analyse the separating capacity for the emulsified oil/water mixture. The 500 ml mixture of oil and water was prepared. Filter funnel that has the kapok fibre was placed at the measuring cylinder and then poured the mixture of oil and water at the kapok fibre. The result of the separation of the mixture have been observed by reading the scale on measuring cylinder. The oil that has used are cooking oil, lubricant oil, petroleum oil, two strokes lubricant oil and diesel oil. Figure 1 show the apparatus of filtration systems.

Figure 1: Set up for Oil/Water Emulsions Separation

3. Results and Discussion

3.1 Filtration Test

In the filtration test, different types of oils are used. Lubricant oil and 2 stroke lubricant oil is represent high viscosity oil, petroleum oil and diesel represent low viscosity and cooking oil the medium viscosity. It has been tested for two times with using the same raw kapok fibre to get the average reading of filtration and get the data for recyclability test. It can see all the the water oil solution have been filtered and the result was decreased for the first filtration and become more decrease for the second filtration. The time taken for the second filtration is longer than the first filtration.

Table 1: Filtration Test

Type of oil	Before filtration	First filtration	Second filtration
Cooking Oil	500 ml	400 ml	370 ml
Lubricant Oil	500 ml	445 ml	400 ml
Petroleum Oil	500 ml	410 ml	340 ml
Two Strokes Lubricant Oil	500 ml	395 ml	360 ml
Diesel Oil	500 ml	415 ml	345 ml

From Figure 2 shows that the higher oil sorption capacity is the lubricant oil which is 21.50 %. The lowest oil sorption capacity that we can see is the diesel oil which is 14.50 %. It is because the lubricant oil properties which is have high density while the diesel oil is low density. The absorption capacity increased when the density of the oil is increased. In the other hand, the lubricant oil has a high viscosity than the other oils. The viscosity also affects the sorption capacity of the oil. Surfaces with a super-hydrophobic contact angle greater than 150°, are very hydrophobic surfaces. Therefore, kapok fibre only absorbs experimental oil rather than water. Kapok fibre shows great water repellence behaviour, high capacity for oil adsorption. Besides, kapok fibre have an advantage to absorb oil as it can be mechanically forced out to retrieve the oil only as due to its hydrophobic nature.

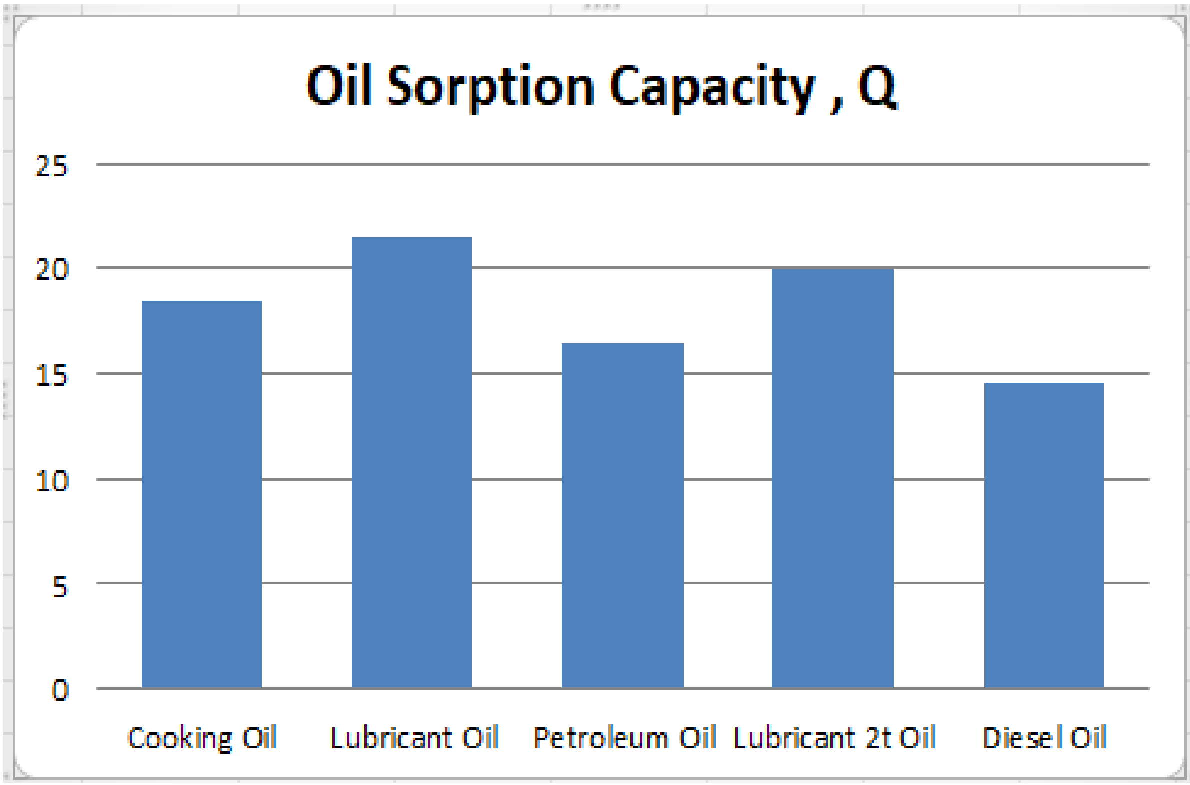


Figure 2 :Oil sorption performance of experimental oil

3.2 Mass of Kapok Fibre

Initial mass is constant, 2 grams, before filtration. Table 1 shows the oil sorption capacity of kapok fibre in various oil. Based on Figure 2, the result of kapok fibre is only 14.5 % low in diesel adsorption compared with other test oil. Kapok fibre while with 21.5 % is more adsorbed to lubricant oil. The other is 20.0 % for two stroke lubricant oil , 18.5 % for cooking oil and 16.5 % for petroleum oil. Kapok fibre is more capable than diesel and petroleum for high-density oil sorption. It is attributable to this that high-density oil is heavier than oil and diesel oil.

Table 2: Absorption capacity of experimental oil

Type of oil	Mass of filtration (g)	Oil Sorption Capacity,Q
Cooking Oil	39	18.5
Lubricant Oil	45	21.5
Petroleum Oil	35	16.5
2 Stroke Lubricant Oil	42	20.0
Diesel Oil	31	14.5

3.3 Comparisons of Oil Sorption Performance

The oil sorption capacity of the kapok fibre on different oils was shown in the figure above. As can be observed, kapok fibre has a low adsorption potential when exposed to diesel relative to lubricant oil, cooking oil, oil and two strokes lubricant oil.

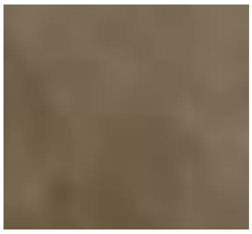
Raw kapok fibre tends to absorb high-density oil such as two strokes lubricant oil than diesel because it has a higher viscosity. This is because two strokes lubricant oil higher intermolecular force than the diesel oil [4]. The liquid bridge with a similar level of stability has formed in all types of fibre, following the absorption of lubricant oils with kapok fibre. As the oil concentration increases, the sorbent capacity also increases until the equilibrium is reached. The floated oil was quickly absorbed into the fibre during the sorption process and no oil dispersion was seen after the sorbent was added to the experimental oil and water mix [20].

The physicochemical characteristics of kapok fibre, like surface wax, roughness of the surface, hollow lumen, porosity and fineness, can all influence the oil’s sorption. The large-sized lumen of kapok fibre plays a significant role in maintaining its porous oil absorption structure. To make it highly hydrophobic, and oleophilic makes the high content of surface wax on the fibre surface [4].

3.4 Surface Morphology of Kapok Fibre

Table 3 showing the surface morphology of raw and filtrated kapok fibre. Table 3 (a), (b), (c), (d) and (e) show the surface of the kapok fibre before being filtrated with lubricant oil, cooking oil, petroleum oil, two strokes lubricant oil and diesel oil and table 3 (f), (g), (h), (i), and (j) are the surface of the kapok fibre after being filtrated with cooking oil, lubricant oil, petroleum oil, two strokes lubricant oil and diesel oil respectively. It can be shown that surface morphology has changed since being treated with different types of an oil-in-water emulsion. Raw kapok fibre have a smooth surface without ripples because of their natural wax coverage, while the sample surface is rough, and the wrinkles and grooves are unique. It suggests eliminating the surface wax of the kapok fibre and showing the hydrophilic surface. Without a hollow structure or rip, a raw kapok fibre can be seen with a smooth surface. Wax on the surface is attributable to the plant, the smooth surface shown by the raw kapok is determined and the fibre structure demonstrates the boom capabilities of kapok fibre and the use of kapok fibre as materials for reinforcement. Up to 90% of the whole structure will reach this hollow ratio. The hollow fibre segment is where the fibre absorbs the oil. As shown in the Table 3, the kapok fibre shown a sticky and oily behaviour after being filtered with a different oil.

Table 3 : Surface morphology of Kapok fibre

Type of oil	Before filtration	After filtration
Cooking oil	(a) 	(f) 
Lubricant oil	(b) 	(g) 
Petroleum oil	(c) 	(h) 
Two Stroke Lubricant oil	(d) 	(i) 
Diesel oil	(e) 	(j) 

3.5 Recyclability

Recyclability test has been identified based on the absorbance value and the number of test runs. The recyclability of kapok fibre have been concluded that immediately after the first run decreases. It shows that the fibre becomes less sorbent with the number of cycles. Fibre can efficiently be used up to 3 cycles as an outcome have been determined.

4. Conclusion

Kapok fibre is an excellent oil absorbent that can be used in high oil water treatment. With increased viscosity of the oil, the sorption capacity increased. The morphology of kapok fibre is not affected physically after absorption, so the potential is used repeatedly, which decreases the absorption expense. However, this study has been achieved the objective which is to analysed the characteristic of kapok fibre with different types of oil.

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