A Comparison Study of Carbonized Kapok Fibres Treated by Sodium Hydroxide Solution and Hydrochloric Acid Solution as an Absorbent in Removing Oil Waste

Nik Ahmad Faisal Nik Mohd Azlin Shah¹, Mohammad Abdullah¹, Muhamad Azrul Aizad Mohamed Saadun¹, Siti Nurul ‘Ain Zaiton⁵, Hairul Amiza Azman⁶, Diana Che Lat³, Ahmad Khudzairi Khalid⁴, Nurhaslina Hambari¹

¹Faculty of Chemical Engineering, Universiti Teknologi MARA Johor Branch, Pasir Gudang Campus, Bandar Seri Alam, 81750 Masai, Johor.
²Faculty of Applied Sciences, Universiti Teknologi MARA Johor Branch, Pasir Gudang Campus, Bandar Seri Alam, 81750 Masai, Johor.
³Faculty of Civil Engineering, Universiti Teknologi MARA Johor Branch, Pasir Gudang Campus, Bandar Seri Alam, 81750 Masai, Johor.
⁴Faculty of Computer & Matematical Sciences, Universiti Teknologi MARA Johor Branch, Pasir Gudang Campus, Bandar Seri Alam, 81750 Masai, Johor.
E-mail: moham3767@uitm.edu.my

Abstract. Hydrophobic-oleophilic properties of Kapok (Ceiba pentandra) fibre enables it to show good oil absorption capacity. In this study, Kapok fibre was treated with two types of solvent which is Hydrochloric acid solution (HCl) and Sodium Hydroxide solution (NaOH). Both solutions function to remove lignin, pectin and wax that surrounds the outer surface of Kapok fibre. To achieve its carbonized properties, both samples of Kapok fibre were burned in a furnace at 450°C for approximately an hour. By doing this, it was found that activation time between carbonized Kapok fibre porosity shows a positive result, thus enhancing the capability of Kapok fibre as an absorbent. Absorption rate of two samples of Kapok fibre which is NaOH-treated Kapok fibre and HCl-treated Kapok fibre were evaluated on different types of oils which are diesel, lubricant oil, petrol and used vegetable oil. Mass used for each absorbent samples differ by using 0.2 g, 0.4 g, 0.6 g, 0.8 g and 1.0 g respectively. Dosage reusability and percentage of oil removal were examined for this two samples of absorbent. From the dosage reusability experiment it showed that both carbonized Kapok fibre can absorbed the oil after six cycle of using the same absorbent dosage. Meanwhile, the absorption oil experiment showed that HCl-treated Kapok fibre higher than NaOH-treated Kapok fibre. It is proven that HCL-treated Kapok fibre can perform better compared to NaOH-treated Kapok fibre.

1. Introduction
Oil pollution from food production either restaurant, hotel or cafeteria, household effluent, factories and accidental spills from ships have made a huge negative impact on society and severely affected the ecological environment [1]. Researchers have come out with numbers of ideas to clean up oil from polluted areas including mechanical extraction, in situ combustion and chemical degradation. It was proven these ideas were not the most convenient method. To suit a more economical way, the use of fibers from plants as an absorbent has been considered to concentrate, transfer and absorb spilled oil [2]. Studies on the characterization and the mechanism of adsorbents from natural organic materials has
been done in recent years [3-4]. The examples are rice husk, coconut husk, cotton, milkwood, silk-floss fiber, cattail, Kapok fiber, populus seed fibre, coconut hulls and sugar cane pulp [5]. Kapok trees are well known plants that are planted at most countries in Southeast Asia [4]. Kapok fibre has a fluffy texture, yellowish coloured, non-toxic and odourless [5]. The Kapok fibre is mainly composed of lignin, polysaccharide and has a wax covering the fibre surface which causes it to have a hydrophobic properties [2]. Moreover, Kapok fibers are in high demand to be used as oil adsorbent due to its hollow structure and hydrophobic characteristics [6-7]. In fact, Kapok has the advantages over traditional oil-absorbing materials: low cost, biodegradability and high sorption capacity [6-8]. Therefore, the main purpose of this study is to compare between sodium hydroxide and hydrochloric acid as treated agent in enhancing the ability of carbonized Kapok in treating oil spill. Several experiments have been conduct to show the differences between this two types of carbonized Kapok in terms of its rate of sorption, and dosage reusability.

Experimental

1.1. Pre-treatment of Kapok using Sodium Hydroxide and Hydrochloric acid
Kapok that is used in this experiment is treated beforehand by using alkali and acid treatment. The purpose for these treatments are to ensure lignin, wax, and pectin that surround the outer surface of Kapok are bleached [3][9]. The treatments also increase the size of lumen in Kapok fiber so that it can trap more oil and increase sorption rate. About 0.5M of sodium hydroxide solution used to treat the Kapok. Sample raw of Kapok are soaked in the solution for one day. The sample of Kapok that treated with sodium hydroxide solution (NaOH-treated Kapok fibre) is neutralized with 0.5M of hydrochloric acid solution. The samples then were left for 20 minutes before dried in an oven for 100°C at an hour. The procedure was same for HCl-treated Kapok fibre but it started with soaking in 0.5M of hydrochloric acid solution and neutralized with sodium hydroxide solution.

1.2. Types of Oil
Various types of oil are used to test absorption rate of Kapok with different viscosity from different type of oil. Four different oil are used which is vegetable oil, diesel, petrol and lubricant oil.

1.3. Synthesis of Carbonized Kapok
After treating the raw Kapok fibre with sodium hydroxide and hydrochloric acid both samples were burned in a furnace at 450°C for approximately an hour. This purpose to achieve its carbonized properties.

1.4. Dosage Reusability
The main purpose for this testing is to know the retention of Kapok on oil absorbency. Four different types of oil are used which is diesel, petrol, used vegetable oil and lubricant oil. The sample was placed in the teabag which has 107.1 cm³ volume. About 0.5 g of adsorbent dosage used for both sample and soaked in four different types of oil for 20 seconds before dripped for 30 seconds. Afterwards, sample of Kapok is weighed and data is recorded.

1.5. Percentage of oil removal
The NaOH- treated Kapok and HCl-treated Kapok were soaked in different types of oil to measure a percentage of oil removal. It differs depends on viscosity of oil. Duration taken for soaking the samples into the oil are at least 15 min [7]. The percentage of oil removal was calculated using equation (1).

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\text{Percentage of oil removal (\%) = } \frac{\text{Final weight} - \text{initial weight}}{\text{initial weight}} \quad (1)
\]
2. Results and Discussions

2.1. Adsorbent Reusability capability
The adsorbent reusability of NaOH-treated Kapok and HCL-treated Kapok in a volume of a used vegetable oil (UVO), petrol, diesel and lubricant oil were conducted for a few cycles till the constant weight obtained. The result showed that for both adsorbent it can be reused as absorbent in removing all types of oil stated before for six cycle. The results have shown that without severe disruption of the fibre hollow lumen, the reusability of the Kapok can be increased. The carbonization of Kapok using NaOH and HCL as chemical treatment also shown its potential to become a good modification through the results obtained [4]. This is because the same adsorbent can be reused six time for oil removing. All the result showed in figure 1, figure 2, figure 3 and figure 4.

![Figure 1](image1.png)

**Figure 1.** Adsorbent Reusability of Kapok on used vegetable oil waste

![Figure 2](image2.png)

**Figure 2.** Adsorbent Reusability of Kapok on lubricant oil waste
2.2. Percentage of Oil Removal

The percentage of oil removal is necessary to determine the amount of oil that has been dripped out from the adsorbent. The oil removal was calculated using NaOH treated Kapok and HCl treated Kapok at different weight of samples varying at 0.2g, 0.4g, 0.6g, 0.8g and 1.0g. Based on Figure 5, the percentage of oil removal, has shown a constantly decreasing percentage against an increasing weight of sample. This has resulted due the change in the amount of adsorbent. The reduction of oil removal may have caused by the contraction of fibre interspace and the presence of residual oil in fibre bundles [10]. The NaOH treated Kapok has recorded a removal percentage of 94.66% using 0.2g and 91.3% using 1g of Kapok. Generally, NaOH treated Kapok stated a constantly decreasing percentage of oil removal mainly due to the activation of porous through the carbonization of Kapok that allowed the fibres to store a huge amount of oil [11]. However, the characteristics of the Kapok did not imply on lubricant oil due to its very high viscosity. The removal percentage of oil by NaOH treated Kapok towards petrol and diesel are merely the same. Based on Figure 7, the percentage of oil removal using 0.2g of Kapok was 87.25% while 84.4% of removal percentage was recorded when using 1g of sample. The percentage is low due to the physical characteristics of petrol which is high volatility.

Meanwhile, the percentage of oil removal of untreated Kapok on lubricant oil showed a positive result mainly due to the high viscosity of the lubricant. The oil was observed to have gummy on the surface of the treated Kapok causing a heavier weight of absorbed Kapok. Based on Figure 6, 97.7% of oil was removed when using 0.2g of Kapok sample while 96% of removal were recorded when 1.0g of
untreated Kapok was used. Furthermore, 98.4% of oil removal of diesel were tabulated upon using 0.2g and 94.19% of diesel (Figure 8) removal was recorded when using 1.0g. Undoubtedly, the result indicated a slight decrements of oil removal mainly due to viscoisty properties of diesel. The result showed that the treated Kapok can hold much oil without releasing it in a long period of time. So, this gives an advantage to natural sorbent which has a lower oil removal percentage compared to other chemical sorbents. Economically, they are cheap and are easy to be obtained in Malaysia.

**Figure 5.** Percentage of oil removal towards used vegetable oil waste

**Figure 6.** Percentage of oil removal towards lubricant oil waste
3. Conclusions
In this study, chemically modified carbonized Kapok fibre has been successfully prepared by using sodium hydroxide and hydrochloric acid. It showed positive result for oil removal and an adsorbent reusability at six cycle. Besides, its properties contribute largely to oil absorption and retention. On top of that, testing of Kapok fibre with several types of oil shows that carbonized Kapok fibre can absorb high viscosity in longer period of time compared to oil with less viscosity. To conclude, chemically modified carbonized Kapok fibre using hydrochloric acid act as a better sorbent compared with the treated using sodium hydroxide.

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