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A study on Efficiency of Natural Fiber Sorbent prepared from Water Hyacinth for Oil Sorption

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Abstract: *Natural fiber sorbent is prepared from water hyacinth by viscose process for oil sorption. This study evaluated the effect of performance of natural fiber sorbent, concentration of sodium hydroxide, quantity of carbon disulfide and sodium sulfate ratio. The natural fiber sorbents were tested for oil sorption capacity and compared with standard sorbent. The condition of 18% sodium hydroxide, 25% quantity of carbon disulfide, and 1:1.5 sodium sulfate ratios showed the highest oil sorption capacity. The efficiency of oil sorption from engine oil, diesel oil and vegetable oil were 11.35 g (oil)/g (sorbent), 11.77 g (oil)/g (sorbent) and 10.66 g (oil)/g (sorbent) respectively. Comparing to conventional sorbent material (polypropylene), the oil sorption rate of natural fiber sorbent was higher than 1.23 times in engine oil, 1.15 times in vegetable oil and 1.43 times in diesel oil. In this study, it concluded that the natural water hyacinth fiber sorbent was effective in oil sorption. The utilization of water hyacinth is possible for developing and new products of waste management efficiency and environmental friendliness.*
Keywords: *water hyacinth, oil, sorption, sorbent material, viscose process*

I. Introduction

Oil is an organic compound that widely used both in industry and households. The opportunity to contaminate the environment can be by improper disposal, accidental and stealth throw away of oil. The environment pollution can occur if the oil is discharged into soil and water. Pollution problem of oil spill can affect on ecology and economic of the environment [1-2]. Oil spills had to be eliminated earlier before they can cause damages , possibility before the oil had become emulsified. In case of emulsification, the oil combine with water and the mixture product can turn to a heavy sludge. Emulsified oil is very hard to clean by normal methods, and moreover, oil contains many toxic and very harmful chemicals to the environment where they can have impacts on living organisms [3-4].

The general methods for oil spill cleanup are physical, chemical, biological processes. Whereas each process had its own. Adsorption is one of physical methods that is normally use due to its usefulness over the other method. But absorbent materials such as polypropylene had the problem of waste disposal [5].

In this present study, the importance of oil sorption on the natural fiber sorbent prepare from the water hyacinth *(Eichhornia crassipes (Mart.) Solms)* is investigated. The water hyacinth is generally found in fresh water where it grows, propagate very rapidly causing adverse effects on the water source. The water hyacinth covers the surface water, blocking water transportation and reducing the oxygen into the water which can have impacts on the aquatic animals and the ecosystem of the environment and economic system. The removal of water hyacinth by putting into the landfill can cause all so the waste management problems [6-7]. This encourage the researchers to fine method to take advantage of the water hyacinth as well as to reduce wide space propagation. So that the efficiency of oil sorption on naturel fiber sorbent prepared water hyacinth is investigated in this study.

II. Materials and Methods

2.1 Preparation of natural fiber sorbent.

Water hyacinth *(Eichhornia crassipes (Mart.) Solms)* was use as the base of natural sorbent in this research. It was collected from Phanat Nikhom district, Chonburi, Thailand. Then, its impurity was removed by pure water. Dry it in sunlight for a week. The stem of the dried plant was ground and after that it was dried in hot air oven at 105 ºC for 3 hours and then soaked in 18-22 wt% aqueous sodium hydroxides (NaOH) for 1 hours at room temperature. Then, it was aged at 95 º C for 20 hours. After that, the water hyacinth powered was allowed to react with carbon disulfide (CS_2) and covered with Para film, for 3 hours at room temperature. The 4% sodium hydroxide solution was added to the water hyacinth. Then it was aged at 0 º C for 20 hours to obtain a viscous dark orange colored solution called "viscose", which is the basis for the manufacturing process. This starting of viscose formation is mixed viscose with sodium sulfate (Na_2SO_4) under controlled conditions (25%, 30%. 35%). The mixture was evenly poured onto the glass tray and immerse into 10% dilute sulfuric acid

(H_2SO_4) bath for 1-2 hours to form a natural fiber sorbent. After that, the resulting sorbent was washed by distilled water and dried in air and store in a vacuum container. The oil sorption will be carried by using the standard stand method ASTM F726-06 Standard test method for sorbent performance of adsorbents [8].

The processes of manufacturing viscose rayon are illustrated and clarified below [9-10].

1. Cellulose is converted to alkali cellulose during Steeping.
   $(C_6H_{10}O_5)n + nNaOH \rightarrow (C_6H_9O_4Na)n + nH_2O$
2. Carbon disulfide reacts with alkali cellulose. Cellulose xanthate is produced during Xanthation.
   $(C_6H_9O_4ONa)n + nCS_2 \rightarrow (C_6H_9O_4O\text{-}SC\text{-}SNa)n$
3. Viscose solution is formed during dissolution.
   $C_6H_9O_4OCSSNa + NaOH \rightarrow$ Viscose Solution
4. Cellulose xanthate is decomposed to get cellulose during Ripening.
   $(C_6H_9O_4O\text{-}SC\text{-}SNa)\,n + nH_2O \rightarrow (C_6H_{10}O_5)\,n + nCS_2 + nNaOH$
5. Recovery of cellulose from cellulose xanthate by acid decomposition during forming.
   $(C_6H_9O_4O\text{-}SC\text{-}SNa)\,n + (n/2)H_2SO_4 \rightarrow (C_6H_{10}O_5)\,n + nCS_2 + (n/2)Na_2SO_4$

2.2 Testing on oil sorption.

In this study, the oils used to be investigated are diesel oil, engine oil and vegetable oil. The period time of oil sorption is about 30 minutes. The 100 ml of oil was poured into a beaker and after that sorbent was placed on the oil surface allowing the sorbent to sorb oil in times. The sorbent was removed by using a stainless steel wire mesh and drained for 30 seconds and then weighed, repeat the processes 3 times. The oil sorption capacity (g oil/ g sorbent) was determined using equation (1). The average of oil sorption capacity (Avg.) was calculated by the following equation (2).

$$\text{Oil absorbency} = \frac{S_s}{S_0} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where S_0 is initial dry adsorbent weight, S_sT is weight of adsorbent samples at end of oil test and S_s is net oil adsorbed (S_sT - S_0).

$$Avg. = \frac{1}{n} * \sum_{i=1}^{n} x_i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Where n is the number of terms, x_i is the value of each oil sorption capacity item in the list of numbers being averaged.

2.3 Characterization of natural fiber sorbent from water hyacinth by using SEM studies.

The surface of the natural fiber sorbent was observed for the structure by using LEO 1450VP scanning electron microscope. Before the SEM observation, all the samples were statically attached on aluminum stubs with double sided conductive adhesive tapes and coated with gold. The SEM micrographs were examined by using acceleration voltage at 15 kV.

III. Results and Discussion

3.1 Characterizations of natural fiber sorbent from water hyacinth.

The surface of natural fiber sorbent from water hyacinth was examined by scanning electron microscope (SEM). (Fig. 1) showed that the pore was different in size across the surface. This was the result of the sodium sulfate solution reacted with the sulfuric acid causing pores surface on the natural fiber sorbent.

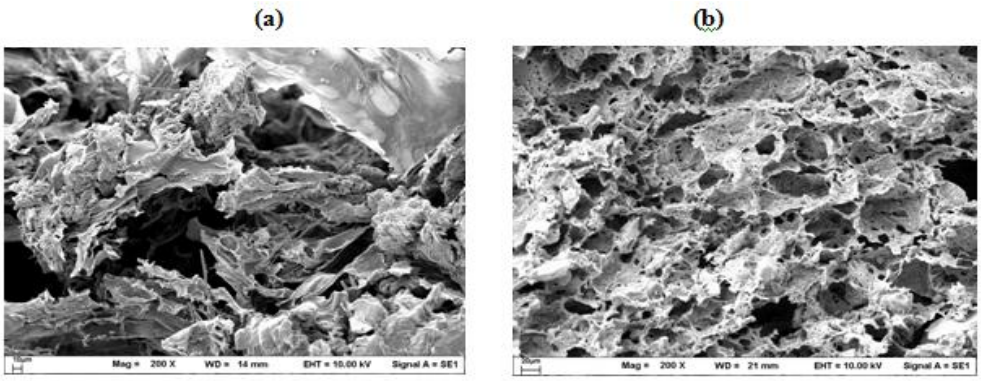

Fig. 1 SEM images of natural fiber sorbent from water hyacinth (a) surface area (b) cross section area with 200x magnifications

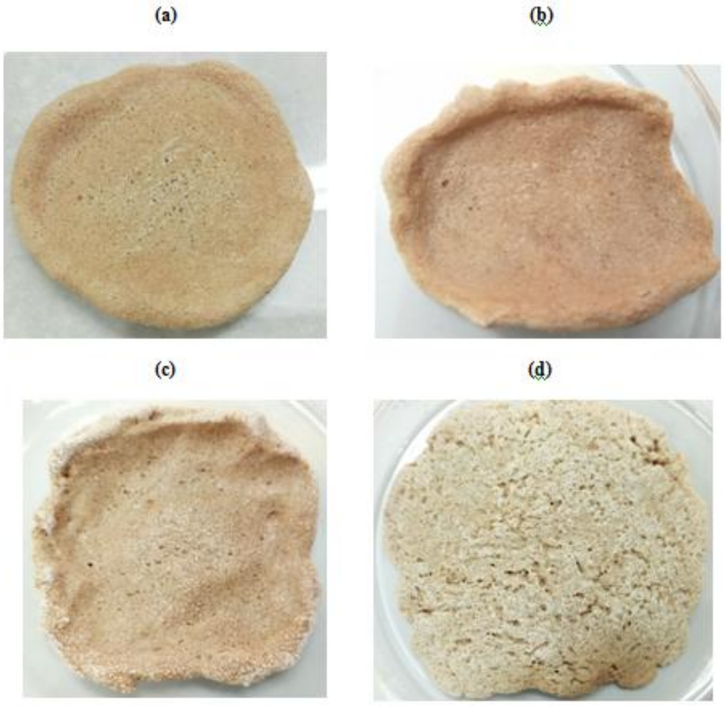

Fig.2 Natural fiber sorbent under condition of 18% sodium hydroxide, carbon disulfide 25% (a) sodium sulfate ratio 1:1.5 (b) sodium sulfate ratio 1:2 (c) sodium sulfate ratio 1:2.5 and (d) sodium sulfate ratio 1:3

3.1 The performance of natural fiber sorbent on sorption of oil.

The results of the average sorption of engine oil vegetable oil and diesel are presented in Table 1. The sorption capacity of sorbent material prepared from 18% sodium hydroxide, 25% carbon disulfide and sodium sulfate ratio 1.:1.5 (A1) has the highest ability to sorb oil of 11.35 g (oil)/g (sorbent) in engine oil, 11.77 g (oil)/g (sorbent) in diesel oil and 10.66 g (oil)/g (sorbent) in vegetable oil. The conventional sorbent material (polypropylene) has the ability to sorb 9.25 g (oil)/g (sorbent) in engine oil, 9.30 g (oil)/g (sorbent) in vegetable oil and 8.21 g (oil)/g (sorbent) in diesel oil.

Table 1: The average efficiency of oil sorption.

Sample	% NaOH by wt.	CS_2 (%)	Ratio of Na_2So_4(g/g)	Oil sorption capacity(Avg.) (g oil/g sorbent)		
				Engine oil	Vegetable oil	Diesel oil
A1	18	25	1:1.5	11.35	10.66	11.77
A2	18	25	1:2	9.33	9.92	8.66
A3	18	25	1:2.5	10.53	9.72	9.03
A4	18	25	1:3	9.63	7.45	8.18
A5	18	30	1:1.5	11.22	10.52	9.50
A6	18	30	1:2	9.71	9.75	9.07
A7	18	30	1:2.5	11.08	10.51	10.86
A8	18	30	1:3	8.72	7.24	7.21
A9	18	35	1:1.5	9.76	9.69	7.31
A10	18	35	1:2	10.40	10.43	9.33
A11	18	35	1:2.5	11.13	10.55	9.77
A12	18	35	1:3	9.24	8.50	7.92
A13	20	25	1:1.5	10.36	9.63	8.71
A14	20	25	1:2	10.83	9.23	8.26
A15	20	25	1:2.5	11.14	8.55	9.94
A16	20	25	1:3	10.31	9.76	9.95
A17	20	30	1:1.5	7.95	7.00	6.82
A18	20	30	1:2	10.17	8.85	8.13
A19	20	30	1:2.5	9.44	9.09	8.67
A20	20	30	1:3	8.01	6.60	9.30
A21	20	35	1:1.5	8.61	7.65	8.23
A22	20	35	1:2	9.01	8.63	9.09
A23	20	35	1:2.5	8.99	8.57	7.66
A24	20	35	1:3	6.37	5.62	4.37
A25	22	25	1:1.5	5.45	4.81	5.34
A26	22	25	1:2	8.00	7.85	6.23
A27	22	25	1:2.5	9.26	9.06	7.35
A28	22	25	1:3	9.56	8.91	7.59
Polypropylene	-	-	-	9.25	9.30	8.21

3.2 The effect of factors on sorption of oil

3.2.1 The effect of percent concentration of sodium hydroxide on sorption of oil.

An effect of percent concentration of sodium hydroxide in the range of 18%, 20% and 22% is shown in Fig. 4. The natural fiber sorbent had been prepared in the conditions of carbon disulfide 25 %, sodium sulfate ratio 1:1.5. The sorbent material prepared from 18% sodium hydroxide had a highest ability to sorb oil of 11.35 g (oil)/g (sorbent) in engine oil, 11.77 g (oil)/g (sorbent) in diesel oil and 10.66 g (oil)/g (sorbent) in vegetable oil. The ability to sorb oil decreases as the concentration of sodium hydroxide increases. This is the result of the sodium hydroxide at concentrations higher than 18 percent can completely degrade the cellulose into sugars.

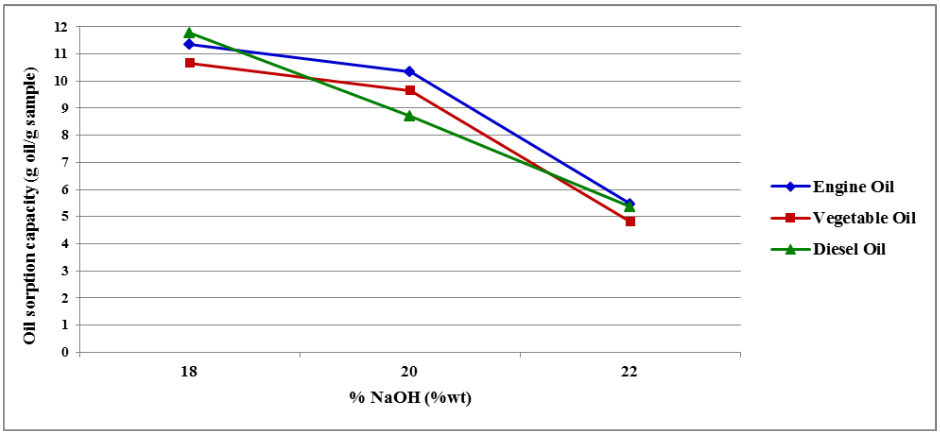

Fig.4 Oil sorption capacity vs. %NaOH

3.2.2 The effect of carbon disulfide on sorption of oil.

An effect of carbon disulfide in range of 25%, 30% and 35% is shown in Fig. 5. The natural fiber sorbent has prepared in the conditions of 18% sodium hydroxide, sodium sulfate ratio 1:1.5. The sorbent material prepared from carbon disulfide 25% has the highest ability to sorb oil as 11.35 g (oil)/g (sorbent) in engine oil, 10.66 g (oil)/g (sorbent) in vegetable oil and 11.77 g (oil)/g (sorbent) in diesel oil. The ability to sorb oil decreases as the quantity of sodium disulfide increases. This is due to the dissolution of cellulose that cannot regenerate that natural fiber to perform the sorption again.

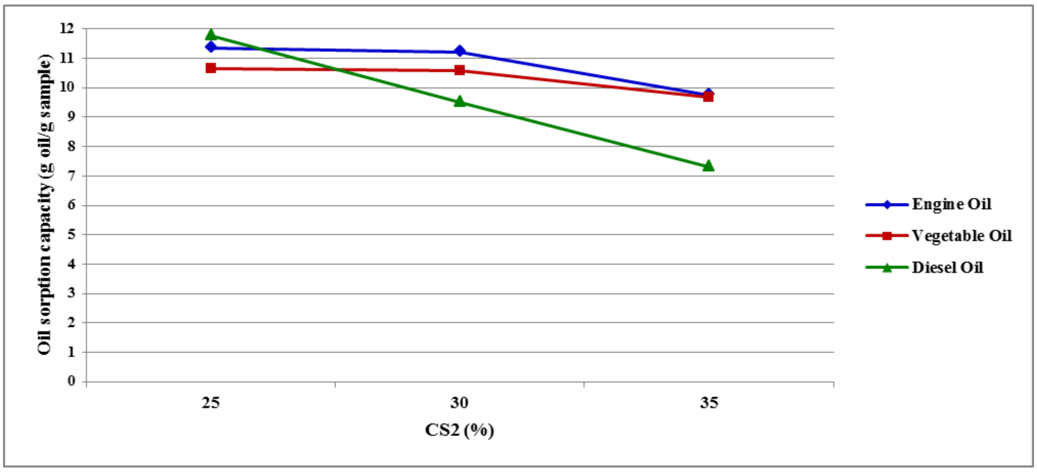

Fig.5 Oil sorption capacity vs. CS_2(%)

3.2.3 The effect of sodium sulfate ratio on sorption of oil.

An effect of sodium sulfate ratio in range of 1:1.5, 1:2, 1:2.5 and 1:3 is shown in Fig. 6. The natural fiber sorbent has prepared in the conditions as 18% sodium hydroxide, carbon disulfide 25 %. The sorbent material prepared with sodium sulfate ratio 1:1.5 has the highest ability to sorb oil as 11.35 g (oil)/g (sorbent) in engine oil, 11.77 g (oil)/g (sorbent) in diesel oil and 10.66 g (oil)/g (sorbent) in vegetable oil. The ability to sorb oil decreases as the quantity of sodium sulfate ratio increases. This is due to the excess quantity of sodium sulfate causing agglomerate that can block the pore on the surface of the natural fiber sorbent resulting in the reduction of sorption capacity.

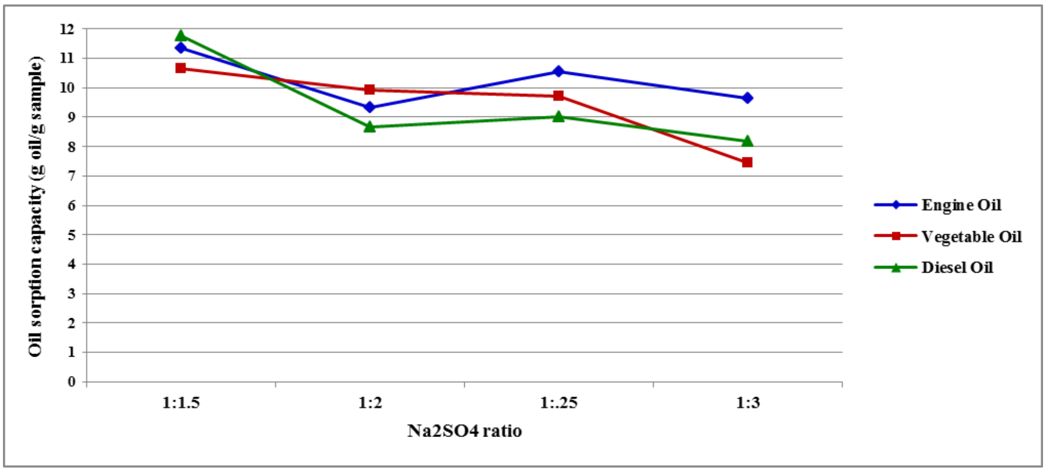

Fig.6 Oil sorption capacity vs. Na_2SO_4 ratio

IV. Conclusion

The study on the production of natural fiber sorbent had shown that the concentration of sodium hydroxide, the quantity of carbon disulfide and the ratio of viscous solution with sodium sulfate have effect on efficiency of oil sorption. In condition of 18% Sodium hydroxide, 25% Carbon disulfide and 1:1.5 ratio of sodium sulfate can modify highest efficiency sorbent product that have the ability to sorb than conventional sorbent material 1.23 times in engine oil, 1.15 times in vegetable oil and 1.43 times in diesel oil. Water hyacinth, a weed commonly found abandoned a lot each year can adversely affect ecosystems and difficult to be eliminate. The solid waste problems from water hyacinth can be reduced if it is used to produce natural fiber sorbent material. The results of the research project assume that the water hyacinth can be inexpensive and biodegradable oil sorbent in the environment.

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