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Effect the Viscosity of Used Oil by Adding Chitosan Based on Shellfish and Cellulose

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Abstract *This study explores the innovative use of chitosan from shellfish and natural cellulose as an additive to decrease the viscosity of used lubricating oils. We synthesized and applied chitosan and cellulose as adsorbents to filter impurities and enhance the rheological properties of the oil. During the experiment, different amounts of chitosan and cellulose were used, and the Ostwald method was used to measure the viscosity. As expected, adding more chitosan (20 grams) made the viscosity much better compared to mixes with cellulose. This led to a viscosity of 658.20 cP, while a 15:5 chitosan-to-cellulose ratio made the viscosity the lowest, at 513.06 cP. FTIR analyses confirmed the structural integrity of chitosan post-synthesis. Challenges in optimizing chitosan production, particularly in achieving standard deacetylation levels, were noted as potential limitations. The results suggest that using biopolymers like chitosan and cellulose together is a long-term way to improve oil recovery and reuse, lower waste, and make industrial uses better. In the future, researchers should concentrate on enhancing the manufacturing process of chitosan to enhance its adsorption capabilities, and explore alternative functional modifications that could enhance its utility in a wider range of scenarios.*

Keywords: *chitosan, shellfish, cellulose, viscosity, FTIR*

1. INTRODUCTION

Studies of late reveal that chitosan, a biopolymer obtained from shellfish waste and considered to be eco-friendly, can be feasibly used to recover metal content in waste oil. As an adsorptive polymer, its biopolymer has been derived from chitin, which occurs naturally, and finds its greatest application for adsorption in water treatment and environmental remediation. It is recognized that its molecular structure is characterized by amino and hydroxyl functional groups and thus can bond with metal ions and this way, jaw specializes as a heavy metal sorbent. So these studies may not have addressed the use of chitosan with waste oil but the principles of adsorption that they portrayed with aqueous solutions can be effective with waste oil because, chitosan and metal ions interact chemically rather than depending on the medium in which they are encased.

It has also been noted that chitosan can be enhanced through various physical or chemical modifications that may improve its adsorption properties. Such modifications include, adding functional groups or making composites with other materials that would enhance chitosan affinity towards specific metal ions present in waste oil. The ion-

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imprinting method highlighted by is another modification method that has been customized for targeting specific metal contaminants that would be in used oils.

While it is true that literature available so far makes no mention to chitosan being employed as an adsorbent of metals with waste oils, its practical success in elimination of metal ions from water should enable waste oils. In order to improve its use in oil adsorption, more tests and modification of chitosan to meet the needs of the utilized oil's chemical composition is paramount. Impurities contained in used oil, especially metals, are a significant challenge in performing recycling or re-use of spent oil due to environmental and machinery harm they may cause. One of the chitin-derivatives biopolymer, chitosan, has also been reported to be one of the highly efficient adsorbents in case of oil or oil-based liquid contaminated with metals. However, there is a need to perform several adaptations in order to optimize the utilization of chitosan. Various approaches can be explored, including changing the molecular structure of the chitosan compound and adjusting the pH level and the duration of oil contact. Modifications in chitosan's capacity to absorb materials will aid in enhancing the quality of used oil and reducing the adverse effects caused by metal impurities.

In addition, this procedure can lead to considerable cost savings as well as enhancing sustainability in the recycling industry. As cross-linking or grafting or combining with other adsorbent materials, or ion templating, or changing the structure of chitosan into hydrogels, nanoparticles, and nanofibers, etc are different optimization techniques which can be employed to improve metal adsorption with chitosan. Such transformations result in the development of structures that possess superior adsorption capabilities. Several authors have written about the possibilities of using chitosan based adsorbents to improve the ability of Absorption. It has been shown that chitosan as biopolymer derived from chitin has a high capacity of heavy metal adsorption due to high densities of amino and hydroxyl functional groups. Heavy metals such as pb and cd have been adsorbed onto Chitosan, and thus, it can be suggested this biomaterial might be useful in removing metal impurities from spent oil.

2. LITERATURE REVIEW

The use of chitosan which is a biopolymer obtained from chitin, the second most abundant natural polymer after cellulose has attracted interest in various fields due to its biocompatibility, biodegradability, and its being non-toxic. Chitosan is generally obtained through a deacetylation from crustaceans namely the exoskeletons of shrimps and crabs. This material special structure contains reactive amino and hydroxyl functional groups, which facilitates its chemical modifications and enhances its applicability for many purposes.

In as far as the petroleum and materials engineering industries are concerned, chitosan has been studied as an additive for altering the rheological characteristics of hydrocarbon based materials. As an example, chitosan was used as a surfactant for heavy crude oil and the results showed that with an increase in concentration of chitosan, the viscosity was improved which is important in the transportation and processing of crude oil. In a similar manner, the use of modified chitosan derivatives as bitumen modifiers led to an increase in the complex shear modulus, as well as the rutting resistance which should lead to more durable and resilient pavement materials. Another area of research also involved the combination of chitosan with cellulose, which is also a naturally occurring polymer to form composite materials with enhanced properties. Chitosan-cellulose composites also exhibit improved mechanical strength, thermal stability, and adsorption abilities.

This indicates that they may be applied for water purification, enhancement of biomedical devices, or alteration of different industrial processes' viscosity. The biopolymers that are utilized in the formation of these structures are complementary to each other, so that the resultant materials perform satisfactorily and are ecologically sound. It may be worth considering the incorporation of chitosan, especially with cellulose, since it is reasonable to expect enhancement in the viscosity of spent oils with such additives. Such an approach does improve the functional properties of the oils, but it is also in line with the increasing trend in many industries that require strict environmental standards. Chitosan based additives are also biodegradable and are non-toxic, hence they can provide a practical solution to replacing chemical additives. This provides potential for the use of environmentally friendly methods to improve oil viscosity and other parameters.

3. METHODS

The experimental method used in this study involves using chitosan from mangrove shells and natural cellulose as absorbents to reduce the viscosity concentration of used lubricating oil. This method can alter the viscosity of the oil, ensuring that the concentration of the filtered oil remains relatively similar to that of the used oil.

It was broken down into three steps: demineralization, deproteinization, and deacetylation. It was then mixed with seaweed cellulose and put in a 200-ml tube that contained five different amounts of chitosan and cellulose (20 grams of chitosan, 10 grams of chitosan/10 grams of cellulose, 20 grams of cellulose, 15 grams of chitosan/5 grams of cellulose, and 15 grams of cellulose/5 grams of chitosan). The settling time was 4 hours.

Material and Equipment

Materials

Figure 1. Documentation

a. Used oil (e.g. motor oil)
b. Shellfish
c. Hydrochloric acid (HCl)
d. Sodium hydroxide (NaOH)
e. Acetic acid
f. Distilled water
g. Stirrer
h. Heating equipment
i. Filtration settings
j. pH meter
k. viscometer

The equipment and materials used in this study are;

a. 1000 ml glass measuring cup
b. 500 ml glass measuring cup
c. 500 ml measuring cylinder
d. 3-necked flask
e. 50 ml glass tube
f. Petri glass
g. Ostwald viscometer
h. Sonic digital scale SSA -1000
i. Reflux distillation
j. Magnetic strimmer

k. Vacuum pump
l. Flour grinding machine

Chitosan Making Process

The stages of making chitosan are as follows:

Step 1: Making Chitosan from Mussel Shells

a. Cleaning and Crushing:
   1) Collect Mussel shells and remove any organic matter or dirt.
   2) Wash the shells thoroughly with distilled water.
   3) Dry the shells in an oven at 60°C until completely dry.
   4) Crush the dried shells into a fine powder using a mortar and pestle or mechanical grinder.

Figure 2. Documentation

b. Demineralization Stage.

A total of 30 grams of mangrove shell powder is placed in a three-necked flask. Next, add 1N HCL solution with a ratio of 15:1 (w/v) then reflux for 3 hours at a temperature of 90°C. The reflux results are then washed using distilled water until the pH is neutral and filtered using filter paper assisted by a vacuum device, then oven at 60°C until the sample is completely dry.

Figure 3. Documentation

c. Deproteinization Stage

19 grams of powder from the demineralization stage were put into a three-necked flask and Caustic Soda was added as a substitute for 4% NaOH with a ratio of 15:1 (w/v) the mixture was left for a moment after that it was refluxed at a temperature of 90^{o}C for 1 hour and accompanied by stirring. Furthermore, the mixture was filtered and washed using distilled water until the pH was neutral. The solid obtained was then ovened at a temperature of 60^{o}C until a consistent weight was obtained for chitin products from mangrove shells.

d. Distillation Stage

15 grams of the chitin powder that was made was put into a flask with two necks. Caustic soda was added in place of 60% NaOH at a ratio of 15:1 (w/v). The flask was then heated to 120°C and stirred continuously for one hour. After that, the mixture was washed using distilled water and filtered using a vacuum device until the pH was neutral. The solid obtained was dried in an oven at a temperature of 60°C until a constant weight of mangrove shell chitosan was obtained.

e. Drying

Dry the final product (chitosan) in an oven at 60°C until it reaches a constant weight. During the process of deproteinization, caustic soda as much as 4% and the reflux process for 1 hour and washed with distilled water until the pH of the sample becomes neutral so that chitin is seen from the shellfish story.

4. RESULTS

Deproteinization Stage

The chitin that has been obtained is then tested using an FTIR tool. The movement of chitin is as follows.19 grams of powder resulting from the demineralization stage was put into a three-neck flask and caustic soda was added as a substitute for 4% NaOH in a ratio of 15:1 (w/v). The mixture was allowed to stand for a moment, then refluxed at 90°C for 1 hour and accompanied by stirring. Next, the mixture was filtered and washed using distilled water until the pH was neutral. The solid obtained was then placed in an oven at 60°C until a consistent weight was obtained as a chitin product from mangrove shells.

From the deproteinization process using 4% caustic soda with a reflux process for 1 hour and washed with distilled water until the pH of the sample becomes neutral so that chitin is obtained from the shells. The chitin that was obtained was then tested using an FTIR tool. The movements of chitin are as follows:

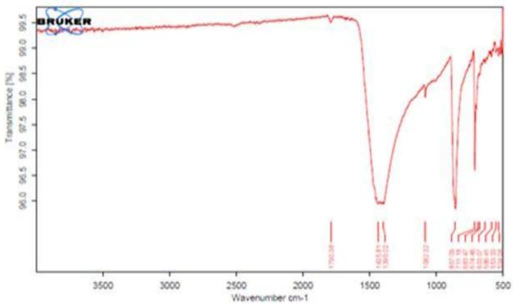

Figure 4. Graph of chitin content from the deproteinization process

Distillation Stage

A total of 15 grams of the resulting chitin powder was put into a 2-neck flask and added with 60% caustic soda as a substitute for NaOH in a ratio of 15:1 W/V, refluxed at 120°C for 1 hour and accompanied by stirring. After that, the mixture was washed using distilled water and filtered using a vacuum until the pH was neutral. The solid obtained was dried in an oven at 60°C to obtain a constant weight of mangrove shell chitosan.

The results of the distillation process where the sample that has been proteinization is then refluxed using 60% caustic soda with a reflux time of 1 hour, after which the sample is washed using distilled water until the pH is neutral and filtered using a vacuum device. The resulting solid is in the form of chitosan, the chitosan which has become a solid is then further analyzed using the FTIR test equipment again.

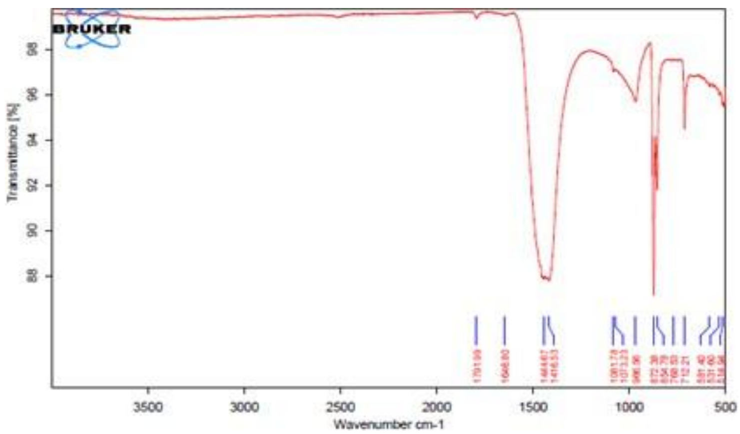

Figure 5. Graphic chitosan from the distillation process

From the graphic above, for each variation of absorbent material, it can affect the viscosity concentration in used oil. The lowest result is using an absorbent material concentration of 15 grams of chitosan / 5 grams of cellulose with a viscosity result of 513.06, and the highest result is 658.20 from a comparison of 20 grams of chitosan concentration. **Data collection process**

To determine the viscosity of the following oil, researchers use the Ostwald method. The steps taken are. First, determine the density of a 50 ml flask tube using a digital weighing scale, then insert the oil sample into the tube until it is parallel to the top tube cap and weigh it again. After the mass is known, insert the weighed sample into the Ostwald viscometer until it is parallel to the pipe line B, then use a vacuum balloon to pull the liquid up into tube A until it passes the predetermined time line, and the next step is to calculate the speed of the liquid when it drops to the existing line and then record it. Repeat the process until all samples have known viscosity.

Before testing the viscosity of the oil, the oil must first go through a filtering stage. To carry out the filtering process, prepare 1500 ml of oil. The following is the sequence of sample comparisons that will later be measured for viscosity using the Ostwald method:

a. 200 ml of used oil mixed with 20 grams of CHITOSAN, then stirred briefly and left for 4 hours. After being left for 4 hours, the oil is then filtered using filter paper assisted by a vacuum and the results obtained will be measured for viscosity using the Ostwald method.
b. 200 ml of used oil mixed with 10 grams of CHITOSAN and 10 grams of

CELLULOSE, then stirred briefly and left for 4 hours. After being left for 4 hours, the oil is then filtered using filter paper assisted by a vacuum and the results obtained will be measured using the Ostwald method.

c. 200 ml of used oil mixed with 20 grams of CELLULOSE, then stirred briefly and left for 4 hours. After being left for 4 hours, the oil is then filtered using filter paper assisted by a vacuum and the results obtained will be measured using the Ostwald method.

d. 200 ml of used oil mixed with 15 grams of CHITOSAN and 5 grams of CELLULOSE, then stirred briefly and left for 4 hours. After being left for 4 hours, the oil is then filtered using filter paper assisted by a vacuum and the results obtained will be measured using the Ostwald method.

e. 200 ml of used oil mixed with 15 grams of CELLULOSE and 5 grams of CHITOSAN, then stirred briefly and left for 4 hours. After being left for 4 hours, the oil is then filtered using filter paper assisted by a vacuum and the results obtained will be measured using the Ostwald method.

After carrying out the filtering stages in each comparison above. Samples that have been measured using the Ostwald method are then calculated for their viscosity which aims to determine changes in the characteristics of the oil that has been filtered.

Table 1. Viscosity test data on used oil

Absorbent Material	Concentration (grams)	Oil Samples Tested	Viscosity
Used oil	-	200 ml	762,21
Chitosan	20	200 ml	658,20
Chitosan / Cellulose	10 / 10	200 ml	576,09
Cellulose	20	200 ml	603,32
Chitosan/ Cellulose	15 / 5	200 ml	513,06
Cellulose / Chitosan	15 / 5	200 ml	588,01

From the table above, for each variation of absorbent material, it can affect the viscosity concentration in used oil. The lowest result is using an absorbent material concentration of 15 grams of chitosan / 5 grams of cellulose with a viscosity result of 513.06, and the highest result is 658.20 from a concentration comparison of 20 grams of chitosan.

5. DISCUSSION

Chitosan obtained from shellfish and cellulose incorporation was found to decrease the viscosity of the used lubricating oils to significant levels. This indicates an advanced approach on how to enhance the quality of recycled oil. As per the findings of the tests conducted, 20 grams of chitosan produced the maximum thickness of oil, at 658.20 cP. This shows that the oil is of high quality and can be expressed for further utilization in industrial processes. On the other hand, the combination of 15 grams of chitosan and 5 grams of cellulose showed the lowest viscosity of 513.06 cP. First, chitosan was synthesized through demineralization, deproteinization, and distillation of shellfish, then the product was confirmed through FTIR for chitosan's structural veracity. However, the results indicate that nevertheless chitosan can be naturally utilized to reduce oil viscosity without chemicals adding up as a thickening agent. However, the synthesis of chitosan was found to be associated with challenges in attaining the required deacetylation level which in return impacted the chitosan quality and regularity of the results.

Replacing commonly used chemical additives with natural substances like chitosan and cellulose, which are biopolymers, during oil recovery processes is quite a remarkable eco-friendly approach. This study holds a view that through the use of natural materials, it is possible to improve the quality of used oils, hence reducing industrial waste and promoting a circular economy. The subsequent researches should comprise of optimizing the processes of chitosan production with emphasis on increase in adsorption capacity and the degree of deacetylation of chitosan in order to retain a uniform quality of chitosan. Also, by performing various modifications such as cross-linking or incorporation of other adsorbents to chitosan some additional improvements in oil thickening and purification may be done. To conclude, these advancements may lead to improvement of recycling process for used oils making it the industries and the environment friendly.

6. CONCLUSION

When neutralizing the wet content that previously went through the reflux stage using 4% NaOH and 60% NaOH, this greatly affects the value of the chitin and chitosan content. For the oil filtration process, make sure the oil is truly pure from engine oil waste when choosing oil; make sure the used oil does not contain water; and make sure again that the used oil is pure oil from changing engine oil; it should not be mixed with other types of oil, such as gearbox oil.For further research, it would be better to master the manufacture of chitosan, look for more recent references to the manufacture of chitosan so that the chitin and chitosan content obtained is higher according to the chitosan standard which is at a wave approaching 3000 or more. Of course, in addition to chitosan, the material used is cellulose, which is intended to reduce the metal content in used oil. Why is that? Because the metal content can affect the lubrication process when the oil contains a lot of metal compounds. the oil heats up quickly so that the engine temperature rises quickly. this can cause the engine to overheat due to the oil drying out and there being no lubricant in the engine room. The output of this study is mainly on reducing the viscosity of used oil for the output results obtained with a ratio of 15:5 with a result of 513.06 cP, which is close to the viscosity standard for pure oil in the range of 100-500 cP, so for this result the oil is suitable for use for types of motorcycles in 125 cc where the engine torque is not too large and is suitable for using oil that is relatively thin.

LIMITATION

The shortcomings of this study are that the chitosan material does not approach the previous chitosan standards so that researchers add synthetic natural cellulose in the filtering process. There is also a problem in the process of making chitosan is the incomplete equipment in the laboratory so that researchers must repeat each chitosan making process until they get200 grams of chitosan in 17 repetitions, and researchers must also test the results in other places, this of course requires extra time and energy.

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