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CONVERSION OF FISHING VESSEL LUBRICANT WASTE INTO PURE OIL AND DIESEL FUEL: PROCESS AND POTENTIAL

Konversi Limbah Pelumas Kapal Perikanan Menjadi Minyak Murni Dan Bahan Bakar Diesel: Proses Dan Potensi

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ABSTRACT

Bitung city is one of the industrial, port, and tourist centers in North Sulawesi Province, with many fishing vessels passing through and docking in Bitung waters. Consequently, there is a potential for marine environmental pollution due to oil spills and the intentional or unintentional discharge of used oil into the sea. According to BPS data in 2022, there are approximately 1,100 fishing vessels operating in Bitung waters. Therefore, the daily demand for oil to meet the lubrication needs of main and auxiliary engines is increasing. This poses a significant environmental problem because fishing vessels in Bitung are generally not equipped with oil-water separators. The aim of this activity is to recycle used oil and refine it, while also converting the used oil into diesel fuel. The method used involves collecting used oil from fishing vessels, dissolving it with H_2SO_4 and NaOH, and separating it through a fractionation process to remove water molecules and heavy metals trapped in the long hydrocarbon chains of the oil. The results of the study indicate that this technology is effective in reducing contamination and producing products that meet standards. The addition of NaClO-NaOH-NaClO solution to kapok fiber enhances its hydrophilic properties, and the combination of H_2SO_4 and NaOH successfully binds impurities in the used oil. The use of activated charcoal effectively changes the color of the oil and removes contaminants. The recycled oil has a density of 0.837 g/cm³ and a specific gravity of 0.884, meeting the existing standards. The diesel fuel produced has a density of 0.801 g/cm³, approaching the industrial standard of 0.820 g/cm³. Thus, recycling used oil has the potential to be a suitable solution for addressing environmental issues while supporting the local economy.

Key words: Marine Environmental Pollution, Used oil, Diesel Fuel, Fishing Vessels, Bitung City

ABSTRAK

Kota Bitung merupakan salah satu pusat industri, pusat pelabuhan, dan kota wisata di Provinsi Sulawesi Utara sehingga banyak kapal penangkap ikan yang melintas dan bersandar di perairan Bitung. Dengan demikian, potensi pencemaran lingkungan laut dapat terjadi dalam bentuk tumpahan dan pembuangan minyak bekas ke laut secara sengaja maupun tidak sengaja. Berdasarkan data BPS tahun 2022, jumlah kapal penangkap ikan di perairan Bitung sekitar 1.100 unit. Dengan demikian, penggunaan minyak untuk memenuhi kebutuhan pelumas mesin utama dan mesin bantu setiap harinya akan meningkat. Hal ini menjadi masalah besar di lingkungan laut karena kapal-kapal penangkap ikan di Kota Bitung umumnya jarang dilengkapi dengan pemisah minyak air. Tujuan dari kegiatan ini adalah untuk mendaur ulang minyak bekas dan membersihkannya kembali, sekaligus mengurangi minyak bekas menjadi bahan bakar diesel. Metode yang digunakan adalah minyak bekas yang dikumpulkan dari kapal penangkap ikan dilarutkan dengan H_2SO_4 dan NaOH dan dipisahkan melalui proses fraksinasi untuk memisahkan molekul air dan logam berat yang terperangkap dalam rantai panjang hidrokarbon dalam minyak. Hasil penelitian menunjukkan bahwa teknologi ini efektif dalam mengurangi kontaminasi dan menghasilkan produk yang memenuhi standar. Penambahan larutan NaClO-NaOH-NaClO pada serat kapuk meningkatkan sifat hidrofiliknya, dan kombinasi H_2SO_4 dan NaOH mampu mengikat kotoran dalam oli bekas. Penggunaan arang aktif berhasil mengubah warna oli dan menghilangkan pengotor. Oli hasil daur ulang memiliki densitas 0,837 g/cm³ dan specific gravity 0,884, memenuhi standar yang ada. Solar yang dihasilkan memiliki densitas 0,801 g/cm³, mendekati standar industri yaitu 0,820 g/cm³. Dengan demikian, daur ulang oli bekas berpotensi menjadi solusi yang tepat dalam mengatasi masalah lingkungan serta mendukung ekonomi lokal.

Kata Kunci: Bahan Bakar Diesel, Kapal Penangkap Ikan, Kota Bitung, Minyak Bekas, Pencemaran Lingkungan Laut

INTRODUCTION

Hazardous and Toxic Waste is the remainder of a business or activity that contains B3 in very small concentrations but still contains hazardous and toxic materials (Azharuddin et al., 2020; Lina, 2021). This type of waste includes used batteries, used light bulbs, cosmetics and vehicle lubricants which generally contain ingredients that cause environmental damage and health problems (Gutberlet & Uddin, 2017; Putra et al., 2019). One of the workshop wastes is oil or lubricating oil which can be estimated to cause contamination of drinking water as much as one million gallons. If used oil is wasted in the environment, such as water sources or rivers and the sea, it will have an impact on the death of living creatures in it (Cordes et al., 2016; KILIÇ, 2021; Yanis et al., 2021).

Used oil is one of the wastes produced by motor vehicles and can be used as fuel which is environmentally damaging, because it contains many types of dangerous and toxic materials which are very exploitative in the loss of good elements in the environment. Increasingly, more and more B3 waste is being dumped into the sea and in high concentrations, resulting in environmental pollution on a local scale (Briffa et al., 2020; Nuruddin, 2020). Used oil is a category of liquid B3 waste which contains heavy metals from motor engines and also the residue produced is corrosive and deposits. (Islami M.L, 2019; Yohanes & Rukmana, 2020).

B3 waste contamination in used oil can cause various diseases such as lipid pneumonia, lipid granulomas in the lungs, eczema, folliculitis, and oil acne (Dikshith & Diwan, 2003). B3 waste enters the environment through water, soil, air and biota which influence it continuously and discontinuously, gradually and suddenly, regularly and irregularly. B3 waste poisons living creatures through the food chain, causing organisms (plants, animals and humans) to be exposed to toxic substances. The effects of B3 waste on living creatures, especially humans, include acute effects (nerves, digestion, respiration), chronic effects (cancer), mutagenetic effects, terotegenic effects (congenital defects), damage to the reproductive system, skin and death (Putra et al., 2019).

Currently, the use of used oil is still very minimal, namely only used as a lubricant for motorbike chains and when dismantling the engine. For this reason, many researchers have conducted research on the use of used oil recycling to overcome the large amount of used oil waste so that it can be reused sustainably. Research on used oil is carried out in order to reduce its viscosity, flash point, reduce dirt and heat produced from burning it. Processing used oil waste with constant heat treatment will produce liquid fuel with physical properties that meet standards. (Panda, 2011; Putra et al., 2019).

Several studies show that recycling used oil is an appropriate technology on a household and MSME scale to help the community's economy (Muchtiwibowo et al., 2016; Nuruddin, 2020). Using the acid-clay treatment method with a combination of alkyl benzene sulfonate in the process will remove contaminants in the oil. The result of the method is that it is able to reduce Pb in lubricating oil with a combination of adsorbents in the form of kapok fiber which is hydrophobic in nature so that it can separate used oil from oil and water (Pratiwi, 1998).

Recycling used oil using sulfuric acid and NaOH is carried out using a heating method to form a precipitate that can purify the oil (Suparta et al., 2015). Sulfuric acid is a strong acid compound that functions as a rust binding and alkylating agent in used oil. Meanwhile, NaOH is an alkaline chemical substance, which is useful for neutralizing the acidic properties of the used oil mixture during the dissolution process. The addition of activated charcoal is also used in the process to bind dye particles and purify the final result of used oil because it contains high levels of carbon, hydrogen, sulfur, oxygen and nitrogen (Prasetyo et al., 2023). The final stage of the used oil cycle process is conversion into diesel fuel, namely using the pyrolysis distillation method by breaking down large molecules from used oil and making it possible to make diesel fuel (Maceiras et al., 2016).

Based on this background, researchers conducted research on oil recycling using the chemical compounds sulfuric acid, NaOH, activated charcoal (active carbon), methanol, and kapok fiber as adsorbents. This theory aims to shorten the carbon chains in the oil.

METHODS

1. Material

Used oil was the main material in this research which was obtained from fishing vessels and industrial factories in Bitung City, North Sulawesi. NaOH solvent (R&N Chemicals, USA). H2SO4 and Methanol were obtained from PT. Main Source of Pure Chemistry Surabaya, Indonesia. Activated charcoal comes from coconut shells. The NaClO solution was obtained from PT. Jayamas Medica Industri, Sidoarjo regency, Indonesia. Kapok taken directly from Aertembaga District, Bitung City. This research was carried out in June 2023 at the Basic Laboratory of the Bitung Marine and Fisheries Polytechnic.

2. Eksperimen

This research uses an experimental method which aims to test the influence of one variable on other variables.

Preparation of kapok fiber from hydrophobic to hydrophilic

Kapok fiber is washed and cleaned until dry. Next, 10 grams of kapok were soaked in a NaClO solution (200 ml) with a concentration of 5% for 1 hour plus a 1% NaOH solution (5 ml), stirred for 10 minutes then washed thoroughly until pH 7. Then soaked in a 1% NaClO solution (200 ml) heated at a temperature of 70°C for 10 minutes and dried at a temperature of 40°C for 24 hours (Wolok et al., 2019).

Preparation of kapok fiber from hydrophobic to hydrophilic

A total of 100 g of activated charcoal was crushed evenly and soaked in 30 ml H2SO4 solution with a concentration of 0.35 molar and 40 ml mineral water for 48 hours. After soaking, wash until pH 7 and dry for 1 hour at 45℃, then carbonize. (Chikwe et al., 2020; Miskah et al., 2019).

Used Oil Treatment

Used oil treatment begins with settling for 24 hours to separate impurities trapped in the oil. Then filtration was carried out and the H2SO4 solution was added to the filtrate and left for 24 hours using a concentration of 5%. Next, the sediment and filtrate are separated. Used oil that still contains H2SO4 will be neutralized with a 5% NaOH alkaline solution. The NaOH solution functions as a base that will bind the strong acid H2SO4. Next, the used oil is filtered using kapok with two layers. The top layer is kapok without treatment to separate used oil from water and the bottom layer is kapok which has been treated with NaClO-NaOH-NaClO so that it is hydrophilic to absorb heavy metals that are still in the used oil.

Next, the used oil filtrate is placed in a container and methanol is added, heated and NaOH is added in a certain ratio. The purpose of adding methanol is to remove fatty acids in used oil and NaOH to neutralize it. Next, it is heated and continued with the addition of activated charcoal and the transesterification process.

Used Oil Decolorization and Transesterification Process

A total of 500 ml of used oil is placed in a container and mixed with 20 g of activated carbon. Next, it is heated at a temperature of 150oC for 1 hour, 30 minutes. Next, cool it to room temperature for 2 hours and separate the filtrate and residue using filter paper.

Density and Specific Gravity measurements

To measure density and specific gravity, you can use equations (1) and (2) below.

$$\text{Density} = \frac{mass\ of\ substance}{volume\ of\ substance} \quad \text{.......(1)}$$

Specific gravity (S.G) at °C

$$= \frac{Density\ of\ substance}{Density\ of\ water\ of\ same\ volume} \quad \text{.......(2)}$$

RESULT

1. Kapok Fiber Preparation from Hydrophobic to Hydrophilic

The addition of a NaClO-NaOH-NaClO solution in a certain ratio to kapok fiber can increase the hydrophilic properties of the fiber. In several studies, it was stated that the addition of NaClO solution together with NaOH was able to increase the amount of kapok fiber cellulose and remove a number of other non-cellulose compounds, such as pectin, wax and lignin (Wolok et al., 2019). The change in hydrophobic to hydrophilic properties can be seen from the water absorption capacity of kapok without treatment and kapok with treatment as can be seen in Figure 1.

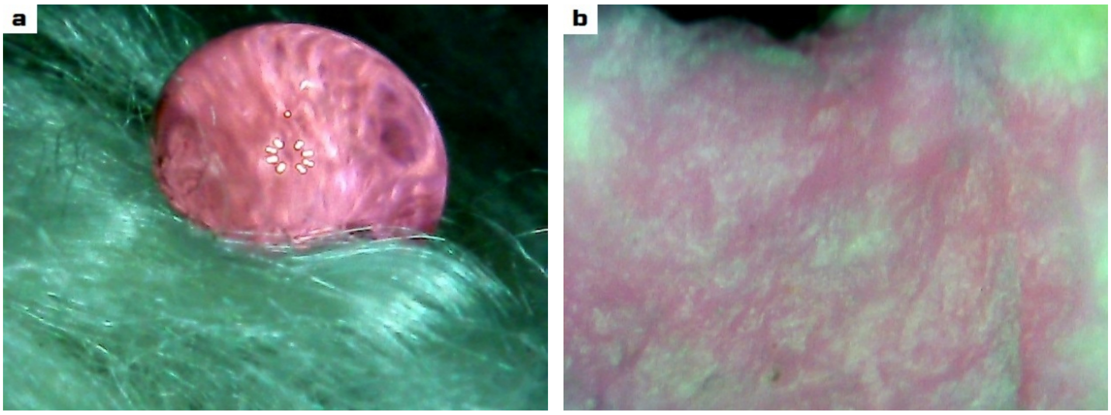

Fig 1. Water drops on: a) untreated kapok and b) kapok treated NaClO-NaOH-NaClO

The change in properties from hydrophobic to hydrophilic was caused by the breaking of the benzene ring chain in the phenolic functional group, which indicated the loss of lignin compounds in the kapok fiber and an increase in the hydroxyl functional group in the kapok fiber (Chung et al., 2008). Apart from testing water, absorption testing was also carried out on used oil. Figure 2 shows the uptake that occurred in both kapok without treatment and kapok with treatment.

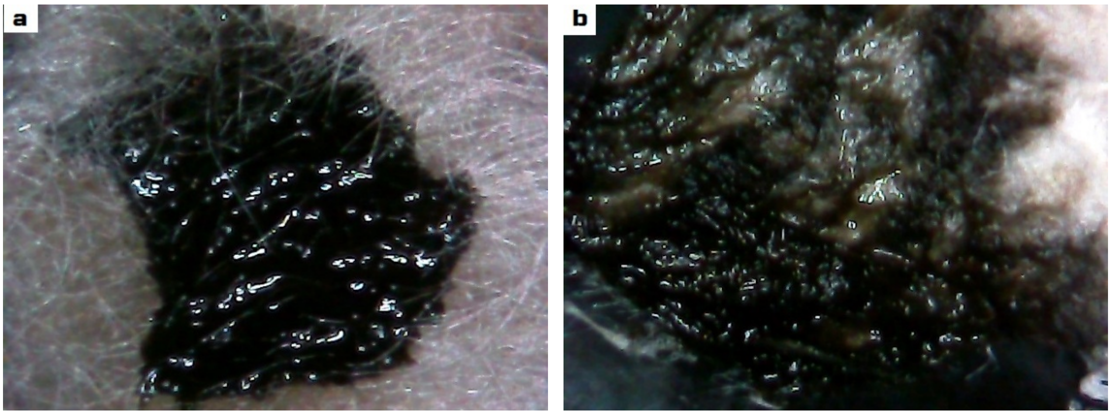

Fig 2. Drops of used oil on: a) untreated kapok and b) kapok treated NaClO-NaOH-NaClO

From Figure 2 we can see that used oil can pass through kapok fibers, both raw materials and treated kapok fibers. This will make it easier to separate sediment, water and heavy metal substances.

2. Synthesis of Pure Oil and Diesel from Used Oil

The used oil recycling process uses a combination of various chemical solutions such as H2SO4, NaOH and methanol to produce new products in the form of pure oil and diesel. H2SO4 and NaOH are acidic and basic solutions that are able to bind water and residues that are trapped in oil molecules. Used oil that has been mixed with the H2SO4 solution produces 2 layers in the form of sediment and water. In several studies, sulfuric acid is used as an activator which will bind fatty acids in used oil. Apart from that, H2SO4 functions to bind other impurities in used oil (Miskah et al., 2019). Then the NaOH solution is added to neutralize the acid in the oil which has been mixed with the H2SO4 solution. The addition of the NaOH solution is able to separate solid particles that have not been absorbed by the H2SO4 solution. The addition of acid-base compounds can be seen in Figure 3.

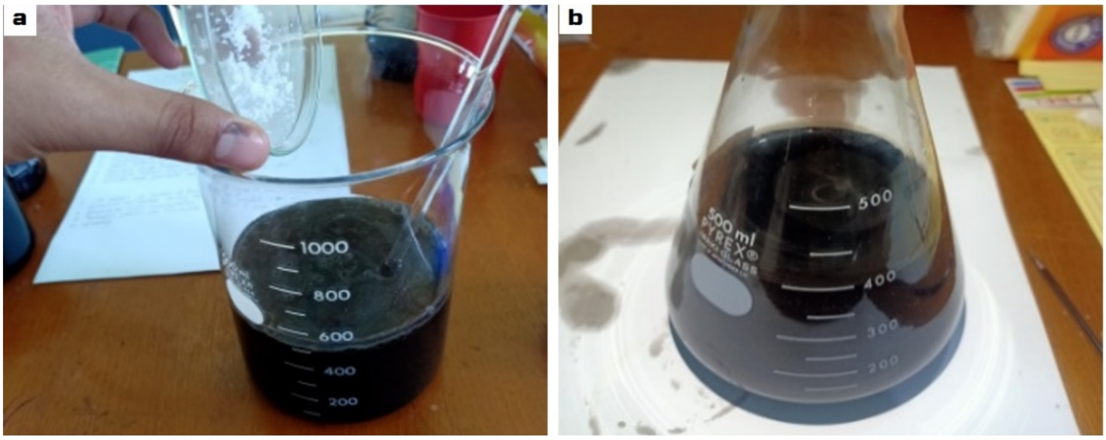

Fig 3. Oil with H_2SO_4 and NaOH solution

The amount and concentration of NaOH added to used oil follows the amount of H_2SO_4 solution added through the equilibrium concentration. The volume of NaOH (1 M) used was 200 ml for every 100 ml of H_2SO_4 (1 M). The sediment and water formed were then separated using kapok fiber in two layers. The top layer is untreated kapok and the bottom layer is kapok treated with a NaClO-NaOH-NaClO solution.

Used oil that has been filtered is then added with methanol to remove remaining fatty acids that are still trapped in the used oil. Next, NaOH is added at a certain concentration to neutralize the acid compound. Used oil that has gone through a sediment/impurity removal process is then mixed with activated charcoal. Figure 4 shows the process of mixing activated charcoal into used oil.

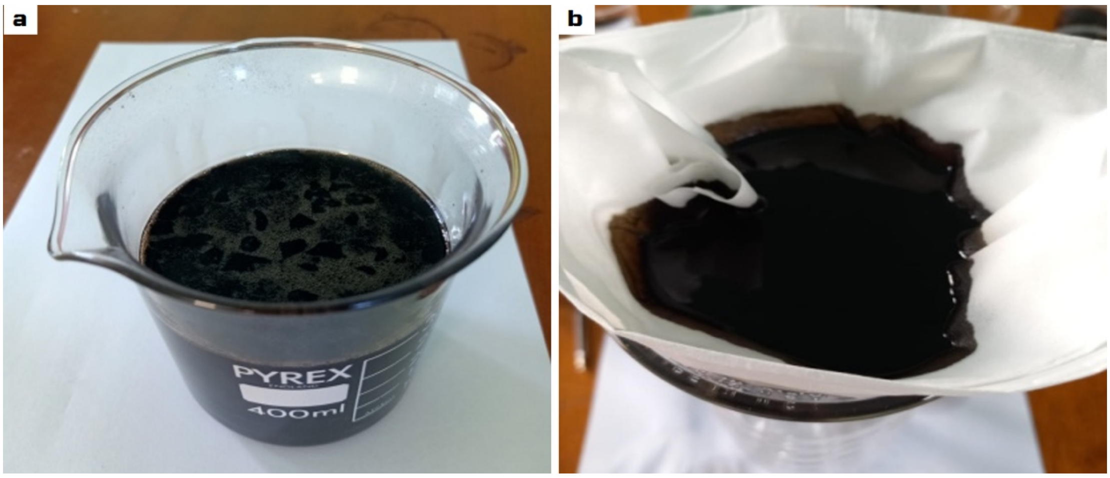

Fig 4. Used oil is mixed with activated charcoal to absorb any impurities remaining in the oil

The main purpose of adding activated charcoal adsorbent is to attract and bind impurity compounds, especially heavy metals and other non-hydrocarbon compounds that are still carried in used oil. After separating the activated charcoal, a transesterification process is carried out with heating to separate the diesel from the oil. The adsorption results with activated charcoal can be seen in Figure 5.

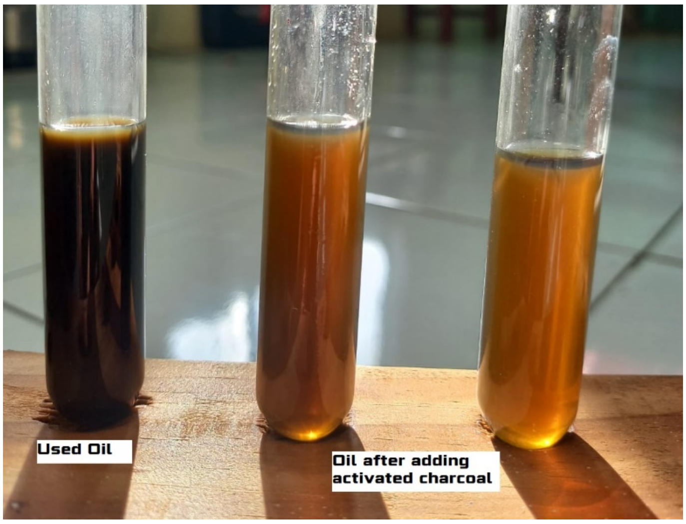

Fig 5. Comparison of used oil and oil after adding activated charcoal

From Figure 5 it can be clearly seen that the color change occurs before and after adding activated charcoal. Activated charcoal functions to bind metal ions or impurity compounds trapped in used oil. After separation with activated charcoal, the transesterification process continues by applying heat at a temperature of 200-250oC to separate diesel fuel from used oil. The separation results can be seen by comparing the color of the solution in Figure 6.

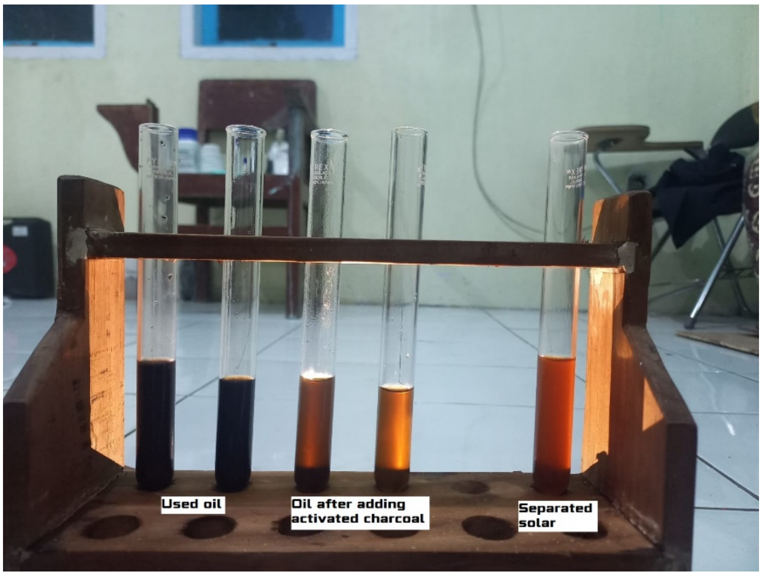

Fig 6. Comparison of used oil, oil after adding activated carbon, and diesel fuel that has been produced from the separation process

The process of separating diesel from oil is through a transesterification process with the addition of methanol-oil at a certain ratio. The results obtained were then tested for density and specific gravity. The results of the density and specific gravity tests can be seen in the table 1.

Table 1. Density and specific gravity in several test specimens at 25°C

No	Sample Name	Test Density	Density Theory	*Specific Gravity uji*	*Specific Gravity Teori*
1	Distilled Water	0,974 g/cm^3	1,000 g/cm^3	1,000	1,000
2	Used oil	0,821 g/cm^3	-	0,843	-

3	Oil after adding activated charcoal	0,837 g/cm^3	0,868 ± 2,14 g/cm^3 (Gideon & Tarigan, 2020)	0,884	0,800 – 1,000
4	Solar after separation	0,801 g/cm^3	0,820 g/cm^3	0,822	0,800 – 1,000

From Table 1, you can see the density and specific gravity of several solution samples. Based on these results, the oil resulting from the addition of activated charcoal meets the standards, while the diesel produced has a density value that is still below the industrial density, namely 0.801g/cm^3.

DISCUSSION

1. *Preparation of Kapok Fiber from Hydrophobic to Hydrophilic*

The addition of NaClO-NaOH-NaClO solution to kapok fiber has been proven to increase the hydrophilic properties of the fiber. This increase occurs due to chemical reactions that change the molecular structure of kapok fiber, especially by removing non-cellulose components such as pectin, wax and lignin. This change from hydrophobic to hydrophilic properties is very important, especially in applications that require high water absorption, such as fillers for sanitary products or textiles.

Research shows that the addition of NaClO-NaOH-NaClO can increase the amount of cellulose in kapok fiber. This chemical reaction involves breaking the benzene ring chain at the phenolic group, which indicates a loss of lignin and an increase in hydroxyl groups. This change can be observed through the increased water absorption capacity of kapok fiber after treatment (Figure 1).

Apart from that, this research also tested the ability of kapok fiber to absorb used oil. Test results show that used oil can easily pass through kapok fibers, both untreated and treated. This shows that kapok fiber, both before and after treatment, has the potential to be used in oil-water separation applications, which could be very useful in industrial waste management (Figure 2).

2. *Synthesis of Pure Oil and Diesel from Used Oil*

This research describes the process of recycling used oil using a combination of various chemical solutions to produce pure oil and diesel. The combination of H2SO4 and NaOH is used to bind and separate residues and impurities in used oil. The addition of H2SO4 produces two layers: sediment and water. The role of H2SO4 as an activator and binder of fatty acids in used oil is very important in this process. Next, the addition of NaOH aims to neutralize the acid that has been mixed with H2SO4 and separate the remaining solid particles (Figure 3).

After the initial separation process, methanol is added to remove residual fatty acids. This process is followed by the addition of NaOH at a certain concentration to neutralize the remaining acid. Then, the used oil is mixed with activated charcoal which has been activated. The addition of activated charcoal aims to bind and attract impurity compounds, especially heavy metals and non-hydrocarbon compounds (Figure 4). Comparison of used oil before and after the addition of activated charcoal shows a significant color change, indicating the effectiveness of activated charcoal in the used oil purification process (Figure 5).

The final process is transesterification by heating at a temperature of 200-250°C to separate diesel fuel from used oil. The results of this separation are shown through a comparison of the color of the solution in Figure 6. Density and specific gravity analysis of the resulting product shows that the oil produced after adding activated charcoal meets standards, while the diesel produced has a density slightly below industry standards (Table 1). This method not only improves the functional properties of kapok fiber but also provides a sustainable solution for the management of used oil waste, which is a significant environmental challenge.

CONCLUSSION

Based on research conducted on the used oil recycling process which produces pure oil and diesel fuel using materials in the form of sulfuric acid solution (H2SO4), NaOH, methanol, activated charcoal and the use of kapok fiber as an adsorbent. A solution of sulfuric acid (H2SO4), NaOH turns out to be able to bind dirt in the form of sediment in used oil, and activated charcoal which can change the color of used oil. This shows that the existence of appropriate technological treatment in the used oil recycling process can produce pure oil with a shorter carbon chain and diesel fuel, so that it can overcome the community's economy by reducing the costs of purchasing fuel and the ongoing scarcity of fuel. reduce.

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