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Research Paper

Electro-adsorption as a Hybrid Processing to Removed Oil from Synthetic Oily Solution by Using Activated Carbon and Iron Electrodes

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Abstract

Biosolar contains oil, fatty acids, emulsifiers, bactericides, and other chemicals. If the oil contents are mixed with water, it will become hazardous waste and affect drinking water sources, endanger human health, air pollution, affect agricultural production, and damage the natural landscape, so the oil content must be processed to reduce its hazardous content. One of the methods used in treating oily solutions is adsorption. The adsorption method for oily solution treatment is ineffective because it requires several stages, so the required capital is relatively larger and takes longer. Electro-adsorption is one of the methods that is being developed for treating oily solutions. Electro-adsorption is a hybrid separation technology to break down oil emulsions in wastewater and some other organic content. The purpose of this study is to characterize the activated carbon and determine the effect of voltage and time on synthetic oily solution treatment in terms of COD value and oil-fat content. A synthetic oily solution is made by mixing 1 g of biosolar/B30 into the water from the Musi River to a volume of 1 L. The application of the electro-adsorption method uses commercially activated carbon as an adsorbent and iron as an electrode. Variations given to the process with voltage 0, 5, 10, 15 V and time 0, 5, 10, 15, 20, and 25 minutes. The characteristic of activated carbon showed a size change in the pore size from 2.58 μm to 1.98 μm and a reduction of surface area from 740 (±180) m^2/g to 730 (±120) m^2/g. The electro-adsorption method was effective in treating oily solutions. The decrease of COD reaches the maximum level at a voltage 10 V for 25 minutes, which was 75.92% from 62.33 mg/L to 15 mg/L initially, while the concentration of oil-fat obtains the maximum level at a voltage of 5 V for 5 minutes that is equal to 99.65%, initially 303.19 mg/L to 1.05 mg/L. The optimum condition of the electro-adsorption process in synthetic oily solution was at the voltage of 5 V and a time of 5 minutes. The electro-adsorption process is an effective method to treat synthetic oily solutions.

Keywords
Activated Carbon, Electro-Adsorption, Hybrid Technology, Iron Electrode, Synthetic Oily Solution

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1. INTRODUCTION

The oil and gas industry is vital because it produces products that people need in their daily lives. High demand for products requires factories to continue to produce products in large quantities. The conducted process of producing products will also form waste. The oil and gas industry is an industry that produces hazardous and toxic waste. One of the industrial wastes is an oily liquid waste. Other industries that produce oily liquid waste are metallurgical, food, leather, and metal industries (Coca-Prados and Gutiérrez-Cervelló, 2010). Oily liquid waste cannot be directly discharged into the environment because it can affect drinking water sources, endanger human health, air pollution, affect agricultural production, and damage the natural landscape (Poulopoulos et al., 2005). It means that the waste must be treated first before being discharged into the environment. Oily liquid waste contains oil (mineral, vegetable, or synthetic oil), fatty acids, emulsifiers, bactericides, and other chemicals (Gryta et al., 2001).

The present oily wastewater treatment takes a long period and is inefficient. Therefore, a new method that is shorter, efficient, and able to process large waste at a time considering the large amount of waste produced due to the large mass production of oil in the oil and gas industry. Many methods can be used as a treatment process for oily wastewater. One of the methods is electro-adsorption which is a hybrid process of a combination of two methods between adsorption and electrolysis.

According to the United States Environmental Protection Agency (USEPA) that the adsorption process by utilizing activated carbon is one of the best environmental treatment technologies (Sivakumar et al., 2012). Activated carbon adsorbent is widely used because it has a high adsorption rate, high specific surface area, and even distribution of pores. In addition, it can adsorb up to 50% of the mass of the carbon itself (Khairunisa, 2008).

The adsorption and electrolysis methods each have an excellent ability to carry out the process. The adsorption method with the addition of voltage in the process can increase the ability of the adsorbent to adsorb unwanted substances. Combining the two methods can be seen in its ability in the research of Xie et al. (2018), which used electrochemical adsorption and succeeded in adsorbing solid particles with sizes below 10 m with an efficiency rate of more than 90%. Research conducted by Ziati et al. (2017) showed a high reduction rate using the electro-adsorption method to reduce chromium with the result reaching 96%.

Electrolysis is alternative energy used to produce hydrogen by breaking down water components into clean and pollutant-free hydrogen and oxygen (Saputra, 2018). The water electrolysis process is also considered to have high effectiveness in producing hydrogen, reaching more than 70% (Barbir, 2005). The adsorption and electrolysis methods each have an excellent ability to carry out the process. The adsorption method with the addition of voltage in the process can increase the ability of the adsorbent to adsorb unwanted substances.

The electrolysis method for doing its reaction process requires electrodes. Electrodes are a carrier consisting of electrolyte carriers and ionic carriers (Rivai, 1995). The materials which can and are often used ad electrodes are graphite, platinum, and gold. Other materials or electrodes that have been used for many research are carbon, iron, aluminum, copper, and stainless steel.

In this study, the electrode that will be used are iron electrodes. Iron is widely used as an electrode because iron is one of the materials with high durability and has a lower cost compared to aluminum (Casillas et al., 2007). The availability of iron electrode material is also abundant and its use has proven effective (Larue et al., 2003). Iron is also an excellent material to use at the anode because it is a trivalent ion. Trivalent ions have a higher ability to adsorb particles in water than bivalent ions due to their higher density (Koren and Syversen, 1995).

The research of Mohammed et al. (2011), treats oily liquid waste by adsorption method. The adsorbents used in his research were activated carbon and zeolite with expanded beds as a tool for adsorption. The sample used was corn oil which was prepared by mixing corn oil in distilled water. The best adsorption results from the two adsorbents were shown by activated carbon. The result can be seen from the oil concentration of the research results. By using an adsorbent weighing 2-8 grams for 20 minutes at a temperature of 30°C, activated carbon reduced the residual oil concentration from 20,000 ppm to zero ppm while in the zeolite adsorbent, the final oil residue concentration was 10,000 ppm.

Activated carbon is a combination of carbon atoms with a vast surface area obtained from the activation of the carbon. Activation is the treatment of charcoal or carbon to enlarge the pores. This activation is carried out by breaking the hydrocarbon bonds or by oxidizing the molecules from the surface until carbon change's physical and chemical properties. These changes are shown by increasing the size of the carbon surface and will affect the adsorption power (Sembiring and Sinaga, 2003). One gram of activated carbon that has been activated will be equivalent to a material having a surface area of 500m^2. The purpose of activation is usually to enlarge the carbon pores, but some of the activations are associated with increasing the adsorption power of activated carbon (Idrus et al., 2013).

Xie et al. (2018) used the electrochemical adsorption method on drilling fluids waste from domestic oilfields. The adsorbent used in his research is in the form of bentonite. The study was conducted by the electro-adsorption plate with a distance between plates of 5 cm, and the voltage used was 1.3 V and 1.6 V for 5 minutes. Electrosorption carried out aims to adsorb and remove solid particles with a size below 10 microns. This research obtained the efficiency of removing solid particles measuring 1-10 m up to more than 90% by using the single factor experiment.

The research that has been mentioned above focused on adsorption or electrolysis only. The combination of adsorption and electrolysis named electro-adsorption was done by Xie et al. (2018) and Ziati et al. (2017) also didn't focus on oily treatment by using activated carbon and iron electrodes. The adsorption method with activated carbon as an adsorbent is known to have a high level of oil adsorption in the waste. The combined method with the electrolysis process can also increase the oil absorption rate compared to without electrolysis. The advantages of both methods encourage the search for research on electro-adsorption. The research that will be carried out this time uses the electro-adsorption method using activated carbon adsorbents and iron electrodes to process synthetic oily solutions as a substitute for oily wastewater.

This study aims to determine changes in the characteristics of activated carbon and the effect of voltage and time on the electro-adsorption method on the synthetic oily solution as a replacement for the oily wastewater treatment process, which is resistant to COD levels and oil-fat content. The adsorbent used is commercial activated carbon. The activated carbon wrapping container used a type of spunbond fabric made from polypropylene. The electrode used in this study is iron electrodes. Synthetic oily solution treatment using the electro-adsorption method is expected to provide a better percentage of absorption than using only the electrolysis method or only adsorption method.

2. EXPERIMENTAL SECTION

2.1 Materials

The materials used for this research are the synthetic oily solution (using biodiesel/B30), commercial activated carbon in granular shape, Musi River water, and aquadest. The tools used are a 2 liters glass beaker, iron electrode plates with size

Table 1. The COD and Oil-Fat Content of Synthetic Oily Solution After Electro-Adsorption Process

Time (minutes)	Voltage (V)	COD (mg/L)	Oil-fat (mg/L)
5	0	23.5	7.99
	5	18	1.05
	10	19	1.15
	15	19	1.64
10	0	26.5	7.57
	5	20	1.82
	10	21	2.03
	15	20	1.89
15	0	23	7.71
	5	18	2.04
	10	21	1.78
	15	18	2.03
20	0	23	7.85
	5	18	1.73
	10	18	1.89
	15	18	1.77
25	0	24.5	7.98
	5	17	1.31
	10	15	2.04
	15	18	1.97

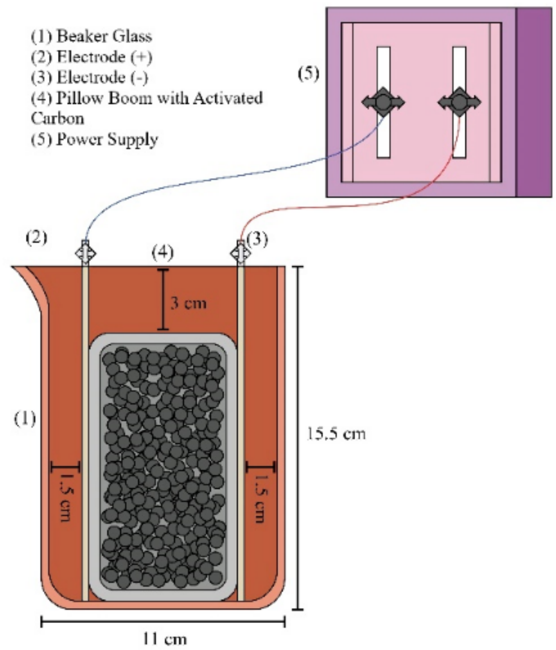

Figure 1. Schematic of Electro-Adsorption Equipment

17×5×0.1 cm, a power supply, a spunbond cloth made of polypropylene with size 12×8 cm, and a stopwatch.

The synthetic liquid solution used in this study was made by mixing the Musi River water and biodiesel (B30) into one vessel. A synthetic oily solution is made by mixing 1 g of biosolar/B30 with water from the Musi River to a volume of 1 L. The Musi River was used because this is the main source of water for Palembang society and this synthetic oily solution is analogous to biosolar/B30 spills to the river. The COD and oil-fat content of synthetic oily solution before the process is analyzed to obtain the initial characteristic to be compared later with the processed or final synthetic oily solution.

The activated carbon used in this research is commercial activated carbon. Activated carbon received from the seller still contains a lot of impurities, so the activated carbon needs to be washed before its utilization (Sahara et al., 2017). The activated carbon was first washed with water from the Palembang Regional Drinking Water Company then followed by doubled aquadest washing to remove dust and other impurities. The washed adsorbent was then dried in an oven at 110°C for 1 hour. The dried activated carbon as much as 50 g was placed into a spunbond bag made of polypropylene.

The research was conducted by applying an electric potential to the electrodes of 5, 10, and 15 V with specific time intervals (5, 10, 15, 20, and 25 minutes). As a comparison, a test was also carried out without using an electrode (voltage 0 V). The research procedure started when 1 mg/L of the synthetic oily solution is filled into the beaker glass with the electrode plates placed on the right and left sides in it. The electrodes are connected to the power supply. Then, the wrapped activated carbon is set in the middle of the electrodes. After all, the components are set in each of their places, turned on the power supply with the appropriate voltage, and countdown the time of the process, as seen in Figure 1. At the end of the process, turned off the power supply, took the adsorbent out, and analyzed the lean solution.

The activated carbon characterized by using Scanning Electron Microscope (SEM) and Fourier Transform Infra-Red (FTIR). The electro-adsorption process results are analyzed for COD levels based on SNI 6989.2:2019 and oil-fat concentrations based on SNI 06-6989.10-2004. The percentage reduction in COD and oil-fat concentrations are calculated using Equation (1), where C_0 is the initial COD/oil-fat concentration and C_t is the COD/oil-fat concentration at time t.

$$\% \text{ Removal} = \frac{C_0 - C_t}{C_0} \tag{1}$$

3. RESULTS AND DISCUSSION

The synthetic oily solution used in this study was made by mixing Musi River water and biodiesel (B30). The initial sample of the synthetic liquid solution was tested to be used as an initial sample characteristic before conducting research using the electro-adsorption method on the sample. The initial COD was 62.33 mg/L and the oil-fat content was 303.19 mg/L. The maximum permissible level based on the Regulation of the Minister of the Environment No. 19 the year of 2010 concerning the quality standard for the disposal of process wastewater from petroleum processing activities for COD was 160 mg/L and oil-fat was 20 mg/L. Based on that regulation the oil-fat content of the sample was 15 times more than the maximum permissible level.

The synthetic oily solution is then electroadsorbed with the variation of voltages of 0, 5, 10, and 15 V for 5, 10, 15, 20, and 25 minutes. The electroadsorbed oily solution was analyzed with COD and oil-fat parameters. The results of COD and oil-fat content of oily solution samples after the electro-adsorption process can be seen in Table 1.

Table 1 showed the results of the analysis with a big difference from the initial value. The oil-fat concentration in Table 1 ranged from 1.05 mg/L to 2.04 mg/L. That means the electro-adsorption process was effective to reduce the oil-fat content to a value that is lower than the permissible point of oil-fat content on the regulation of The Minister of Environment No. 19 the year of 2010. Similar results also occurred for COD values, that ranged from 15-21 mg/L. The results indicate that the electro-adsorption process has an influence on the analyzed parameter namely COD and oil-fat content which the effect explained later. At the voltage 0 volts which can be called as adsorption process only, the COD and oil-fat content resulted in 23-26.5 mg/L and 7.57-7.99 mg/L respectively.

3.1 Activated Carbon Characteristic

The activated carbon used in this research is commercial activated carbon. The activated carbon was prepared with the procedure explained in section 2. Characterization methods to determine the morphology and functional group in the activated carbon were Scanning Electron Microscope (SEM) and Fourier Transform Infra-Red (FTIR) respectively. Analysis of the activated carbon characteristics was carried out on activated carbon before and after the electro-adsorption process. The adsorbent samples to be tested were the highest oil-fat electro-adsorption results (at an operating voltage of 5 V for 5 minutes) to see the changes that occurred in it. SEM analysis results of activated carbon before and after the electro-adsorption process can be seen in Figure 2 and Figure 3.

The initial and final activated carbon presented in Figures 2 and 3 were characterized using SEM at a magnification of 5000×. Figure 2 showed rough topography (surface texture) and morphology, irregular porosity, and uneven pore size diameter. The pore size diameter ranged from 1.64 to 4.77 μm, with an average pore diameter of 2.58 μm.

In contrast, the pore diameter after the electro-adsorption process reduced, as seen in Figure 3. The shortest and the longest pore diameter were 1.16 μm and 2.92 μm respectively, with an average pore size diameter was 1.98 μm. The topography, morphology, and porosity were similar to Figure 2. This

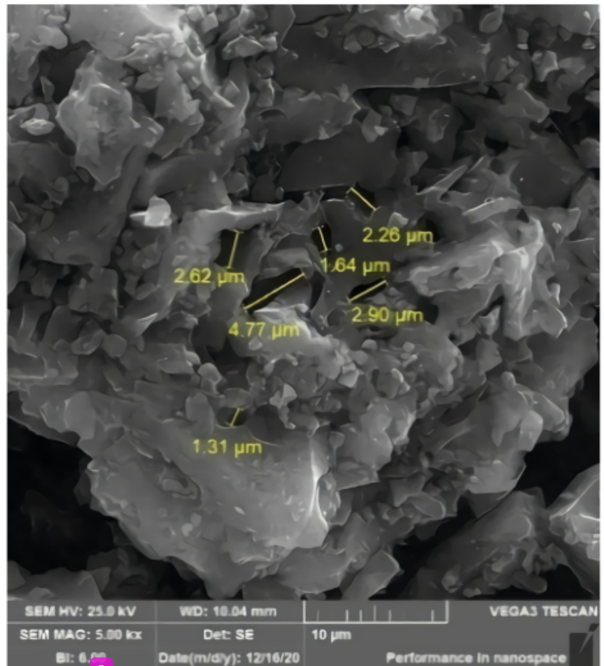

Figure 2. SEM Analysis of Initial Activated Carbon (Before Electro-Adsorption Process)

indicated the adsorption of oil molecules onto the activated carbon that stuck and covered the pore. The result of this activation was the degradation of the pore size diameter of the activated carbon. At the beginning of the process, the active site of the carbon was still empty so the adsorption process occurred in the fast stage. As time goes by, the oil molecules began to fill the active site of the carbon which causes the adsorption process to enter a slow stage. This matter is also supported by FTIR results that can be seen in Figure 4.

Based on analysis results using BET analyzer, the surface area of activated carbon before and after the electro-adsorption are 740 (±180) m^2/g and 730 (±120) m^2/g respectively. The reduction in surface area after electro-adsorption process indicates the presence of substances that are absorbed by the activated carbon.

Figure 4 showed the analysis results using FTIR before and after the electro-adsorption process. The green line in Figure 4, which was the FTIR result for activated carbon before the electro-adsorption process, did not show any peaks formed, that indicated no oily molecules adsorbed. The red line in Figure 4, the FTIR result of activated carbon after the electro-adsorption process, showed the peak of the wave, although not very sharp. The first peak formed at wavenumber 3700 - 3000 cm^{-1}, the wide wavenumber pointed the absorbance activity of the double bond with the H-OH hydroxyl group (3570-3200 cm^{-1}); the second peak formed at wavenumber 2150-2000

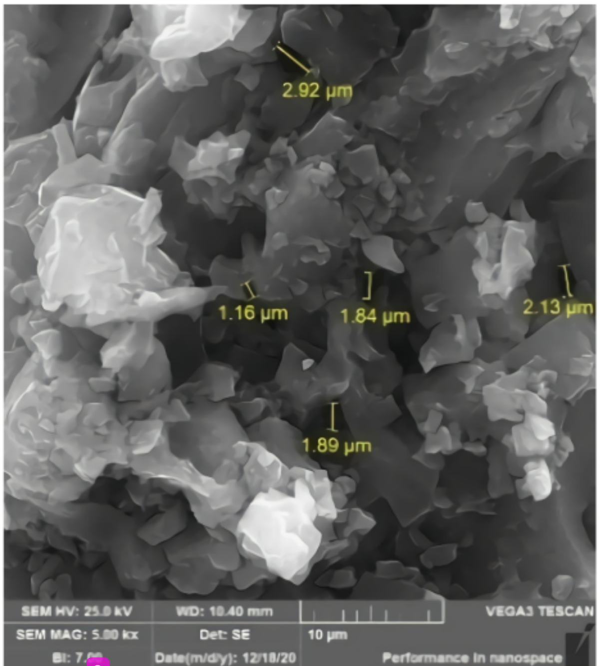

Figure 3. SEM Analysis of Final Activated Carbon (After Electro-Adsorption Process)

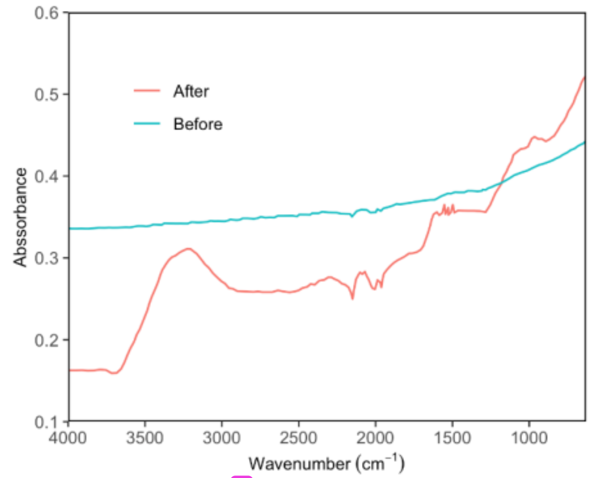

Figure 4. FTIR Analysis of Activated Carbon (Before and After Electro-Adsorption Process)

cm^{-1} showed the wavelength region of the triple bond; and the third peak formed that the smallest peak at wavenumber 1700-1500 cm^{-1} indicated the absorbance of the group with varying double bonds (Nandiyanto et al., 2019). This indicated the presence of a group of biosolar (B30) that adsorbed into the activated carbon.

3.2 Effect of Voltage and Time Variations on COD Levels

Chemical Oxygen Demand (COD) is the amount of oxygen needed to chemically oxidize organic and inorganic materials in water (Riyanti et al., 2019). The higher the COD number indicates the reduced dissolved oxygen content in the water so that water pollution is high. The effect of voltage and time variations on decreasing COD levels in synthetic oily solution samples was shown in Figure 5.

Figure 5 showed the results of COD level analysis ranging from 15 to 21 mg/L. The maximum reduction in COD level was 75.92% at a voltage of 10 V for 25 minutes, that reduced from 62.33 mg/L to 15 mg/L. A very drastic decrease in COD levels in the treatment of oily solution was shown in the first 5 minutes of the processing that pointed fast electro-adsorption, this result similar to Okiel et al. (2011) and (Ramli and Ghazi, 2020). In the next minutes, the changes that occurred were not as significant anymore, that showed slow electro-adsorption. The optimum condition for all of the voltage variations happened at contact time at 5 minutes. This showed the equilibrium condition of the electro-adsorption process. This was because the pores in the activated carbon had been filled with oil molecules that affected the adsorbent ability to degrade the COD level (Ramli and Ghazi, 2020).

According to Siregar et al. (2015), the longer the operation time, the ability of activated carbon to remove COD levels decreased which caused degradation of efficiency. The ability of activated carbon to adsorb is reduced due to the saturated pores of the activated carbon. As a comparison to see the effect of time on the COD levels reduction, a sample was time-tested at a voltage of 15 V for 75 minutes and obtained a final COD level of 20 mg/L. This value was still within the range of COD produced for 0-25 minutes.

Based on research conducted by Hamid et al. (2017), the addition of voltage to the process decreased the COD levels. Based on Figure 6, the average value of COD levels at various voltages of 5, 10, and 15 V were 18.2, 18.8, and 18.6 mg/L respectively. This showed that the addition of voltage had no significant effect on decreasing COD levels in electro-absorption of synthetic oily solution. This happened because if the voltage used was too high, a decomposition reaction will occur, which will affect the results of reducing the COD of oily solution (Xie et al., 2018).

Figure 6 described the percentage of COD removal ranged from 57.46% to 75.92%. This value was greater than the study conducted by Hamid et al. (2017) but lower than Yan et al. (2011). Hamid et al. (2017) reduced COD levels in domestic wastewater treatment using the electrolysis method from 192.96 mg/L to 85.92 mg/L or 55% COD removal. Yan et al. (2011) also researched the electrolysis method of petrochemical waste treatment using graphite type electrodes, get the best results at 60 minutes and 12 V, namely a reduction in COD levels from 1027 to 80.89 mg/L or 93.1%.

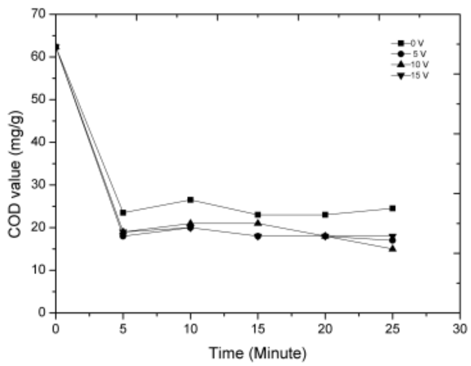

Figure 5. The Effect of Voltage and Time Variability of Electro-Adsorption Process on COD Levels

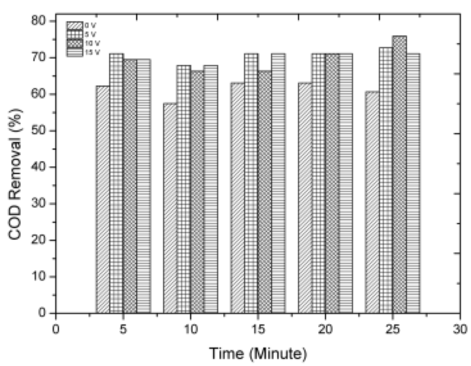

Figure 6. Percentage of COD Removal of Synthetic Oily Solution by Using an Electro-Adsorption Process

Figure 7 showed a comparison result of the percentage of COD removal using electrolysis, adsorption, and electro-adsorption methods. The average value for each process sequence was 50.24%, 61.32%, and 70.14%. COD removal by electro-adsorption method has the highest percentage. These results indicated that applying voltages to the adsorption process can increase the adsorption rate of COD from synthetic oily solutions.

3.3 Effect of Voltage and Time Variations on Oil-Fat Content

Oil and fat content are included in one of the water quality measurement parameters. High levels of oil and fat in wastewater indicate the amount of oil contained. The more oil content in the water showed a high level of water pollution by oil. The wastewater could not be directly discharged into the environment. The effect of voltage and time variations on the oil-fat

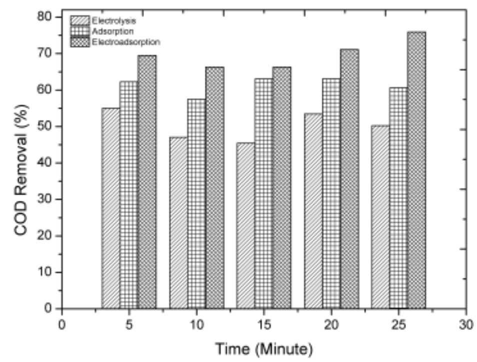

Figure 7. Comparison of Percentage of COD Removal with Various Methods

content of the synthetic oily solution was shown in Figure 8.

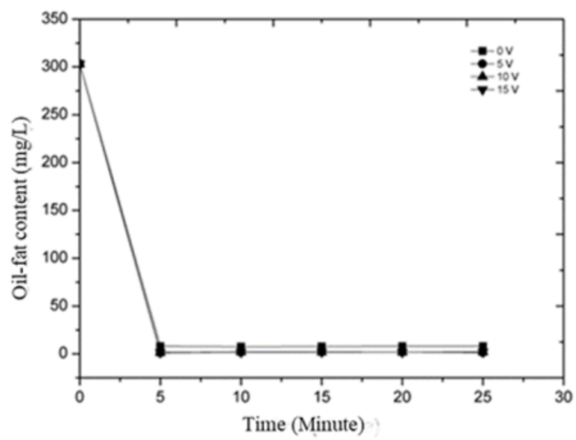

Figure 8. The Effect of Voltage and Time Variability of Electro-Adsorption Process on Oil-Fat Content

Figure 8 showed a drastic reduction in oil-fat content in the first 5 minutes of application. In the next minutes, there were no significant differences in the oil-fat data. The analysis results of the oil-fat content after the electro-adsorption method ranged from 1.05 mg/L to 2.04 mg/L. These values are appropriated with the Regulation of the Minister of the Environment No. 19 of 2010. The oil-fat and COD data showed a similar trend, where fast electro-adsorption occurred at the beginning of 5 minutes and slow electro-adsorption at the rest of the time applied (Ramli and Ghazi, 2020).

The oil-fat content in the sample was influenced by the duration of processing time. The longer the contact time between the adsorbent and the waste, the lower the oil-fat content (Okiel

Table 2. Comparison with Another Researcher that Focused on Oily Wastewater Treatment

Researcher	Process	Result
This research	Electro-adsorption	By using activated carbon and iron electrodes, the COD removal resulted from 57.46% to 75.92% and the oil-fat removal resulted from 99.33% to 99.65%.
Mohammed et al., 2011	Adsorption	Final oil concentration with adsorbent weight 2-8 g for 20 minutes from 20,000 ppm is 0 ppm (100% removal) for activated carbon and 10,000 ppm (50%) for zeolite
Okiel et al., 2011	Adsorption	The oil removal percentage using powdered activated carbon obtained 82.6% for oil concentration 836 mg/L and 72.5% for oil concentration that increased to 1613 mg/L
Xie et al., 2018	Electrochemical adsorption	Waste water-based treatment using electrochemical adsorption is a treatment without the potential environmental hazard
Ziati et al., 2017	Electrosorption	The application of potential had a significant result. The adsorption without potential obtained 33.7%, whereas with the application of -0.7 and -1.4 V potential, the adsorption of chromium up to 90% and 96%
Ramli and Ghazi, 2020	Adsorption	The results of maximum oil removal resulted from 99.89% at 1 mL/min flowrate with an oil concentration 5%w/v
Ulucan and Kurt, 2015	Electrocoagulation / electroflotation and Electrofenton	The results using an iron electrode in electrocoagulation process and electrofenton, for COD removal, resulted from 36.2% and 71%, for oil-grease removal resulted from 12.5% and 68.8%
Bhagawan et al., 2018	Electrocoagulation	The maximum COD removal using iron electrode obtained 60% in 40 minutes

et al., 2011). The highest reduction in oil-fat levels in synthetic oily solution reached 99.65%, and occurred at a voltage of 5 V for 5 minutes from the initial condition of 303.19 mg/L to 1.05 mg/L. The optimum condition for all of the voltage variations on oil-fat content is similar to COD, which happened at a contact time of 5 minutes. This showed the equilibrium condition of the electro-adsorption process. The pores of the adsorbent had been covered with oil molecules, thus inhibiting the next electro-adsorption process.

Experiments using a voltage of 0 V (with no electrodes applied), the process that took place only adsorption, showed that the oil-fat content ranged from 7.57-7.99 mg/L. These values were higher than the 5, 10, and 15 V electro-adsorption processes which have values ranging from 1.05-2.04 mg/L. These results explained that the application of voltages in the electro-adsorption process affected the absorption of synthetic oily solution in terms of oil-fat content.

Figure 9 showed the percentage of oil removal in synthetic oily solution ranged from 99.33% to 99.65%. These results are better than the research of Okiel et al. (2011) on activated carbon adsorbents, which succeeded in removing 82.6% and 72.5% oil-fat with initial oil concentrations of 836 mg/L and 1613 mg/L, respectively. Based on the research that had been done, the phenomenon of the electro-adsorption process occurred in the early minutes of the study; in the following minutes, there was no significant change. The same trend also occurred in the research of Ramli and Ghazi (2020), namely the oil-fat content with a concentration of 10% oil, which can be removed 99.87% in 2 hours. However, after 24 hours of application, it decreased to 73.04% due to the saturation level of activated carbon.

Figure 10 showed the comparison of the percentage of oil-fat removal using electrolysis, adsorption, and electro-adsorption methods. The average percentages for each process sequentially were 92.13%, 97.42%, and 99.39%. The graph pointed to the highest oil-fat removal reached by the electro-adsorption method. These results were not much different from the adsorption method, which successfully adsorbed oil-fat of 97.42%. These results indicated that the addition of voltage in the adsorption process could increase the efficiency of oil-fat adsorption from synthetic oily solutions. Another researcher that focused on oily wastewater treatment and the result comparison showed in Table 2.

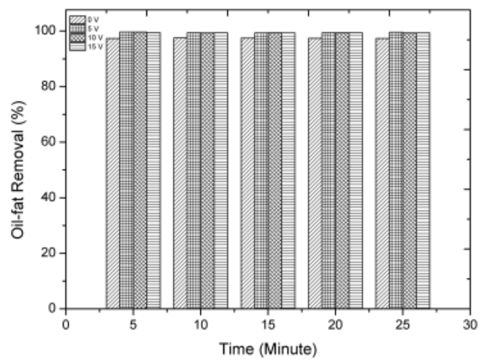

Figure 9. Percentage of Oil-Fat Removal of Synthetic Oily Solution by Using Electro-Adsorption Process

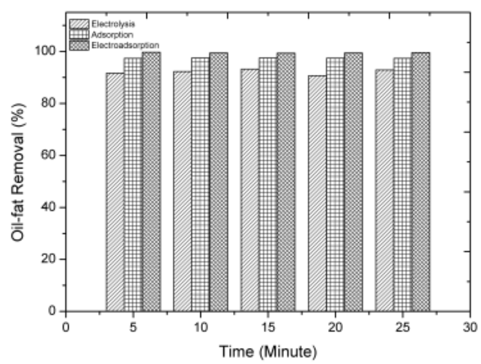

Figure 10. Comparison of Percentage of Oil-Fat Removal with Various Methods

4. CONCLUSIONS

Characteristics of activated carbon showed rough topography (surface texture) and morphology, irregular porosity, uneven pore size diameter. The average pore size changed from 2.58 μm to 1.98 μm. The surface area reduced from 740 (±180) m^2/g to 730 (±120) m^2/g. The changes occured due to the presence of COD components and the oil-fat content of synthetic oily solution that adsorbed onto the activated carbon.

The highest reduction in COD levels was produced at a voltage of 10 V for 25 minutes, which was 75.94% from 62.33 mg/L to 15 mg/L. The highest reduction in oil-fat content was produced at a voltage of 5 V for 5 minutes of 99.65% from 303.19 mg/L to 1.05 mg/L. The oil-fat and COD data showed a similar trend, where fast electro-adsorption occurred at the beginning of 5 minutes and slow electro-adsorption at the rest of time applied. That indicated the optimum condition of electro-adsorption process in synthetic oily solution was at voltage of 5 V and time of 5 minutes. After the first 5 minutes, the process reached equilibrium condition. It could be concluded that electro-adsorption process is an effective method to treat synthetic oily solution.

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