The effect of treatment with activated carbon on the metal content in reuse of lubricating oil waste

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Abstract. The effect of treatment with activated carbon to the metal content in the reuse of lubricating oil waste has been done. Waste lubricating oil has treatment using 1-butanol and KOH as a solvent and coagulant. The research studies of the effect of activated carbon to the metals are Pb, Cr, Ca, Mg and Fe in lubrication oil waste after treatment. Waste lubricating oil treatment by the adsorption method using activated carbon with various weight are 0,5; 1,0; and 1,5 g. The metal concentrate was analysis after and before treatment using Atomic Adsorption Spectrophotometer (AAS). The analysis result shown the best weight of activated carbon for decreased of metals contains in lubricating oil waste is 1.5 g. Metal concentration of Pb, Cr, Ca, Mg and Fe in lubricating oil waste before treatment are 181.0002, 10.7198, 1019.0220, 325.8788 and 365.1329 mg/L (ppm), respectively. Metal concentration of Pb, Cr, Ca, Mg and Fe in lubricating oil waste after treatment are 47.5670, not detection, 2.6871, 44.3251 and 222.043 mg/L (ppm), respectively. Base on ASTM D5185 standard shown the Ca, Mg and Cr metals concentration according to the new lubricating oil quality standard. Pb and Fe metals concentration after process are still above the new lubricating oil quality standard. As a conclusion is activated carbon is a good material for treatment of waste lubricating oil, especially to reduce metal concentrations.

1 Introduction

Waste lubricating oil is hazardous and toxic waste according to Government Regulation No.101, the year 2014. Waste lubricating oil can hazards to humans, the environment, and other living creatures so that there is a need for B3 waste management processes including waste oil. Waste lubricating oil waste contains contaminants such as water, salt, impurities, metals and others [1]. The metal on used oil is derived from engine wear. On the move of the engine is turned on, the moving machine will occur friction on the metal which will cause the release of particles or metal molecules from the event [2].

Heavy metals are very toxic and will harm the environment. The properties of heavy metals are difficult to degrade, can accumulate in organisms including shellfish and fish, and endanger human health, easily accumulate in sediments, so their concentration is higher than the concentration of metals in water. The waste lubricating oil contains heavy metals are Fe, Ca and Mg which are semi toxic metals and toxic metals are Pb and Cr.

According to Ali et al. [1], the potential of waste lubricating oil is very extraordinary. So many industries have done waste oil waste management into new oil that can be used again. Methods used such as the method of vacuum and hydrotreating distillation. This method is difficult to be a low investment model in small scale industries, as well as with acid clay method. The acid clay method has low investment but is not environmentally friendly with its tar products containing sulfuric acid and is very dangerous.

Several studies of waste lubricating oil processing into new oil have been widely practiced, for example, Mohammed et al. [3] using solvent extraction and adsorption methods. In the extraction process varied solvents are n-hexane, 1-butanol, ether, 1-hexanol, carbon tetra chloride and acetone. Udonne [4] has been to recycle waste lubricating oil using four methods are adding acid, vacuum distillation, acid addition and addition of activated charcoal. The quality of the oil is tested at the point of flame, pour point, type density, metal content, viscosity, and sulfur content. The extraction and adsorption of lubricants have been done by Kamal and Khan [5]. In this study, the best solvent was 1-butanol produced by the maximum sediment followed by methyl ethyl ketone, 1-hexanol, and 2-butanol. Hussein, et al. [6] has been researched is oil refining may be performed by solvent extraction. The solvents used are alcohols (methanol, 1-propanol, butyl alcohol and isobutanol), ketones (acetone and methyl ethyl ketones) and hydrocarbon solvents ie n-hexane.

Reduction of the concentration of heavy metal content in waste water using activated carbon has been done by Dinesh et al. [7]. Activated carbon has a good ability to absorption of heavy metals. Several researchers has been used activated carbon for absorption Pb^{2+} [8], absorption of heavy metals [9] and removal of heavy metals from

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industry waste water [10]. Heavy metals analyzed in this research are metal Pb, Fe, Cu, Cd. Maoura, et al. [11] in the study explains that the oil waste has a substance that is carcinogenic such as PAH so that the research aims to reduce the content of PAH in used oil. The best method of waste lubricating oil treatment has been done by Mohammed et al. [3]. Waste lubricating oil has been treatment using 1-butanol dissolution with a 3: 1 ratio with oil, coagulation using KOH and adsorption using acid-activated clay. The method uses fewer organic solvents, uses most of the processes at room temperature and reduces the effects of global warming and has a lower investment. Fuadi et al. [12] has been done using activated carbon as the heavy metal adsorbent in leachate water is able to absorb heavy metals in the waste.

The weakness of some researchers conducted is not yet report the effect of treatment on the metal content and conformity with ASTM standard. In this paper will deliver the results of the study the effect of treatment with activated carbon to the metal content and organic compounds in the reuse of lubricating oil waste. The aim of this study was to the effect of treatment of waste lubricating oil using activated carbon to the metals concentrations (Pb, Cr, Ca, Mg, Fe). The quality of new lubricating oil or waste lubricating oil after treatment was compared with ASTM standard.

2 Experimental Sections

2.1 Materials and Instrumentations

This study uses chemicals such as waste lubricating oil from collected from a motor vehicle repair shop, potassium hydroxide (KOH), 1-butanol, activated carbon, hydrochloride acid (HCl), nitric acid (HNO_3). All chemicals used in this research are of pro analysis grade and manufactured by Merck. All the solutions in the research have been prepared using distilled water. This research was used Atomic Absorption Spectrophotometer (AAS) from Perkin Elmer PinAAcle 900T for determination of heavy metals and Gas Chromatography-Mass Spectrometry (GC-MS) from Shimadzu QP 2010 SE was used for determination of organic compounds in before and after waste lubricating oil treatment.

2.2 Waste lubricating oil treatment

Waste lubricating oil and 1-butanol is inserted into 100 mL beaker glass with a ratio of 1: 3. The mixture is added 2 g of potassium hydroxide (KOH). The mixture is stirred for 30 minutes or until all of the mixture dissolves at 350 rpm. After stirring process is allowed to stand for 24 hours at room temperature. Then the solution is filtered with Whatman filter paper 4.2 with the help of the vacuum pump. The filtrate is distilled to separate 1-butanol with oil. The end result of this step is the new lubricating oil. The activated carbon is inserted into the porcelain cup, then activated with the oven at 105 ° C for 1 hour. Activated carbon with a variation of 0.5, 1.0 and 1.5 g. The activated carbon is introduced into the sample solution. The mixture was stirred with the stirrer for 60 minutes or until all mixed and heating 60 °C. The mixture is allowed to stand for 24 hours, then filtered. The result is new lubricating oil and analysis using AAS and GC-MS.

2.3 Preparation of sample for analysis heavy metals using AAS

Waste lubricating oil before and after treatment was weighed 1.68 g in the porcelain cup, and then heated with the oven at 100 °C for 1 hour. The sample was heated for 1 hour with a temperature of 600 °C using the furnace. The result of this process is ash. The ash was added HNO_3 and HCl each of 5 mL, then heated until the vapor is lost. The sample solution is included in a 100 mL volumetric flask and diluted with distillate water. The solution was analyzed by AAS to determine the heavy metal content of Mg, Fe, Pb, Ca, and Cr.

2.4 Preparation of sample for analysis organic compounds using GC-MS

Waste lubricating oil before and after treatment was taken as much as 15 mL and added with n-hexane as much as 60 mL and acetonitrile as much as 40 mL. The sample is inserted in a separating funnel, then shaken for 1 hour and allowed to stand for 30 minutes until two layers are formed. The upper layer is collected and then evaporated using rotary evaporator at 74°C and analyzed by GC-MS.

3 Result and Discussion

3.1 Waste lubricating oil before and after treatment with activated carbon

Figure 1 shows the color changes of waste lubricating oil before treatment (1A) and wastes lubricating oil before treatment (1B). Waste lubricating oil after treatment is obtained oil with the same color as new oil or lubricating oil before use. Waste lubricating oil has a black color and wastes lubricating oil after treatment has a brownish yellow color. Waste lubricating oil that has been the treatment to produce oil that has the same color with the new oil.

3.2 Chromatogram GC-MS waste lubricating oil before and after treatment

Figure 2 and Table 1 shown the waste lubricating oil has been chemicals compounds are 3-penten-1-ol, n-Hexane, methyl cyclopentane, 1,2,4-trimethyl benzene, cyclopentane, cycloheptane, 2-methyl naphthalene, hexadecanoic acid methyl ester, nonyl-diphenylamine, octyl-diphenylamine, 1,2-benzene dicarboxylic acid, dioctyl ester, 1,4-dibutoxybutane. The 3-penten-1-ol and n-Hexane in the waste lubricating oil have the highest levels compared to other compounds. The compounds of n-hexane have been derived from the solvent used in the extraction process. Carboxylic compounds are produced from the oxidation process of the compound with the OH group.

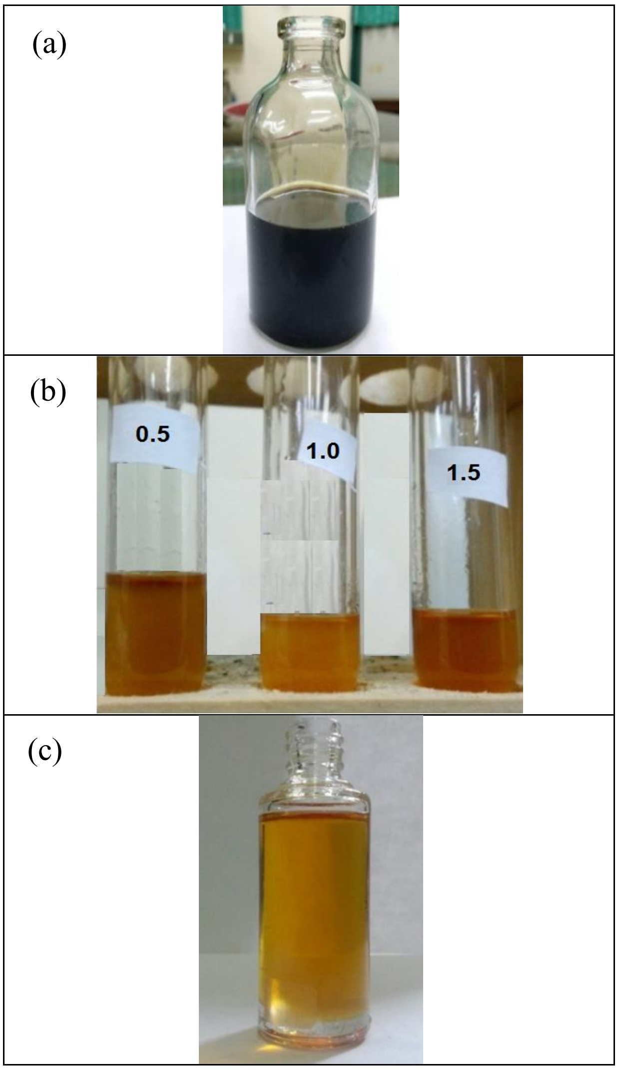

Figure 1. Image of waste lubricating oil before treatment (A) after treatment with activated carbon 0.5, 1.0 and 1.5 g (B) and new lubricating oil (C)

The results of this study are different from the results of the study Khalaf et al. [13]. Khalaf et al. [13] has been done separation and identification of organic compounds in lubricating oil additives using GC-MS. Lubricating oil have compounds are 2-ethyl-1-hexanol, 2-(t-butyl)-phenol, 2,4-bis-(t-butyl)-1-methoxy benzene, 2,6-bis-(t-butyl)-2,5-cyclohexadiene-1,4-dione, 2,4-bis-(t-butyl)-phenol, 3,5-bis-(t-butyl)-phenol, decanoic acid methyl ester, tridecanol, 1,1-diphenyl hydrazine; 1,2-benzene dicarboxylic acid dibutyle ester, S-triazol 1,5-A-pyridine 8-amino 2-phenyl, phenol-2,6-bis-(t-butyl), phenol-2,5-bis-(tbutyl), phenol - 2,4,6-Tris-(t-butyl).

Waste lubricating oil after treatment using butanol 45 and 60 mL has been the result the chemicals compounds is di-9-octadecenoyl-glycerol. This chemicals compound is the main compound in the lubricating oil. The n-butanol compound in the waste lubricating oil is from the solution was used treatment.

Table 2 shown is the effect of treatment of waste lubricating oil using activated carbon to the concentration of Pb, Cr, Ca, Mg and Fe metals. Waste lubricating oil to contain the metals of Pb, Cr, Ca, Mg and Fe is 181.00, 10.72, 1019.02, 325.88, and 365.13 mg/kg, respectively. When the values obtained in the waste lubricating oil after treatment with activated carbon samples were compared with the standard values, it has been determined that the metals have reached to standard levels for the new lubricating oil (Table 2). The Pb, Cr, Ca, Mg, Fe concentrations in waste lubricating oil before and after treatment were compared with international standards. Pb and Fe values were higher than standard values of ASTM D5185. The obtained results showed that, with the exception of Pb and Fe, the metal concentrations in water did not exceed ASTM D5185.

A significant decrease in concentration occurred in Cr metal. Cr metal concentration on waste lubricating oil of 10.2 mg/kg drops to very low concentration so it is not detected with AAS (Table 2). Cr metal is the heavy metal so its presence in oil is very dangerous. Cr metal is very low concentrations indicate excellent oil quality. Zajac et al. [14] has been the determination of metals content in used oil using XRF method. The contents of iron, and copper also were high, at Fe 16.5-267 mg/kg. Low manganese, chromium, and lead contents were found in the ranges Mn 0.41-4.27 mg/kg, Cr 0.36-10.66 mg/kg, and Pb 0.9-13.71 mg/kg. The difference in the results is due to the difference in the sample of used oil analyzed.

Pb and Cr metals are classified as hazardous, toxic and carcinogenic substances. Pb and Cr, when introduced into water reservoirs, is significantly absorbed by sediments. However, it also is subject to strong bioaccumulation, particularly in phytoplankton, which effects its fast incorporation into the food chain. In lubricating oils metals mainly comes from the piston rings and the shaft.

3 Conclusions

Waste lubricating oil after treatment has color same new lubricating oil. The color is brownish yellow produced by using adsorbed by activated carbon with weight as 1.5 g. The resulting color is brownish yellow, while the new lubricating oil color is crystal clear yellow. The effect of adsorbed by activated carbon with weight as 1.5 g to metal contained in waste lubricating oil is the decrease in Ca and Pb metals. The best amount of activated carbon used for metal adsorption in waste lubricating oil treatment is 1.5 g. This indicates that the increasing amount of activated carbon, the increase of absorption capacity of the metal in the waste lubricating oil. As a conclusion is activated carbon is a good material for treatment of waste lubricating oil, especially to reduce metal concentrations.

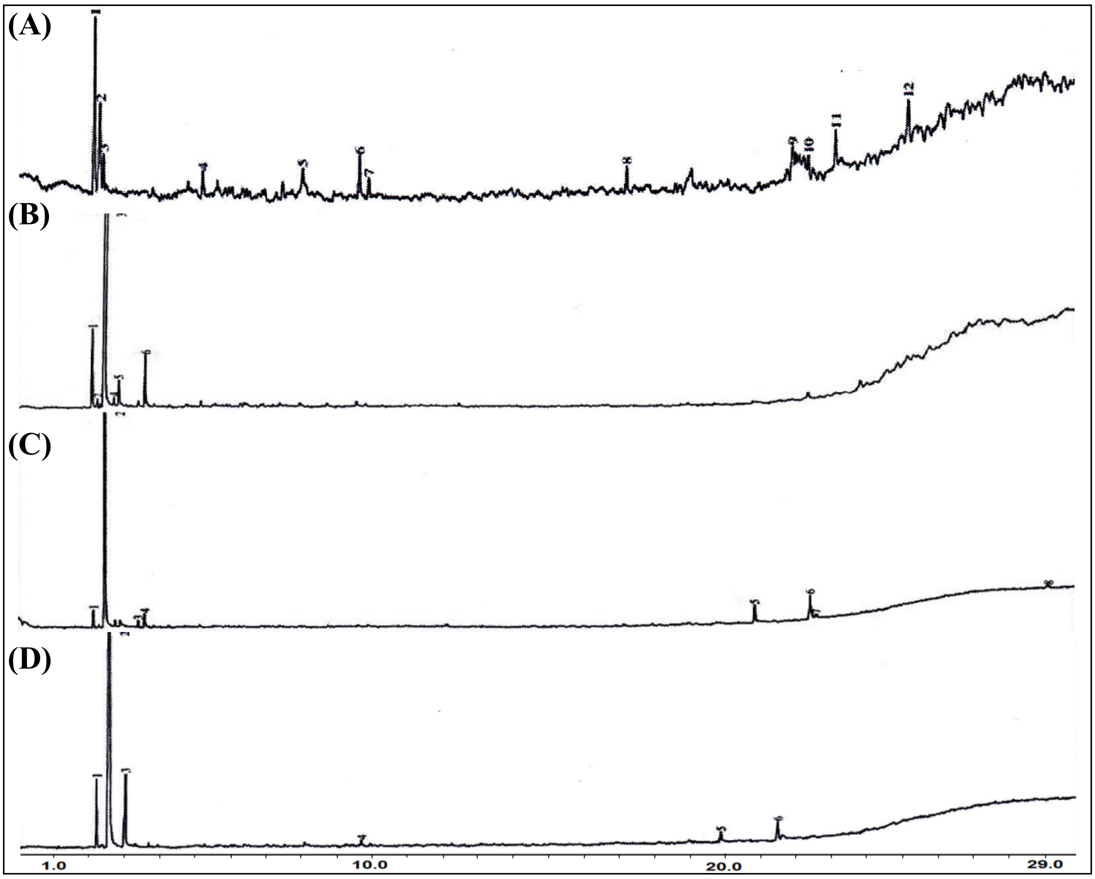

Figure 2. Chromatogram from analysis waste lubricating oil (A) after treatment using 30 (B) 45 (C) and 60 mL (D) n-butanol using GC-MS

Table 1. Chemical composition of waste lubricating oil before and after treatment using 30, 45 and 60 mL butanol

Retention time	Name of compounds	Waste lubricating oil % area	After treatment with Butanol in mL (% area)		
			30	45	60
2.192	3-penten-1-ol	28.69	-	-	-
2.367	n-Hexane	19.86	-	-	-
2.467	Methylcyclopentane	4.80	-	-	-
5.267	1,2,4-Trimethylbenzene	4.59	-	-	-
8.100	Cyclopentacycloheptane	3.01	-	-	-
9.725	2-Methylnaphthalene	7.87	-	-	-
9.988	2-methyl-naphthalene	3.42	-	-	-
17.283	Hexadecanoic acid methyl ester	4.40	-	-	-
21.967	Nonyl-diphenylamine	5.72	-	-	-
22.408	Octyl-diphenylamine	3.16	-	-	-
23.183	1,2-Benzene dicarboxylic acid, dioctyl ester	6.65	-	-	-
25.200	1,4-Dibutoxybutane	7.83	-	-	-
2.201	3-Pentyn-1-ol	-	2.11	0.94	1.21
2.367	2-methyl-butanal	-	0.31	-	-
2.531	Butyl alcohol-N	-	95.50	92.77	96.20
2.831	2-methyl-1-butanol	-	0.32	-	-
2.962	Acetamide	-	0.71	-	1.85
3.660	3-methyl-butanoic acid	-	1.06	0.71	-
3.482	2-methyl-3-hexanone	-	-	0.45	-
20.905	2-hydroxy-1,3propanediyl ester-hexadecanoic acid	-	-	1.56	-
22.492	Di-9-octadecenoyl-glycerol	-	-	2.42	0.46
22.667	2-hydroxy-1,3propanediyl ester-Octadecanoic acid	-	-	0.42	-
29.225	2-hexadecanol	-	-	0.73	-
9.716	1-methyl-naphthalene	-	-	-	0.10
19.857	Butyl ester hexadecanoic acid	-	-	-	0.18

Table 2. The effect of treatment using activated carbon of waste lubricating oil to concentration of metal

Sample	Concentration of metal (mg/kg)				
	Pb	Cr	Ca	Mg	Fe
Waste lubricating oil	181.00	10.72	1019.02	325.88	365.13
0.5 g activated carbon	158.25	nd*	41.34	15.31	46.70
1.0 g activated carbon	51.33	nd*	15.34	21.18	90.58
1.5 g activated carbon	47.57	nd*	2.69	44.33	222.04
ASTM D5185 standard	16	0.12	1103	870.80	2.76

nd* = not detection

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