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Research article

Recycling of Used Engine Oil into Reusable Oil: A Waste to Wealth Inventiveness

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ABSTRACT

This study examined recycling of used engine oil into reusable oil: a waste to wealth inventiveness. Using a unique combination of solvent extraction and activated alumina adsorbent, the refinement of lubricating oils from used lubricating oil was investigated. Experimental evaluation of these solvent extraction blends' activity using oil-to-solvent ratios ranging from 1:1 to 1:3 was done for combination blends of toluene, butanol, and methanol (A), toluene, butanol, and ethanol (B), and toluene, butanol, and isopropanol (C) (C). The outcomes show that solvent mixture (A) removed the most sludge with the best efficiency. With an increase in the solvent-to-oil ratios, the maximum percent of sludge removal improves. Measurements were made of the recycled oil's physical characteristics. The outcomes demonstrate improved efficiency and a change in the characteristics of recycled oil.

Keywords: *Used Engine Oil; Recycling; Reusable Oil*

Introduction

When an engine is in use, the different internal combustions are lubricated by the engine oil, making this feasible. The oil can become contaminated with numerous contaminants, including dirt, metal scrapings, water, and chemicals, which causes the oil to lose its original qualities and become useless for further use (Bridianian & Sattarin, 2006), In order to prevent damage to the engine, it is advisable to change the oil when it loses its lubricating properties, at which point the oil changes color and typically turns blackish. It is essential and strongly advised that engine oil be routinely checked and replaced due to the essential role it plays in maintaining engines. Engineers and vehicle mechanics typically handle this.

Because it contains potentially toxic polycyclic aromatic hydrocarbons and heavy metals, used engine oil, or "condemned oil," as it is commonly known among auto mechanics and technicians in Nigeria, is one of the major and most frequent sources of soil pollution in that country. It is drained from automobile engines, generators, and other industrial machines after seining. However, the amount and kind of these heavy metals are dependent on the method used to create the waste. It is carelessly disposed of by auto mechanics and other related craftspeople with workplaces on the sides of the roadways and in open areas into gutters, water drains, open unoccupied plots, and farms (Anoliefo and Vwioko, 2001). Their effects include the poisoning of plants and animals as well as the contamination of groundwater and water bodies.

Condemned oil is a recyclable material because it needs to be properly processed to remove contaminants and add color to turn it back into usable base oil. By doing this, it not only protects the environment from the harm caused by the disposal of used engine oil but also essentially gives waste economic value (Okenyi, Ngozi-Olehi, & Njoku, 2011; Awopetu, Coker, Awopetu, Awopetu, Booth, Fullen, Hammond, & Tannahill, 2013). It generates economic prospects for sustainable development, job creation, and poverty alleviation (Olukanni., & Oresanya, 2018).

Statement of Problem

The effect of condemned oil on the soil can be seen by observing places, areas, or locations of engine service facilities throughout Nigeria, such as mechanic workshops and industrial sites. Conversely, there is rising worry over the risks of environmental pollution brought on by a variety of sources, including used engine oil. This project was motivated by the need to prevent spills, maintain a clean environment, and generate revenue from used oil. The goal of the current study is to create usable motor oil by treating used oil with various solvents. The goal of the study is to treat or re-refine used lubricating oil to get it back to its original state or a state close to it so that it may be utilized again. Moreover, to investigate recycling options and the potential application of multi-solvents in the refinement of spent lubricating oil.

Review of Related Literature

Used -Oil

Used oil is defined by the United States Environmental Protection Agency as any refined crude oil or synthetic oil that has been used and is tainted with physical or chemical contaminants as a result of such use (US EPA, 2000). Used engine oil, gear oil, hydraulic oil, turbine oil, compressor oil, industrial gear oil, heat transfer oil, transformer oil, spent oil, and their tank bottom sludge that is acceptable for re-refining are all included in the Ministry of Environment and Forest's definition of used oil (MEF, 2008). It has been discovered that used motor oil also contains a lot of extra parts from engine wear. These materials include ash, water, iron, steel, copper, lead, zinc, barium, cadmium, lead, and copper. Due to the impurities, it carries, the disposal of old motor oil may cause greater environmental harm than the pollution caused by crude oil (US EPA, 2000).

To protect the environment, used oil must be collected safely and handled thereafter. Regrettably, unlike other wealthy nations, Nigeria lacks effective used-oil disposal techniques (Osibanjo, 2004). The majority of industrialized nations collect and recycle spent oil. Direct combustion of used oil, re-refining of used oil into fuel, and regeneration of used oil into base oil are some applications for used oil (Kristensen, 2006). According to Opeyemi (2004), approximately 300 million liters of lubricating oil are sold annually, and it is anticipated that 150 million liters of spent oil are produced. Even while this estimate of used oil generation is very speculative and about a decade old, it nonetheless reveals the likely scope of the issue. As some used oil is re-used informally in other vehicles (taken from newer cars and used in older cars or larger trucks) or is occasionally blended with new lubricants, it is observed that a clear understanding of used oil generation is made more difficult by the fact that there is a strong culture for the re-use of the used oil.

Unknown is the scope of these kinds of practices, but it is said that they are pervasive enough to postpone the time when a sizable amount of lubricant turns into used oil. To protect their environment, a number of nations have implemented strategies and rules to handle the disposal of their old oil. Nigeria, like many other African nations, struggles with the proper management of spent oil. Inadequate methods for collecting, storage, recycling, reuse, disposal, etc. lead a large amount of the waste to pose threats to the environment and public health. (2004) Bamiro and Osibanjo You shouldn't discard used oil. Used oil can still be cleaned and reused even when it gets nasty. In fact, spent oil that has been recycled can be refined again to create new lubricating oil, industrial burner fuel, hydraulic oil, and other items (El-Fadel and Khoury, 2004).

The spent oil contains a sizable amount of hydrocarbons, including the extremely dangerous polycyclic aromatic hydrocarbons (PAH). Also, it has been found that used oil has high levels of the majority of heavy metals, including lead, aluminum, nickel, and iron, which were beyond detection in fresh lubricating oil. These heavy metals may remain in soils as exchangeable cations, oxides, hydroxides, carbonates, or bonded to the organic matter in the soil. When used oil is applied to soil, it can either seep into groundwater through the soil or be washed into surface water by rain, contaminating our water supplies (Zitte, Awi-Waadu, & Okorodike, 2016).

Materials and Method

Materials

Condemned oil, unused engine oil, alumina, Toluene, iso-propanok i-butanoi methanol, ethanol, silica geL rotary evaporator, magnetic stirrer, vacuum pump, and filter paper.

Procedure

The condemned oil was sourced from auto workshops, while the solvents were purchased from licensed vendors in Lagos. A filtration flask and vacuum pump were used to filter the acquired condemned oil prior to treatment. After that, the condemned oil and the solvents will be combined, and the resulting mixture will be agitated using a magnetic stirrer. Then, it was cooled and given some time to be studied. The solvent and the regenerated oil were separated using a rotary evaporator. To improve the color, the produced base oil was combined in a specific ratio with alumina and silica gel. The same process was used for all solvents. The oil-to-solvent ratio was adjusted to find the ideal setting. Following each trial, the percentages of raffinate and sludge were calculated. The oil's density, viscosity, pour point, flash point, ash content, total acid number, and specific gravity were all measured after that.

Results and Discussion

Waste oil is a mixture of combustion byproducts like water, gasoline, road grit, worn metal, and oxidation products that create caustic and complex organic acids. The strength of the Vander Waals forces holding liquid molecules together is known as the latent heat of vaporization (Burke, 1984). Normal representation of the amount of sludge removed from the used oil serves as an important experimental assessment of the solvent extraction re-refining process. The percentage of sludge removed (PSR), which is the amount of sludge removed in grams per 100 g of used oil, can be used to express this. The experimental results suggest that solvent combinations A, B, and C, as given in Tables 1 and 2, have a more effective capacity to remove sludge. The largest amount of sludge was found to be removed by mixture A (52%), followed by mixture B (36.7%) and mixture C (18.9%). As indicated in Table 3, these are ascribed to the base stock oil's solubility in this solvent and their respective dielectric constant. As shown in Tables 1 and 2, solvent mixture A caused the greatest percent drop in raffinate, followed by solvent mixtures B and C. Due to the absence of sludge, as indicated in Tables 1 and 2, the raffinate made from solvent mixture A has a yellow tint.

This outcome is caused by the fact that solvent combination A has a larger solubility than solvent mixtures B and C (22.2 and 21.5 g/m3, respectively), with a solubility of 23.2 (g/m3)1/2. Moreover, Table 3 shows that Solvent Mixture

A has a larger Dielectric Constant than Solvent Mixtures B and C. These findings suggest that, despite the solvent being more miscible with the oil as shown in Table 1-3, its capacity to remove sludge increases as the chain length of its carbon atoms and polarity diminish. The solubility and dielectric constant of solvent mixture A are higher, it is obvious. has the highest level of sludge removal efficiency. Because of its larger dielectric constant than the other two solvent mixes, methanol is better at removing heavier components.

Table 1: Effect of different solvent mixtures on the refining of used oil

	A	*B*	*C*
Raffinate, wt%	48	63.3	81.1
Sludge, wt%	52	36.7	18.9
Color, wt%	YELLOW	BLACK	BLACK

Table 2: Effect of activated alumina on the raffinates

	A	*B*	*C*
Raffinate, wt%	48	42.8	44
Sludge, wt%	52	57.2	56
Color, wt%	YELLOW	YELLOW	YELLOW

Table 3: Solubility and dielectric constant of the three solvent mixtures.

Solvent sample	*Solubility (j/m^3)*	*Dielectric constant*
Toluene + butanol and methanol (A)	23.2	6.994
Toluene + butanol and ethanol (B)	22.2	6.993
Toluene + butanol and iso propanol	21.5	6.992

Table 4: Effect of solvent: oil ratio on the refining of used oil using solvent mixture C.

Solvent: Oil Ratio	*1:1*	*1:2*	*1:3*
RAFFINATE	81.1	70.1	55.6
SLUDGE	18.9	29.9	44.4
COLOR	BLACK	BLACK	BLACK

Table 5: Effect of activated alumina on the refining for raffinates

	C1:1	*C1:2*	*C1:3*
RAFFINATE	41.3	37.9	36.9
SLUDGE	58.7	62.1	63.1
COLOR	YELLOW	YELLOW	YELLOW

Study of Solvent–Oil Ratio

Tables 4 and 5 display the impact of the solvent-oil ratio on the percentage of sludge removal for the solvent combination at 25 C. It is obvious that the maximum percent sludge removal increased and the raffinate oil reduced as the solvent oil ratio increased. This is due to an increase in the medium mutual solubility of the oil and solvent when the oil to solvent ratios rise. The efficiency of re-refining oil increases with the proportion of sludge removed, and this process is less expensive than vacuum distillation and finishing steps involving alumina adsorption or hydro finishing. The findings for a 1:3 solvent oil ratio are discovered to be inside the specifications for base stock oil.

It is obvious that there is a decrease in the oil loss and an increase in the sludge separation following the alumina treatment for sludge removal as indicated in Tables 4 and 5. This is explained by the fact that the adsorbent activity of raffinate oil depends on an adsorbent's capacity to extract unsaturated, polycyclic aromatic molecules as well as resinous, sulfur-containing chemicals.

Effect of Alumina Adsorption

The acid-base surface hydroxyl groups on alumina (Al2O3) are what cause its ion adsorption behavior. These surface hydroxyl groups are protonated and deprotonated, which causes the oxide surface to acquire an electrical charge and facilitate adsorption. At the base (-OH) and acid (-OH) hydroxyl sites, cation and anion exchange occurs.

Activated alumina did, however, make the oil's color better. The specific affinity between the adsorbent and the adsorbate disseminated in the used engine oil determines the surface phenomena of the physical method of refinement using the adsorbent. It is evident that the qualities of the activated alumina-treated oil work best. As indicated in Tables 6 and 7, the treated oil was evaluated for density, carbon residue, ash content, pour point, water content, sulfur content, viscosity, and total acid number in accordance with the established methods in ASTM (ASTM, 2000) and IP (IP, 1999).

Table 6: Physicochemical Properties of Used Oil

Experiment	Origin sample	A	B	C
Density@15.56	0.9116	0.8810	0.8847	0.8826
Specific gravity@15.56	0.9125	0.8818	0.8855	0.8834
Viscosity, cSt, @40	107.48	51.66	76.02	83.67
C @100 C	12.93	8.48	12.1	9.98
V.I	115.1	139.55	155.76	98.4
Pour point, C	0	3	3	0
Water content,ppm	2573.2	143.4	94.1	49.9
Ash content,wt%	1.05	0.0094	0.046	Nil
Carbon residue, wt%	1.12	Nil	0.01	Nil
Total acid number, mg KOH/g	7.8	1.47	0.79	0.59
Sulfur content	0.82	0.74	0.67	0.66

Table 7: Physicochemical Properties for Refined Oil Using Different Solvent

Experiment	1:1	1:2	1:3	Result of Fresh Cooperation Company Oil
Density@15.56	0.8826	0.8825	0.8816	0.8817
Specific gravity@15.56	0.8834	0.8834	0.8825	
Viscosity, cSt, @40 C	83.67	74.14	72.08	52.34
@100 C	9.98	11.80	11.59	7.41
V.I.	98.4	154.31	155.15	92
Pour point, C	0	3	0	3
Water content,ppm	49.9	86.6	3.7	0.003
Ash content,wt%	Nil	nil	Nil	–
Carbon residue, wt%	Nil	nil	Nil	0.067
Total acid number, mg KOH/g	0.59	0.15	0.06	0.34
Sulfur content	0.66	0.42	0.25	

The findings in Tables 6 and 7 describe the physical properties of used oil, refined oil obtained through the solvent extraction process, and oil following treatment with activated alumina. It is obvious that the used oil has a higher density than the treated oils. Sludge and a higher concentration of sulfur compounds are to blame for this. In comparison to refined oil, used oil has a lower pour point. The pour point has been impacted by the lubricant oil and refining process, particularly its de-waxing. Tables 6 and 7 list all measured parameters that have been improved to appropriate values, including water content, ash content, carbon residue, and sulfur content. In the case of solvent mixture A in the raffinate oil, the value of Ash content, which indicates the presence of metallic impurities, has decreased by 89.5%, demonstrating the removal of salts. As may be seen in Table 6, the acid value is similarly decreased. Separations have been made between organic and inorganic acids, esters, phenolic substances, lactones, and resins. suitably.

Table 6 and 7 Physicochemical Properties of Used Oil and Refined Oil by Solvent Extraction and Alumina Treatment.

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Table 7 Physicochemical Properties for Refined Oil Using Different Solvent: Oil Ratio Using Solvent Mixture C and Fresh Co-Operation Company Oil.

The findings also demonstrate that following the refining process, the viscosity improved more. This is as a result of any contaminants in the old oil being converted. The oil must be able to maintain sufficient fluidity at high film temperatures if it is to serve as a coolant or heat transfer medium. As indicated in Table 6, the sulfur concentration decreases from 0.82 weight percent for used oil to 0.64, 0.67, and 0.666 weight percent for solvent mixtures A, B, and C, respectively. It is clear that refined oil's qualities perform best overall.

Conclusion

The parameters of solubility and dielectric constant are reliable predictors of solvent behavior. The solvent mixture (A) is the most effective in removing sludge. As the solvent to oil ratio rises to 3:1, the amount of sludge removed increases. The refined physical characteristics have been improved to a reasonable level.

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