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Characterization and Treatment of Straight or Branched Paraffinic Synthetic Oil by Composite Solvent Method

Archita Chatterjee[1], Firdos Ansari[2], Omeshwar Bhongade[3*], Rajkumar Dhakad[4]
[1,2,3,4]*Student, Department of Chemical Engineering, Indore Institute of Science & Technology, Indore, India*
*Corresponding author: omeshwar.omb@gmail.com

***Abstract*: The paraffinic synthetic oil i.e. lubricating oil with better performance is one of the main reasons behind proper working of industrial equipment, automobiles and domestic gadgets. It reduces friction, heat and wear between mechanical components that are in contact between each other. The prolonged use of this oil causes reduction in its own properties. During normal use impurities such as dirt, metal scrapping, water or chemicals can get mixed in the oil or be generated due to oxidation. The waste lubricating oil is one of these residues that cause water, air, soil pollution when disposed of without treatment. Re-refining is the best way to reuse the waste oil and recovering a vital resource of mineral base oil, being as good/better than original base oil. Composite solvent method is carried out for re-refining of used lubricating oil collecting from automobile service station. In this paper we study the characteristics of paraffinic synthetic oil and try to improve it.**

***Keywords*: Density, Lubricating oil, Paraffinic synthetic oil, Re-refining, Viscosity.**

1. Introduction

Paraffinic synthetic oil (PSO) is well treated lubricating oil (LO) with better performance derived from petroleum, an important resource for all the engines and machines of the Universe. POS, sometimes simply called lubricant/lube, is a class of oils. They are mostly composed of alkenes having slightly longer branches and mono-cyclic alkanes and mono aromatics, which have several short branches on the ring. POS are generally organic viscous liquids, essentially of complex mixture of hydrocarbon molecules. These hydrocarbon molecules generally range from low viscosity oils having molecular weights as low as a 250, up to very viscous lubricants with molar weights as high as 1000. The carbon atom ranges from 20 to 34 [8]. POS is imperative for the correct function of an engines or machines, which forms a separating oil film between adjacent moving parts to prevent their direct contact, decreases friction-induced heat and reduces wear. It may also have the function of transmitting forces, transporting foreign particles, power transmission amongst many others, or heating or cooling surfaces. Therefore, it protects engine. The property of reducing friction is known as lubricity [17, 2]. Grease, which is a semi-solid, also belongs to this group. When POS is used in services, they help to protect rubbing surface and promote easier motion of connected parts. In the process, they serve as a medium to remove high buildup of temperature on the moving surfaces. Further buildup of temperature degrades the LO, thus leading to reduction in properties such as: viscosity, specific gravity, etc. Dirt and metal parts worn out from the surfaces are deposited into the lubricating oils. With increased time of usage, the lubricating oil loses its lubricating properties, as results of over - reduction of desired properties, and thus must be evacuated and a fresh one replaced [4]. POS in use degrade over time, the degree of this degradation is dependent on the environment and operating conditions where the oil was used, however, a point is reached where the engine oil would no longer be able to perform its functions [1, 8]. POS is rendered temporarily unsuitable to perform its functions mainly because of contaminants such as particles, oil, dirt, dust, carbon residue, metals, depleted additives and products from the incomplete combustion of fuels. Degradation causes alterations in the viscometric properties of the oil as a result of a transformation in the lubricating oils molecular structure caused by cracking, isomerization and polymerization reactions which are usually triggered by high temperatures. The consequence of this degradation is the formation of compounds with low molecular weight as well as oxidized products. The degradation of lubricating oil under working conditions arises principally because of the following reasons: oxidation and thermal decomposition of the lubricating oil at high temperatures, which changes the initial composition of the oil as well as generation of suspended particles [14].

2. Environmental Pollution

The contaminants in waste oil have adverse impact on health as well as environmental. It forms a layer on the water surface that stops oxygen getting to the animals and plants live in the water, also destroyed the insulating ability of fur-bearing mammals, sea otters. The presence of degraded additives, contaminants, and by-products of degradation render waste oils more toxic and harmful to health and environment than virgin base oils [9]. When directly sent to landfill or dumped in soil, they can migrate into ground and surface waters though

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numerous land treatment processes. In addition, uncontrolled used oils are a threat to animal life and plant life too, which can further result in economic losses. For example, used oil from internal combustion engines generally accumulates a variety of contaminants, which increase the oil's toxicity [13].

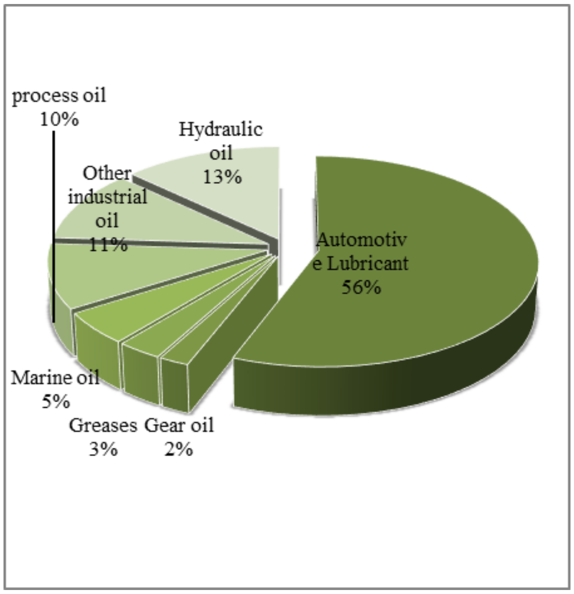

Fig. 1. Percentage contribution of different form of oils that cause environmental pollution

3. Need of Waste Oil Recycling

Improper used oil disposal is simply a waste of a valuable resource. Every gallon of used motor oil not recovered results in the need to drill for more oil and in some cases it results in increases in oil import. Today, however, most of the crude petroleum produced throughout the world contains very little of the special hydrocarbon chains necessary for motor oil. Lube base oil can be recovered and 'regenerated' to the quality equal to or better than its original virgin form. A large range of waste oils can be recycled and other options could include recovering its heating value and/or using in other lower level applications. Certain types of waste oils, lubricants in particular, can be reprocessed allowing for their direct reuse. The use of waste oils, after treatment, can be either as lube base stock comparable to refined virgin base oil or as clean burning fuel [7].

With the large amount of engine oils used, the disposal of lubricating oils has now become a major problem. Many nations are now addressing the problem of environmental pollution posed by waste or used lubricating oils in their countries [5]. When waste oils are released directly into the environment (in water, in sewage and soil networks) or when there is an uncontrolled burning, they cause serious soil, water and air pollution problems. Environmental legislation nowadays does not allow used lubricating oil to be discarded into rivers, lakes or ocean or the soil [15]. When released into the soil, the waste oils seep into the ground with the rainwater contaminating the soil they pass through, and when they reach underground groundwater, they also pollute the water from fountains and wells [12, 19]. This is not unconnected with the alarming report of sea pollution from used oil. Since used lubricating oil contains dirt, water and metallic elements due to wear and corrosion processes, the removal of these contaminants is necessary for re-use. When discharged into wastewater drainage systems, they pollute water-receiving facilities and also cause significant damage to wastewater treatment plants. The used oil contains high levels of hydrocarbons and metals, being the most representative iron, lead, zinc, copper, chromium, nickel and cadmium [10]. The indiscriminate burning of the lubricating oil used, without prior treatment of de-metallization, generates significant emissions of metallic oxides in addition to other toxic gases, such as dioxins and sulfur oxides. Some of these contaminants (heavy metals, poly-cyclic hydrocarbons, poly-aromatic benzenes) constitute the noxious and carcinogenic effect of used lubricating oil [11]. Extensive research work is underway worldwide on degradation of fuels, lubricants, their analysis and recycling. [18, 19] The recycling of waste lubricating oils may be a suitable and economical alternative to burning and incineration. [3] Recycling used oil is fast becoming the preferred way to handle used lubricating oils in order to protect the environment and conserve natural resources. Automotive lubricants are generally considered to be the higher quality than industrial oils for recycling to base lubricating oils or lube. The valuable foreign exchange of lubricating oil has resulted in the efforts of regenerating used lubricating oil into clean lubricants.

4. Functions of Paraffinic Synthetic Oils

Paraffinic synthetic oils are used for various purpose, some of them are as follows:

i. *Reduces Friction:* PSOs are basically use for reducing friction. Thus their use reduces the overall system friction. Reduce friction has the benefit of reducing heat generation, reducing formation of wear particles as well as improved efficiency because of lubricant-to-surface friction. Paraffinic synthetic oil formulated with additives known as friction modifiers. Lubricant-to-surface friction is always lesser than the surface-to-surface friction in a system without any lubrication.
ii. *Prevent Corrosion:* Good quality PSO formulated with additives known as friction modifiers that form chemical bonds with metal surface to prevent from corrosion and rust.
iii. *Keep moving parts apart:* Typically, PSOs are used to keep moving parts apart in the system. Paraffinic synthetic oils achieved many properties in this way, by forming physical barrier i.e. a thin layer of lubricant separate the moving parts.
iv. *Transmit power:* When the fluid film is much thinner between the moving parts because of temperatures and pressures, then this will allow the transmission of some forces. Paraffinic synthetic oils are known as

hydraulic fluids are used as working fluids in hydrostatic power transmission. The automatic transmission's torque convertor is another important application for power transmission with LOs.

v. *Transfer heat:* Paraffinic synthetic oils are typically used as heating or cooling lubricants as they have the additional benefit of reducing thermal stress on the lubricant. On account of high specific heat capacity both liquid and gas lubricants can transfer heat by constantly circulated to form a cooler part of the system when a regulated temperature is required. This circulating flow also determines the amount of heat that is transferred or carried away in a given unit of time. An automotive oil-cooled turbocharger is a typical example of heat transfer.

vi. *Protect against wear:* Paraffinic synthetic oils may contain anti-wear or extreme additives to boost their performance against wear and fatigue. Paraffinic synthetic oils protects against wear because they keep the moving parts apart by forming a thin film.

vii. *Seal for gases:* Paraffinic synthetic oils will occupy the clearance between moving parts through the capillary force, thus sealing the clearance. This effect can be used to seal pistons and shafts.

5. Selection Criteria and Characteristics of Good Paraffinic Synthetic Oils

Paraffinic synthetic oils having following characteristics for their selection as good lubricating oil are as follows,

i. High boiling point.
ii. High viscosity index.
iii. High thermal stability.
iv. High resistant to oxidation.
v. High resistant to Corrosion.
vi. Good hydraulic Stability.
vii. Low freezing point.
viii. High resistant to friction.

Table 1
Characteristics of fresh oil

S. No.	Characteristics	Fresh oil (SAE 40)
1	Specific gravity	0.8818
2	Viscosity @40ºC	58.98
3	Viscosity @100ºC	9.5
4	Flash point	218
5	Pour point	-9
6	Color	Yellow
7	Water content	< 0.20
8	Viscosity index	92.80

6. Literature Review

Mohammad Shakirullah et.al. in their study, adopted the aluminum sulphate sodium silicate acid base technique and solvent treatment process- CCl_4-alcohol method, Dodecane-alcohol method and Toluene-alcohol method for the re-refining of used lubricating oil drained from the automotive engine of Shell Rimula-C (SAE 50) and Castrol GTX (SAE 20W-50) after an engine run of about 2000 km. It was found that effective recovery can be obtain when the used lubricant was mixed with Dodecane Toluene and CCL_4 in a ratio of 1:3:3:3. The yield of the process 72% of re-refined neutral lubricating oil base stock with kinematic viscosity 86% cst for aluminum sulphate-sodium silicate acid-base methods, 75% cst for CCl_4 alcohol method, 83% cst for Dodecane-alcohol method and 84% for Toluene-alcohol method recovered at 37.8 ^{0}C respectively.

Fathonatu Anisa Khowatimy was done the work, Blending of ZnO into Y-Zeolite (mass ratio of Y-Zeolite ZnO = 1) decreased the character of Y-Zeolite. The ZnO was located on the surface of the Y-Zeolite particles which covered most of the Y-Zeolite surface. The acidity of catalytic hydrocracking increased after the combination process. The highest total conversion of the lubricant using the Y-Zeolite/ ZnO catalyst was 99.49 wt% while the Y-Zeolite was 99.10 wt.% at 623 K and without catalyst (thermal hydrocracking) was 98.99 wt.% at 673 K. The highest liquid product at 623 K was achieved by Y-Zeolite/ZnO(24.75 wt.%) with the selectivity for gasoline and diesel fractions was 25.92 wt.% and 74.08 wt.%.The Y-Zeolite catalyst was more selective for gasoline fractions, whereas the ZnO and Y-Zeolite/ ZnO catalysts was more selective for diesel fractions.

H. Bridjanian et.al. made study on modern recovery methods is used oil re- refining, by using the hea3ting the used oil up, vacuum distillation for the separation of gas oil, passing the base oil through a guard bed and hydro-treating of the obtained base oil. In their experiment, a spent middle distillate hydro-cracking catalyst (HC-102) was used. The comparison made between the re-refined oil and SAE30 base lube oils shows that the approximate much similarities, re-refined oil with kinematic viscosity 9.63 c.st @100^{0}c and viscosity index 92. Moreover, almost no harmful or useless byproduct hydrocarbon is produced via this method.

Ghassan Roken Daham et.al made study on re- refining of used lubricating oil by solvent extraction using Central Composite Design method Absorption method was used for the recovery of used for the recovery of used oil. Central Composite Design was applied as the statistical method. Response surface methodology was then used to find the optimum conditions in the process of extraction: ratio of solvent/used oil 2.4 & 3.12 vol/vol. temperature 54°C and 18°C, speed of mixing 569 and 739 rpm for 1- butanol and methyl ethyl ketone (MEK) respectively. Various flocculation agents were used with the solvent, such as Sodium hydroxide (NaOH), Potassium hydroxide (KOH) and monoethyleamine provide an increase in efficiency. The recovered oil showed the properties including viscosity @100°C 8.32 and 9.22 cst, flash point 210.12 and 223.04°C, pour point 17.35 and 22.23°C. The TAN of 0.25 for two type of base oil recovered using MEK, 1-butanol with activated bantonite respectively.

A comparative study of recycling of used engine oil using extraction by composite solvent, single solvent, and acid treatment methods carried out by Rashid Abro et.al. They were collected the samples of used engine oil of heavy vehicles, light vehicles and blended oil from transport office. The solvent extraction divided into single solvent and multicomponent solvent and the solvent where recovered by vacuum distillation and then acidified material was neutralized with caustic soda of 20% solution and filtered to remove precipitate in result of neutralization. The filtration gave the clear re-refined useful product oil, where the viscosity values of refined engine oil by composite solvent method, single solvent method and acid treatment are 94cp, 98cp and 92cp respectively at room temperature.

A comparative study of recycling of used lubrication oils using distillation, acid and activated charcoal with clay method was carried out by Udonne J.D. The procedure for the purification of used lubrication oil consists of filtration of the oil before subjected to treatment by collecting 2L of the used lube oil of two samples respectively. The re-refined oil was blended with fresh oil, test showed that viscosity increased from 25.5 for used lube oil to 86.2 for distillation, 89.10 for acid/clay treatment and 80.5 is for activated/clay treatment. This is compared with 92.8 cst for fresh lube oil. Other results from the different tests showed varied degrees of improvement with the best results obtained using the acid/clay treatment.

Merai Yash P. et. al. conducted the study with re-refining of used lubricating oil carried out by various methods such as-dehydration, vacuum distillation, solvent extraction and finely atmosphere distillation. Followed by this process we can obtained the oil having properties similar to that of the virgin engine oil. In dehydration process oil was heated at temperature of 130°C in close vessel. Methyl Ethyl Ketone (MEK) was used as a solvent in ratio of 2:1. Solvent was recovered in atmospheric distillation to 80°C, which is boiling point of MEK.

A comparative study of recycling of used engine oil by different solvent was carried out by Doaa l. Osman et.al. used lubricating oil was collected from Egyptian Petroleum Institute oil service station. The refining of used lubricating oil was examined utilizing a novel blend of solvent extraction and activated alumina absorbent. The activity of these solvent extraction blends {Toluene, butanol and methanol (A), {Toluene, butanol and ethanol (B)} and {Toluene, butanol and isopropanol (C)} was evaluated experimentally. The maximum percentage of sludge removal improves with increase in solvent to oil ratios. The used lubricating oil was subjected filtration before treatment. From result it is found that mixture (A) removed maximum sludge (52%) followed by mixture (B) (36.7%) and mixture (C) removed lower percentage (18.9%). The change in oil properties measured, viscosity of 107.48-83.67cst @40°C, specific gravity of 0.9125-0.8834.

A comparative study of re-refining & recycling of used lubricating oil: An option for foreign exchange and natural conservation resource in Ghana was carried out by Henry Mensah Brown. The sample of used lubricating oil was obtained from the crankcase of salon cars. The crankcase lubricating oil collected was re-refined using the caustic treatment and vacuum distillation method to obtain lube oil base stock. The recommended IP136/65-ASTM D974-12 standard test method for insoluble in used lube oil was used. The sample was treated with 1% by weight sodium hydroxide (NaOH) at about 150 °C to dehydrate. The vacuum distillation was carried out at the range of 272 to 400 °C. The stock had a viscosity index of 105. After all the processes the treated oil shows the similar properties to that of VLO.

7. Experimental Materials and Method

Collection of Used Engine Oil: Samples of used engine oil of heavy vehicles, light vehicles, and blended oil will be collected from the automobile service station of Indore.

Experimental work:

i. *Mixing of collected waste oil:* Collected samples will be mixed properly in a single container. The mixing process will be carried out with the help of agitator.
ii. *Gravity settling:* The well mixed oil will allow to settle under gravity for a period of 3-5 days for the removal of high dense particles, the particles settle at the bottom of the container.
iii. *Dehydrating water:* This process will be carried out to remove the compounds of hydrogen broken down in the engine oil because of the hydrogen brake down compounds in engine oil decreases the viscosity of engine oil. Water compound present in the engine oil make the combustion process illegible and decreases the power of a combustion stroke. Also the water molecule present in the engine oil increases the aeration and accelerates the rust and corrosion of combustion chamber. The oil will be heated up to 120ºC in a glass beaker. The water molecule present in the engine oil will burnt out as vapor.
iv. *Filtration:* It is an essential process in refining to remove the macro particles, impurities such as metal chips, sand, dust particles and to give clean original color to the engine oil. The filtration will be done using a funnel with a filter paper placed in it. This process will remove the strain and macro particles and in homogeneous color of the engine oil.
v. *Preparation of composite solvent:* The composite solvents has two single components: basic compound miscible with base oil and a flocculating compound that improves segregation and flocculation of waste oil impurities. Butanol, propanol, and butanone will be used to form a composite solvent then that will be mixed with oil in the ratio (oil: composite solvent) of 1 : 2, 1 : 3, and 1 : 4 in that order. Each sample will be stirred at 300 rpm for 30 min and will be heated at 35ºC in the water bath for 30 min to maintain constant temperature.
vi. *Extraction of oil:* This process will be followed by the

separation of sludge phase from mixture of solvent and oil will be extracted. Standard distillation process (batch distillation) will be used to separate the extracted oil from the mixture.

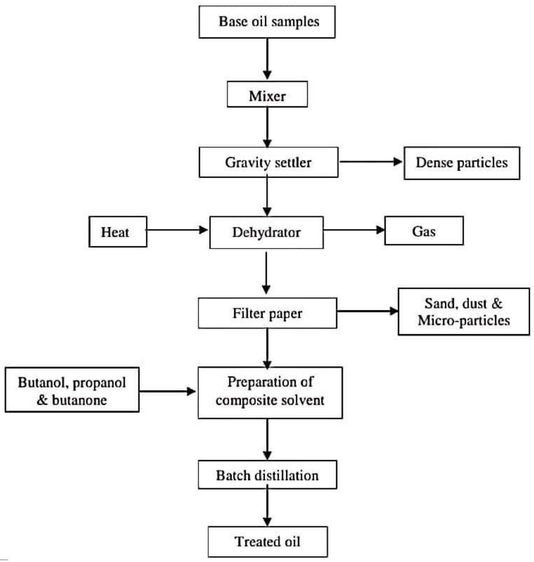

Fig. 2. Important stages of Composite solvent method

8. Conclusion

This paper has given the explanation that re-refining of lubricating oil is must to prevent environmental pollution. The above study discusses the characterization and treatment of paraffinic synthetic oil. It has been noted that the composite solvent method is more suitable for the treatment of paraffinic synthetic oil. It is found that this method effectively removed contaminants from used lubricating base oil and returned the oil to a quality essentially equivalent to oils produced by fresh lube oil stocks. Thus the future progress in the composite solvent method, more work will needed to be done with better solvents.

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