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TREATING THE USED AUTOMOBILES OILS USING SOLVENTS

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ABSTRACT

Used automobile oils were subjected to filtration to remove solid material and dehydration to remove water, gasoline and light components by using vacuum distillation under moderate pressure, and then the dehydrated waste oil is subjected to extraction by using liquid solvents. Two solvents, namely n-butanol and n-hexane were used to extract base oil from automobile used oil, so that the expensive base oil can be reused again.

The recovered base oil by using n-butanol solvent gives (88.67%) reduction in carbon residue, (75.93%) reduction in ash content, (93.73%) oil recovery, (95%) solvent recovery and (100.62) viscosity index, at (5:1) solvent to used oil ratio and (40 oC) extraction temperature, while using n-hexane solvent gives (60.25%) reduction in carbon residue, (76.54%) reduction in ash content, (89.06%) oil recovery, (94.78%) solvent recovery and (100.3) viscosity index, at (6:1) solvent to used oil ratio and (50 oC) extraction temperature.

INTRODUCTION

There are many possible processes to regenerate base oil from used oil. The unused oil contain (71-96 wt. %) base oil, and the rest were additives Juma [1]. There are many types of additives some of them contain metal and others are high molecular weight hydrocarbons. During automobile running, some of the above chemicals will be broken down or cracked to smaller molecules. It is essential to remove most carbon residue, ash content, sludge and increase the obtained base oil viscosity index and improve base oil color. Economic plays a great role in deciding the type of the solvent used and the operation process. The process may vary from country to country. It depends on the type of origin base oil and type of

Some of the previous used solvents are alcohols, organics acids, organic bases and N-Methyl-2-Pyrrolidone (NMP) Dturnell [2], U. S. Patent No. 6117309 [3], Whisman [4].

In order to extract base oil from used oil, many solvents were studied. Some of solvents were expensive, and others were cheap but not efficient in improving extract base oil properties. Different solvents or, combination of solvents at different temperatures and solvent to used oil ratio were reported. The aim of this research is to select a solvent that can be able to extract the base oil from automobile used oil without causing adverse effects on the physical properties of the solvent and of the extracted base oil, and can be recycled and used again continuously.

EXPERIMENTAL WORK

Materials

Feed stock

The used lubricating oils are collected directly from different automobiles, small saloon cars (Internal Combustion Engine) at different operating conditions. Table 1 shows the determined properties of the used lubricating oils.

Table 1 Properties of the used lubricating oils.

Specification	Values	ASTM
Specific Gr. @ 60/60 °F	0.897	D1298-77
Viscosity, cSt, @ 40°C	69.84	D445-83
Viscosity, cSt, @ 100°C	8.5	D445-83
Viscosity index	90.2	D227-79 IP 226/80
Ash wt.%	0.81	D482-80
Carbon Res. wt.%	5.12	D524-76
Water wt.%	1.5	By distillation
Flash point, oC	158	D97-77

Solvents

Two solvents were used in this work. These solvents are n-Butanol (Hopkin &Williams Chadwell Heath Essex, England) and n-Hexane (Gainland Chemical Company, U.K.). Table 2 shows the manufactures properties of these solvents.

Table 2 Properties of n-Butanol and n-Hexane.

Specification	n-Butanol	n-Hexane
Molecular Weight	74.12	86.17
Specific gravity @ 60/60 oF	0.81	0.659
Boiling point, °C	117	69
Freezing point, °C	-79.9	-94
Purity	95%	95%

Experimental Procedure

In order to remove water, gasoline and light component from used oil. The used oil was dehydrated initially under vacuum pressure (40 mbar), and at (200° C), using vacuum distillation unit as shown in Fig. 1. The obtained dehydrated used oil was subjected either to vacuum distillation or to extraction base oil from used oil by selected solvent (n-Butanol or n-Hexane).

The dehydrated used oil was carried out by vacuum distillation unit by using vacuum pressure (5, 10 and 15 mbar). After each experiment, the vacuum distillation apparatus was washed with n-hexane solvent in order to remove any contaminants that accumulated in the unit. After washing all connections and joints, they were re-lubricated, and prepared for next experiment.

For n-Butanol, the operating conditions are extraction temperature range from (30 to 60°C), solvent to used oil ratio from (1:1 to 5:1 vol. /vol.). N-butanol is alcohol solvent. It is liquid at normal condition. It is used to dissolve the base oil that presence in used oil and separate it from contaminants by settling, were become two layers as shown in Fig. 3. The top layer was the n-butanol and base oil, while the bottom layer was contaminants and small amount of n-butanol and oil. The upper layer was separated from lower layer. Then the solvent was separated from extract oil by using distillation unit. The solvent and extract oil were re-weighted to make material balance.

For n-Hexane, the operating conditions are extraction temperature range from (30 to 60°C), solvent to used oil ratio from (2:1 to 6:1 vol. /vol.). N-hexane is aliphatic solvent. It is liquid at normal condition. It is used to dissolve the base oil that presence in used oil and separate it from contaminants by settling, were become two layers. The top layer was the n-hexane and base oil, while the bottom layer was contaminants and small amount of n-hexane and oil. The upper layer was separated from lower layer. Then the solvent was separated from extract oil by using distillation unit. The solvent and extract oil were re-weighted to make material balance.

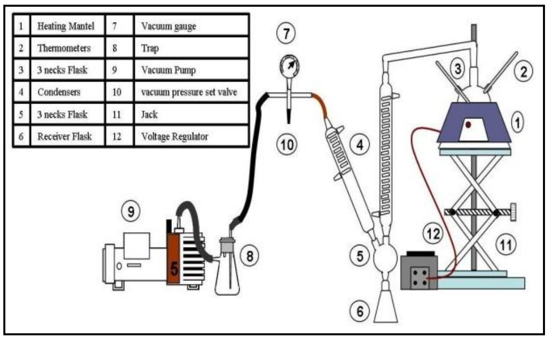

Fig. 1 Flow Diagram of the vacuum distillation unit.

Fig. 2 Photos of laboratory vacuum distillation unit.

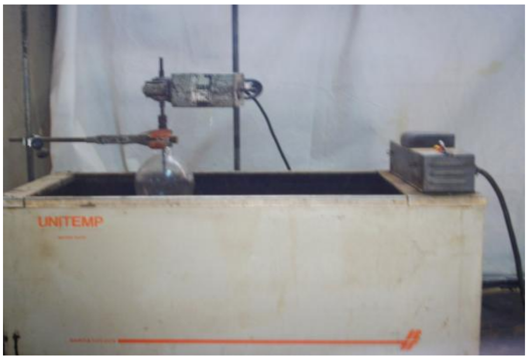

Fig. 3 Photo of the Laboratory Extraction Unit.

RESULTS AND DISCUSSION

Vacuum Distillation

In order to separate the base oil from the used oil, vacuum distillation at (5, 10 and 15 mbar) was carried out. The experimental results indicated, as the vacuum pressure increased, from (5 to 15 mbar), the oil recovery decreased from (77.9 to 75.2 wt. %), and the carbon residue reduced from (87 to 86 wt. %), and ash content reduced from (74.8 to 73.5 wt. %), respectively, as shown in Fig.4.

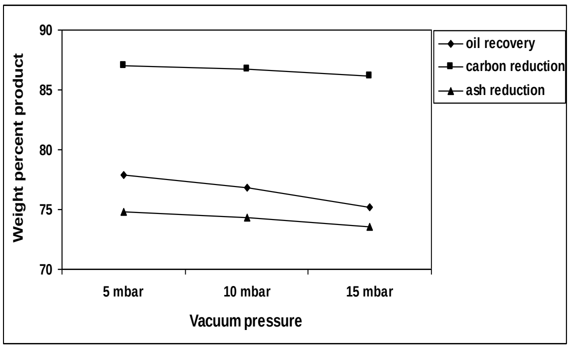

Fig. 4 Vacuum pressure vs. weight percent product.

Solvents Extraction

N-Butanol Solvent Extraction

The experimental results indicated, increasing in percent of oil recovery with increasing of solvent to used oil ratio at different temperature. The ratio of solvent to used oil were from (1:1 to 5:1 vol. /vol.), while the studied temperatures were from (30 to 60° C). The results indicate an increasing in oil recovery from used oil from (88.6 to 93.7 wt. %), when solvent to used oil ratio increase five times. The higher the solvent quantities the more recovery oil was obtained till to (5:1 vol.

/vol.) solvent to oil ratio. Higher solvent to used oil ratio gave unnoticeable change in oil recovery because the solvent recovered most of the base oil and no longer can remove small quantities of base oil, as shown in Fig. 5. Similar results were obtained for solvent recovery as shown in Fig. 6.

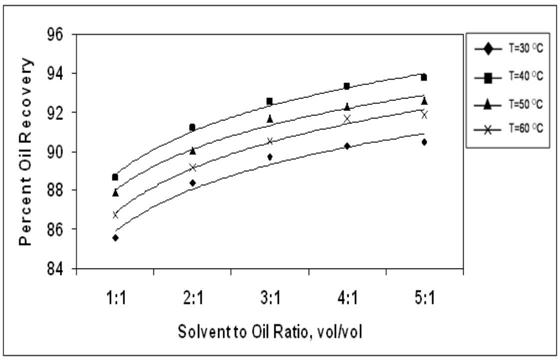

Fig. 5 Effects of solvent to used oil ratio on the percent of oil recovery at different extraction temperatures for extraction by n-butanol.

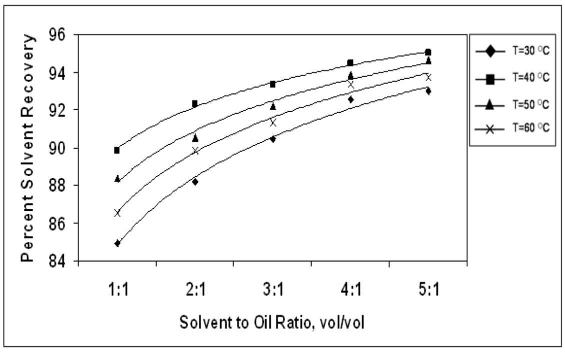

Fig. 6 Effects of solvent to used oil ratio on the percent of solvent recovery at different extraction temperatures for extraction by n-butanol.

The results indicated that at (40° C) gave best oil recovery, and at (50° C) gave less oil recovery, while (60° C) gave even less oil recovery then (50° C). This means an increasing in oil recovery from (30° C up to 40° C) and then decreasing in oil recovery from (40° C to 60° C) as shown in Fig. 2. Similar behavior was obtained for solvent recovery, as shown in Fig. 3. Where (93.7 wt. %) oil recovery and (95 wt. %) solvent recovery, at (40° C) when solvent to used oil ratio was (5:1 vol. /vol.).

Similar results were obtained for carbon residue reduction. The results indicated higher carbon residue reduction with increasing solvent to used oil ratio. Temperature gave similar behavior as the results indicated (40° C) which gave the best percent carbon residue reduction. The best obtained carbon residue reduction is (88.6 wt. %), as shown in Fig. 7

Percent ash content reduction increases with increasing solvent to used oil ratio till it reaches an optimum value at (5:1 vol. /vol.). After that the solvent to used oil ratio will not affect on the percent ash content reduction. Similarly high temperature will increase percent ash content reduction up to (40° C). Higher temperature than (40° C) will decrease percent ash content reduction. The best obtained percent ash content reduction is (75.9 wt. %), as shown in Fig. 8.

The viscosity index indicates different behavior than the above mentioned parameters, since at (60° C) gave better results than at (40° C). The viscosity index increased from (96.4 to 102.6) at solvent to used oil ratio (1:1 to 5:1 vol. /vol.) and at (60° C) as shown in Fig. 9.

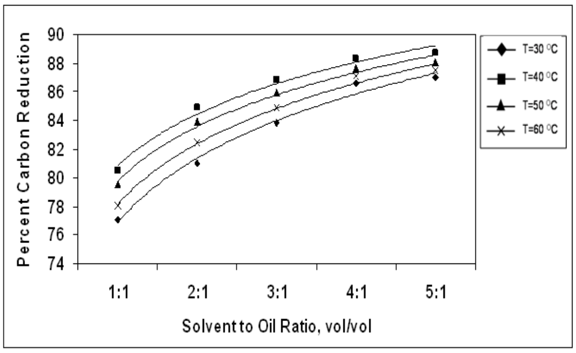

Fig. 7 Effects of solvent to used oil ratio on the percent of carbon residue reduction at different extraction temperatures for extraction by n-butanol.

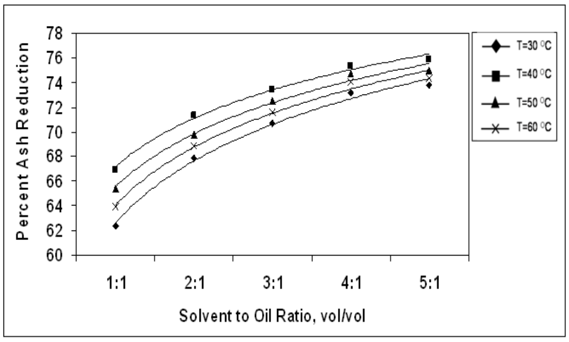

Fig. 8 Effects of solvent to used oil ratio on the percent of ash content reduction at different extraction temperatures for extraction by n-butanol.

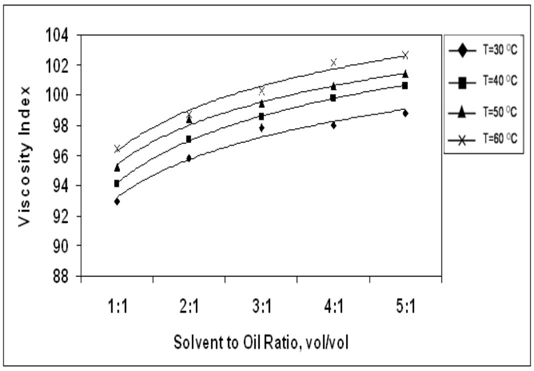

Fig. 9 Effects of solvent to used oil ratio on the viscosity index at different extraction temperatures for extraction by n-butanol.

N-Hexane Solvent Extraction

Increasing the solvent to used oil ratio will increase the percent of oil recovery. It was found that (6:1 vol./vol.) solvent to used oil ratio will be the optimum ratio in order to obtain high percent of oil recovery (i.e. 89 wt.%). It was found not at (40° C) but (50° C) gave higher percent of oil recovery, as shown in Fig. 10. The result also indicated high temperature gave lower percent of oil recovery.

Solvent recovery increase with increase solvent to used oil ratio, as shown in Fig 11. The percent of solvent recovery increased from (84.8 wt.% to 94.7 wt.%) when solvent to used oil ratio increased from (2:1 to 6:1 vol./vol.). The optimum temperature was found to be (50° C), where it gave best percent of solvent recovery. High temperature above (50° C) will decrease percent of solvent recovery, as shown in Fig. 8.

Percent carbon residue reduction and percent ash content reduction were shown in Figs. 12 and 13. Similar result was obtained for high temperature up to (50° C) and for higher solvent to used oil ratio up to (6:1 vol. /vol.). These results indicate percent carbon residue reduction and percent ash content, which were (2.035 wt.% and 0.19 wt.%) respectively. From initial carbon content and ash content of (5.12 wt. % and 0.81 wt.%) respectively.

The viscosity index indicates different behavior than the above mentioned parameter. Since at (60° C) gave better results than at (50° C). The viscosity index increased from (94.5 to 101.2), at (60° C) and at solvent to used oil ratio (2:1 to 6:1 vol. /vol.) respectively, as shown in Fig. 14.

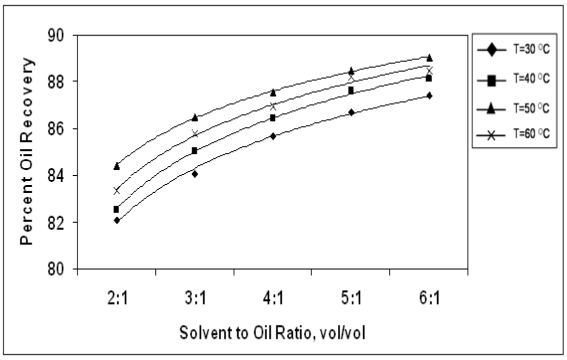

Fig. 10 Effects of solvent to used oil ratio on the percent of oil recovery at different extraction temperatures for extraction by n-hexane.

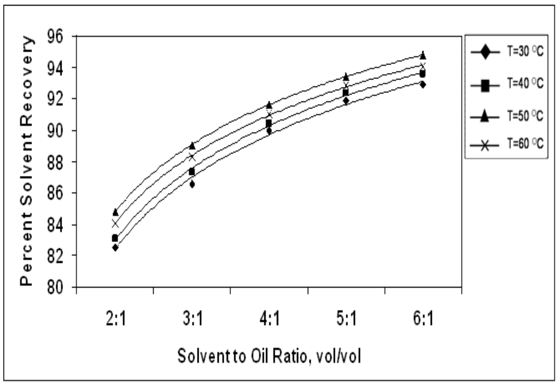

Fig. 11 Effects of solvent to used oil ratio on the percent of solvent recovery at different extraction temperatures for extraction by n-hexane.

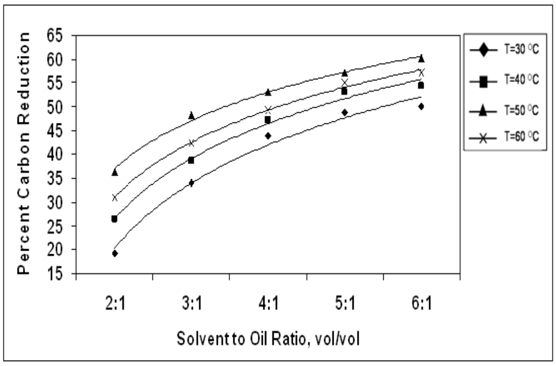

Fig. 12 Effects of solvent to used oil ratio on the percent carbon residue reduction at different extraction temperatures for extraction by n-hexane.

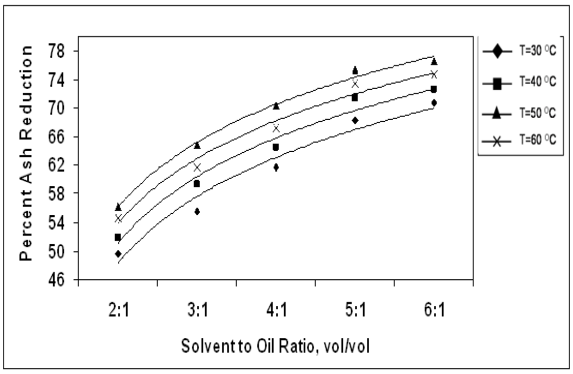

Fig. 13 Effects of solvent to used oil ratio on the percent ash content reduction at different extraction temperatures for extraction by n-hexane.

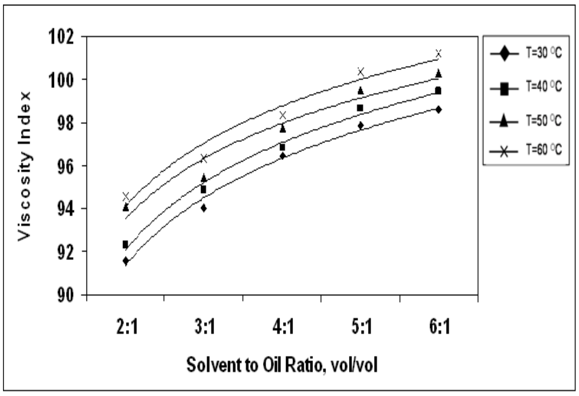

Fig. 14 Effects of solvent to used oil ratio on the viscosity index at different extraction temperatures for extraction by n-hexane.

CONCLUSIONS

The following conclusions were obtained:

1- N-butanol, which are liquid at normal conditions; gave oil recovery (93.7%), solvent recovery (95%), carbon residue reduction (88.6%), ash content reduction (75.9%) and viscosity index (100.6), at (40° C) and (5:1 vol./vol.) solvent to used oil ratio.

2- N- hexane, which are liquid at normal conditions; gave oil recovery (89%), solvent recovery (94.7%), carbon residue reduction (60.2%), ash content reduction (76.5%) and viscosity index (100.3), at (50° C) and (6:1 vol./vol.) solvent to used oil ratio.

3- Vacuum distillation was uneconomical to be operated industrially. But, it gave good color (deep yellow), carbon residue reduction (87%) and ash content reduction (74.8%), at (5 mbar), which was best operating.

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