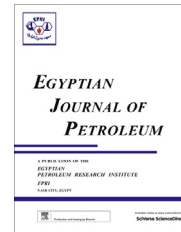




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FULL LENGTH ARTICLE

Solvent refining of heavy wax distillate for the removal of carcinogenic compounds

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Abstract Neat ethylacetoacetate (EAA) and its mixtures with a co-solvent and an anti-solvent have been studied for refining of heavy wax distillate fraction to produce substantially non-carcinogenic base oil. The co-solvent and anti-solvent used are dipropylene glycol (DPG) and ethylene glycol (EG) respectively. The solubility characteristics of the main solvent and its mixed solvent systems were studied. Selection of the optimum solvent mixture and extraction variables has been studied. The effect of co-solvent and anti-solvent addition on the carcinogenic potential and raffinate quality has been determined under clearly comparable conditions.

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1. Introduction

The base mineral oils are manufactured from crude of vacuum distillation to produce several distillates and a residual oil. In relation to the health hazards, all crude oils contain some polycyclic aromatic compounds (PACs) some of which are known to be carcinogenic, particularly the four or more condensed ring compounds [1–4]. The content of polycyclic aromatic compounds in base oil must be greatly reduced usually to

the extent that the refined product is no longer carcinogenic by the refining processes and the level or severity of treatment.

Furfural, phenol and N-methyl-2-pyrrolidone have been used for industrial scale lube oil refining till now. All have advantages and disadvantages from a technical and economical stand-point [5–8].

The European commission has adopted chemical test method IP 346 as the sole criterion for classifying base oil carcinogenicity, in line with its policy to minimize the regulatory requirements for animal testing. The adoption of IP 346 was based on its ability to predict the threshold of carcinogenicity as indicated by animal test data [1]. In Europe, suppliers of lubricant base oils must classify their products against European Union (EU) criteria, which say that “lubricant base oils must be classified as carcinogenic unless they can be demonstrated to contain less than 3% (w/w) DMSO extract by IP 346” [1,2,9].

The present work aims to study the effect of solvent refining at severe treatment conditions on the carcinogenic potential of

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the heavy wax distillate and to produce substantially non-carcinogenic base oil. Thus, ethylacetoacetate EAA was used as a basic solvent for refining the local heavy wax distillate fraction, as it has good selectivity for aromatics; low toxicity and it is non-corrosive and non-carcinogenic [10,11].

2. Experimental

Feedstock:

Heavy wax distillate fraction (b.r. 450–510 °C) was offered by the Suez Oil Processing Company.

Solvents:

Ethylacetoacetate (EAA) as the basic solvent.
Dipropylene glycol (DPG) as a co-solvent.
Ethylene glycol (EG) as an antisolvent.

2.1. Solvent extraction

All the solvents were of normal laboratory reagent grade. These solvents are considered not to be toxicant or mutagenic or carcinogenic to humans [11–14].

The heavy wax distillate fraction was subjected to bench scale extraction with the basic solvent and its mixtures with the co-solvent and the antisolvent. A jacketed mixer settler apparatus was used. The extraction variables were studied as follows:

2.1.1. EAA

Extraction temperatures (60–90 °C) and solvent oil ratios (ranging from 2:1 to 7:1).

2.1.2. EAA + DPG mixture

Solvent composition (the percentage of DPG from 0–20 wt%), solvent oil ratios (ranging from 2:1 to 5:1) and at two extraction temperatures of 60 and 70 °C.

2.1.3. EAA + EG mixture

Solvent Composition (the percentage of EG from 0–15 wt%), solvent oil ratios (ranging of 2:1–5:1) and at two extraction temperatures of 80 and 90 °C.

2.2. Solvent dewaxing

Dewaxing process was carried out for the raffinate obtained under the most suitable extraction conditions with the solvent mixture of EAA + 15% EG, solvent oil ratio of 3:1 and extraction temperature of 80 °C. Methyl isobutyle ketone (MIBK) was used as dewaxing solvent, solvent feed ratio of 3:1 and 1:1 for dilution and washing respectively at dewaxing temperature of –15 °C [15].

2.3. Finishing

The finishing process was considered the final step in refining processes. The dewaxed oil was treated with adsorption via

percolation technique using bentonite as adsorbent at 75 °C and under elution of N₂ gas carrier at 10 psi. The bentonite was firstly activated at 120 °C for 2 h. Percolation technique was carried out via a continuous process, where the dewaxed oil was passed through a static bed of bentonite in a double jacket long glass column to purify and decolorize and finish the oil.

The feedstock, raffinats, dewaxed oil and base oil were subjected to the following analysis:

- The physico-chemical characteristics according to the standard methods [16].
- Polycyclic aromatics content (PCAs) by IP 346 method as an inspection test of carcinogenicity [17].
- The hydrocarbon component analysis by using liquid solid column chromatography technique [18].
- The structural group analysis based on physical constants by n-d-m method [16,19].

3. Results and discussion

The physical characteristics, hydrocarbon component analysis and structural group analysis of the feedstock are presented in Table 1.

Table 1 Physical characteristics, hydrocarbon component analysis and structural group analysis of the feedstock.

Characteristics	Feed
Refractive index, 70 °C	1.4918
Density (gm/cc) 70 °C	0.8839
Mean molecular weight	415
Pour point (°C)	47
Sulfur content (wt%)	1.80
Kinematic viscosity 40 °C, cSt	99
Kinematic viscosity, 100 °C, cSt	9.8
Viscosity index	70
Conradson carbon residue (wt%)	0.630
PCAs (IP346) (wt%)*	9.28
<i>Component analysis</i>	
Total saturates (wt%)	47.53
Total aromatics (wt%)	52.47
Mono aromatics (wt%)	16.42
Di aromatics (wt%)	26.01
Poly aromatics (wt%)	10.05
<i>Structural group analysis</i>	
Carbon distribution	
%C _A	17.47
%C _N	20.81
%C _R	38.28
%C _P	61.72
<i>Ring content analysis</i>	
R _A	0.89
R _T	2.25
R _N	1.36

* PCAs = Polycyclic aromatics content; C_A = Aromatic carbon; C_N = Naphthenic carbon; C_R = C_P + C_A; C_P = Paraffinic carbon; R_A = Aromatic ring; R_N = Naphthenic ring; R_T = R_A + R_N.

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