MOTOR OIL PERFORMANCE IN TERMS OF CHEMICAL STRUCTURE OF BASE OILS

THESIS

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By

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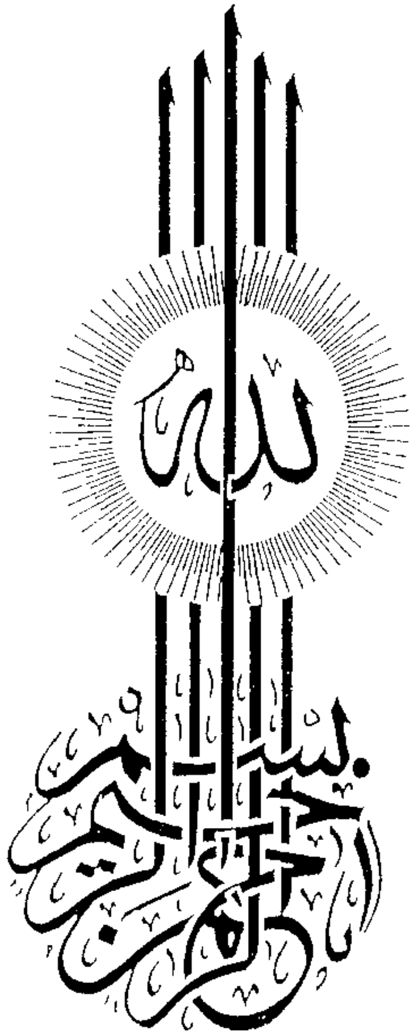
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SUMMARY

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Physico-chemical properties and elemental analysis are determined according to the standard test methods for base oils, commonly incorporated in local motor oil formulations. Base oil A, BOA is an imported solvent-refined neutral oil whereas base oil B, BOB is its equivalent locally produced one. Base oil C, BOC on the other hand is a bright -stock oil which usually mixed with either BOA or BOB to formulate motor oils with different viscosity grades and performance levels.

The BOA records lower density and refractive index as well as higher flash and aniline points in comparison to BOB, which shows on the other hand, lower kinematic viscosity, Conradson carbon residue and molecular weight. The bright -stock oil BOC has the higher density, refractive index, kinematic viscosity, aniline point, carbon residue, flash point and molecular weight values, which agree with the chemical nature of bright-stock oils. However, no traces are detected for acidity and saponification values which indicate satisfactory refining of the three oils. A lower C/H ratio is recorded for BOA which reflects its relative high paraffinic character while C/H ratio for BOC describes its aromatic nature. No remarkable differences are reported for nitrogen content, whereas

sulphur analysis shows higher value for BOC in comparison to BOA.

Structural group analysis, hydrocarbon classes and aromatic-type distribution are also evaluated for the three oils through infrared spectroscopy and column chromatography methods. The BOA shows the lowest percent mole of aromatic bonded carbon atoms whereas BOB has the lowest percent mole of paraffinic bonded carbon atoms. The bright-stock BOC on the other hand, shows the lowest percent mole of naphthenic bonded carbon atoms, and the highest percent mole of paraffinic bonded carbon atoms, which indicates that its high molecular weight is due mainly to the increase in carbon atoms in side chains rather than in ring structures. The BOA is also found to consist mainly of saturated hydrocarbon compounds and only monocyclic -type aromatics, whereas BOB is composed of saturated hydrocarbon compounds, monocyclic, dicyclic and polycyclic-type aromatics. The bright-stock BOC on the other hand, consists mainly of aromatic molecules of monocyclic type with small amount of polycyclic aromatic structures.

The oxidation stability is also studied for the three base oils undertest and for their mixed blends as well as for their additive-containing formulations which verify both MIL-2104 B and MIL-2104 C motor oil specification levels. A modified IP 157 oxidation test method procedure is used for the evaluation of oxidation stability for the different oil blends whereas the IP 229 rotary bomb oxidation method is applied only for unadditive base oils. The stability in the initial and final oxidation stages for the additive-free and additive -containing blends is evaluated and explored for convenient correlation with the chemical structure of base oils.

Linear, logarithmic, exponential and power curve fittings as well as multiple linear and polynomial regression analyses are therefore applied.

The BOA shows an autoacceleration behaviour with the oxidation reaction progress whereas BOB exhibites autoretarding characteristics, which is attributed to the monoaromatics acceleration effects and the diaromatic retarding influences respectively. The bright-stock BOC on the other hand, gives the poorest autoaccelerating response which is mainly due to its higher sulphur and monoaromatic contents. However, in the initial oxidation stages, the total acidity is found to correlate to the sulphur percent weight with 0.87 correlation coefficient, R^2. The natural oxidation inhibition expressed by the induction period in the rotary bomb oxidation method on the other hand, is proved to correlate with the percent mole of aromatic bonded carbon atoms plus sulphur percent weight, (R^2 = 0.99).

In the final oxidation stages the total acidity and kinematic viscosity percent increase at 100^{o}F are found to correlate respectively with sulphur percent mole, (R^2 = 0.95) and sulphur percent weight,(R^2 = 0.93). The kinematic viscosity percent increase at 100^{o}F is also proved to correlate with total aromatics, monoaromatics and diaromatics plus sulphur contents by multiple linear regression analysis, (R^2 = 0.96). On the other hand, the viscosity percent increase also correlates with the diaromatics plus sulphur content through polynomial regression, (R^2 = 0.81).

When the base oils are blended with additive package that verifies the MIL-2104 B performance level, the BOA and bright-stock BOC samples respond better to the oxidation reaction although the autoacceleration behaviour still holds with the oxidation progress. The autoretarding response of BOB on the other hand,is reversed to autoacceleration with corresponding high reduction in its oxidation stability.

When the MIL-2104 C additive package is incorporated, the oxidation stability of BOA is seriously decreased whereas the bright-stock BOC records relative higher oxidation stability rating.

However, for both MIL-B and MIL-C formulations convenient correlations are established between their total acidity as well as kinematic viscosity percent increase values and the total aromatics, monoaromatics as well as diaromatics plus sulphur contents, ($R^2 = 1.00$). The diaromatic plus sulphur content is also found to correlate with acidity and viscosity percent increase in the initial and final oxidation stages,($R^2 = 1.00$).

Additionally, the oxidation reaction kinetics for base oils and mixed base oil blends are studied, whereby the oxidation reaction order and rate are successively estimated. The oxidation reaction is found to be a first order reaction which depends upon the availability and activity of free radicals in the reaction medium.

A proposed reaction mechanism is also suggested to verify the oxidation reaction order. On the other hand, the reaction rates are satisfactorily determined, where their values agree with the observations recorded for the physico-chemical properties change with oxidation.

The MIL -2104 B and MIL - 2104 C motor oil formulations are also tested for engine performance rating on the standard Petter AVA-1 engine according to a modified IP 175