Part I

Acrylate Based Polymeric Compounds as Multifunctional Lube Oil Additives

Chapter I

BACKGROUND OF THE PRESENT INVESTIGATION

With the development of modern technology, original equipment manufacturers (OEM) are trying to make modern and advanced engines. These types of engines require lubricants with multifunctional performance. But the existing lubricants cannot fulfill the requirement of modern engines and technology. Therefore it is necessary to prepare lubricants with multifunctional performance so that they can fulfill all the demands of the modern engine. All the commercially available lubricants contained some additives in them to add additional performance to the lube oil. Additive percentages in lube oil may vary from 1% to 30% or in some cases more [1]. The different types of additives which are normally added to the lube oil to improve its performance are:

i. Viscosity index improvers (VII) [2].
ii. Pour point depressant (PPD) [3].
iii. Anti-rear additives [4].
iv. Antioxidant [5].
v. Detergent/dispersant [6].
vi. Corrosion inhibitor [7].
vii. Extreme pressure additives [8].

When these types of additives are added to the lube oil they not only enhance the performance present in it but also add some new properties. Since chemical additives are not cost-effective and very harmful to the environment. So it is necessary to prepare some polymeric additives which are multifunctional so that they can fulfill the demand of modern engine and equipment.

In accordance with the present investigation it is very relevant to include a brief review on viscosity index improver (VII), pour point depressant (PPD), anti-wear (AW) properties, and shear stability. As already discussed in the general introduction the viscosity index (VI) is a unitless arbitrary number of a fluid that measures the change in viscosity with a temperature change. The lower-value of VI indicates that viscosity is more affected by change in temperature on the other hand higher value of VI indicates that the change of viscosity is very less with temperature change. This is because when the oil temperature is low, the polymeric additives are coiled up into tight balls which flow readily with the oil molecules. With the increase in temperature, they expand into large stringy structures that restrict the normal oil flow, resulting in a thickening effect on the oil. When the oil cools down, the polymers go back to their original shape [9], [10]. The polymers which have high molecular weight also increase effective volume in the lube oil solution and as a result, the polymers which have higher molecular weight exhibit a higher value of VI compared to the polymer of the same type with lower molecular weight [11]. The pour point of an oil is the lowest temperature at which an oil will pour or flow when cooled. Most of the lube oils contain some paraffin wax and complete removal of this paraffinic wax from the lube is not only difficult but also expensive. At low temperatures, the wax left in the lubricant base stock comes out of solution as wax crystals, producing a gel-like structure that impedes the flow of lubricant to critical engine parts which badly affects the performance of the engine. The polymeric additives which are used as pour point depressant have some pendant alkyl groups. When copolymers are used as PPD, there should be an appropriate distance between pendant chains with proper monomer ratios in the copolymers [12], [13].

Initially, the mechanical action of PPD assumed that the alkylated aromatic compounds act by coating the surface of the wax crystals and prevent for further growth. More recently it is to be believed that PPD acts by nucleation, co-crystallization, which inhibits the formation of their three-dimensional wax crystal network [14]. The anti-wear additives were used to prevent direct metal-metal contact of the two moving parts of the engine when oil film over the metal surface is broken down. The anti-wear additives increase the life of the machine. Generally strong adsorption or chemisorption takes place between the metal surface and the anti-wear additives and form a film on the metal surface. The shear stability of a lubricant is one of the essential criteria that determine the suitability of the additive in a lubricant formulation. The loss of viscosity of a lubricant under shearing conditions can be expressed in terms of permanent viscosity loss (PVL) or permanent shear stability index (PSSI). The PVL/PSSI value was determined as per the ASTM D-3945 method by the following relation [15].

$$\text{PVL}\ (\%) = (V_i - V_s)/\ V_i\ \text{X}100 \qquad (1)$$

$$\text{PSSI}\ (\%) = (V_i - V_s)/\ (V_i - V_o)\ \text{X}100 \qquad (2)$$

Where,

V_i = Kinematic viscosity of lube oil with polymer before shearing at 100°C

V_s = Kinematic viscosity of lube oil with polymer after shearing at 100°C

V_o = Kinematic viscosity of lube oil at 100°C

The lower the PVL/PSSI value, the higher is the shear stability of the polymer.

The homopolymer and copolymer of acrylate-based polymers specially dodecyl acrylate, behenyl acrylate, isodecyl acrylate, ionic liquid blend homopolymer of behenyl acrylate, and ZnO nanocomposite of poly dodecyl acrylate are widely used as viscosity index improver (VII) which is also known as viscosity modifier (VM), pour point depressant (PPD) and anti-wear. The home and copolymers of alkyl acrylate with styrene, 1-Decene are widely used as viscosity index improver (VII), pour point depressant (PPD) anti-wear, and shear stability improver. The following patents discussed the same.

U.S. patent number 5834408 described the procedure for the synthesis and performance evaluation of acrylate-based co-polymers as a pour point depressant in lube oil compositions.

US patent number 4073738 described the application of alkyl methacrylate alkyl acrylate or as PPD for lube oil in which the alkyl group can have 8 to 22 carbon atoms.

U.S. Patent number 3897353 described the oil composition comprising lubricating oil and n-alkyl methacrylate as a point depressant.

U.S. patent number 4968444 described the use of mixed polyacrylates as multifunctional lube oil additives.

There are several numbers of literature available on the efficiency of poly alkyl acrylate as VII and PPD [16]-[18].

From the above literature study, it has been found that alkyl acrylate-based homo and copolymer can be used as potential multifunctional additives for lube oil. In our present investigation, we have synthesized some long chain alkyl acrylate-based homopolymer and copolymer with Styrene and 1-Decene. Our present investigation also comprises ionic liquid and ZnO nanoparticle blended long chain alkyl acrylate-based homopolymer.

References

References are given in *BIBLIOGRAPHY* under “Chapter I of Part I” (Page No. 136-138).