ABSTRACT

A lubricant is a substance introduced to reduce friction between surfaces in mutual contact, which ultimately reduces the heat generated when the surfaces move. It may also have the function of transmitting forces, transporting foreign particles, cooling the surfaces, protection against wear and prevent corrosion.

The lubricant contains base oil and an additive package. The function of additives is either to enhance an already-existing property of the base fluid or to introduce a new property.

Present work comprises synthesis, characterization and performance evaluation of multifunctional additives for lube oil. The additives synthesized were poly acrylate based. In case of copolymers, the other monomers used were styrene, 1-Decene, β- pinene and different vegetable oils. The polymers were synthesized thermally or by microwave method in presence of BZP/AIBN as initiator. Characterization of the polymers was done by spectral analysis (FT-IR, ^{1}H NMR and ^{13}C NMR), followed by molecular weight determination (viscometric / GPC) and finally analysis of thermal stability by Thermo gravimetric analysis (TGA). Additive performance of the polymers were investigated in base oils as viscosity modifier (VM), pour point depressant (PPD) and in some cases as anti wear (AW) additive according to standard ASTM methods. The shear stability and oil thickening property of the polymers has also been investigated. In case of biodegradable polymeric additives, biodegradability analysis was performed by Disc diffusion method against fungal pathogens and by Soil burial degradation test as per ISO 846:1997. Since the additives were multifunctional in nature (PPD, VM and/ or AW), interest of research on this area gives a new horizon in the lubrication technology.

The thesis starts with a general introduction of present investigation. Then the detailed research work has been divided in three parts: Part I, Part II and Part III. Part I, "Liquid crystal blended polyacrylate as multifunctional lube oil additive" is divided into four chapters, Chapter I, Chapter II, Chapter III and Chapter IV. Chapter I comprises background of respective work. Chapter II describes synthesis, characterization and performance evaluation of multifunctional additive derived from cholesterol benzoate (CB) blended polydodecyl acrylate. CB is known to possess liquid crystalline properties, which can lead to induce effective anti wear performance of them. Again poly acrylates are well known VM and PPD. With this background 100 ppm of cholesterol benzoate was blended with poly dodecyl acrylate in anticipation of getting VM, PPD and AW activity in resultant blend. Poly dodecyl acrylate was synthesized from dodecyl acrylate, followed by spectral characterization (FT-IR, ^{1}H NMR and ^{13}C NMR) and viscometric molecular weight determination. The polymer was then blended with 100 ppm cholesterol benzoate and the additive performance of both the homo polymer and the blend was carried out in two base oils. The blended sample found to be better VM, PPD and AW additive. Chapter III is further subdivided into two sections, Section A and Section B. Section A describes detailed work on multifunctional additive performance of liquid crystal blended poly decyl acrylate, whereas Section B comprises similar study on systems containing ester based liquid crystals and poly decyl acrylate. Detailed comparative investigation on the homo poly decyl acrylate and poly acrylate-liquid crystal blended samples confirmed better additive performance of the later as VM, PPD and AW additive. Ester functionality in the liquid crystals was found to play an important role in anti wear performance. Chapter IV comprises synergistic effect of liquid crystals

on additive performance of polymer of mixed acrylate. The mixed acrylate was synthesized from octyl, decyl, dodecyl alcohols and acrylic acid. The polymer of mixed acrylate was found to be more effective lube oil additive than any of the constituent poly acrylates. The liquid crystals chosen for the study had different functional groups. Samples containing liquid crystals with long alkyl chain and ester functionality showed better performance as lube oil additive.

Part II, "Investigation on anti wear properties of some well known viscosity modifiers" is divided into three chapters, Chapter I, Chapter II and Chapter III. The first Chapter deals with background of respective work. Chapter II is "Viscometric and wear performance of methacrylate based lubricants". Homo poly hexadecyl methacrylate and two of its copolymers with 1-Decene and styrene were synthesized, characterized and evaluated for viscosity modifier and anti wear performance. Molecular weights of the polymers were determined by GPC analysis. Thickening effect and shear stability of the polymer samples were also determined and reported. Additive concentration and additive chemistry were the key factors of additive performance. Chapter III, "Correlation of anti wear performance and shear stability with the chemistry of some commercial viscosity modifiers for lube oil" deals with anti wear activity of three major kinds of commercial viscosity modifiers, *viz.* poly methacrylate (PMA), olefin copolymer (OCP) and hydrogenated styrene isoprene copolymer (SIP). Anti wear activity was investigated under 20 kg and 40 kg load conditions. Degradative stability of the samples was measured in terms of shear stability index and permanent shear loss. Oil thickening effect was also measured and reported.

Part III, “Biodegradable lube oil additives” is segregated into three chapters, Chapter I, Chapter II and Chapter III. Chapter I is brief review on background of the topic. Chapter II describes biodegradable lube oil additives obtained from copolymer of olive oil and isodecyl acrylate. The copolymers were characterized by spectroscopy, TGA and molecular weight. Biodegradability was measured by i) Disc diffusion method and ii) Soil burial test. The polymer samples recovered after the tests were measured to calculate effective weight loss. GPC analysis and FT-IR spectra of recovered samples were compared with respective results before the tests to confirm the biodegradable nature of the copolymers. The copolymer samples found to be biodegradable VM and PPD additive for lube oil. Chapter III comprises similar investigation on three systems *viz.* i) poly isodecyl acrylate + rice bran oil, ii) poly isodecyl acrylate + peanut oil and iii) poly isodecyl acrylate + β-pinene. 5% and 10% copolymers were synthesized for each of them, followed by characterization and performance evaluation. Biodegradability analysis was also carried out for the samples. The copolymers were found to show excellent biodegradability and significant VM, PPD properties for lube oil.