The Lubricating Ability, Properties & Applications of Ionic Liquids

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Abstract— Friction and wear become the most dominant factors affecting the efficiency of industrial production sector. The development of advanced lubricants and lubricant additives to reduce the friction and wear failures will lead to vital economic and environmental benefits. Recently, ionic liquids received good attention as potential and environmentally-friendly alternate lubricants and lubricant additives. The ionic liquids exhibit enhanced performance in terms of corrosion, viscosity and temperature dependent characteristic and thermal and hydrolysis stabilities. In this study, applications and properties of ionic liquids are discussed.

Key words: Friction, Wear, Lubricants, Ionic Liquids, Additives

I. Introduction

Wear is a persistent service condition in many engineering applications with economic and technical consequences. In terms of economics, the cost of abrasion wear has been estimated as ranging from 1to 4% of the gross national product of an industrialized nation. The effect of abrasion is particularly evident in the industrial areas of agriculture, mining, mineral processing, and earth moving which in fact defining or limiting the functional lifetime of a component. If a mechanical system is not lubricated, the presence of oxide powder may not necessarily signify fretting but, rather, wear [1]. A lubricant is a substance, usually organic, 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 and transporting foreign particles. Lubrication is the process or technique of using a lubricant to reduce friction and/or wear in a contact between two surfaces [2].

II. Roll of Additives in Lubrication

The lubricating performance liquid lubricants are poor when it is working at high temperature and Extreme Pressure (EP) conditions where the lubricants are decompose and fail to maintain the thickness of oil film to separate the interacting surfaces in relative motion. To face such conditions EP additives are homogeneously dispersed into the lubricating oils and it is called as EP Lubrication. Lubricants dispersed with nanoparticles are known to be the most effective method to reduce the friction and wear at contact metal parts. The lubricants with dispersed milli or micro-sized particles have not been applied to any industrial sectors due to the problem of dispersion stability of suspensions that involve coarse-grained particles [3-5].

Recently nanomaterials are added into the liquid lubricants to improve its physical and chemical properties. The oils based nanoparticle dispersions are referred as Nano lubricants which are prepared by homogeneously dispersing nanoparticles into liquid lubricant oils. Their nanometer size allows them to enter into the contact area like molecules. They are very quick effective even at ambient temperatures. Therefore, no induction period is necessary to obtain interesting tribological properties. These additives interact with metal surfaces in a chemical process, at molecular level, to create a protective compound which increases the thermal stability of metal surfaces which actually bond with the metal surface. This is not a film or coating over the metal. It is a permanent modification of the metal surface. Using the nanomaterials in the lubricant has the specific advantages such as very good thermal and chemical stability, high load carrying quality, increased heat transfer and very good anti-wear properties with reduced friction. At EP conditions the additives prevents the direct metal-metal interaction and uses lubricant film having around their circumferences for lubrication purposes.

III. Dispersion Stability of liquid lubricants containing nanomaterials

The dispersion stability of liquid lubricants containing nanoparticles is very poor. The presence of surfactant increases the dispersion stability of two phase interfaces by decreasing the surface tension leading to the formation of foam. The presence of additives, such as nanoparticles, polymer, salt, alcohol and combination of different surfactants are potential to improve the performance and dispersion stability produced from single surfactant system.

An ionic liquid is a salt in the liquid state. Recently, researchers investigated the process capability of ionic liquids as alternative additives in enhanced oil recovery processes and it has been promoted as novel surfactant due to its ability to reduce oil/water interfacial tension/surface tension at various salinity and temperatures. The choice of the cation has a strong impact on the properties of the ionic liquid and will often define the stability. The chemistry and functionality of the Ionic Liquid is, in general, controlled by the choice of the anion [6].

IV. Ionic liquids

An ionic liquid is a salt in the liquid state. In some contexts, the term has been restricted to salts whose melting point is below some arbitrary temperature. The ionic bond is usually stronger than the Van der Waals forces between the molecules of conventional liquids. Due to this reason, common salts melt at higher temperatures than other solid molecules [7].

In the last decade, ionic liquids have received attention as high performance lubricants and lubricant additives. Ionic liquids can be defined as salts with melting temperatures below 100°C. The strong ionic or coulomb interaction results a negligible vapor pressure and in a high thermally as well as electrochemically stable ionic liquid product [8-11].

A. Properties of Ionic Liquids

Ionic liquids are often moderate to poor conductors of electricity, non-ionizing, highly viscous and frequently exhibit low vapor pressure. Their other properties are diverse: negligible volatility, wide liquid-range, low combustibility, non-flammability, thermal stability and have favorable solvating properties for a range of polar and non-polar compounds. Thermal stability and melting point of ionic liquids depend on the liquid's components. In addition to these properties, ionic liquids have the ability to form adsorbed layers on the metal surfaces which prevents the direct contact between interacting surfaces [7-11].

The thermochemical kinematic viscosity, dispersion stability, wetting performance and other physicochemical as well as thermal properties of ionic liquids are important factors to consider for the lubricants applications [7-11].

B. Applications of Ionic Liquids

Ionic liquids have been considered for many industrial applications. Their properties of thermal stability and low vapor pressure make them attractive in many gas storage and handling applications [11].

The ionic liquid 1-butyl-3-methylimidazolium chloride has been investigated as a non-aqueous electrolyte media for the recovery of uranium and other metals from spent nuclear fuel and other sources [11].

Ionic liquids are potential heat transfer and storage media in solar thermal energy systems. Concentrating solar thermal facilities such as parabolic troughs and solar power towers focus the sun's energy onto a receiver which can generate temperatures of around 600 °C. This heat can then generate electricity in a steam or other cycle [11].

Ionic liquids can aid the recycling of synthetic goods, plastics and metals. They offer the specificity required to separate similar compounds from each other, such as separating polymers in plastic waste streams [11].

Ionic liquids can replace water as the electrolyte in metal-air batteries. Ionic liquids are attractive because of their low vapor pressure, increasing battery life by drying slower [11].

Ionic liquids can act as dispersing agents in paints to enhance finish, appearance and drying properties. It has been proposed as an absorbent in carbon capture. They have various advantages over traditional absorbents, such as the currently dominant amine-based technologies. Ionic liquids' low volatility effectively eliminates a major pathway for environmental release and contamination. However, this property is distinct from toxicity. Ionic liquids' aquatic toxicity is as severe as or more so than many current solvents [11].

V. CONCLUSION

The thermochemical kinematic viscosity, dispersion stability, wetting performance and other physicochemical as well as the thermal properties of ionic liquids are the most important factors to consider for the lubricants applications. Ionic liquids are gaining acceptance globally due to their enhanced properties, environmentally friendly and sustainable behaviors than the conventional lubricants. Indeed, the potential for ionic liquids to eventually replace conventional liquid lubricants is presently found in the literature as possible.

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