Halogen-Free Ionic Liquids Composed of Bis(salicylato)borate Anion as Lubricants Additive

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1. Introduction

Need to conserve energy and environment has catalyzed an interest to develop a new generation green lubricants or lubricant additives, which can improve the energy efficiency of engineering system, where two or more surfaces are in contact and moving relative to each other. In recent years, ionic liquids have attracted significant attention for diversified range of applications owing to combination of their unique and tunable physico-chemical characteristics such as low vapor pressure, good thermal stability, non-flammability, excellent conductivity and high viscosity. These features make ionic liquids as potent candidates for tribological applications to reduce friction and wear. An inherent polar nature of ionic liquids facilitate their interaction with sliding surfaces, resulting in lube thin film formation. Such thin film of ionic liquids avoid metal-to-metal contact, consequently reduction in friction and wear. However, recently, it was noted that the presence of halogen content in hydrophilic ionic liquids is detrimental to the contact surfaces, particularly at high temperature and pressure owing to formation of halogen acids. Hence, there is an emergent need to develop halogen-free ionic liquids, which not only reduced friction and wear significantly but also protect engineering surface and environment.

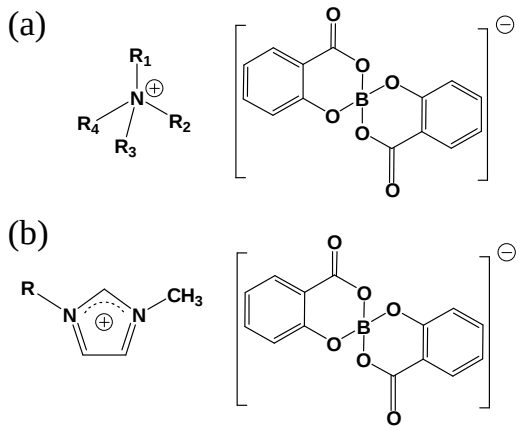

Figure 1: Representative molecular structures of (a) tetraalkylammonium bis(salicylato)borate and (b) alklymethylimidazolium bis(salicylato)borate ionic liquids. In this study, alkyl groups are varies from C_2 to C_8 with normal chain configuration.

Herein, we report synthesis of halogen-free ionic liquids composed of bis(salicylato)borate anion having two different category of cations i.e. imidazolium and ammonium. In each category of ionic liquids structural changes have been made by changing the alkyl chain length to probe their effect on tribological properties. The synthesized ionic liquids were thoroughly characterized by NMR, FTIR and TG-DTA analyses. Poly(ethylene glycol)-200 and finished commercial engine oil 10W-40 were selected as lube base stock to probe the lubrication properties of bis(salicylato)borate anion based ionic liquids. These ionic liquids found to have good miscibility in both lube base stock. All tribological test were conducted on four ball test machine as per the ASTM D-4172 standard test method. Bis(salicylato)borate anion based ionic liquids as additives in PEG 200 and 10W-40 oil exhibited excellent friction-reduction and anti-wear behavior. At optimized concentration of alkylmethylimidazolium bis(salicylato)borate (Alkyl: Cn = 2, 4 and 6) ionic liquids, the friction-coefficient and WSD were reduced by 12 - 20 % and 17 - 30%, respectively. Tetraalkylammonium bis(salicylato)borate (Alkyl: Cn = 1, 4, 5 and 8) also exhibited significant reduction in friction and anti-wear properties (10 - 22 % and 22 - 26 % reduction in friction coefficient and WSD, respectively). The microstructural and elemental analysis on the worn surfaces based on FESEM and EDX measurements, respectively, reveals the role of ionic liquids for the improved lubrication characteristics.