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Tribological Behavior of Hybrid Nanolubricants for Internal Combustion Engines

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Abstract : The need to develop new lubricants that offer better anti-friction and anti-wear performance in internal combustion vehicles is one of the great challenges of lubrication in the automotive field. The addition of nanoparticles has emerged as a possible solution and, combined with the lubricating power of ionic liquids, may become one of the alternatives to reduce friction losses and wear of the contact surfaces in the conditions to which tribo-pairs are subjected, especially in the contact of the piston rings and the cylinder liner surface. In this study, the improvement in SAE 10W-40 engine oil tribological performance after the addition of magnesium oxide (MgO) nanoadditives and two different phosphonium-based ionic liquids (ILs) was investigated. The nanoparticle characterization was performed by means of transmission electron microscopy (TEM), Fourier-transform infrared spectroscopy (FTIR), Raman spectroscopy, X-ray diffraction (XRD), and scanning electron microscopy (SEM). The tribological properties, friction coefficients and wear parameters of the formulated oil modified with 0.01 wt.% MgO and 1 wt.% ILs compared with the neat 10W-40 oil were performed and analyzed using a ball-on-three-pins tribometer and a 3D optical profilometer, respectively. Further analysis on the worn surface was carried out by Raman spectroscopy and SEM microscopy, illustrating the formation of the protective IL and MgO tribo-films as hybrid additives. In friction tests with sliding steel-steel tribo-pairs, IL3-based hybrid nanolubricant decreased the friction coefficient and wear volume by 7% and 59%, respectively, in comparison with the neat SAE 10W-40, while the one based on IL1 only achieved a reduction of these parameters by 6% and 39%, respectively. Thus, the tribological characterization also revealed that the MgO and IL3 addition has a positive synergy over the commercial lubricant, adequately meeting the requirements for their use in internal combustion engines. In summary, this study has shown that the addition of ionic liquids to MgO nanoparticles can improve the stability and lubrication behavior of MgO nanolubricant and encourages more investigations on using nanoparticle additives with green solvents such as ionic liquids to protect the environment as well as prolong the lifetime of machinery. The improvement in the lubricant properties was attributed to the following wear mechanisms: the formation of a protective tribo-film and the ability of nanoparticles to fill out valleys between asperities, thereby effectively smoothing out the shearing surfaces.

Keywords : lubricant, nanoparticles, phosphonium-based ionic liquids, tribology
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