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Dispersion and tribological behaviors of modified functionalized surfaces of single and hybrid nanoparticles in water-based lubrication

Abstract

This study investigated the dispersion and tribological effetcs of modifying surface functionalization on single (GO, Al_2O_3, MgO, SiC) and hybrid (SiC/MgO, Al_2O_3/MgO) nanoparticles in water-based lubricant (WBL) formulations. Polyvinylpyrrolidone (PVP) and glycerol were utilized to further enhance dispersion and viscosity. The experimental findings revealed that incorporating modified nanoparticles surfaces in WBLs improved hydrophilicity and dispersion by introducing additional oxygen functional groups. This effectively reduced direct metal-to-metal contact, resulting in lower interface temperatures and enhanced tribological performance. Hybrid Al_2O_3/MgO nanoparticles exhibited a significant 76.69 percent enhancement in tribological performance in wear mechanisms, synergistically filling microcracks to improve lubricant film formation, bearing, and mending effects. Using a single nanoparticle was found to be insufficient for achieving enhanced tribological effects. All nanoparticles improved bearing effects, except for GO, which promoted a shearing effect. High-hardness nanoparticles such as SiC and Al_2O_3 demonstrated an additional polishing effect.

Keywords

contact mechanism; dispersion stability; friction; nanoadditive; nanoparticle; Water-based lubricant; wear