Nanostructured lubricant additives for titanium alloy: Lubrication by the solid-liquid interface with Coulomb repulsion

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February 2, 2023

Abstract

In this work, the advantage of Coulomb repulsion in the intermolecular forces experienced by molecules on the solid-liquid nanosized contact interface is taken, and the superior friction-reducing property of Cu3(PO4)2·3H2O (CuP) oil-based additives has been confirmed for titanium alloy. 3D CuP nanoflowers (CuP-Fs) with a strong capillary absorption effect are prepared to achieve the homogeneous mixing of solid CuP and lubricating oil. Lubrication by CuP-Fs additives for titanium alloy, friction coefficient (COF) can be reduced by 73.68%, and wear rate (WR) reduced by 99.69%. It is demonstrated that the extraordinary friction-reducing property is due to the repulsive solid-liquid interface with low viscous shear force originating from Coulomb repulsion between polar water molecules in CuP and non-polar oil molecules. However, any steric hindrance or connection between this repulsive solid-liquid interface will trigger the adhesion and increase the viscous shear force, for example, dispersant, hydrogen bondings, and shaky adsorbed water molecules. Besides, the lamellar thickness of CuP and molecular size of lubricant both have a great influence on tribological properties. Here the lubrication mechanism based on interface Coulomb repulsion is proposed that may help broaden the scope of the exploration in low-friction nanomaterial design and new lubricant systems.

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