8TH PACIFIC RIM CONFERENCE ON RHEOLOGY, May 15-19, 2023

EXPLORING THE INTERPLAY BETWEEN INTERPARTICLE FORCES, RHEOLOGY, AND TRIBOLOGY IN NANOCLAY-BASED NANOLUBRICANTS

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ABSTRACT

Nanoclay additives are an eco-friendly solution for improving the friction and wear properties of grease lubricants. These additives' performance is determined by interparticle forces that impact both tribology at the contact interface and the microstructure's dynamic build-up and breakdown during shear. This study aims to explore the impact of concentration and interparticle interaction on nanoclay lubricants' rheology and tribology. Using polyalphaolefin oil, we prepared yield stress fluid suspensions by thickening it with nano-montmorillonite Cloisite 20A (C20A) or oleic-acid functionalized Cloisite 20A (C20A-OA) at varying concentrations. The suspensions were then examined using a modular rotational rheometer under steady and dynamic shear flows, while a frictional steel ball-on-three-steel plates setup was used to analyze their tribology. Atomic force microscopy and a profilometer were used to examine the interaction forces and wear scars. Our findings reveal that increasing the C20A concentration led to greater nanoparticle crowding and agglomeration, increasing lubricant stiffness and reducing the boundary friction at the tribocontact. However, C20A functionalization with OA increased nanoparticle dispersion and affected stiffness and aging dynamics. Microstructural investigation and time-dependent rheology uncovered that these changes are driven by increased repulsive forces, decreased inter-particle friction between C20-OA nanoparticles, and faster reorganization of the C20-OA nanoparticle network under shear. Greater interparticle repulsion enabled C20-OA nanoclays to align in the direction of shear, reducing overall viscosity. Furthermore, the presence of OA on nanoclays decreased inter-particle friction and particle-steel surface friction. These results provide insight into the interplay between nanoclay network evolution and the resulting rheological and lubricating properties of the derived nanolubricants, offering a platform for the development of novel, high-performing nanolubricants.