TRIBOLOGICAL PROPERTIES OF NANO-SIZED MOLYBDENUM DISULFIDE PARTICLES

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ABSTRACT

This paper summarizes the tribological properties of MoS2 nano-particles with about 30 nm under different frictional conditions. By four-ball tribometer, the results showed that as the nano-MoS2 content is over 0.5 wt% the extreme pressure of lubricating oil is higher than to 30% than that of lubricating oil with same content of common MoS2. The nano-MoS2 particles can decrease the friction coefficient of lubricating oil obviously. However the results showed that their friction reductions have not obvious difference by the ring-on-block tribometer. The analyses of surface composition conducted by XPS and SEM images showed that the nanoparticles form a protective film (WO3) allowing an increase in the load capacity of rubbed pairs. The main advantage of the nanoparticles is ascribed to the release and furnishing of the nanoparticles from the valley onto the rubbing metal surface and their confinement at the interface.

INTRODUCTION

It has been very well known that MoS2, especially nanosized MoS2, presents considerable applications in many fields such as solid lubrication and additives for lubricating oils and potential self-lubricating polymer materials [Wo et al, 2004]. It is reported that MoS2 nanoparticles mixed in oil, grease or impregnated into porous matrix of powdered materials appear to enhance the tribological properties in definite loading range in comparison to typical metal dichalcogenides particles [Greenberg et al, 2004, Hu et al, 2004]. There are many different kinds of methods to prepare ultrafine molybdenum disulfide particles. However, using different preparation methods will result in the variations of morphology and performance of nanosized MoS2 particles.

The present paper reports the tribological properties of the lubricating oil with nanosized MoS2 particles by the gas-solid reaction of MoS3, obtained by Na2MoO4 and Na2S with quick homogeneous precipitation method (QHPM) at ambient temperature, and H2.

EXPERIMENTAL

Preparation of lubricating oil samples

Nano-MoS2 with a diameter of about 30 nm was prepared in our previous study. Commercially available MoS2 particles (about 1.5 µm in diameter) were produced from Anhui Metallurgical Institute as the comparison of tribological performance with nano-MoS2. A kind of base oil (N46 engine oil) was purchased from Anhui Petro-Chemical Company.

Friction and wear tests

Friction and wear tests were conducted with a MM--200 tribometer using a block-on-ring arrangement with the AISI 1045 steel block sliding against the AISI E52100 (HRC 60-62) ring in air (R. H. 80%) at room temperature (25 ºC) under oil-dropping lubrication condition with 60 drops per minute. The friction and wear tests were performed at a sliding velocity of 400 rpm (0.84 m/s) at the contact surfaces. The blocks were polished with 600 grade SiC paper. The extreme pressure, friction reduction and wear resistance were carried out under four-ball friction condition by Q-800 four-ball tribometer in which AISI E52100 steel ball was used with a diameter of 12.7 mm and HRC 60-62.

Characterization of particles and lubricity

A Hitachi H-800 transmission electron microscope (TEM) was used for observing the morphology of particles. X-650 scanning electron microscope (SEM) was used to investigate the topographies of worn surfaces. ESCALAB MKII X-ray photoelectron spectroscopy (XPS) using Al K-Alpha as source has been used to investigate the surface chemical state on the rubbed surface and determine the evidence of surface modification from an influence of MoS2 particles.

RESULTS AND DISCUSSION

The tribological behavior of the MoS2 nanoparticles as additive in N46 mineral oil with different concentrations was comparatively investigated with that of commercial micro-sized MoS2 particulates (c.a. 1.5 µm in diameter) on a four-ball machine. The extreme pressure properties of different size of MoS2 particles in the N46 mineral oil can be shown in Figure 1. Figure 2 showed the variations of their friction reductions. The chemical states of the elements on the worn steel surface under different lubricating conditions were determined on an X-ray photoelectron spectroscopy, while the morphologies of the worn steel surfaces lubricated with different lubricant systems were observed on a scanning electron microscope. Under four ball friction pairs, the improvements of extreme pressure and friction reduction could be attributed to the easier adsorption of the MoS2 nanoparticles on the sliding steel surface and the formation of a molybdenum trioxide-containing lubricating and protective film thereon by the readily oxidation of the nanoparticles in the sliding process, which is also from the release and furnishing of the nanoparticles from the valley onto the rubbing metal surface and their confinement at the interface.

From ring-block tribometer, the results showed that the N46 mineral oils with nanosized MoS2 additive have higher wear resistance than others with micro-MoS2. However, its friction reduction was not improved obviously, as shown in Figure 3. The variation of friction reduction of nano-MoS2 particles under different rubbing conditions is related with the hardness and the surface roughness of frictional block on the ring. SEM characterization reveals a worn surface is smooth.
as using nano-MoS2 additive, and XPS analysis indicates that more molybdenum oxide and iron sulfide in the antitrust thin film formed on the rubbed surface, compared with using common MoS2. Figure 4 showed the morphology of nano-MoS2 by TEM and the rubbed surface of upper ball in the four ball experiment by SEM, respectively.

CONCLUSIONS AND FUTURE WORKS

The improvements of the extreme pressure and wear resistance of lubrication oil are of potential as adding nano-MoS2 particles. The influence of nano-MoS2 particles on the friction reduction of lubricating oil was limited by the friction conditions, especially by the surface roughness and hardness.

However, the friction and wear mechanisms of nano-MoS2 particles in lubricating oil are not still clear; the relation between of micro-properties of nano-MoS2 particles and macro-tribological results is also worthy studying in the future.

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REFERENCES


FIGURES

Figure 1. Variation of extreme pressure by four-ball tribometer

Figure 2. Variation of friction reduction by four-ball tribometer

Figure 3. Variation of friction reduction by ring-block tribometer

Figure 4. Morphology of Nano-MoS2 by TEM (a); rubbed surface by SEM (b)