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PEI-RGO NANOSHEETS AS A NANOADDITIVE FOR ENHANCING THE TRIBOLOGICAL PROPERTIES OF WATER-BASED LUBRICANTS

TRACK OR CATEGORY
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INTRODUCTION
In order to overcome the issues of failure of machineries and energy loss between interacting tribo-elements because of the friction, lubricants are broadly used in various mechanical units and operations [1]. Apart from reduction of friction and wear, lubricants can also improve heat transfer capacity, reduce vibration and noise and clean the dirt and contaminants. Some materials named as lubricant additives are commonly added to the conventional lubricants to adjust friction characteristics, prevent direct friction pairs contact and improve the lubricity [2]. Nowadays, with the rapid development of nanotechnology, nanoadditives are introduced as new additives to the lubricants such as metal [3,4], mental oxide [5-9], mental sulfide [10], organic material [11], silicate [12] and carbon materials [13-16] because of the advanced tribological properties of lubricants with nanoadditives. Graphene is considered to be a potential material for nanoadditives in lubricant owing to its unique mechanical performance, electrical conductivity, high thermal conductivity and low surface energy [17, 18]. It shows high chemical inertness, high strength and the atomically smooth surface, which expected to become potential solid lubricant for micro/nano mechanical systems [19, 20]. However, few other reports were found on the use of graphene or its derivatives as additives in water lubrication in tribology behaviors of steel contacts.

1. Friction tests
As shown in Fig. 1, the friction tests were carried out by CFT-type material surface performance tester with a ball-on-disk configuration. The ball was made by GCr15 bearing steel with the diameter of 3 mm. The fiction pairs were 201 stainless steel disk and GCr15 bearing steel ball, which were cleaned ultrasonically in turn with petroleum ether and ethanol for 10 min before friction tests. Each test was repeated three times. The coefficient of friction (COF) was obtained by a relative sliding test of fiction pairs with single reciprocating length of 3 mm for 30 min.

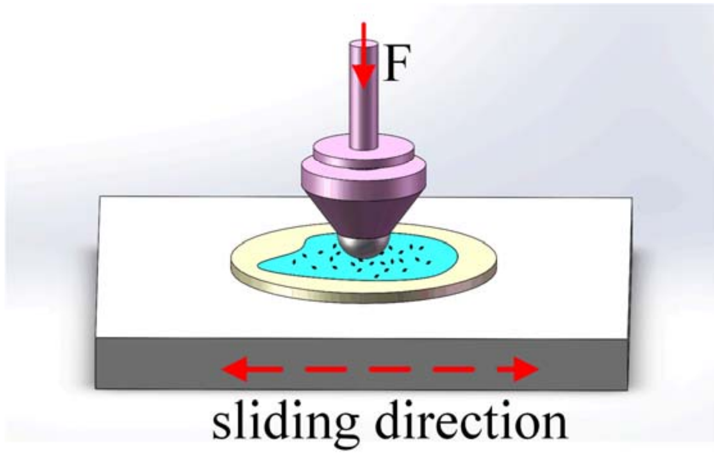

Figure 1. Schematic presentation of friction test.

2. Tribological characterization

First, when the sliding frequency was 3 Hz and the applied load was 4 N, the friction experiments were carried out for water solution with different concentration of PEI-RGO. The concentration of PEI-RGO were 0 wt%, 0.03 wt%, 0.05 wt%, 0.07 wt%, 0.1 wt% respectively. The results were shown in Fig. 2a, the COF declined with the increase of the mass fraction of PEI-RGO from 0 wt% to 0.05 wt%. However, the COF changed slightly by the continue increasing concentration of PEI-RGO. As shown in Fig. 2b, the maximum value of mean COF was 0.49392 when the lubricant was pure water. When the concentration of PEI-RGO was 0.05 wt%, the mean COF had an obvious reduction up to 52.3% compared with pure water. As shown in Fig. 8c, the trend of wear rate was roughly consistent with that of mean COF. But there is a difference that when the concentration of PEI-RGO was 0.1 wt%, the wear rate approaches to the minimum.

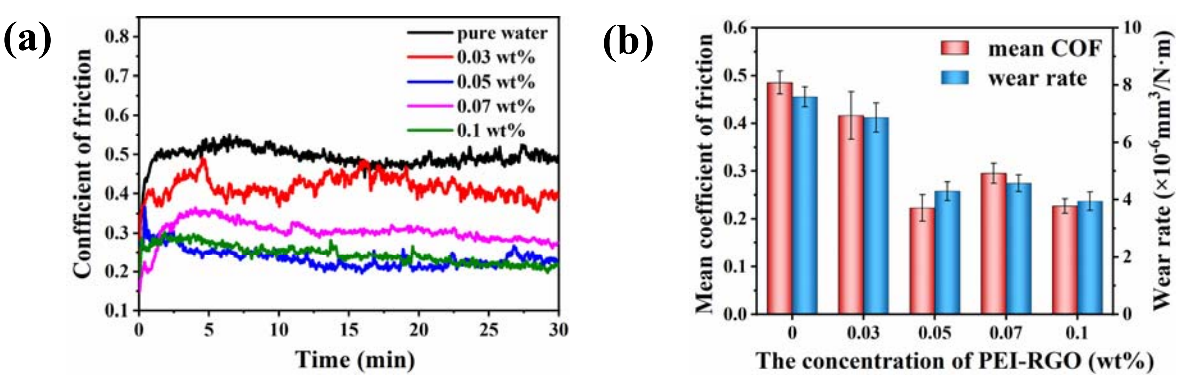

Figure 2. Tribological properties of water solution with different PEI-RGO mass fraction lubricated at frequency 3 Hz under 4 N load at ambient environment. (a) COF; (b) mean COF and wear rate.

3. Lubrication mechanisms of PEI-RGO

The lubricant was mainly working in the boundary and mixed regime of lubrication based on the above results, there are not enough water lubricants in the contact area between the friction pairs leading to particularly high to friction and wear during the friction test with the pure water lubricant. When a small amount of PEI-RGO nanoadditive was added to pure water, because of the weak interlayer van der walls force of PEI-RGO, two adjacent layers were easily slipped and exfoliated into smaller nanosheets under a shear force during the sliding friction tests, thus entering to the contact area. The sliding movement of adjacent layer and small structure of PEI-RGO may o□er lower shear stress and prevent direct interaction between the surface of friction pairs, so PEI-RGO has a good friction and antiwear properties. Therefore, the mean COF and the wear rate decreased compared with pure water lubrication. With the concentration of PEI-RGO rising, the hydrophilic and lubricating PEI-RGO nanosheets entered the contact area of the friction pairs as more as possible to prevent the direct contact between steel surfaces by forming a carbonaceous lubricating and protective film, thereby, improved the lubricant behavior of the water-based lubricant. However, when the mass of PEI-RGO was more than 0.05 wt%, it is difficult for a large amount of PEI-RGO nanosheets to enter the contact area, therefore, the PEI-RGO nanosheets were accumulated in the outside of the contact area. Therefore, the depth of wear track in the contact area increased and the bathtub-shaped cross section of wear track was formed.

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KEYWORDS
Antiwear Additives, Carbon, Lubricants Water-Based