7th World Tribology Congress, WTC 2022
July 10-15, 2022, Lyon, France

Lubrication of Low-dimensional Carbon-based Coatings

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With the development of precision manufacturing mechanical systems, interest in novel materials with superior tribological properties has increased rapidly. Low-dimensional carbon-based materials such as graphene and carbon nanotubes (CNTs) are one of the promising candidates for the lubricants due to high intrinsic mechanical properties and exceptional lubrication performance for prolonged lifetime of various mechanical components. In this work, we investigated the lubrication performance of the carbon-based coatings on a target substrate. The experimental results and corresponding analysis revealed that the carbon-based coatings would aid in the advancement of precision mechanical systems in a wide range of tribological applications.

Keywords: Tribology, Friction, Wear, graphene, CNTs

1. Introduction

In the past decades, superior tribological properties have been exhibited by using a thin-film coating technology with aim to prolong the lifetime of mechanical components. General strategies to impart superior tribological properties to the coatings include high hardness, stiffness control, special nanostructures, low shear strength and surface energy reduction [1].

To date, low-dimensional carbon-based coatings such as graphene and carbon nanotubes (CNTs) exhibit outstanding performances including high intrinsic strength, outstanding lubricating performance, eco-friendliness and cost-effectiveness. Reinert et al. have demonstrated the use of CNT coating as a solid lubricant on a surface textured stainless steel to achieve coefficient of friction (COF) as low as ~0.2 for 10,000 sliding cycles with no noticeable wear [2]. CNT coatings were considered as a roller bearing layer to efficiently separate the stainless-steel substrate from the counter surface which resulted in reducing the friction and wear. As for the graphene coating, Berman et al. has demonstrated graphene not only as an outstanding solid lubricant in nano- to macro- scale but also as effective additives to oils, composites and solvents for the friction and wear reduction [3].

In this work, we investigated the feasibility of applying the carbon-based coatings as lubricants for various mechanical components in a wide range of tribological applications.

2. Methods

An electrohydrodynamic spraying process (ESP) was selected in this work to deposit carbon-based coatings on a target substrate. Prior to ESP, commercially available graphene and CNTs were well-dispersed in the mixture of ethanol and distilled water. Figure 1 presents transmission electron microscope (TEM) images of the graphene and CNTs used in the experiment. To characterize the surface of the coating, the surfaces were observed with an atomic force microscope (AFM), a scanning electron microscope (SEM) and a confocal microscope. Also, X-ray diffraction (XRD) was utilized to characterize the structural properties and chemical bonding composition of the graphene and CNT coatings.

Followed by the general characterization of the coatings, tribological characteristics were investigated by using a tribotester. The normal and lateral forces were monitored in real-time to obtain COF with respect to the sliding cycles. The surface topography observation and corresponding chemical analysis of the wear tracks were performed to verify the superior lubrication mechanism of the carbon-based coatings.

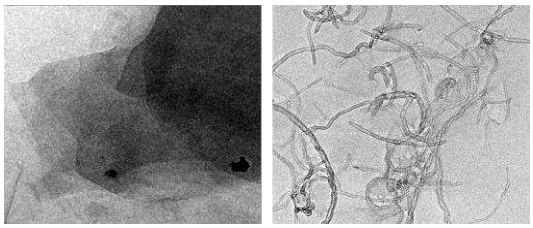

Figure 1: TEM images of graphene (left) and CNTs (right).

3. Discussion

The experimental results revealed that low-dimensional carbon-based coatings could serve as an effective lubricant layer for the reduction of friction and wear. With further optimization of the deposition process to lower the surface roughness of the carbon-based coatings, the coatings could be considered as one of the promising lubricants which will aid in fast advancements of precision mechanical components in a wide range of tribological applications.

Acknowledgment

The work was financially supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (NRF-2019R1C1C1004104).

4. References

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