ENVIRONMENTAL EFFECTS ON TRIBOCHEMISTRY AND WEAR OF SNO_2 INTERFACES

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KEYWORDS

Friction; Tribofilms and 3rd bodies; Coating; Volatile organic compounds

ABSTRACT

Tribology, the study of friction, wear, and lubrication is a fundamental pillar of mechanical efficiency and industrial sustainability [1]. It is increasingly recognized that environmental factors such as humidity and airborne contaminants (e.g volatile organic compounds), can drastically alter the behavior of sliding interfaces [2,3]. Understanding these subtle interactions is vital for mitigating the wear that leads to costly mechanical failures and resource waste.

Our study explores the environmental sensitivity of SnO_2, a metal oxide widely utilized in gas sensing for its high reactivity to ethanol, and evaluates its tribological behavior when sliding against 100C6 steel. Friction tests were performed under varying atmospheres, including humid air and nitrogen (N_2) contaminated with ethanol.

To characterize the resulting chemical transformations, Time-of-Flight Secondary Ion Mass Spectrometry (ToF-SIMS) and Transmission Electron Microscopy (TEM) were employed. Our analysis shows significant reduction of friction and wear when ethanol molecules pollute the atmosphere, revealing distinct chemical signatures governed by the atmosphere. In humid air, N_2 and ethanol environments, the surface remained dominated by Sn and SnOH outside the wear track. A significant transition occurred within the wear track and along its borders, a depletion of Sn based species coincided with the clear emergence of Fe and FeH. In N_2+ethanol environment, a detection of CxHy and OH fragments appears to be higher. Further, TEM analysis demonstrated that this 3rd body layer is a composite material composed of crystallized Sn+O nanoparticles embedded in an amorphous Fe+O+C matrix. It is mostly a 10-20nm thick film covering all friction track, with few patches filling the few grooves (fig.1). These results suggest that ethanol actively mediates the tribochemical interaction between the SnO_2 film and the counter-body, facilitating material transfer. This research provides critical insights into how common airborne contaminants can be leveraged or managed to control the longevity of metal oxide interfaces in industrial applications.

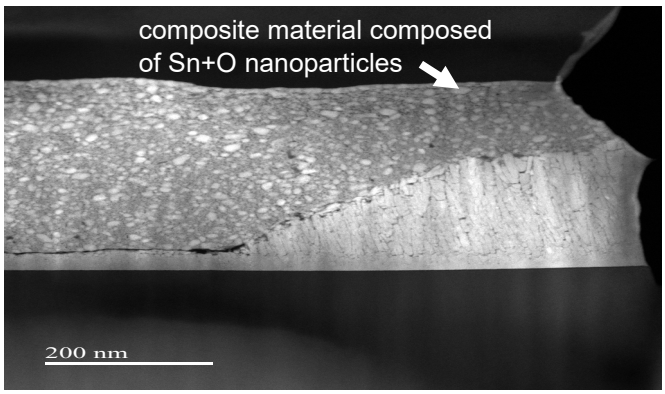


Fig.1 Cross-sectional TEM image of a selected zone of the wear track formed after friction. The rounded bright contrasts correspond to a composite third body composed of Sn+O nanoparticles embedded in an amorphous Fe+O+C matrix. The columnar structures are identified as SnO_2.

REFERENCES

[1] Gellman, A. J. and Ko, J. S., "The Current Status of Tribological Surface Science," Tribology Letters, 10, 1, 2001, 39–44.

[2] Liew, W. Y. H., "Effect of Relative Humidity on the Unlubricated Wear of Metals," Wear, 260, 2006, 720–727.

[3] Argibay, N., Babuska, T. F., Curry, J. F., Dugger, M. T., Lu, P., Adams, D. P., and Chandross, M., "In-Situ Tribochemical Formation of Self-Lubricating Diamond-Like Carbon Films," Carbon, 138, 2018, 61–68.