

TRIBOLOGICAL BEHAVIOR OF ENVIRONMENTALLY-FRIENDLY MoS₂-BASED SOLID LUBRICANTS AT COLD TEMPERATURE

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ABSTRACT

MoS₂-based solid lubricants are extensively used in tribological interfaces within the aerospace sector due to their advantageous lubricating properties. Pure MoS₂ is frequently doped with different elements or compounds, including Pb-based compounds, to enhance its load-carrying capacity and endurance life in humid environments. While MoS₂ lubricants with Pb-based compounds may provide enhanced performance, there is a growing interest in shifting towards environmentally friendly alternatives due to the toxic and harmful nature of Pb to both the environment and human health. Hexagonal boron nitride (hBN) is a lamellar material known for its favorable lubricating behavior [1] and could be a potential alternative to Pb-based compounds in MoS₂-based solid lubricants. In addition, Polyetheretherketone (PEEK) is a high-performance polymer known for its lower thermal conductivity and outstanding mechanical properties (e.g., high strength-to-weight ratio and stiffness) compared to other traditional polymers [2] and, thus, could be a potential candidate for MoS₂-based lubricants.

The characteristics of thermoplastic polymers are significantly influenced by temperature variations. As the temperature decreases, Young's modulus and hardness of these polymers tend to rise, leading to a reduced real contact area in tribosystems. Consequently, friction and wear are expected to decrease as the temperature decreases [3]. When incorporated into MoS₂-based solid lubricants, PEEK can enhance the load-bearing capacity of the lubricant, allowing it to withstand higher pressures and loads without significant wear or failure. Indeed, studying the effect of cold temperatures on the performance of solid lubricants is crucial for a wide range of applications, including liquid nitrogen pumps, refrigeration plants, space mechanisms, satellites, space vehicles, space propulsion systems, space antennas, and space platforms [4]. The low temperatures may induce phase transitions, changes in crystal structure, or alterations in the lubricant's chemical

composition.

Thus, the main objective of this study is to develop and critically evaluate the tribological performance of MoS₂-based solid lubricants at cold temperatures while also aligning with environmentally friendly standards and contributing to sustainability. The research involves applying MoS₂-based coatings with varying concentrations of hBN and PEEK onto stainless steel substrates using a spray bonding technique (see Table 1). The friction behavior of the coatings is evaluated using a ball-on-disc tribometer under constant normal load at a cold temperature (-50°C). Subsequently, ex-situ analysis techniques such as Scanning Electron Microscopy (SEM) and Atomic Force Microscopy (AFM) are utilized to evaluate the interfacial processes.

Table 1 The composition of MoS₂-based solid lubricants.

Dopant	Concentration (%)				
hBN	9.5	11.5	13.5	15.5	17.5
PEEK	1.4	1.9	2.4	2.9	3.4

REFERENCES

- [1] R. Kumar, I. Hussainova, R. Rahmani, and M. Antonov, "Solid Lubrication at High-Temperatures—A Review," *Materials*, vol. 15, no. 5, p. 1695, Feb. 2022, doi: 10.3390/ma15051695.
- [2] Leyu Lin, Stefan Emrich, Michael Kopnarski, Alois K. Schlar, " Lubrication performance of a polyetheretherketone (PEEK) and polytetrafluoroethylene (PTFE) blend within a steel/steel tribosystem", *Wear*, Vol. 484-485, 2021, doi: 10.1016/j.wear.2021.203997
- [3] J. Zhao, "Capillary Force and Surface Wettability," in *Encyclopedia of Tribology*, Q. J. Wang and Y.-W. Chung, Eds., Boston, MA: Springer US, 2013, pp. 295–298. doi: 10.1007/978-0-387-92897-5_465.
- [4] A. Abdelbary and L. Chang, "Lubrication and surface engineering," in *Principles of Engineering Tribology*, Elsevier,

