SPRAYED ALKYLPHOSPHONIC ACID AS LUBRICANT IN AIR AND VACUUM

M.A. Chetouani [a], X. Roizard [a], J.M. Cote [b], V. Tissot [a], S. Margueron [b], F. Lallemand [a], G. Colas [a*]
*Guillaume.colas@femto-st.fr
[a] Univ. Franche-Comté, CNRS, institut FEMTO-ST, F-25000 Besançon, France,
[b] SUPMICROTECH, CNRS, institut FEMTO-ST, F-25000 Besançon, France,

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ABSTRACT
The development of lubricants for the space industry is a challenge. Whether on the ground in air, in a vacuum, in a thermal vacuum, or in space, systems evolve in a succession of extreme environments. A range of lubricants already exist, each with different specificities and fields of application: fluid lubrication (oils) for systems with relatively high operating speeds within a restricted temperature range, solid materials (e.g coatings) for low speeds and wide temperature ranges, etc. All existing solutions give rise to recurring constraints, such as: (i) maintaining performance in different environments, notably air and vacuum, (ii) ease of application and associated cost, (ii) thickness management. In order to address these constraints, the study explores lubricant operating at a macro-molecular scale using alkylphosphonic acid (APA) molecules directly sprayed on surfaces. Initially developed to lubricate contacts subjected to high mechanical stress, such as in stamping operations, this lubricant has demonstrated its ability to lubricate sliding contacts with moderate to medium life, with a coefficient of friction consistently between 0.05 and 0.1 [1-3]. Finally, sprayed layer is stable under vacuum (SEM study possible).

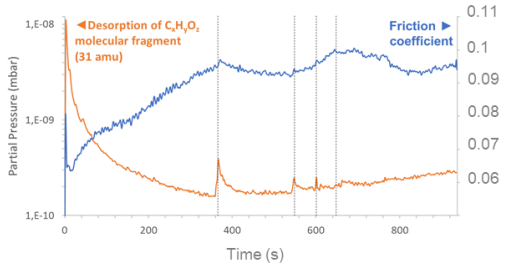

Figure 1 - Friction coefficient vs hydrocarbon desorption, in vacuum

In this study, pin on disc friction tests were hence performed in both vacuum (4. 10^{-7}mbar), and humid air. Maximum Hertz contact pressure and sliding speed were 850 MPa, and 40 mm/s respectively. In vacuum, after 500 friction cycles, a repeatable friction coefficient close to 0.1 was obtained (Fig.1), similar to that obtained in air. This also results in limited surface damage, and the creation of a carbonaceous 3rd body material. Raman spectroscopy (Fig.2) demonstrates tribochemical transformation of the molecules into either turbostratic carbon or graphene-oxide like materials. In vacuum, changes in friction variations can also be linked to the desorption of hydrocarbon molecules during friction (Fig.2). APA, hence demonstrate lubrication capabilities in both environments.

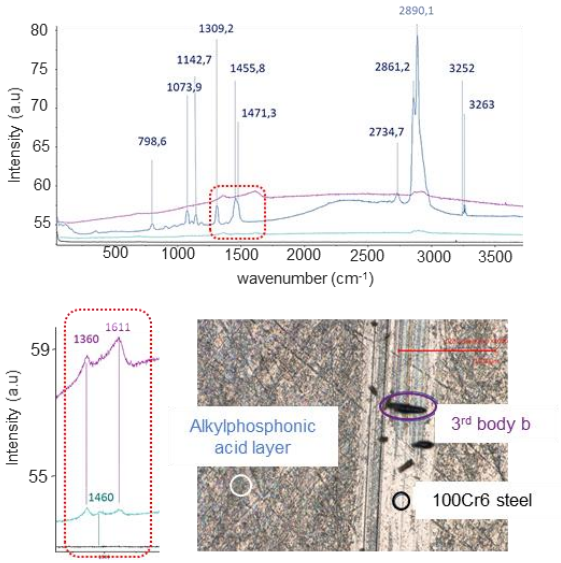

Figure 2 - Raman spectroscopy of pristine APA layer and resulting 3rd bodies. Spectrum localized inside and outside friction track

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