Original free sliding oscillating ball-on-flat tribotests reveal some features of the frictional behaviour of alkylphosphonic acid self-assembled molecules

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KEYWORDS

Self-assembled molecules, Free sliding oscillating motion, Viscous damping, Solid friction, Dissipated energy.

ABSTRACT

Previous studies have highlighted the interest of self-assembled alkylphosphonic acid as lubricant for deep-drawing process [1, 2]. This functionalization method consists in low concentrated in a solvent molecules self-adsorption on oxidized metallic surfaces. Main practical interests of this method for metal-sheet working processes are grafting of molecules method easily carried out, very low environmental impact, and the lack of cleaning operation usually necessary after process completion. But above all, classical linear-reciprocal or pin-on-disc tribotests have demonstrated high lubricating performance of this functionalization method compared with classical lubricants used in deep-drawing process [2].

Preceding papers showed that the macroscopic friction coefficient (less than 0.1) is due to the establishment of a third body over the track [1, 2]. This third body originates from crushing and then spreading of alkylphosphonic acid crystallites which were primarily formed on the surface after solvent evaporation. Nevertheless, the nature of the third body frictional behaviour remains unclear and is the purpose of the study presented herein.

Tribotests were performed using an original tribometer achieving ball-on-flat free sliding oscillations [3]. Experiments were performed under a 350 MPa maximal hertzian contact pressure, with different alkyl chain length (*CL*) of the originated molecules. Some tests were realized in dry conditions. For others tests conducted on contacts immersed in the solvent, alkylphosphonic acid molecules were introduced when a series of consecutive free oscillations were imposed. Simulating the overall tribo-system (including the studied contact) as a single-degree-of-freedom mechanical oscillator allowed for discriminating the Coulombian and the viscous components of friction forces. Hence, the viscous damping coefficient ζ_k and the friction coefficient μ_k of the ball-on-functionalized-surface interaction could be quantified without any force measurement [3, 4]. Energy dissipated by both solid friction (independent of the sliding velocity) and viscous friction (sliding velocity dependent) were then calculated.

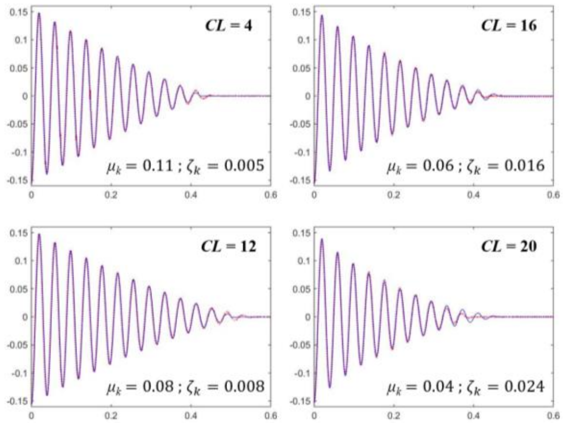

Fig. 1: Experimental signals obtained in dry condition (dotted red curves) and simulations (blue curves) for CL ranging from 4 to 20. Abscissa axis: time [s] ; Ordinate axis: sliding speed [m/s].

Main results highlight the significant viscous nature of the third body frictional behaviour in both immersed and dry conditions. This non-Coulombian component of friction is higher during the first friction cycles and highly depends on alkyl chain length *CL*.

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