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Transient frictional response of thin hydrogel films: the role of poroelasticity

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Hydrogels are advantageously biocompatible, chemically versatile, transparent and soft. Used as thin coatings, they find applications in surface engineering (surgical implants) or optics (anti-fog coatings), where their lubricating properties are of primary importance. When a thin hydrogel coating is pressed against a rigid probe, enhanced contact stresses promote water transport through the porous hydrogel network. Then, the mechanical response of the gel involves a coupling between network elasticity and solvent permeation through the porous network. The importance of such poroelastic effects on frictional properties of thin hydrogel films in steady state was evidenced in a previous study by Delavoipière et al. [1]. Here, we consider a contact between a rigid spherical glass probe and a micrometer-thick hydrogel film and we examine the role of poroelasticity on friction in the transient regime corresponding to the application of a lateral relative motion to the contact initially at rest. From experiments with *in situ* contact visualization, we measure friction force, normal load and contact size over time (Fig. 1). Depending on both static contact time and sliding velocity, either an overshoot or an undershoot in the friction force is observed during the transient regime. We show that the relaxation of the friction force towards steady state is uniquely dictated by the time-dependence of the contact radius whatever the velocity or the applied normal load. These results are discussed in the light of a poroelastic contact model developed using a thin film approximation and based on the assumption that friction arises solely from viscous water flow within the hydrogel network without any significant contribution from adhesion at the interface [2]. We believe our work has direct applications in mechanically resistant coating design since we provide a full description of both the occurrence and the amplitude of the friction peak at sliding initiation : this peak could indeed lead to damages in the coating.

[1] J. Delavoipière, Y. Tran, E. Verneuil and A. Chateauminois, Langmuir. 34, 9617-9626 (2018)
[2] L. Ciapa, J. Delavoipière, Y. Tran, E. Verneuil and A. Chateauminois, Soft Matter. 16, 6539-6548 (2020)

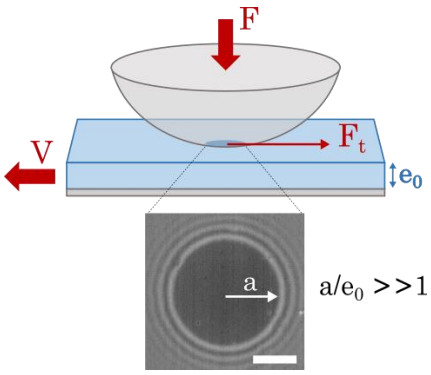

Figure 1 : (Top) Schematic of a glass sphere sliding with a velocity V under an imposed normal load F on a hydrogel layer (thickness e0) grafted to a glass substrate. Friction force Ft is measured. (Bottom) An image of the contact is shown: the hydrogel/glass sphere interface appears as a black zone of radius a while rings are interference fringes of equal thickness in white light. Scale bar = 100 µm.