

468g Molecular Dissipation Phenomenon of Sliding Friction in Polymers

Rene M. Overney, Tomoko Gray, and Scott Sills

The issue of interpreting sliding friction in terms of intrinsic material properties, as opposed to extrinsic tribological attributes, dates as far back as the 1960s, where Grosch [1] and Ludema and Tabor [2] attempted to deduce intrinsic properties of rubbery materials from friction force-velocity isotherms. By illuminating friction from a rheological perspective, the focus from the molecular adhesive process of separating surfaces involving molecular 'bond ruptures' at the interface, was shifted towards an intrinsic deformation phenomenon within the soft polymer matrix, if a hard probing surface was used. Grosch [1] showed that temperature and velocity dependent friction can be expressed for rubber material with a single master curve, known as the Williams, Landel and Ferry superposition principle. Thereby, the segmental relaxation of the polymer chain above the glass transition was found to be a critical mode for friction dissipation [1.2]. Recent nanoscale experiment involving scanning force microscopy (SFM), showed that also other relaxations within the polymer can be activated during frictional sliding [3]. In this paper, we will discuss specific modes of frictional dissipation process in thin polymer film systems and address issues of material constraints and critical relaxation properties. We will show that both the energetics involved in frictional dissipation and the length scale over which the energy is dissipated can be directly linked to molecular relaxation processes.

[1] Grosch, K. A. Proc. R. Soc. London, Ser. A, 274, 21 (1963). [2] Ludema, K. C.; Tabor, D. Wear, 9, 329 (1966). [3] Sills, S.; Overney, R.M. Phys. Rev. Lett., 91, 095501 (2003).