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Low Friction Flow of Liquid at Smooth and Nanopatterned Interfaces[1]

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With the recent important development of microfluidics systems, miniaturization of flow devices has become a real challenge. Microchannels, however, are characterized by a large surface to volume ratio, so that surface properties strongly affect flow resistance in submicrometric devices. Although the no-slip boundary condition used for describing simple liquids flows at a macroscopic scale is very robust, it is now admitted that simple liquids may undergo substantial slip on solid surfaces, which cannot be neglected at the scale of tenth of micrometers. However, experimental results on this topic are still controversial : slip effects reported vary quantitatively (over order of magnitudes) as well as qualitatively (regarding their linear or non-linear variation with the shear rate), without clearcut relation with expected relevant parameters for interfacial hydrodynamics, i.e. liquid-surface interactions and surface roughness. We first report an accurate determination of what we expect to be an *intrinsic* slip length of water and organic solvants on smooth hydrophilic and hydrophobic surfaces. This boundary slip is well defined, does not depend on the scale of investigation (from 1 to several hundreds of nanometers) neither on shear rate (up to 5.10^3 s^{-1}). On smooth highly hydrophobic surfaces, the magnitude of slip is 20 nm, in good agreement with theory and numerical simulations. We then present results showing that the concerted effect of wetting properties and surface roughness may considerably reduce friction of the fluid past the boundaries. The slippage of the fluid is shown to be drastically reduced by using surfaces that are patterned at the nanometer scale. This effect occurs in the regime where the surface pattern is partially dewetted, in the spirit of " superhydrophobic' effect that has been discovered at the macroscopic scale. Our results show that in contrast to the common belief, surface friction may be reduced by surface roughness. They also open the possibility of a controlled realization of the " nanobubbles " that have long been suspected to play a role in interfacial slippage.

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