Effect of Hydration and Organic Solvent on Structure and Friction in Ionic Liquid Nanoscale Films

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Room temperature ionic liquids (RTILs) recently attracted a lot of scientific attention as the flexibility in the choice of the cation/anion molecules allows the properties of the liquid to be fine-tuned. The behavior of RTILs in confined geometries is of great interest for different fields, ranging from biological systems to super-capacitors, micro/nano-fluidic, and lubrication.

It is very difficult to ever have pristine RTIL films, as RTILs tend to sorb water from humid air, but even small amount of water ("solvent-in-salt") can have a dramatic effect on the structure and dynamics of nanoscale films. We have found that penetration of water into the film can screen the electrostatic interactions between the ions and thus influence the response of the films to the applied electric field and shear. In particular, water adsorption changes the orientation of molecular ions and the slip conditions at the solid-liquid interfaces, resulting in a reduced resistance against squeezing-out of the film by an external load. The impact that this kind of screening has on friction involves several aspects that have been systematically analyzed and will be presented in this talk.

Despite the remarkable tribological properties of RTIL lubricants, their use has been hindered in recent years due to their high cost. Furthermore, RTILs exhibit high viscosities, which reduce mass flow slowing down the dynamic response, essential for switching technologies. The addition of organic solvents to RTILs might provide a solution, first by reducing the cost of RTIL lubricants, and second by enhancing their dynamic response. We foud that under nanoscale confinement conditions, diluted RTIL solutions, of just ~10% molar fraction, still feature a remarkable variation of the friction force with the electrode surface charge density, not weaker than had been earlier shown for nanoconfined pure RTILs. Importantly, our simulations show that charged electrodes are coated with ions even at low IL concentrations. These ion-rich layers adjacent to the charged plate surfaces are not squeezed out even under very high normal pressures. Our results highlight the potential of diluted RTIL mixtures as cost-effective electrotunable lubricants for future nanotribological applications.