

Novel Phase Transition in a Biomimetic Lipid Monolayer

and

Nature of Electron Mobility in TiO₂

Mischa Bonn

Institute of Chemistry, Leiden University, P.O. Box 9502, 2300 RA Leiden, the Netherlands

Phospholipids are key constituents of cell membranes. Thanks to their amphiphilicity and ability to self-organize they form the skeleton of living cells. Knowledge of the behaviour of the self-organization of these phospholipids thus forms an important aspect in the understanding of cell structure. We have investigated the self-organizing behaviour of a phospholipid monolayer, in contact with water. We can map the order inside the alkyl chains using Vibrational Sum-Frequency Generation (VSFG), and the mesoscopic properties of the monolayer using fluorescence microscopy. This unique combination of optical tools allows us to observe, as the molecular surface area is increased, a novel, sharp phase transition, attributed to the curling up of the apolar alkyl chains as their exposure to the polar water environment increases, in addition to the known transitions. We also present recent results on the novel application of VSFG to non-planar surfaces.

For TiO₂-based dye-sensitized solar cells, it has been demonstrated that the efficiency is limited by electron transport through TiO₂ nanoparticles. Although the transport of electrons in TiO₂ has therefore received considerable attention, the nature and efficiency of electron mobility in TiO₂ has remained ambiguous. We reveal the nature and efficiency of electron mobility in single crystal TiO₂ using the contact-free technique of THz time-domain spectroscopy. Room temperature conduction is limited by strong interaction of the electron with the TiO₂ lattice, in particular with the 800 cm⁻¹ lattice vibration, resulting in the formation of a polaron — a quasi-particle consisting of an electron and a local lattice deformation. This explains the low room temperature electron mobility of ~ 1 cm²/Vs, with substantial anisotropy for transport along the two different crystallographic axes. Consequences to solar cell applications are discussed.