

Density Profile of Water Confined by Two Ion-exchanged Mica Surfaces

Wednesday, 18 September 2013 12:15 (2 hours)

Two surfaces in contact are found in everyday life. For hydrophilic surfaces in contact, the natural presence of a confined layer of water in the narrow gap between them has important implications for geochemical and biological processes such as swelling of clays and diffusion of water through nanopores [1]. Numerous surface force experiments have been performed on such systems [2]. However, force studies do not provide information on the molecular structure of the confined water.

We have adapted a surface force apparatus (SFA) [3] to be used as confinement device X-ray reflectivity (XRR) experiments conducted at the cSAXS (XSA12) beamline of the Swiss Light Source at PSI. A pair of cylinder-shaped muscovite mica membranes were made to approach each other until a flat contact area was formed. We have then performed XRR experiments from the contact area as a function of the momentum transfer q ranging from 0 to 3.5 Å⁻¹. Model dependent fits [4] to the measured reflectivity $I(q)$ allowed us to determine the minimum gap distance and the electron density profile along the confinement direction [5].

After a first set of experiments on water confined between freshly cleave mica membranes, in order to shed light on the effect of the surface ions on the structure of the confined fluid, we exchanged the natural layer of K⁺ ions present on cleaved mica surfaces with monovalent Rb⁺ or divalent Sr²⁺ ions. The ion-exchanged membranes were brought into contact in a nitrogen environment with controlled relative humidity (RH). XRR measurements were then made at 0 and 60 % RH.

We observed layered electron density profiles within the gap with the period of layering equal to the hydration shell of the cations. We also determined quantitatively the minimum gap distance between the mica surfaces under the influence of different surface ions (1.82 nm for Rb-exchanged mica at 0% RH and 2.04 nm for Sr-exchanged mica at 0% RH), which increases for higher RHs.

References

1. Israelachvili, J.N., Intermolecular and surface forces: revised third edition. 2011: Academic press.
2. Pashley, R., DLVO and hydration forces between mica surfaces in Li⁺, Na⁺, K⁺, and Cs⁺ electrolyte solutions: A correlation of double-layer and hydration forces with surface cation exchange properties. *Journal of Colloid and Interface Science*, 1981. 83(2): p. 531-546.
3. Perret, E., et al., Molecular liquid under nanometre confinement: density profiles underlying oscillatory forces. *Journal of Physics: Condensed Matter*, 2010. 22(23): p. 235102.
4. Perret, E., et al., X-ray reflectivity theory for determining the density profile of a liquid under nanometre confinement. *Journal of synchrotron radiation*, 2010. 17(4): p. 465-472.
5. Chodankar, S., et al., Density profile of water in nanoslit. *EPL (Europhysics Letters)*, 2012. 99(2): p. 26001.

Primary author: Mr CHODANKAR, Shirish (Paul Scherrer Institut)

Co-authors: Dr DIAZ, Ana (Paul Scherrer Institut); VAN DER VEEN, Johannes Friso (Paul Scherrer Institut); Prof. HEUBERGER, Manfred (EMPA, 9014 St. Gallen, Switzerland); Dr ESPINOSA-MARZAL, Rosa M (ETH Zürich, 8093 Zürich, Switzerland); LIUZZI, Simone (Paul Scherrer Institut)

Presenter: Mr CHODANKAR, Shirish (Paul Scherrer Institut)

Session Classification: Poster session I and lunch