Interfacial Liquids Shear Elasticity Measurements

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Abstract

The investigation of molecular physics of liquids in a nanoscale at solid/liquid interfaces is of relevance in science fields like (micro-) flow of liquids, lubricants, blood flow in micro vessels, confined water, water in biological structures, etc. \cite{1, 2}. The resonant vibrating gold electrode surface of the quartz crystal microbalance, QCM, was used to measure the mechanical properties of fluids submitted to a shear stress in the nanoscale range at a resonant frequency \( f \) of 5MHz in the interfacial layers. A model fitted to the measured frequency and resistance values in the interface gives the shear mechanical properties of the probed liquids. Figure 1 shows the dependence of \( G^\prime \) and \( G^\prime\prime \) on \( \rho \eta^{1/2} \). The fluids used where numbered from 1 to 13: air, aqueous sucrose solutions (0%, 1%, 2.5%, 5%, 7.5%, 10%), n-hexane, NaCl 0.2M, ethanol, propanol, urea 10%, cyclohexane, respectively. All measured liquids presented shear elasticity with values in the range of \( 10^4 \) Pa, contrary to the every conventional expectation.

The particular behavior of water at interfaces can be attributed to the different ability to optimize hydrogen bonding between the water molecules at the solid/liquid interface in the interfacial water layer. However, the observed existence of \( G^\prime \) for non polar fluids, without hydrogen bonds like cyclohexane and hexane shows that liquid state close to surfaces is not well understood. It seems that a viscoelastic relaxation process due to a collective interaction of molecules of the liquid should be occurring at interfaces\cite{3, 4}. The clusters formed would explain the large relaxation time observed and the existence of shear elasticity at the interfacial layer in the liquid state.

Acknowledgements: CNPq funding Grant No.140031/2010-3. FAPESP.

References