Interfacial Liquids Shear Elasticity Measurements

D. M. Soares[a], W. E. Gomes[a], C. A. Bertran[b] and O. Teschke[a]
a- Instituto de Física, b- Instituto de Química
Universidade Estadual de Campinas, 13083-970 Campinas, SP, Brasil.

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. [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´ and G´´ 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.

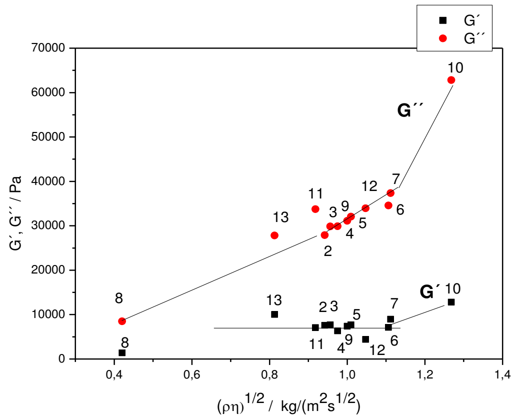

Figure 1. Shear modulus of storage G´and shear modulud of loss G" dependence on $\rho\eta^{1/2}$.

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´ 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[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.

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References

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