ESRF

Experiment title:	Experiment number:
MOLECULAR ORIGIN OF THE BENDING ELASTICITY OF AMPHIPHILIC MONOLAYERS	SC-234

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Report:

The aim of this experiment was to investigate the relationship between the bending elasticity of amphiphilic monolayers and their detailed molecular properties. This is of considerable importance because the properties of amphiphilic assemblies generally crucially depend on the elastic properties of such films.

Through experiments SC-15 (6-11 October 1994), SC-54 (11-16 April 1995) and SC-98 (4-9 October 1995), a method has been developed to measure the height-height correlation function of a single interface or film down to molecular length-scales. In particular, it was established that the Helfrich Hamiltonian could be used to describe the fluctuations of films on a neutral subphase, and the possibility of an accurate determination of the bending rigidity modulus was demonstrated. In the present experiment, we began a thorough investigation of the role of chain length, molecular area and chain packing on curvature elasticity.

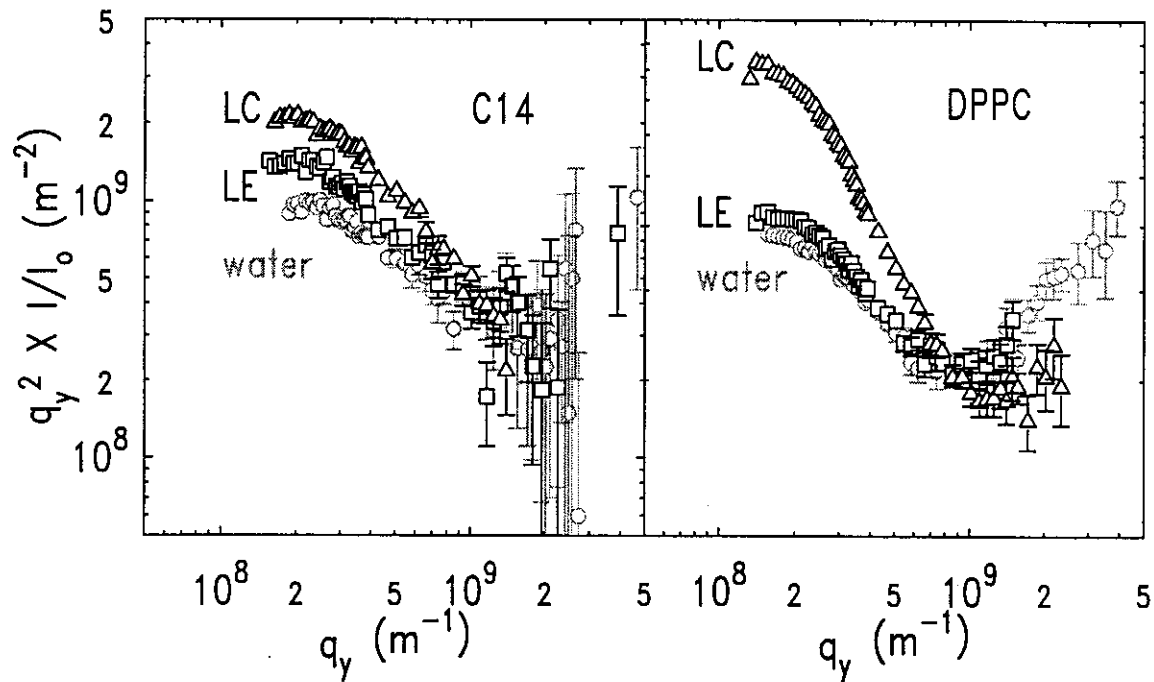
The experiment SC-234 began with the installation of a Si(111) monochromator on the Troïka beamline as the diamond monochromator had been found to be faulty. Although such a configuration had not often been used, it was found to be quite satisfactory. A SiC mirror was used to suppress the third and higher harmonics. The installation of our Langmuir trough required us to dismount the detector arm vertical circle. As we intended to study the surface diffuse scattering in the plane of the interface, the diffractometer detector arm was configured with a second, two-reflection channel-cut Si(111) analyzer crystal. An Ar gas, position-sensitive detector oriented vertically was used to better discriminate surface from non-surface (bulk, vapor and window) scattering.

In this high resolution, "triple-axis" configuration the signal-to-noise ratio for the surface diffuse scattering was found to be insufficient due to the very small resolution volume in Fourier space. As the use of Soller collimator slits (3 *mrad*) would be inappropriate at such small scattering angles, an intermediate resolution configuration (0.5 *mrad*) was adopted using two very narrow (0.5 *mm*) but high (30 *mm* and 70 *mm*) vertical slits (fabricated from two stainless-steel rulers).

The following samples were studied :

- bare water surface. We could reach a higher q value than previously and evidenced scattering due to density fluctuations in the 10 nm thick (penetration depth) surface layer (increase in $q_y^2 \times I/I_0$, $q_y \leq 10^9 m^{-1}$ in the figure). Quantitative analysis is in prgress.
- myristic acid $CH_3(CH_2)_{12}COOH$, in the liquid expanded and liquid condensed phases. The scattering is reduced at large q due to bending stiffness. This short-chain fatty acid could be studied at different temperatures and different surface pressures.
- behenic acid $CH_3(CH_2)_{20}COOH$,
- DPPC: 1,2-Dipalmitoyl-sn-glycero-3-phospho-choline - $C_{40}H_{80}NO_8PH_20$, a double chain phospholipid deposited on a ultra-pure water subphase.

Preliminary analysis indicates that anomalous power laws (exponent ≈ -3) are obtained for the fluctuation spectra in the condensed phase.



Representative diffuse scattering spectra of a short-chain fatty acid and of a double-chain phospholipid deposited on a ultra-pure water subphase. The scattering intensity increases at small q as the monolayer condenses upon compression due to the increase in surface tension and drops at large q due to bending stiffness.

Finally, the experiments depend upon measuring diffuse-scattering intensities less than 10^{-10} of the incident beam. The background scattering from the subphase, vapor and trough windows must be systematically measured and subtracted; In order to obtain reasonable statistics, long counting-times (about 3 to 4 hours per measured spectrum) were necessary and the experiment was flux-limited. Thus, the *16-bunch* operation mode with only $45 - 90$ mA in the storage ring is *not* the most appropriate for these experiments.