Grazing incident diffraction on Langmuir monolayers

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Introduction

The process for characterizing molecular monolayers on water surfaces by surface pressure vs. area isotherms was first described by Langmuir in 1917 [1]. Since then, a wide variety of amphiphilic molecules and their behavior on the water surface have been characterized. To obtain x-ray diffraction patterns of monolayers requires a specialized technique developed over the past two decades. The technique is called grazing incidence x-ray diffraction (GIXD) and requires intense x-rays from synchrotron sources [2]. In order to extend the capabilities of beamline 10-ID to allow investigations into the structure of Langmuir monolayers, a GIXD experimental system was designed and commisioned. This new capability will allow detailed studies into the structural order of newly designed organic and mixed organic/inorganic Langmuir monolayers.

Methods and Materials

The diffraction experiments were carried out at the Advanced Photon Source (APS) insertion device beamline 10-ID employing a double silicon monochromater, operated by MR-CAT. X-rays of energy 8050 eV were deflected onto the water surface at a critical angle of 1.8 mrad by a glass deflecting mirror coated with a platinum stripe. The Langmuir trough assembly was specially designed and constructed by KSV Instruments, Finland, to be housed inside an eight-circle Huber goniometer. The trough was mounted on MOD1 vibration isolation table, purchased from Hylnics, Germany. The trough environment was kept under a helium perge to minimize radiation damage to the monolayer. Monolayers of einicosanoic acid ($C_{20}H_{41}COOH$) were spread on the water surface from a dilute chloroform solution. The subphase was cooled to 5º C and the monolayer compressed to a pressure of 30 mN/m. Diffraction over Kxy and Kz was monitored by a NaI scintilation counter and normalized to the incident beam intensity. Background scattering was reduced with xy and z soller slits mounted in front of the diffraction detector.

Results and Discussion

The diffraction pattern obtained from $C_{20}H_{41}COOH$ at 5º C and 30 mN/m is shown in Figure 1. The trace is a Lorentzian fit to the data. The two peaks can be indexed to a rectangular cell. This compound was used as a standard film since it has been well studied in the literature. The high signal-to-noise ratio obtained in the diffraction pattern clearly demonstrates the ability of the new experimental setup to provide high-quality diffraction data of ordered Langmuir monolayers. These results open the way for new detailed studies into the organization of other monolayer films on water surfaces. Future work will involve studies of both polymeric organic films and extended two-dimensional inorganic networks formed at the air/water interface.

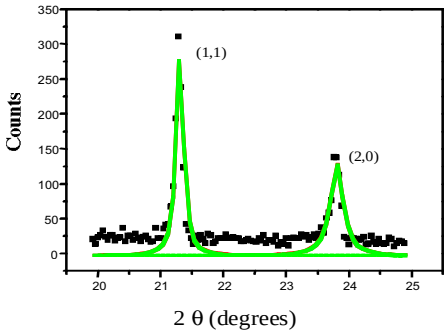

Figure 1: GIXD pattern for $C_{20}H_{41}COOH$ monolayer at 30 mN/m and 5º C. The pattern is indexed to a centered rectangular cell. The trace is a Lorentzian fit to the pattern.

Acknowledgments

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References

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