Steacie Institute for Molecular Sciences

Neutron Program for Materials Research

Neutrons and Biomaterials

Model Membranes

Biologically Relevant Conditions

Aligned Lipid Bilayers

Sample Environments

NEUTRON FACT SHEET #6

Background

The Biomaterials program focuses primarily on the study of lipid/water systems using a variety of scattering techniques particularly neutron diffraction. Furthermore, we attempt to study orientationally aligned systems since the experimental information is greatly enhanced when compared to liposomal or "powder" preparations. Although we have traditionally aligned bilayers using rigid substrates (e.g., glass, silicon, quartz, mica etc.), recently we have studied a "biologically relevant membrane" which is highly alignable in the presence of an applied magnetic field (B) (1). Such a system promises to be an excellent "substrate" for orienting membrane associated peptides and proteins irrespective of the macromolecules intrinsic magnetic properties.

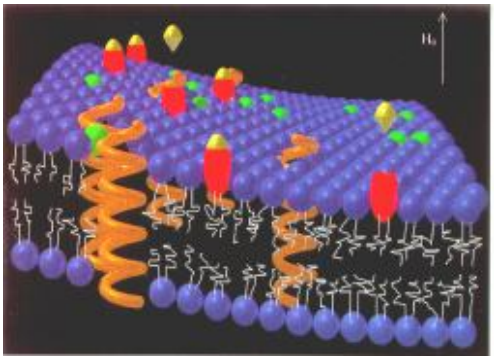

Figure 1: Magnetically alignable bicelle containing the peptide gramicidin A. [Prosser et al., Biophys. J. 75, 2163 (1998)]

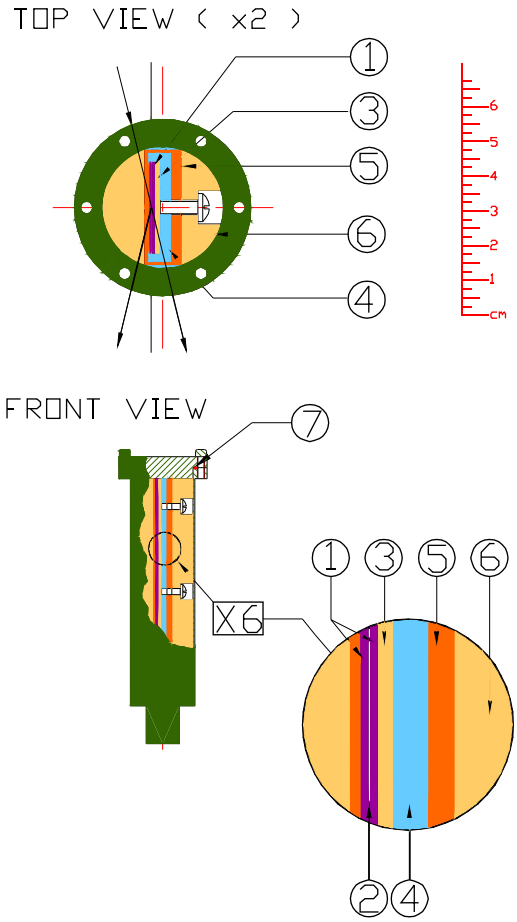

Figure 2: Schematic of aluminum sample holder for neutron diffraction studies capable of producing samples under physiologically relevant conditions.
(1) Silicon/teflon assembly containing the aligned lipid bilayers. (2) Lipid multibilayers. (3) Aluminum pressure plate. (4) Water reservoir. (5) Removable aluminum cassette that retains the silicon/teflon assembly and the pressure plate. (6) Aluminum billets. (7) Indium seal.
[Katsaras, Biophys. J. 73, 2924-2929 (1997)]

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Recent Developments

Using rigid substrates we have developed novel and simple methods of aligning model membrane systems under conditions of excess water and Which will enable a variety of techniques (e.g., neutron and x-ray diffraction, nuclear magnetic

Figure 3: Full elevation and partial top view of neutron or x-ray sample holder capable of achieving humidities approaching 100%.

resonance, electron spin resonance, attenuated total reflection infrared spectroscopy, etc.) to study such systems under physiologically relevant conditions (e.g., relevant pH and ionic strengths, excess water conditions, La phase lipid bilayers).

Another development has been the hydration, using sample ovens capable of reaching ~ 100% relative humidity, of fully hydrated samples using water vapour. Previously, lipid multibilayers hydrated from water vapour exhibited

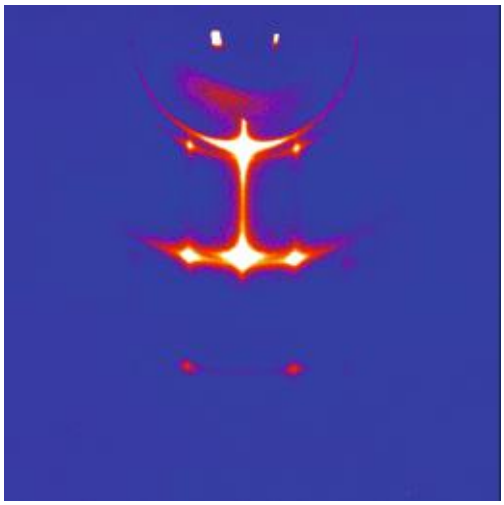

Figure 4: Diffraction pattern from aligned, fully hydrated lipid multibilayers in the ripple, Pb' phase hydrated from water vapour.

repeat-spacings much smaller than their liposomal counterparts in contact with liquid water.

Since the chemical potential of water in the liquid and vapour phases, under equilibrium conditions, is the same this phenomenon became known as the "vapour pressure paradox". This perennial problem was recently resolved using neutron diffraction (2).

References

(1) J. Katsaras et al., Phys. Rev. Lett. 78, 899 (1997).

(2) J. Katsaras, Biophys. J. 75, 2157 (1998).

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