Hydrostatic Pressure Effects on the Structure and Stability of Lipid Membranes and Lyotropic Mesophases

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Abstract

Lyotropic liquid crystals of 1-, 2-, or 3-dimensional periodicity spontaneously assemble when lipids are mixed with solvent under various conditions of temperature, pressure and hydration. The mesophases formed include the 1-D fluid lamellar (Lα), 2-D hexagonal (H_I/H_{II}) and 3-D cubic phases (Q_I/Q_{II}). Although the flat fluid lamellar phase is the structure on which biomembranes are generally based, there is increasing evidence that curved structures such as the inverse cubic phases may be present in cell membranes, and/or may facilitate various cellular processes such as endo- and exocytosis, membrane budding, and fusion,

We have been using high pressure and pressure-jump X-ray diffraction to investigate lyotropic phases and phase transitions in a range of lipid systems. We have studied the effects of pressure on the gel-fluid transition in sphingomyelin bilayer membranes, and have found that the ordering of the chains and the development of the ripples on forming the gel phase occur on different timescales. We have previously shown that by addition of weakly-polar amphiphiles such as diacylglycerols to phospholipids, one can tune the interfacial curvature to be strongly inverse, leading to the formation of a discontinuous cubic phase of spacegroup Fd3m. We have investigated the effect of hydrostatic pressure on the structure and stability of this phase, and have discovered a number of novel effects. We also discovered a lyotropic liquid crystal phase of space group $P6_3/mmc$, whose structure is based upon a hexagonal close packing of identical quasi-spherical inverse micelles. This novel phase has a number of unique features which may render it useful for a wide range of applications. We have studied the effect of chain branching on glycolipid thermotropic and lyotropic phases for a series of synthetic β-D-glucosides derived from Guerbet alcohols. A wide range of liquid-crystalline phases was observed, with the C_{16} Guerbet glucoside (i.e. β-Glc-$C_{10}C_6$) forming an inverse bicontinuous cubic phase of space group *Ia3d* in excess water, which is very unusual behaviour.