Biophysics 2007 vol.52 N5, pages 453-461

Water state and diffusion through lipid bilayers: Effect of hydration degree

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Abstract

The dependences of adsorbed water state (obtained from the variations in 1H NMR spectra with the angle between the bilayer normal and magnetic field direction) and water diffusion along the bilayer normal (measured using pulsed field gradient 1H NMR) on hydration degree have been studied in macroscopically oriented bilayers of dioleoylphosphatidylcholine. The angle dependences of the shape of NMR spectrum are qualitatively different only for water concentrations higher and lower than that achieved by hydration from saturated vapors (χeq, about 23%). At concentrations lower than χeq, all water in the sample either makes the hydration shells of the lipid polar heads or is in fast exchange with the shell water, so the spin-echo signal from water is detected only within a narrow range of angles close to the magic angle, 54.7°. At concentration exceeding χeq, the spin-echo signal from water is retained at all orientations, suggesting that a portion of water between bilayers (quasi-free water) slowly exchanges with water bound to the polar heads. There is an inverse dependence of the coefficient of water self-diffusion through the bilayer system on the hydration degree, which is described in the Tanner model with account of water self-diffusion in the hydrophobic part of the bilayer. Bilayer permeability, distribution coefficient of molecules between aqueous and lipid phases, and water self-diffusion coefficient in the hydrophobic region of the bilayer are estimated.

http://dx.doi.org/10.1134/S0006350907050016

Keywords

Biological membranes, Lipid bilayers, Water diffusion