diffusion-fundamentals.org

The Open-Access Journal for the Basic Principles of Diffusion Theory, Experiment and Application

Water permeation across lipid bilayers studied by pulsed field gradient NMR

Frank Lange*, Jan-Nicolas Leiste, Ruth Bärenwald, Kay Saalwächter

Martin-Luther-Universität Halle-Wittenberg, Institut für Physik, Halle, Germany
*frank.lange@physik.uni-halle.de

The investigation of the physicochemical properties of lipid membranes is most important for understanding the structure, dynamics and function of biological membranes. One special feature of lipid membranes is the permeability for small molecules and especially for water. So far, this property has been studied for instance by isotope exchange [1], NMR relaxation [2], theoretical approaches [3] and pulsed field gradient (PFG) NMR [4, 5, 6]. The latter technique has benefited from improvements in the preparation of macroscopically oriented lipid bilayers covering glass plates, which results in samples with an anisotropic diffusion coefficient for water and lipids. This anisotropy can be characterized by application of pulsed field gradients in different directions with respect to the bilayer normal.

In this contribution we will examine the permeability of water through model bilayer systems consisting of phospholipids in the L_α phase. First, we will try to reproduce the observations of Filippov and coworkers [5, 6], who determined diffusion coefficients of water parallel to and across oriented lipid bilayers. The application of Tanner's model for diffusion through permeable parallel barriers [7] then allows the calculation of the bilayer permeability. Furthermore, we will investigate the dependency of the permeability on several experimental parameters, e.g. temperature, degree of hydration and cholesterol content.

References

[1] M. Jansen, A. Blume: *A comparative study of diffusive and osmotic water permeation across bilayers composed of phospholipids with different head groups and fatty acyl chains*. Biophys. J. **68**, 997–1008 (1995)

[2] J. Andrasko, S. Forsén: *NMR study of rapid water diffusion across lipid bilayers in dipalmitoyl lecithin vesicles*. Biochem. Biophys. Res. Commun. **60**, 813–819 (1974)

[3] S.-J. Marrink, H.J.C. Berendsen: *Simulation of water transport through a lipid membrane*. J. Phys. Chem. **98**, 4155–4168 (1994)

[4] P. Wästerby, G. Orädd, G. Lindblom: *Anisotropic water diffusion in macroscopically oriented lipid bilayers studied by pulsed field gradient NMR*. J. Magn. Reson. **157**, 156–159 (2002)

[5] M. Rudakova, A. Filippov: *Water transbilayer diffusion in macroscopically oriented lipid bilayers as studied by pulsed field gradient NMR*. Appl. Magn. Reson. **29**, 451–457 (2005)

[6] A.M. Khakimov, M. Rudakova, A.V. Filippov: *State of water and its diffusion across lipid bilayers: Effect of hydration degree*. Biofizika **52**, 840–849 (2007)

[7] J.E. Tanner: *Transient diffusion in a system partitioned by permeable barriers. Application to NMR measurements with a pulsed field gradient*. J. Chem. Phys. **69**, 1748–1754 (1978)