Dynamic imaging of lipid membranes by means of water

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Biological membranes are highly dynamic and complex lipid bilayers, responsible for the fate of living cells. To achieve this function, the hydrating environment is crucial. Here, we show that we can use second harmonic (SH) microscopy to follow membrane hydration of freestanding lipid bilayers on millisecond time scales. Without labels, we SH imaged symmetric and asymmetric lipid membranes, while varying the ionic strength and pH of the adjacent solutions. We show that the nonresonant SH response of water molecules aligned by charge−dipole interactions with charged lipids can be used as a label-free probe of membrane structure and dynamics. The orientational ordering of water is used to construct electrostatic membrane potential maps. The average membrane potential depends quadratically on an applied external bias, which is modeled by nonlinear optical theory. Spatiotemporal fluctuations on the order of 100-mV changes in the membrane potential are observed. These changes imply that membranes are very dynamic, not only in their structure but also in their membrane potential landscape. This spatial and temporal heterogeneity could have important consequences for membrane function, mechanical stability, and protein/pore distributions.

References:

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