

# Low-frequency Raman spectroscopy of phospholipid membranes

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Various experimental techniques are applied to the phospholipid bilayers, being models of biological membranes, candidates for biosensors, and cargos for drug delivery. Raman spectroscopy, a noninvasive and label-free experimental technique, is one of those. However, the low-frequency ( $< 100 \text{ cm}^{-1}$ ) Raman spectroscopy was not used for phospholipid membranes before. A number of peculiar features in the terahertz vibrational spectrum, which is manifested in the low-frequency Raman spectrum, are expected for 2D-like objects with the nanometer thickness as phospholipid bilayers. One can hope that the low-frequency Raman spectrum should have information about the thickness breathing mode of the phospholipid layers and about the acoustic-like excitations. Our recent works reviewed in the present report reveal this. Manifestation of the low-frequency Raman features, their relation to the elastic modulus and layer thickness, their temperature dependences, the sensitivity to the phase state and to domain coexistence are discussed in the present work.