Nanoscale Mid-infrared Spectroscopic and Imaging Studies of Single Phospholipid Bilayers as Models of Biological Membranes

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We aim to use nanoscale IR spectroscopy to understand how the molecular structure of lipids contributes to the properties of cell membranes. In this preliminary work, we use supported phospholipid bilayers as models of biological membranes. Past work has already demonstrated the possibility to record nano-FTIR spectra of the protein complement of membranes using the sSNOM (scattering-mode Near Field Optical Microscopy) configuration [1]. We now show, for the first time, that the same configuration provides the sensitivity requiredto measure spectra of phospholipids in individual bilayers in the 800 cm^{-1} – 2000 cm^{-1} spectral range. We observe the main absorption bands of the dipalmitoylphosphatidyl choline headgroup in this spectral region above noise level, including the ester carbonyl and phosphate stretching modes (Figure 1A). These bands are sensitive to the interaction between phospholipids and their surrounding environment, including the aqueous medium, other lipids and biomolecules external to the bilayer [2]. Therefore, they are among the most useful internal probes to study the biochemical properties of the membrane. We also perform mapping of the phosphate absorption band at 1070 cm^{-1} simultaneously with the AFM topography.We show that we can achieve sufficient contrast to discriminate between single and multiple phospholipid bilayers and other structures, such as liposomes(Figure 1B and Figure 1C). This work opens the way to future studies that use nano-IR spectroscopy to describe the biochemistry of cell membranes and model systems.
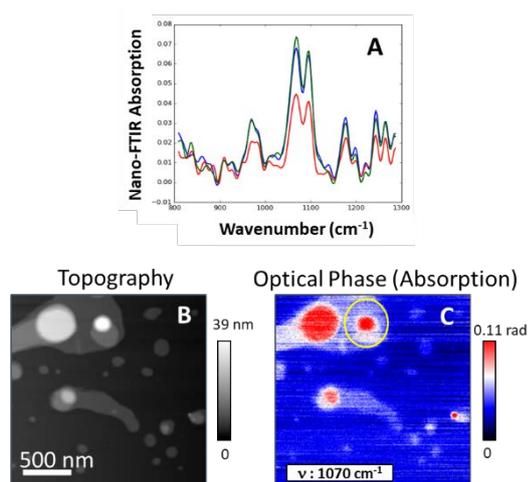

Figure 1. Nano FTIR spectra and single wavelength maps of supported DPPC single and multibilayer patches. **A**. Nano FTIR spectra of a single bilayer (red) and two double bilayers (blue and green) in the phosphate group region. **B.** AFM topography image of a region of the sample. **C.** Nano IR image at 1070 cm^{-1} recorded simultaneously with the topography. The difference in intensity allows to discriminate between single, double and triple bilayer patches. The circle indicates a liposome.

References
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