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Compositional Depth Profiles of Biomaterial Interfaces by Specular Neutron Reflection

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We present the results of recent studies which illustrate the power of specular neutron reflectivity and diffraction for determining the compositional depth profiles of thin films and multilayered structures of interest in biology and biotechnology. Research discussed includes: probing the interactions of melittin (a model peptide for antibiotics and membrane proteins) with hybrid bilayers; the structural characterization of a polyelectrolyte/terpolymer/phospholipid sandwich; the orientation of adsorbed biomineralization proteins; and the location of cholesterol within lipid membranes. Using specular neutron reflection from single-repeat lamellar assemblies or diffraction from periodic multilayers as probes, cross sectional composition depth profiles, with spatial resolutions of the order of a nanometer and Angstrom, respectively, can now be obtained. We demonstrate, in the context of the aforementioned work, how the neutron's sensitivity to different isotopes, in particular hydrogen and deuterium, enables detailed structural information – for example, the water concentration profile across the thickness of a film -- to be revealed through selective substitution in organic materials. We also show how the high transmission of neutrons through inorganic single crystals, e.g., silicon, sapphire, and quartz, allows such crystals to serve as both substrate for the film of interest as well as fronting medium for the incident and specularly reflected neutron beams. This in turn makes it possible to study the film in intimate contact with a fluid reservoir -- which may be, for instance, part of a functioning electrochemical cell. Finally, the uniqueness of a depth profile obtained from neutron reflection data is considered, together with the degree of uncertainty in the density and the spatial resolution.