CORE-CM SEMINAR
Michigan State University

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Nanostructured Biomimetic Systems: Synergy at the Nano/Bio Interface

Living cells use 5-nm thick biomembranes to perform diverse functions, including compartmentalization, charge separation, selective transport, signaling, and catalysis. Biomembranes are composed of a bilayer lipid membrane (BLM) decorated with proteins. Mechanisms by which these complex nanocomposite materials function are now being elucidated. In principle, these mechanisms could be mimicked through the use of synthetic nanostructured biomimetic systems that integrate biologically derived nanomaterials (e.g., phospholipids and membrane proteins) with synthetic nanomaterials.

As an example of this approach, we have been studying the interaction of engineered nanomaterials (ENM) with BLM. Our approach has focused on measuring ENM-induced ion leakage either using a planar BLM (pBLM) suspended across an orifice, or a tethered BLM (tBLM) attached to an electrode. The effect of silica-core nanoparticles and biodegradable polypropargyl glycolide nanoparticles on tBLM resistance (R_m) was studied using electrochemical impedance spectroscopy. Changes in the R_m following ENM exposure were analyzed using an empirical, exponential-decay model and a simple mechanistic kinetic model. Statistical analysis of the model parameters for each ENM showed that the method could distinguish between ENM having identical core nanoparticles but different surface functional groups.

We have also adapted electrophysiology methods to study how 20-nm polystyrene nanoparticles (PNP) induce pores in pBLM. The PNP's charge was varied by using either positive (amidine) functional groups or negative (carboxyl) functional groups. The pBLM's charge was varied using dioleoyl phospholipids having cationic (ethylphosphocholine), zwitterionic (phosphocholine), or anionic (phosphatidic acid) headgroups. Both positive and negative PNP induced pBLM pores for all lipid compositions studied. The results demonstrated for the first time that PNP can induce ion-selective pores in pBLM, and that the degree of ion selectivity is influenced synergistically by the charges of both the lipid headgroups and functional groups on the PNP. These results provide insight into mechanisms by which ENM interact with biomembranes and may lead to improved methods to screen ENM libraries for a desired combination of functional and biosafety profiles.

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Room 1400 – BPS