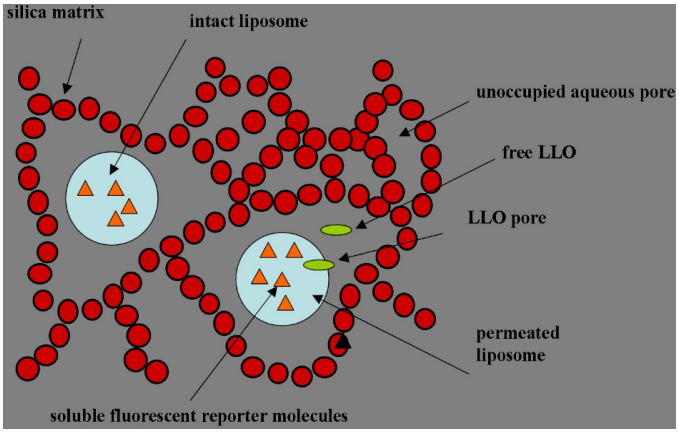
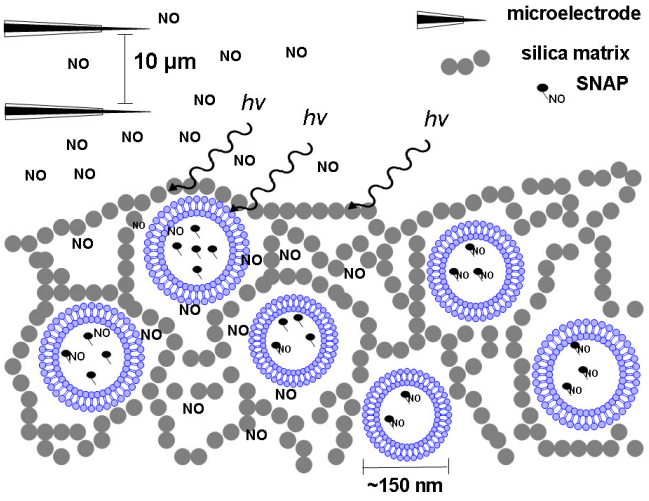
Multicompartment Hybrid Biological/Inorganic Nanocomposites

Biological functionality is typically a property of organic molecules and molecular complexes, while long-term stability and easy integration into engineered devices is a property of inorganic solids. Dr. Jenna Rickus and co-workers at Purdue University are developing new ways to integrate biological and inorganic materials to bring biological function into engineered devices. The schematic below illustrates a recent example. Lipid membrane vesicles (~100 – 200 nm in diameter) are doped within the aqueous interstitial phase of porous silica. The vesicles mimic the membranes of living cells as well as create a second aqueous compartment within their lumen. The solid silica matrix stabilizes the vesicles for many months and allows integration into devices such as electrode surfaces or portable sensors.



In one application, the vesicles serve as surrogates for living cells for the detection of pore forming toxins. Here the toxin listeriolysin O (LLO), which is produced by the foodborne pathogenic bacteria, Listeria monocytogenes, forms a functional pore in the vesicle membranes. Pore formation releases a fluorescent molecule from the vesicle lumen creating an optical signal that can be detected. The silica pores allow access of the toxin while stabilizing the vesicles in a solid film that could easily be packaged in a simple device designed to detect pathogens in food products.



A similar approach was used to create dynamic materials for the spatial and temporally controlled delivery of nitric oxide (NO) to living cells in culture. NO is a key molecule involved in normal cell functions as well as cellular dysfunction during inflammation and injury. The vesicle lumen stores an aqueous NO donor molecule. The silica matrix stabilizes the vesicles, maintains their spatial location, and creates a surface for cell growth. Delivery of light releases NO from the donor. NO can diffuse through the membranes of the vesicles and silica pores to stimulate the cells at the material surface. Different patterns and intensities of light enable the calibration of nitric oxide flux, which is confirmed by an NO microelectrode.

John J. Koehler, Jianxiu Zhao, Sabrina S. Jedlicka, D. Marshall Porterfield, Jenna L. Rickus. (**2008**) "A Compartmentalized Nanocomposite for Dynamic Nitric Oxide Release" J. Physical Chemistry. 1112(47) p. 15086–15093

Zhao, J., Jedlicka, S.J., Lannu, J.D., Bhunia, A.K., Rickus, J.L. (**2006**) "Liposome-doped Nanocomposites as Artificial-Cell-Based Biosensors: Detection of Listeriolysin O", Biotechnology Progress, 22:32-37

Contributing Agencies: USDA/CSREES