NATURE-INSPIRED MULTI-COMPARTMENT AND MULTI-LAYERED CAPSULES

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This talk will describe the design and synthesis of new capsule structures, made from biocompatible polymers through directed assembly in aqueous solution. Our inspiration for creating these structures comes from nature. In one case, the inspiration comes from the architecture of the eukaryotic cell, which has multiple inner compartments (organelles), each with a distinct function. In this vein, we have created biopolymer-based multicompartment capsules (MCCs) using an oil-free microfluidic technique. Our approach exploits the electrostatic complexation (coacervation) of oppositely charged polymers dissolved in aqueous media. We can control the overall size of the MCCs, the sizes of the inner compartments, and the number of inner compartments. More importantly, we can encapsulate different payloads in each of the inner compartments, including colloidal particles, enzymes, and microbial cells. A hallmark of biological cells is the existence of cascade processes, where products created in one organelle are transported and used in another. We will show examples of such cascade processes using our MCCs.

A second class of capsules are inspired by natural structures that include eggs, embryos, body parts like blood vessels and the spinal disc, plant seeds, and vegetables like the onion. All these structures have multiple concentric layers, with each layer typically having distinct composition, and thereby function. The creation of multilayered structures in nature typically proceeds by the initial formation of an inner layer or core, followed by a first shell, and a further progression outwards to add more shells. We draw inspiration from natural morphogenesis to create multilayered (onion-like) polymer capsules by an “inside-out” technique. Each polymeric shell grows outward from the surface of the previous shell; thus, the thickness of a given shell steadily increases with time and can be controlled. Using this technique, we can juxtapose different polymers next to each other among the concentric layers in a capsule. We will show that these capsules exhibit a range of interesting properties, including in their ability to release solutes, and in their mechanical strength.