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Multi-compartment globular structures assembled from polymer-based materials may soon serve as cell prototypes

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The cell is a host of many complex reaction pathways. These pathways usually do not interfere with each other because they are contained within membrane-bound compartments, known as organelles. The lipid membrane is extremely selective—only allowing certain signalling molecules to permeate through—and plays an important role in biological processes, such as protein synthesis and the regulation of enzymatic reactions. Madhavan Nallani from the A*STAR Institute of Materials Research and Engineering and co-workers have now synthesized a new type of multi-compartment structure known as a polymersome, which mimics cellular compartmentalization through the use of self-assembling polymers.

Although many researchers have created artificial structures designed to imitate cells, their efforts have primarily been restricted to lipid and polymer-based structures with only one compartment. Nallani and his team designed a system consisting of two compartments self-assembled sequentially. "Most importantly, the membranes of different compartments are made from different materials," Nallani says. As a consequence of this unique feature, the properties of the membranes can be tuned.

To make the polymersomes, the team opted for amphiphilic block copolymers—polymers composed of subunits with opposite affinity to water. Nallani explains that this difference in wettability is what drives the copolymers to self-organise into compartments. “One of the challenges that we encountered is the selection of materials to form such architectures,” he adds.

The researchers first synthesized single-compartment particles using one copolymer. They then entrapped each of these first structures in a second shell by adding a solution containing another type of copolymer. In the resulting multi-compartmentalized architectures, the inner particle consisted of a tightly packed, low-permeability membrane and was surrounded by a semi-permeable outer membrane that lets small molecules through.

Nallani and his team tested the selectivity of the compartment membranes for the encapsulation of biomolecules. As a proof of concept, they encased one kind of fluorescent protein that emits green light and another variety that displays red-light emission in the polymersomes. The inner part of the particles emitted green light while the outer compartment emitted red light (see image). The result suggests that the proteins were localized in two separate sections according to their type.

“Our system may add value in applications such as drug delivery and multi-enzyme biosynthesis,” says Nallani. The researchers are currently designing compartments that allow different components to mix just before reaching target cells. They are also introducing membrane proteins within these compartments that may facilitate the transport of products formed in one compartment to another.

More information: Fu, Z., et al. Multicompartmentalized polymersomes for selective encapsulation of biomacromolecules. *Chemical Communications* 47, 2862–2864 (2011).

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