Adaptive polymer nanoreactors with life-like features

Compartmentalization is generally regarded as one of the key prerequisites for life. In living cells, not only the cell itself is a compartment, with its properties controlled by the semipermeable cell membrane, but also the organelles play a crucial role in protecting and controlling biological processes. To better understand the role of compartmentalization, there is a clear need for model systems that can be adapted in a highly controlled fashion, and in which life-like properties can be installed. Polymer-based compartments are robust and chemically versatile, and as such are a useful platform for the development of life-like compartments. In this lecture both artificial organelle and cell systems will be discussed. The artificial organelles are composed of biodegradable amphiphilic block copolymers that self-assemble into vesicular structures. These so-called polymersomes are loaded with enzymes and are semi-permeable for small molecule substrates. Upon introduction in living cells, they affect metabolic pathways as artificial organelles.1 A different type of polymersome is created via a shape change process in which a bowl-shaped structure is obtained. Within the cavity of the bowl enzymes are loaded which provide the nanostructure with motility upon conversion of chemical energy into kinetic energy.2 The morphology of these stomatocytes furthermore resembles that of red blood cells. Upon loading with hemoglobin and decoration with the isolated cell membrane of erythrocytes nano-red blood cells are created with biomedical potential.3

The synthetic cell platform is composed of a complex polymer coacervate, stabilized by a biodegradable block copolymer. The specific feature of the polymer membrane is its semipermeable character. Enzymes inside the protocell can therefore still be reached by their substrates, and small molecule products can be excreted. This allows protocell communication with this robust synthetic platform.4

References

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