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Editorial corner – a personal view
From physico- to bio-responsive polymers

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Polymeric structures that undergo rapid phase transitions upon variation of environmental conditions have recently received increasing attention. Poly(N-isopropylacrylamide) and a range of related or comparable macromolecules have been successfully applied in the development of temperature-responsive systems that are used, for instance, as functional coatings of cell culture carriers to harvest cell sheets without enzymatic treatment or as valves in microfluidic circuits. Comparable effects can be achieved in polymers carrying high densities of dissociable groups, such as poly(acrylic acid), upon variation of the pH and/or ionic strength of the adjacent milieu. Polymers responding to further physical stimuli, such as magnetic or electrical fields, are also studied following the same idea.

A new class of stimuli-responsive materials goes even further: bio-responsive polymers. These macromolecules change their properties in response to recognition events with biomolecules such as growth factors, antibodies or enzymes. To make this happen, tight binding of specific molecular components to the polymeric chains is used to produce macroscopic responses such as sol-gel-transitions. Alternatively, enzymes are employed to selectively cleave susceptible segments of the macromolecules, resulting in their fragmentation. Common examples include glucose-responsive systems, enzymatically cleavable peptide-containing poly(ethylene glycols) and disulfide-based triblock copolymers responding to the gluththione levels. The responsive polymer structures are often assembled into networks or particles to maximize the macroscopic effect. Obviously, such materials can be directly used for sensoric/diagnostic applications in combination with appropriate detection principles. Beyond that, drug release systems will massively benefit from the resulting options: In a pioneering study, an antibiotic-sensing hydrogel was developed to enable the trigger inducible release of human vascular endothelial growth factor through the systemic level of an aminocoumarin antibiotic.

However, there are even more exciting options ahead. For example, using the responsiveness of macromolecules to environmental levels of biomolecular components is expected to enable feedback controlled scaffold structures for tissue engineering. We envision these materials having an in-built adaptation of physical properties, such as elasticity or permeability, to the local levels of biomolecular components, which may, in turn, control the downstream response of the biosystem brought into contact with the polymeric material. With such advances, synthetic polymeric architecture will come closer to the dynamic nature of living matter.

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