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HYDROGELS

Mineral shapeshifters

Conventional petroleum-based plastics are not only environmentally unfriendly to synthesize but are non-biodegradable and costly to recycle. Plastics that are cheap, easy to synthesize and recyclable are thus highly desirable. Writing in *Angewandte Chemie*, Helmut Cölfen and colleagues report a promising alternative — a hydrogel made of calcium carbonate nanoparticles cross-linked with poly(acrylic acid) that can be reversibly dried to form a rigid, transparent, plastic-like material.

Natural materials made by biomineralization, such as sea shells, are largely composed of calcium carbonate and have a definite shape once formed. Inspired by these structures, Cölfen and colleagues reasoned that if the amorphous calcium carbonate phase is stabilized using polymers, it may be possible to obtain a re-shapeable material that can reversibly solidify. Indeed, the introduction of flexible polymer chains binding the calcium carbonate particles together renders the hydrogel with the ability to be crafted into different shapes and stretched into very long fibres. The hybrid hydrogel can also self-heal within a few seconds. “Because this material is mainly composed of minerals and exhibits plastic-like properties, we dubbed it ‘mineral plastic,’” says Cölfen.

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Once dried, the hydrogel turns into a rigid and transparent material with a very smooth surface, similar to shrimp shells but much harder. Moreover, it is also harder than conventional plastics. The material returns to a hydrogel after day-long immersion in water, after which it can be re-shaped and then re-dried, providing a very convenient recycling route. At the end of its usable life, the material can be dissolved using weak, commonly used acids, such as citric or acetic acid.

The road to practical applications remains long, but it’s not difficult to imagine how the material could be used. “Any application where plastics are required to work in dry conditions could be made from mineral plastics,” explains Cölfen. “In addition, they would be useful in situations in which a plastic component with a certain shape is needed as a temporary replacement for a broken part.” If a crack appears in the dry material, it is sufficient to apply water to the damaged area to revert it to the self-healing hydrogel, and then proceed to dry the object again once the crack is closed. In addition, the synthetic route to produce the hybrid hydrogel is very simple: the components are mixed in water at room temperature. “We hope that, one day, mineral plastics will be good enough to replace conventional plastics in certain fields,” concludes Cölfen.

In future studies, new compositions need to be explored to yield hybrid hydrogels with improved chemical and physical properties, in particular, stiffness and toughness. The use of biodegradable binder polymers could also be advantageous, because it might lead to the development of entirely environmentally friendly plastic-like materials.

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