

New reusable and recyclable environmentally friendly hydrogel

December 20 2023, by Adam Hadhazy



Princeton researchers have developed a new type of recyclable hydrogel that can be cut and molded into different forms. Credit: Dan Komoda/Princeton University

Princeton researchers have created a new type of hydrogel that is recyclable, yet still tough and stable enough for practical use (and reuse).

As flexible networks of polymer chains suffused by water, hydrogels

possess excellent properties including softness, elasticity and biocompatibility. Accordingly, the squishy materials have already found widespread use as contact lenses and wound dressings. Hydrogels also hold great promise for drug delivery systems, agriculture and food packaging, among other applications.

Unfortunately, conventional hydrogels pose environmental pollution problems because they cannot be effectively recycled or reprocessed. Hydrogels also degrade from [long-term use](#). The researchers said these limitations derive from the materials' structure.

Conventional hydrogels rely on chemical bonds for their firmness and ability to soak up water and other solvents. On a chemical level, these bonds are cross-linked, meaning that bonds form among different polymer molecules within the hydrogel. This cross-linking, characteristic of resins undergoing curing or rubber vulcanization, gives hydrogels flexibility and strength. But it also makes them extremely difficult to separate into components for recycling.

The study's lead author, Xiaohui Xu, a postdoctoral researcher, previously worked with hydrogels for use in water purification and wondered if she could create a more environmentally sustainable hydrogel. Xu and her colleagues took a new approach to building hydrogels. Rather than relying on chemical bonds to connect different polymers, the researchers decided to harness [phase separation](#), a familiar phenomenon in which mixed liquids, such as oil and water, separate into components.

"Hydrogels offer tremendous societal benefit, but their lack of sustainability has loomed as a significant issue," said Xu, a postdoctoral researcher in the lab of Rodney Priestley, the Pomeroy and Betty Perry Smith Professor of Chemical and Biological Engineering at Princeton.

"In this study, we have shown how taking advantage of phase separation

can lead to new kinds of hydrogels that are durable and recyclable and still have good mechanical properties."

The researchers described the process in a study titled, "Tough and Recyclable Phase-Separated Supramolecular Gels via a Dehydration–Hydration Cycle," [published](#) in *JACS Au* in September.

To make the new hydrogel, the researchers formulated polymers with a complex and varying relation to water. Polymer molecules are long chains of smaller molecules (called monomers). The researchers created polymers that are water-loving in some sections of the chain and water-repelling in other sections. When they added water to the [polymer](#) mix, parts of the polymers absorbed the water, while other parts repelled it. This tension gave the hydrogel its structural strength.

Unlike conventional hydrogels, the strength is based on [physical characteristics](#) rather [chemical bonds](#) among the polymers. So, recycling the hydrogel into its component polymers is relatively easy, as is repeatedly dehydrating and rehydrating the material.

What is more, Xu said, the process allows engineers to tailor the characteristics of a hydrogel by adjusting the components of the polymers. The research team took advantage of this to create a hydrogel that could be cut and molded into any desired shape. For the research, Xu made an octopus.

"Xiaohui used phase separation as a way to control the morphology, and ultimately, the properties of these hydrogel materials," said Priestley, the paper's senior author and Dean of the Graduate School at Princeton. "This work demonstrates an environmentally friendly approach for making tough and reusable hydrogels."

The Princeton researchers put the new hydrogel through its paces, testing

its stability in extreme acidic and alkaline conditions and in air and water. Across the board, the hydrogel held up and performed as expected.

With additional testing and development, the novel material could make existing and emerging applications for hydrogels—such as artificial muscles and soft robots for safe operation around humans—more sustainable and environmentally friendly.

"Our general approach for recyclable hydrogels could help expand their applications in all kinds of areas," said Xu. "The benefits of hydrogels can now be better realized without the environmental costs."

Xu said in the long term, the research team is exploring whether hydrogels could eventually serve as a substitute for plastics in many applications. If that is the case, advanced [hydrogels](#) could become a recyclable solution to plastic pollution that threatens the oceans.

More information: Xiaohui Xu et al, Tough and Recyclable Phase-Separated Supramolecular Gels via a Dehydration–Hydration Cycle, *JACS Au* (2023). [DOI: 10.1021/jacsau.3c00326](https://doi.org/10.1021/jacsau.3c00326)

Provided by Princeton University

Citation: New reusable and recyclable environmentally friendly hydrogel (2023, December 20) retrieved 28 April 2024 from <https://phys.org/news/2023-12-reusable-recyclable-environmentally-friendly-hydrogel.html>

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.