Torn but not broken: New polymers give themselves a quick fix

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Video Abstract

Keywords: self-healing polymers, scandium-catalyzed copolymerization, ethylene, anisylpropylenes, Center for Sustainable Resource Science, lime mortar, cracks, chemical reaction, ionic iterations, rare-earth catalyst, crystalline islands, chemical pendants, shape-memory effect, deformation, reheating, freezing, light, pressure, self-repair, RIKEN

Posted Date: September 20th, 2019

DOI: <https://doi.org/10.21203/rs.2.14985/v1>

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Abstract

It might seem like something straight out of comic book fantasy, but this self-healing material is all real. Able to repair itself in mere minutes—with practically no external input—this new class of polymer could hold the key to making plastics nearly invincible. To be sure, self-healing materials aren't all that new. Scientists have discovered that the lime mortar used in Ancient Roman structures like the Colosseum forms tiny plate-like crystals that fill in cracks that develop over time. And researchers long ago cracked the chemistry that enables polymer networks to zip back up after damage. These materials, however, typically involve expensive and sophisticated designs. Many require complex chemical reactions to function or ionic or electronic interactions found only in a small subset of polymers. On top of that, repair often requires an external source of energy, typically in the form of heat, light, or pressure. These new self-healing polymers are much simpler to produce from relatively cheap starting materials and need only time to sew themselves back up. Developed by a group of researchers from the RIKEN Center for Sustainable Resource Science, the base material features two components: bulky anisylpropylene mixed with ethylene, the sweet gas that triggers fruit to ripen. The researchers used a uniquely structured rare-earth catalyst to control how those different components are combined. The best combination for inducing self-repair was determined to be a mixture of relatively long alternating anisylpropylene-ethylene segments and shorter ethylene-ethylene segments. X-ray data suggested that the shorter bits tend to cluster into crystalline islands in an ocean of the longer and more flexible component. That clumping tendency is believed to be the force that drives the material to heal itself after being cut or broken. But the polymers proved capable of much more. By clasping different chemical pendants to the long, flexible chains, the researchers could induce a shape-memory effect. Deformation at high temperature could be frozen into the material by cooling to low temperature. And reheating could restore the material's original structure. More work is needed to refine the unique properties of this novel polymer. But already, the possible applications abound. Tough, tunable, and capable of self-repair, the polymer could pave the way to creating other extraordinary materials from ordinary parts.