Plastics That Change Color When Stressed

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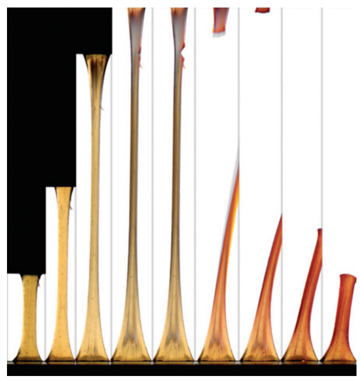

Warning signs. Color-changing plastics begin to turn red when stretched.

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Researchers have created solid plastics that change color under mechanical stress. Down the road, the approach could lead to plastics that signal when they are about to break or trigger a chemical reaction designed to toughen them where they are under the most stress.

This isn't the first "smart" material that senses and responds to its environment. For example, scientists have created self-healing plastics containing tiny capsules that rupture if a crack develops, releasing a catalyst to reform the plastic. But researchers would also like to be able to design self-repair into individual polymer molecules that make up the plastic.

In an effort to do so, researchers led by chemist Jeffrey Moore and materials scientist Nancy Sottos of the University of Illinois, Urbana Champaign, have been working to equip the polymers with the ability to sense and respond to mechanical stress.

Two years ago, some members of the current team showed that they could place small ring-shaped molecules that they call "mechanophores" in the center of polymer chains. In response to mechanical force, these rings break, changing the color of the polymer. But the mechanophores worked only when the polymer was in solution, after the researchers stressed them with high-power ultrasound.

For their current study, Moore, Sottos, and their colleagues wanted to see if the same strategy would work for solid polymers. One concern, however, was whether extreme stress would cause the polymers to break at random locations. If so, the mechanophore would usually remain unchanged and produce no color change. In tomorrow's issue of *Nature*, they report that the mechanophores work as hoped in solids.

Ultimately, such color-changing polymers could be used as coatings on everything from bridges to airplane wings, alerting engineers when vital structures are near failure. It should also be possible, using the same strategy, to design a wide variety of other mechanophores that perform different functions, such as triggering a self-healing chemical reaction, and embed them into polymer molecules. "The thing that is exciting is that this is a general approach," Sottos says.

There are plenty of applications ready and waiting for mechanically responsive polymers, says chemist Chris Bielawski of the University of Texas, Austin. For starters, when materials such as metals and concrete begin to fail, they typically show signs of stress and fatigue, such as small cracks. But plastics often offer little sign before they give way. The new color-changing polymers could lead to plastics that show when they are under undue stress. The new work, he says, "is going to raise a lot of people's eyebrows and get people excited."

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