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A scratched coating heals itself

Collaboration among the University of Fribourg, Case Western Reserve University and the Army Research Laboratory uses light to trigger repair.

FRIBOURG – Your 6-year-old found a nail in the garage and drew pictures across the side of your new car.

Gnash your teeth now, but researchers at the Adolphe Merkle Institute of the University of Fribourg, Switzerland, say the fix-up may be cheap and easy to do yourself in the not-too-distant future.

Together with partners in the USA, they have developed a polymer-based material that can heal itself when placed under ultraviolet light for less than a minute. Their findings are published in the April 21st issue of *Nature*.

The team involves researchers at Case Western Reserve University in Cleveland (OH) led by Stuart J. Rowan, a team at the Adolphe Merkle Institute of the University of Fribourg led by Christoph Weder, and Rick Beyer and Andrew Duncan of the Army Research Laboratory at Aberdeen Proving Ground (MD) led by Rick Beyer.

The scientists envision that re-healable materials like theirs could be used in automotive paints, varnishes for floors and furniture, and many other applications.

Their polymers aren't ready for commercial use, they acknowledge, but prove that the concept works.

The key?

"These polymers have a Napoleon Complex: in reality they're pretty small but are designed to behave like they're big by taking advantage of specific weak molecular interactions," said Stuart Rowan, a professor of macromolecular engineering and science and Director of the Institute for Advanced Materials at Case Western Reserve University.

"Their molecular design allows the materials to change their properties in response to a high dose of ultraviolet light," said Christoph Weder, a professor of polymer chemistry and materials and the director of the Adolphe Merkle Institute.

The new materials were created by a mechanism known as supramolecular assembly. Unlike conventional polymers, which consist of long, chain-like molecules

with thousands of atoms, these materials are composed of smaller molecules, which are assembled into longer, polymer-like chains using metal ions as “molecular glue”. The result: the new materials, which the scientists call “metallo-supramolecular polymers”, behave in many ways like normal polymers.

But when irradiated with intense ultraviolet light, the assembled structures are temporarily unglued. This transforms the originally solid material into a liquid that flows easily. When the light is switched off, the material re-assembles and solidifies again: the original properties are restored.

Using lamps such as those dentists use to cure fillings the researchers repaired scratches in their polymers. Wherever they waved the light beam, the scratches filled up and disappeared, much like a cut that heals and leaves no trace on skin.

Tests showed the researchers could repeatedly scratch and heal their materials in the same location.

“We can simply use heat to heal these materials,” Mark Burnworth, a graduate student at Case Western Reserve University said. “But by using light, we have more control as it allows us to target only the defect and leave the rest of the material untouched.”

The researchers systematically investigated several new polymers to find an optimal combination of mechanical properties and healing ability. They found metal ions that drive the assembly process via weaker chemical interactions serve best as the light-switchable molecular glue.

They also found the materials that assembled in the most orderly microstructures had the best mechanical properties. But, healing efficiency improved as structural order decreased.

“Understanding these relationships is critical for allowing us improve the lifetime of coatings tailored to specific applications, like windows in abrasive environments” Beyer said.

According to Rowan, “One of our next steps is to use the concepts we have shown here to design a coating that would be more applicable in an industrial setting.”

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