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Plastic, heal thyself

Fatigued materials have a new self-help cure.

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A new self-healing plastic may help cracked aircraft wings, circuit boards and tennis racquets to escape the ignominy of the landfill. This clever composite material could mitigate the costly and inconvenient weakening effects of material 'fatigue', say its developers Scott White and co-workers of the University of Illinois at Urbana-Champaign.[1]

Structural composite materials consist of fibres of glass, carbon or some other component embedded in a polymer matrix. When subjected to vibrations, loads and stresses, these materials develop tiny cracks, which get bigger until they render the material useless.

White's team tackled the problem by embedding tiny capsules within the polymer matrix. As the crack propagates, it ruptures the capsules, releasing a liquid healing agent. The liquid molecules come into contact with a catalyst that is also embedded within the polymer matrix, causing the healing agent to polymerize.

The net result is an extended, polymeric network along the crack that bonds the fracture faces together.

To ensure success, the capsules need to have just the right stiffness. If they are much more rigid than the surrounding matrix, tiny cracks that approach them will simply be deflected. If the capsules are more yielding, they will actually attract cracks.

The chemistry put to work to fill the cracks and bond the fracture faces has also been carefully chosen. The healing agent remains stable while contained within the capsules, yet is fluid enough to fill the cracks once it has been released from the capsules. The individual molecules also bond together easily to form the polymer when they come into contact with the catalyst.

When White's team damaged a sample of this carefully prepared material and allowed it to recuperate for two days, they found that the cracks healed and the material regained up to 75% of its original toughness.

This result is "promising news", says Richard Wool, president of Cara Plastics Inc. in Wilmington, Delaware, himself an advanced materials researcher. White and his co-workers are not the first to develop a self-healing structural composite[2,3], but their choice of self-healing agent is particularly elegant and practical.

"Although cost will be a crucial factor when deciding whether to use self-healing structural materials," adds Wool, "it will be an attractive option in cases where it isn't possible, or practical, to repair a material after it has been put to use, such as in prosthetics, artificial organs, large bridges or satellites."

References

1. White, S. R. et al. Autonomic healing of polymer composites. ***Nature*** **409**, 794 - 797 (2001).
2. Dry, C. & Sottos N. Passive smart self-repair in polymer matrix composite materials. *In Smart Structures and Materials 1993: Smart Materials* (ed. Varadan, V. K.) p. 438. Proceedings of 1993 North American SPIE Conference on Smart Structures and Materials, Vol. 1916 in SPIE Proceedings (SPIE, Bellingham, WA, 1993).
3. Dry, C. Procedures developed for self-repair of polymeric matrix composite materials. *Composite Structures* **35**, 263 - 269 (1996).