Editorial corner – a personal view

Polymer self-heals in seconds

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Recently, self-healing polymers capable of autonomously restoring themselves have attracted more and more research interests. Many approaches that impart remendability to polymeric materials by either incorporation of healing agent into the matrices or making use of reversible inter/intra-macromolecular bonding have been proposed. Comparatively, however, most of the research concerns are focused on the extent of properties recovery rather than the speed.

In fact, rapid healing of cracks is highly desired for practical applications. On the one hand, crack propagates very fast; on the other hand, the damaged materials should be healed immediately to prevent occurrence of catastrophic failure.

By reviewing the available literature, we find that the reported time taken for reaching steady state or maximum healing used to be on the level of hour or dozens of minutes. Evidently, it needs to be greatly shortened.

To tackle the problem, SbF_5 (ACS Appl. Mater. Interfaces, DOI: [10.1021/am405989b](https://doi.org/10.1021/am405989b)), a strong Lewis acid, and trifluoromethanesulfonic acid (Compos Sci. Technol., DOI: [10.1016/j.compscitech.2014.08.028](https://doi.org/10.1016/j.compscitech.2014.08.028)), a strong Bronsted acid, were employed for formulating fast healing systems, respectively. In actual operation, the acids were encapsulated by silica, and then embedded in epoxy matrix together with encapsulated epoxy monomer. Upon cracking of the composite, the fluidic chemicals released from the broken microcapsules flowed to the damage sites due to capillary effect and curing of the epoxy monomer occurred, re-connecting the cracked faces. Both impact and fatigue tests demonstrated that mechanical strength of the epoxy filled with the healing agent

can be recovered within seconds at room temperature without manual intervention. Moreover, the healing system consisting of trifluoromethanesulfonic acid-epoxy pair turned out to possess significant thermal stability. It can survive the rigorous processing of high T_g epoxy ($>240^\circ\text{C}$) during composite fabrication and provide the composite that was pre-treated at 180°C for 5 h with the same healing efficiency as the untreated one.

The above investigations also indicate that the healing speed of fast self-healing materials is difficult to be precisely evaluated by the existing destructive tests because of the time consuming recombination of the broken specimens. Fast in-situ measurement protocol like ultrasonic immersion technique that allows for determining elastic constants (Angew. Makromol. Chem., DOI: [10.1002/apmc.1992.051980104](https://doi.org/10.1002/apmc.1992.051980104)) within short time should be introduced.

Although the healing systems based on the encapsulated strong Lewis or Bronsted acids and epoxy monomer have shown their ultrafast healability, much milder substitute with comparable healing speed is still worth being developed in view of easy handling. Besides, the balance between the rate of curing and speed of healing agent delivery should be considered when large damage sites are dealt.

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