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Innovative tough elastomers: designed sacrificial bonds in multiple networks

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We investigated an innovative path to reinforce, both in toughness and stiffness, usually brittle elastomers, without using fillers.

In this work, via a sequence of swelling/polymerization steps, we designed multiple network elastomers from alkyl acrylate monomers. They are interpenetrated network elastomers containing a variable fraction of isotropically prestretched chains. The mechanical properties of multiple network elastomers have been investigated in detail with a special emphasis on small and large strain behavior, dissipative mechanisms and fracture experiments. Compared to simple elastomer networks, our multiple network elastomers show a large increase in initial modulus, in stress at break and in fracture toughness. Those unfilled elastomers are as tough as some filled elastomers. Chemoluminescent crosslinking molecules, which emit light as they break, allowed us to map spatially for the first time where and how many of the internal bonds break ahead of a propagating crack. We unambiguously proved that prestretched chains are acting as sacrificial bonds that dissipate energy in the bulk ahead of the crack tip and toughen the material.

The simple methodology that we use to toughen the networks combined with the molecular information given by the spatial mapping of where bonds break paves the way for the development of new classes of unfilled tough elastomers using knowledge-based methods.