Experiment and modelling of the mechanical and fracture properties of dual-crosslink gels

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One of the strategies used to improve the toughness of polymer networks is the introduction of sacrificial bonds, which can break before the main bonds break. These sacrificial bonds serve a double purpose. They dissipate energy and delay crack propagation, and they redistribute forces in the main bonds avoiding too sharp stress concentrations at the tip of a crack. Simple crosslinked networks of flexible polymer chains possess great reversible elasticitybut over a limited range since they are typically rather brittle. This is particularly true of hydrogels, which are highly swollen with water. Because molecular friction cannot be used in hydrogels to create energy dissipation, the dissipation relies on bond failure where a stretched elastic chain loses its strain energy as it is broken and return to its equilibrium conformation. Two classes of materials have been mainly developed to address this question: materials where the sacrificial bonds are of a similar nature as the main bonds but are overloaded due to network architecture [1, 2]. And materials where a population of weaker bonds is introduced [3, 4]. In this talk we will present some recent results concerning the latter case, where physical reversible bonds have been introduced in an otherwise chemically crosslinked network. Our networks are swollen in water and contain a minority of strong covalent bonds and a majority of weak dynamic bonds that can break and reform. We will discuss in particular two points: How this strategy can be beneficial for fracture resistance, and in particular what is the relation between the bond dynamics and the fracture process, and how such soft solids can be modelled at the macroscopic scale.

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