ENGINEERING POLY(ISOBUTYLENE) AS SELF-HEALING POLYMER

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ABSTRACT

All polymeric materials are subject to thermal, mechanical as well as chemical degradation and destruction during their lifetime. As new materials are designed, the quest for materials with self-healing properties (i.e.: those which can regenerate similar to living matter, especially after mechanical deformation) is increasing, culminating in the need for self-healing polymers after mechano-deformation 1-3. We here report on the realization of two different principles of self-healing polymers, based on either dynamic, supramolecular polymers 4,5, or via the use of encapsulated reagents3,6-8. Whereas in the first principle either hydrogen-bonded, supramolecular polymers5,9 or ionomers 10,11 are responsible for a restorative force to effect multiple self-healing, reactive liquid polymeric components are embedded into separate capsules in the second concept, subsequently reacting via “click”-reactions after rupture of the capsule by mechanical deformation and destruction. The design of the polymers, their synthesis and the underlying autocatalytic effects to achieve sufficiently fast reactivity and thus self-healing properties are discussed.

1. INTRODUCTION, RESULTS and CONCLUSIONS

Critical for a practical application of self-healing polymers is the need to achieve multiple self-healing cycles thus enabling repeated healing after repeated mechanical deformation has occurred (see Figure 1). Thus the underlying crosslinking reactions should act repeatedly and reversibly, putting supramolecular interactions in the limelight of interest. The current paper concentrates on the use of supramolecular interactions such as ionomers10-12 and hydrogen bonds9,13-15, both linked to polymers, to achieve reversible self-healing under reasonable time scales. Critical for the design of such processes is a deeper understanding of association dynamics in the melt-state of such polymeric liquids9,13, most of them in the rubbery or partially thermoplastic state. Focus of the current talk is directed towards poly(isobutylenes) as polymers displaying a high chain mobility and high individual segment-dynamics.

Together with crosslinking as well as post-crosslinking reactions and their associated network formation the thermomechanical and physicochemical properties are thus defined. Combined with conventional crosslinking reactions, such as the azide/alkyne-“click”-reaction (CuAAC16-22) as one of the most prominent “click”-type reactions reaction the kinetics of the CuAAC and the association dynamics of the supramolecular components are discussed, focussing on simple hydrogen bonding systems (such as diaminotriazine/thymine as well as more complex hydrogen bonds (such as the barbituric acid/Hamilton-receptor-moieties).23-25
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REFERENCES