A GENERIC METHODOLOGY TO STUDY SELF-HEALING PROPERTIES OF THERMO-REVERSIBLE POLYMER NETWORKS

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ABSTRACT

Based on the reversible Diels-Alder (DA) reaction between furan and maleimide functional groups, an extrinsic self-healing material was synthesized for coating applications [1]. At elevated temperatures, the DA/retro-DA equilibrium is shifted towards the initial building blocks. This shift in equilibrium allows a temporary increase in local mobility, which is essential to seal damage. The recovery of initial properties takes place in a subsequent cooling by recombination of covalent bonds through the exothermic DA reaction.

Changing the spacer length in the furan functionalized compound leads to a flexible network design and tailor-made network properties with a variable cross-link density and glass transition temperature [1]. Based on these systems, a generic methodology was developed to study the self-healing properties of thermo-reversible networks.

The effect of temperature on kinetics and equilibrium of the reversible DA/retro-DA reaction, and also the effect of diffusion-control was measured (and modeled) by means of Fourier transform infrared spectroscopy, microcalorimetry and Modulated DSC. Both elastomeric and thermosetting reversible networks were investigated.

A maximum sealing temperature was determined to avoid unwanted side-reactions. In case of the DA networks studied, an irreversible homopolymerization of maleimide functional groups occurs above 120 °C. The flow behavior at elevated temperatures was characterized by dynamic rheometry in order to determine the gelation temperature (T_{gel}) of the reversible networks. It was shown that sealing of microscopic scratches is possible below T_{gel}, leading to the advantage for coatings that sufficient mechanical properties remain guaranteed during a thermal sealing/healing procedure. At low temperatures, the exothermic DA reaction was characterized by microcalorimetry and Modulated DSC proving the healing capacity of the networks and showing the repeatability of sealing/healing cycles in an acceptable temperature window. The mechanical properties in this temperature window were studied with dynamic mechanical analysis.

REFERENCES

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