A REMENDABLE POLYMER NETWORK BASED ON REVERSIBLE COVALENT BONDING FOR COATING APPLICATIONS

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Keywords: Diels-Alder, kinetics, equilibrium, polymer network, gel point

ABSTRACT

An extrinsic self-healing material was synthesized based on the reversible Diels-Alder (DA) reaction between furan and maleimide functional groups, designed for coating applications. 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 in order to seal any sustained damages to the coating. The actual recovery of initial properties takes place in a subsequent cooling, where recombination of covalent bonds through the exothermic DA reaction occurs.

The advantage of this particular self-healing system lies in its flexible network design. Changing the spacer length in the furan functionalized compound leads to tailor-made properties, such as cross-link density and glass transition temperature (T_g). Based on the T_g analysis performed by differential scanning calorimetry (DSC), a model system was chosen to evaluate the kinetic parameters of the reversible DA reaction by Fourier transform infrared spectroscopy (FTIR).

A methodology to study self-healing properties was developed in a well-defined temperature window based on the kinetics and equilibrium of the reversible networks. In a first step, a maximum sealing temperature of 120 °C was determined to avoid an irreversible homopolymerization of maleimide functional groups [1]. Secondly, the flow behavior at elevated temperatures was characterized by dynamic rheometry. Frequency sweeps were performed in equilibrium conditions at various isothermal temperatures in order to determine the gelation temperature (T_{gel}). It was shown that sealing of microscopic scratches was possible below T_{gel}, leading to the advantage that mechanical properties remain guaranteed during a thermal healing procedure. In addition, the exothermic DA reaction was characterized by Modulated DSC at low temperatures, proving the healing capacity at low temperatures and showing the repeatability of healing procedures.

REFERENCES

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