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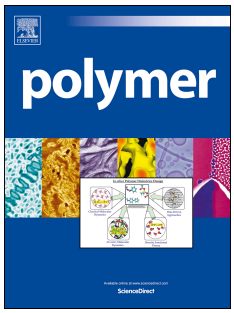

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Moisture-Mediated Self-Healing Kinetics and Molecular Dynamics in Modified Polyurethane Urea Polymers

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Abstract

Self-healing materials offer the ability to repair cracks within a polymeric material of molecular, micro- and macroscopic scale. The previously reported polyurethane urea (PUU) polymer with a high number of associative hydrogen bonding moieties was prepared containing 1-(2-aminoethyl) imidazolidone (UDETA). This chain terminating molecule defines the network density of the polymer and the affinity to water. Self-healing was observed if samples were exposed to moisture at room temperature. The reversible changes of the glass transition temperature T_g caused by variations in moisture, as well as the healing kinetics based upon visual crack disappearance and image grey scale analysis at different relative humidities, were examined in detail. Water is able to change the polymers microstructure and morphology leading to an increase of a mobile fraction (MF) within the polymer network structure. Self-healing kinetic studies proved that exposure to high relative humidity (23 °C, 73% RH) combined with a UDETA amount of 34 mol% facilitated higher molecular dynamics for a complete healing process. Combining the self-healing kinetic studies and dedicated time-domain NMR measurements, a MF threshold for efficient self-healing was defined. In addition, NMR results reported on the softening associated with T_g. MDSC experiments confirmed substantial dynamic inhomgeneities within the samples.

Keywords: intrinsic self-healing, hydrogen bonds, self-healing kinetics

1 Introduction

Stimuli responsive materials in the field of self-healing polymers experience exploding research interest within the last decades. Most conceptual developments include extrinsic and intrinsic healing strategies. Extrinsic healing materials contain liquid-fluid filled capsules [1–9] or hollow fibers [10–12] embedded in a polymer matrix. Intermittent stress loads or cutting of the material destroys the capsule or fiber material, leading to a release of the ingredients and resulting in crack closing by polymerization of the capsule/fiber content. Intrinsic self-healing strategies incorporate a