ONE-POT PREPARATION AND EVALUATION OF THERMO-REMENDABLE POLYURETHANES

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ABSTRACT

In this presentation, the study of furan-based thermoset polyurethanes, which were prepared in a one-pot fashion and self-mended under mild temperature conditions, will be given. Diels-Alder thermoreversible covalent bonds were introduced as crosslinkers into a shape-memory polyurethane material, improving thereby the material mechanical properties. When a crack occurs, Diels-Alder bonds will preferentially break, regenerating free furan/maleimide functional groups. The shape memory effect favors the crack closure upon heating, resulting in a reformation of the reversible crosslinking bonds.
The preparation method involves an initial Diels-Alder reaction among a commercial bis-maleimide and a diol with a pendant furan moiety, easily synthesized on large scale. After the incorporation of polycaprolactone (PCL) as shape memory switching segments, the polyurethane formation reaction takes place in the same reaction vessel. Experimental conditions were chosen to optimize the reversibility and shape memory ability of the system. Different compositions were used to properly understand the role and influence of each component in the system.
The hard segment content does not only affect the physical/structural parameters such as crystallinity, toughness and transparency but also the self-healing characteristics in accordance with the resulting crosslinking degrees. Diels-Alder moieties are then proved to be the main responsible factor for the polyurethane thermo-remendability.
Polyurethanes heal at 50°C after mechanical damage induced by either the application of a large tensile deformation or by performing controlled macro/micro scratches. The PCL melting provides enough mobility to recover the shape in a couple of minutes, enabling the progressive Diels-Alder bonding reformation in this same condition. On-line FT-IR monitoring allowed the kinetic description of the system reversibility for numerous cycles. Furthermore, mechanical recovery was accomplished after multiple cycles of bulky deformation. Complete disappearance of microscratches was also achieved. The results were not only confirmed by scanning electron microscopy but also by instrumental recording of the cross-section profiles before and after healing as well as by confocal microscopic mapping.