Tuning the Heat: Thermally Latent Catalysts for Next-Generation Covalent Adaptable Networks

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The advancement of thermally activated self-healing materials has attracted considerable interest in recent years, largely due to their potential to minimize waste and extend the durability of polymer-based products. Among these materials, vitrimers stand out as covalent adaptable networks capable of intrinsic healing through thermo-driven associative exchange reactions. Above their topology freezing transition temperature (Tv), these dynamic exchanges accelerate rapidly, allowing vitrimers to exhibit viscoelastic flow while maintaining their crosslinked solid-state structure. [1] Vitrimers utilizing dynamic hydroxyl-ester linkages typically require a transesterification catalyst to promote efficient bond exchange above Tv. In response, a diverse collection of thermally latent base catalysts for transesterification in vitrimers have been evaluated. [2] A series of thermo-base generators (TBGs) were synthesized and comprehensively characterized using thermogravimetric analysis (TGA), evolved gas analysis (EGA), nuclear magnetic resonance,- (NMR), and infrared (IR) spectroscopy to assess their decomposition behavior and thermally triggered base release (T_{TBG}). These catalysts enable precise thermal control over activation and deactivation, facilitating the development of multiple thermally switchable dynamic polymer networks. The effectiveness of this strategy was validated through stress relaxation tests, reshaping studies, self-healing evaluations, and tensile experiments. By tuning the molecular structure of the latent bases, decomposition temperatures and activation timelines could be finely adjusted across a broad thermal window. This tunability allows for seamless integration into vitrimers with various Tv values, ultimately supporting a wide range of potential applications in the polymer field and opening new paths for the design of dynamic, sustainable polymeric systems.

Keywords: Thermally Latent Catalysts; Covalent Adaptable Networks; Sustainable Polymer Networks; Green Chemistry in Polymer Design.

References

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