

Synthesis, Structure-Property Relationship Study of Dynamic Acetal Containing Epoxy Resins and Preparation of Recyclable Carbon-Fiber Reinforced Composites.

Toendepi Innocent^{1*}, Yaofeng Zhu¹

¹ *Zhejiang Sci-Tech University, Hangzhou, 310018, Zhejiang, P.R. China.*

*Presenter's email: itoendepi@zstu.edu.cn

ABSTRACT

Epoxy resins have been widely used as polymer matrices for fiber-reinforced composites due to their adhesive capacity, mechanical properties and corrosion resistance. Nonetheless, the inherently infusible and insoluble nature of conventional epoxy resins arises from their intrinsic permanently cross-linked structure, which leads to the inability to recycle the constantly increasing quantity of discarded epoxy-based composites. Therefore, the introduction of dynamic covalent bonds has emerged as a promising solution to prepare recyclable epoxy resins. In this report, a series of liquid acetal-containing epoxides with formal, acetal, ketal, cyclopentyl, furyl and phenyl groups and with different para-substituted (-OCH₃, -Cl and -NO₂) phenyl groups were synthesized. To investigate the effect of electron donating and electron withdrawing groups on the microstructural dynamics and macroscopic recyclability of the resulting epoxy resins. The rheological characteristics, thermal properties, mechanical performances, reprocessability and degradation behaviors of these epoxy resins were investigated in detail. After curing with anhydride, the cured epoxy resins exhibit T_g of 148-218 °C, and tensile strength of 52-71 MPa. Owing to the incorporation of dynamic acetal bonds, all cured epoxy resins are reprocessible, repairable, weldable, and degradable. Among them, the epoxy resin para-substituted with -OCH₃ displays the fastest stress relaxation rate at elevated temperature. As the electron-withdrawing effect of the substituent on the phenyl group increases, the stress relaxation rates of the cured epoxy resins decrease at the same temperature. Under optimized reprocessing conditions, the reprocessed epoxy resins containing -Cl and -NO₂ groups demonstrate the highest (117%) and lowest (85%) retention rates in tensile strength, respectively. In summary, this research investigates the utilization of epoxy resin systems with acetal dynamic covalent moieties attached to different electron inducing substituents, aiming to enhance their mechanical properties, reprocessability, and degradability.