Synthesis and In-Depth Evaluation of Degradable Copolymers via Cyclic Ketene Acetal Incorporation

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Plastic accumulation is an increasing threat to the natural environment, therefore it is imperative that degradable polymers are developed as an alternative to standard petroleum-based plastics. Through radical ring-opening polymerization, cyclic ketene acetals (CKAs) are known to induce the degradation of plastics by inserting ester linkages along the polymer backbone. However, the degradation rates, byproducts, and cytotoxicity of CKA-incorporated polymers are widely unknown, limiting the applications of degradable plastics. In this research, the CKA 2-methylene-1,3-dioxepane (MDO) was integrated into methyl methacrylate and polymerized with crosslinkers to create a new plastic film that exhibits high degradation rates and low cytotoxicity. In addition to qualifying the material properties, the percent mass loss was investigated via base-induced hydrolysis. After stirring films with varying concentrations of MDO in a solution of 1 M NaOH overnight, films with 0% MDO showed an average mass loss of 11%, while those containing 5% and 10% MDO had an average mass loss of 39% and 46%, respectively. Nuclear magnetic resonance spectra of the filtrates reveal that MDO fully degrades, breaking apart the poly(methyl methacrylate) chains. ProTox-II indicates that all chemical reactants and byproducts are noncytotoxic, and the MMA-MDO subunit is 66% less carcinogenic than polyethylene. Ongoing future work involves quantifying material properties such as viscoelasticity and thermal stability using rheometry and differential scanning calorimetry. This research demonstrates that CKAs can contribute to the feasibility of the widespread application of degradable polymers by significantly accelerating degradation, thereby enabling pathways for cost-effective plastic waste management.

Awards Won:

Third Award of $1,000