Preparation and characterization of bio-based co-polyesters: structural diversification

Résumé

The urgent need for sustainable alternatives to fossil-based materials has led to increased interest in biopolymers within the European Union's circular economy action plan(1). Among these alternatives, succinic acid-based polyesters, such as poly(butylene-succinate) (PBS), has garnered attention for desirable thermal and physical properties (2). However, other polyesters derived from succinic acid, such as poly(ethylene-succinate) (PES) and poly(propylene-succinate) (PPS), have been less favored commercially due to their inferior characteristics compared to PBS(3).
This study focuses on the synthesis of succinic acid-based bio-polyesters, including PBS, PES, PPS, poly(octylene-succinate) (POD), and poly(dodecane-succinate (PDD), with the aim of investigating alternatives or upgrades to PBS using green, catalyst-free, and solvent-free conditions. The incorporation of commercially available biobased shorter diols, such as ethylene glycol (EG), butane diol (BD) and propanediol (PD), along with non-commercial longer diols like octanediol (OD) and dodecanediol (DD), is explored to enhance the properties of the polyesters. The effect of diols carbon chain length and ratios of mixed diols on the resulting polyesters' structure, degree of polymerization, and thermal properties is also examined.

Polymerization reactions were conducted in diol excess, 1:1.1, without a catalyst or a solvent. The monomers used are succinic acid as a diacid, and EG,PG, BD,OD, and DD as diols. Confirmation of polymerization was achieved using Fourier-transform infrared spectroscopy (FTIR) and nuclear magnetic resonance (NMR) techniques. The thermal properties of the polyesters were characterized using differential scanning calorimetry (DSC)

The results confirm the successful synthesis (bulk polymerization) of PBS and PES under catalyst and solvent free conditions. Moreover, diol mixes yielded polyesters with diverse properties and appearances, ranging from white powder to waxy materials. These results present attractive alternatives to commercially produced PBS under heavy metal catalysis. Notably, diol mixes with 75% EG and 25% longer diols exhibited a distinct pattern of behavior, while those with 50% EG and 50% longer diols demonstrated similar thermal properties, ester group ratios, and terminal group ratios to 75% longer diols and 25% EG. Further investigations of mechanical properties, thermal stability and rheology involving additional duplicates and a broader range of diol ratios are recommended to gain deeper insights.

References:

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