Synthesis and Characterization of Bioplastics from 1,3-Propanediol, Malonic acid, and Itaconic acid

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1,3-propanediol (PDO), malonic acid (MA), and itaconic acid (IA) were selected as monomers available from renewable resources to produce copolymers containing anhydride, ester, and ether linkages though melt polycondensation. Effects of reaction temperature and time were investigated for PDO-MA and PDO-IA copolymers. The concentrations of anhydride, ester, and ether functionality in the resultant copolymers were monitored by Fourier transform infrared (FTIR) spectroscopy peak height ratios. X-ray photoelectron spectroscopy (XPS) and nuclear magnetic resonance (NMR) were used to confirm the copolymer chemical composition. Average molecular weights and molecular weight distributions were determined by gel permeation chromatography (GPC). Differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA) examined phase transitions and aided in establishing guidelines for thermoforming process conditions. Backbone linkage concentrations, molecular weights, and phase transitions were found to be functions of reaction time and temperature. From this study, bioplastics with a range of chemical and rheological properties were developed that could replace petroleum-based polymers in select applications.