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Designing Recyclable Biomass Biomass-Based Polyesters
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Project Objectives: The overall goal of this project is to design and test new biomass-based polyesters that have comparable thermal or mechanical properties to current polyolefin packaging film polymers and also are chemically recyclable and biodegradable.

Project Goals: The expected outcomes from this work are:

- A new class of chemically recyclable and biodegradable biomass-derived polyesters that have mechanical and thermal properties similar to low-density polyethylene (LDPE)
- Demonstration of new polyesters in three commercial applications
- The relationship between the structure of the polyesters and their properties
- Material and energy balances for chemical recycling of the biomass polyesters
- Continuous production of biomass-derived monomers in laboratory scale reactors
- TEA and LCA models for polymer synthesis and recycling based on experimental data

Description of Project: The focus of this project is to design new biomass-based polyesters that can replace incumbent polymers for packaging, are biodegradable, chemically recyclable and have improved mechanical/thermal properties. The polymers we produce will be chemically analogous to aliphatic aromatic polyesters, like polybutylene adipate terephthalate (PBAT). PBAT polymers are biodegradable alternatives for LDPE in packaging and other film applications. However, PBAT is not produced from renewable resources and has lower mechanical properties than LDPE requiring thicker films to maintain the required stiffness. The central hypothesis of this proposal is that incorporation of biomass-derived monomers into aliphatic-aromatics polymers will improve the mechanical and thermal properties, retain the chemical recyclability and have biodegradability.

Our research team has two decades of experience in developing catalytic pathways for the production of diols and diacids from biomass. We will prepare and test different polyesters having biomass-based content from 50 to 100 wt%. We will characterize the thermal, mechanical, optical and barrier properties as well as the biodegradability of the resulting polymers. We will work with our industrial partners (Amcor and StoraEnso) to test the resins we produce in three applications: 1) mono-layer films for food packaging; 2) multi-layer films for food packaging; and 3) extrusion coating for liquid packaging. We will study the recyclability of the polymers that we produce using chemical depolymerization. A rigorous process model will be developed using the experimental data in this project and used to estimate the economic costs for monomer synthesis, polymer synthesis and recycling.

Potential Impact of Project: This project will create a new class of polyesters that are biodegradable low-cost alternatives to LDPE and LLDPE. This could improve the sustainability of the polymer industry while creating new markets for agricultural waste materials. This project builds on previous DOE BETO programs that have created technologies for production of new monomers.

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