Elastomers from lactones: Synthesis, properties, and enzymatic hydrolyzability (Jan 2018)

The Center for Sustainable Polymers (CSP) connects scientists from the University of Minnesota, Cornell University, Northwestern University, the University of California, Berkeley, Washington University in St. Louis, and the University of Chicago in a manner that promotes highly collaborative research. This environment allows partnership across various scientific disciplines, including polymer, organic, biological, inorganic, and theoretical chemistry. As such, CSP researchers have been able to approach challenging problems related to sustainability with a wide range of expertise.

Cross-linked polymers are extensively used due to their high thermal stability and solvent resistance. However, this class of materials creates significant challenges in the arena of sustainability: 1) virtually all cross-linked polymers are produced from petroleum feedstocks that are not renewable; 2) conventional cross-linked plastics cannot currently be recycled into similar value products because their network architecture prevents processing at elevated temperature; and 3) plastic waste—including cross-linked plastic—generally takes hundreds or even thousands of years to degrade in landfills or in the environment, which has led to an immense increase in plastic waste accumulation. One approach to address these issues has been to develop new, high-performance cross-linked materials with more sustainable characteristics. In particular, aliphatic polyesters have attracted notable interest in the field of sustainable polymers; aliphatic polyesters can be synthesized from various chemicals derived from renewable feedstocks (i.e., biomass), and the ester bonds in the polymer backbone enables degradation on more reasonable timescales.

Recently, a CSP research team spanning three different universities—the University of Minnesota (UMN), Cornell University, and ETH Zürich—has investigated polyester elastomers that demonstrate high performance and great promise for biodegradability and renewability. The elastomers were derived from lactone monomers that could be obtained from biomass. Guilhem De Hoe, a graduate student in Prof. Marc Hillmyer’s research group, prepared a series of polyester elastomers with synthetic contributions from Dr. Jacob Brutman and Dr. Brandon Tiegs, recent graduates from Prof. Marc Hillmyer’s group (UMN) and Prof. Geoff Coates’ group (Cornell), respectively. After characterizing the properties of the materials, Guilhem traveled to Switzerland to study the enzymatic hydrolysis of the elastomers, a process which is key for their biodegradation (i.e., degradation by microorganisms). The success of these studies was facilitated through the instrumentation and expertise supplied by Michael Zumstein, Dr. Michael Sander, and Prof. Kris McNeill at ETH Zürich. This holistic investigation into the preparation, characterization, and biodegradation potential of the polyester elastomers would not have been possible without the collaborative environment provided through the CSP.