Biodegradable Polymers from Renewable Resources: Lactide Polymerization with a Potentially Recyclable Immobilized Zn beta-Diiminate Complex

Christopher W. Jones, Benn C. Wilson and Kunquan Yu
School of Chemical & Biomolecular Engineering, Georgia Institute of Technology, Atlanta, GA 30332

Polymerization processes are among the only large-scale industrial catalytic processes where the catalyst is NOT recycled. For instance, in the preparation of polyethylene and polypropylene, the common transition metal catalysts (Ziegler Natta or metallocene) remain in the product polymer and ultimately result in the landfill after polymer use.

We are investigating environmentally-friendly catalytic processes in an effort to design a true, green polymerization process. Our ideal process involves: (A) a monomer that can be derived from renewable resources, (B) a catalyst that is recoverable and ideally recyclable (C) a product polymer with good, useful properties that will ultimately biodegrade and complete the green material life-cycle - start from the earth and return to the earth. The primary issue that makes the design of recoverable polymerization catalysts more difficult than the design of corresponding small molecule catalysts is separation of the product polymer from the catalyst. To allow this, both the design of the active site and the design of the catalyst pore structure must be considered simultaneously. In particular, the following factors are critically important: 1) when immobilizing a single-site, homogeneous catalyst, the synthetic protocol must give a solid catalyst with a single type of site; 2) the support pore structure must be amenable to facile transport of reactants to the active sites and polymers away from the sites; and 3) quenching the reaction must not be alter the active site (it can not decompose the catalyst) if the catalyst is meant to be recycled[1].

To this end, we have targeted a number of catalytic systems for the polymerization of lactide to polylactic acid. New immobilized, Zn-BDI catalysts have been developed for this[2] and other[1] polymerizations. Additionally, immobilized organic catalysts that are metal-free have also been developed for lactone polymerization[3]. The strengths and weaknesses of all these catalytic systems will be discussed with respect to the vision of eventually developing a true, green catalytic polymerization process.

(1) Yu and Jones, Organometallics, 2003, 22, 2571.
(2) Yu and Jones, J. Catal. 2004, 222, 568.
(3) Wilson and Jones, 2004, manuscript submitted.