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Next-generation renewable polymers

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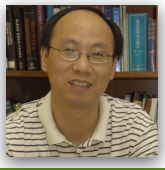

As world population and energy consumption increase, accompanied by growing concerns about global change and atmospheric pollution, there may be an enormous opportunity for renewable natural resources to play a greater role in energy production if fossil fuel prices continue to increase as projected by the US Department of Energy (DOE).[1] This scenario is the concept that renewable resources will be viewed as increasingly important sources of raw materials for commodity products. DOE and US Department of Agriculture outline a 20-year target for utilization of plant/crop products for 10% basic chemical building blocks in 2020.[2,3] This number should increase to 50% by 2050. The addition of renewable natural resources is a necessary contribution to meet future demands.

Prospects for expanding the use of natural resources for producing commodity materials have been ongoing for many years, and our economy can be enhanced by environmental needs and improvements in technology. Among the fossil-fuel-derived commodity products, synthetic plastics account for the use of 7% of fossil fuels worldwide, thus a significant contribution to current carbon emission. Statistical data indicate that in 2007, US chemical industry produced 38 millions of tons of thermoplastic resins including polyethylene, polypropylene, styrene polymers, polyamine and polyvinyl chloride, and 3·8 millions of tons of thermosetting resins including epoxy, urea and melamine and phenolic.[4] All these large-scale synthetic plastics are made of not only petroleum chemicals but also nonecocompatible and nondegradable chemicals. The limited resources and rising price of fossil fuels provide opportunities to seek developing renewable resources for manufacturing of "green" plastics.[5,6] However, applications of renewable polymers lag significantly behind petroleum-derived polymers, partially because of limitations in the basic chemical blocks and derived renewable polymers. Thus, the development of new renewable basic chemical blocks for the synthesis of sustainable materials with desired properties is a burgeoning research area.

This thematic issue and the next issue showcase the latest development on the utilization of natural resources for building green polymers. Conceptualization of these two thematic issues was largely motivated by a symposium on "Next-Generation Renewable Polymers" co-organized by Prof. Marc Hillmyer, Prof. Geoffrey Coates and myself, at the American Chemical Society National Meeting in San Diego, CA, USA, on March 2012. Both ACS and National Science Foundation were enthusiastically supporting this symposium. Articles from academic, government and industrial laboratories are contributed as we all recognize renewable polymers can potentially replace petroleum-derived plastics.

This thematic issue features seven articles on polymers derived from a variety of molecular biomass. Prof. Miller and his coworker report carbonate metathesis polymerization of renewable diols and dimethyl carbonates to prepare polycarbonates, one of the most important engineering plastics. In their article, Prof. Shaver *et al*. describes the use of aluminum-based amine-*bis*(phenolate) complexes for ring-opening polymerization of lactide and caprolactone. Careful kinetic study has been carried out. Dr. Liu and his team from USDA laboratory contribute ring-opening polymerization of epoxidized soybean oil using super acids. Tang *et al*. and Chu *et al*. report new monomers from rosin and their polymerization via step growth and chain growth mechanisms, respectively. In their article, Tang and his coauthors show that rosin and fatty acid can be combined together to prepare renewable polymers. Chisholm and his coworkers have used renewable erucic acid-derived diamine to prepare nylon. They report in their article that nylon has a renewable content of 63 wt%. Prof. Robertson *et al*. report the utilization of triglyceride vegetable oils as components of epoxy resins and characterization of hydrolytic degradation of these epoxy resins.

In conclusion, there is an increasing effort toward the utilization of natural resources for development of renewable polymers and materials. This themed issue provides a glimpse of some recent progress in this field.

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