POPULAR SCIENCE

Plastics are inescapable and versatile materials that are widely used in our daily lives. Many industries, such as textiles, food packaging, building and construction, kitchen appliances, electronics, and automobiles, produce and employ a variety of plastics to fulfill human needs. In 2021, approximately 390 million tons of plastics were produced globally, of which about 99% were based on the use of fossil-based resources. This is not renewable and can contribute to the greenhouse gas emissions and global warming effect. Therefore, production of new plastic materials from renewable recourses such as various biomass resource has attracted growing attention. Another problem of plastic materials is their accumulation in the environment, as most of them do not degrade naturally. Therefore, it is highly interesting to develop bio-based plastics that can be either effectively recycled or degraded naturally.

This thesis focuses on tackling the plastic challenges by designing and developing suitable building blocks and plastics from biomass resources and investigating possible energy efficient recycling methods for those specifically designed polymer structures. In this thesis, various bio-based monomers have been designed and synthesized. Preliminary environmental assessment indicated that these monomers can produce much less greenhouse gases compared to some other commercial monomers. We also demonstrated that strategically designed monomers can help to improve the quality of the resulting polymers as well as making them recyclable. Regarding the quality, I have investigated the impacts of particular structures of bio-based monomers on the materials properties, such as how much they can resist heat and how well they can block oxygen. Regarding recyclability, we investigated the methods for fragmenting bio-based plastics using chemicals or enzymes, which resulted in small sized polymers and building blocks that can be used to make polymers again. This design-for-recycling concept could potentially facilitate the bioplastics circular economy.