Editorial corner – a personal view

Cleaner, greener routes for polyurethanes

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Polyurethanes (PUs) are multiblock copolymers containing repeated urethane groups which are formed from the stepwise addition reaction of polyol with isocyanate. Depending on the type and composition of raw materials, a most broad property spectrum from elastomer to rigid plastics is tailored, and most widely used as coating, adhesive, sealant, elastomer, and various types of foam with an annual production over 18 million tons 2015.

Since they are closely related to our daily life, particular attentions have been paid to reduce the environmental impacts and enhance sustainability. Earlier attempt was to replace petroleum based polyols by bio-based ones using vegetable oils which are ‘broken’, ‘functionalized’, and ‘polymerized into polyols’. They are greenhouse gas neutral with virtually no odors from the end products giving much reduced volatile organic compounds (VOC) during manufacturing, and are more sustainable through the life cycle. However, generally poor properties of bio-based polyol PU are to be enhanced by proper techniques. More harmful than polyols is isocyanates whose synthetic route involves phosgene which is highly toxic. So, an isocyanate-free route to synthesize PU has recently gained great interests. The route is based on an old reaction of dicyclocarbonates and diamines, where isocyanate group is not present at any step. Hydroxyl groups at the β -carbon atom of the urethane moiety increase adhesion. Rich intra- and intermolecular hydrogen bonds and the absence of unstable biuret and allophanate units augment thermal stability and chemical resistance to non-polar solvents.

Isocyanate-free PU based on multicyclic carbonates and polyamines is fabricated using toxic solvent at high temperature, which poses difficulties for indus-

trial application. One promising way is that they can be used to modify epoxy matrix for coating application in industry. They are solvent-free, cured at low temperatures, based on renewable raw materials, and show resistance to weathering, abrasion, and solvents. The lack of commercially available multifunctional cyclic carbonates is a fundamental problem to be resolved.

A most significant way to reduce VOC was to replace organic solvent by water.

Waterborne PU was introduced in market in 1980s and steadily replaces solvent-borne type in many applications although the market is yet to expand. Certain inferior properties pertinent to ionomer nature should be resolved by molecular architecture and hybridization.

Much care was paid to foam production regarding blowing agent. Use of chlorine-containing ones was restricted by Montreal Protocol (1987) and Kyoto Protocol (1997). Carbon dioxide, pentane, HFC-134a and HFC-245fa steadily expand their usage to reduce ozone depletion potential and global warming potential. Global spread of non-emission and non-fugitive catalysts contributes to cleaner atmosphere. All the efforts are expected to continue for cleaner and greener environment.

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