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A Perspective Approach to Sustainable Routes for Non-Isocyanate Polyurethanes

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Abstract

Sustainable routes for the synthesis of polyurethanes with industrial applications are discussed in this article. Polyurethane is currently one of the most commonly used polymers worldwide for various applications such as rigid and flexible foams, coatings, elastomers, adhesives and sealants. However, isocyanate precursors are very harmful at each stages of the life cycle of the polymers. Hence, new synthesis routes for isocyanate-free polyurethanes are reported in literature, but most of them suffer from significant lacks that prevent any industrial application. This feature article focuses on the new challenges and new opportunities of these routes. A first part is dedicated to the market, the manufacture and the hazards of polyurethanes. In a second part, this article deals with the synthesis routes leading to non-isocyanate polyurethane. Hence, the advantages and limits of these routes are reported and discussed. Finally the outlooks for a future and industrial use of non-isocyanate polyurethane in industry are examined.

Keywords

Polyurethane; non-isocyanate polyurethane; hybrid non-isocyanate polyurethane; polyhydroxyurethane; cyclic carbonate

I. Polyurethane, interesting materials for various applications

I.1 Brief history

Polyurethanes were invented back in the 1930's by Otto Bayer and coworkers^[8] from the works of Würtz, who discovered in 1849 the reaction between alcohol and isocyanate yielding urethane (carbamate) groups. These polymers were developed to obtain materials with properties similar than polyamide fibers (nylon) discovered earlier but protected by American patents. The versatility of polyurethanes, and their ability to substitute to other materials, stimulated the development of numerous applications. Around mid-50's, polyurethanes (PUs) found applications in coatings, adhesives, elastomers and rigid foams. In the next years, the development of polyether polyols at low cost

allowed to obtain flexible polyurethane foams for applications in furnishing and automotive areas. Nowadays, PUs find applications everywhere in everyday life: furnishing, cars, clothing, shoes, elastomers, coatings, wall and roofing insulation, etc.

I.2 Polyurethane market

The value chain of polyurethanes involves three key players. The first ones are the industrial chemists that produce the raw materials for the synthesis of polymers. The second players are the formulators that produce polyurethanes from raw materials; and the last ones are assemblers, who include polyurethanes in their final products. The economic players are involved in one, two or these three sectors. In 2016, with a global production of 18 Mt, PUs rank 6th among all polymers based on annual worldwide production. The major part of this

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