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From Carboxylic Acids to Biopyrrolidones - Biomass for Sustainable Polymer Production

AUTHORS
Moritz HAUS / RWTH AACHEN UNIVERSITY, WORRINGERWEG 2, AACHEN
Yannik LOUVEN / RWTH AACHEN UNIVERSITY, WORRINGERWEG 2, AACHEN
Regina PALKOVITS / RWTH AACHEN UNIVERSITY, WORRINGERWEG 2, AACHEN

PURPOSE OF THE ABSTRACT

To date, the lack of efficient conversion strategies for bio-based platform chemicals, such as succinic, itaconic and levulinic acid, hampers the necessary replacement of fossil resources as feedstock of the chemical industries. This is mostly due to the inapplicability of traditional catalytic routes - established in oil-chemicals processing - to the upgrading of oxygen-rich, biomass-derived moieties.[1] In this context, strategies for the introduction of nitrogen functionalities are especially sought-after. Consequently, the manufacture of pyrrolidones from carboxylic acids has been described in several articles, dealing mostly with the production of pharmaceutical intermediates from easily-reducible levulinic acid.[2]

In contrast, our research focuses on the conversion of succinic and itaconic acid[3] towards N-vinyl-2-pyrrolidone (NVP), which may be polymerized to polyvinylpyrrolidone - a water-soluble, non-toxic polymer with numerous applications in the pharma, cosmetic and food industries. While reducing the need for fossil resources, the envisioned valorization chain also has economic potential due to the steadily expanding NVP demand, which leaves room for new producers and production strategies.[4]

Both of our proposed routes for the production of NVP-like monomers are initiated through the reductive amidation of carboxylic acids, either with ammonia or ethanolamine (Figure 1). In this context, we have intensively investigated the exemplary conversion of itaconic acid and ammonia to an isomeric mixture of 3- and 4-methyl-2-pyrrolidone, including analysis of the reaction network, process conditions and catalytic materials.[3] A supported ruthenium catalyst provided high activity and selectivity together with excellent stability upon recycling. The purification of produced pyrrolidones and their further conversion to methyl-substituted NVP through Reppe vinylation was likewise successful. Representative of the second route, we discuss the conversion of succinic acid and ethanolamine to N-(2-hydroxyethyl)-2-pyrrolidone (HEP), which effectively occurs over promoted noble metal catalysts. Subsequent continuous gas phase dehydration leads to the well established NVP monomer.[5]

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FIGURES

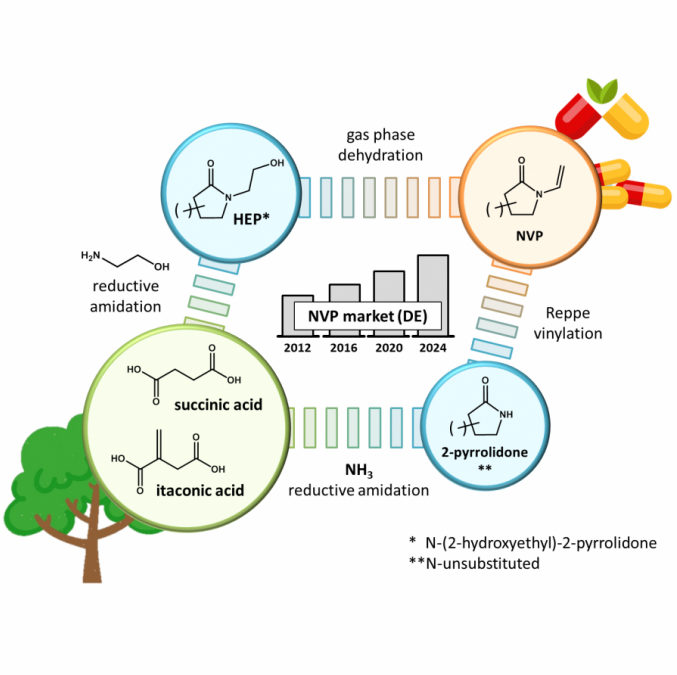

FIGURE 1

Figure 1: proposed valorization chains

Two possible routes to access N-vinyl-2-pyrrolidone and comparable monomers starting from biomass-derived platform chemicals;

FIGURE 2

KEYWORDS

biomass conversion | bioplastics | heterogeneous catalysis | carboxylic acids

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Image Sources

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