Catalytic carbonylation of acrylic acid to succinic anhydride: en route to the synthesis of a bio-based monomer

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PURPOSE OF THE ABSTRACT

Nowadays, the share of plastics in the production of petrochemicals reaches 90%, and the volumes of polymers produced are expected to keep growing in the next years.[1] While fulfilling an increasing demand for these organic materials, it is necessary to improve their sustainability and replace the fossil feedstocks used in their synthesis with renewable alternatives. In this context, we are targeting the formation of a monomer, succinic anhydride, from bio-based starting materials.

The current industrial production of succinic anhydride relies on the hydrogenation of maleic anhydride, which is itself produced from the oxidation of butane, a petrochemical.[2] An alternative route, currently explored at the laboratory scale, consists in promoting the catalytic carbonylation of another petrochemical, namely beta-propiolactone. [3] In order to build a new synthetical pathway towards succinic anhydride, which would fit the challenges described above, our strategy was based on developing the carbonylation of an isomer of beta-propiolactone, acrylic acid. Indeed, acrylic acid is not only a common platform chemical, but it can also be produced from the dehydration of lactic acid.[4]

Early studies on the carbonylation or hydroformylation of acrylic acid highlighted the difficulty of performing a selective, efficient, and direct carbonylation reaction on acrylic acid.[5] Yet, by designing a selective low-valent cobalt complex supported by phosphine ligands, the production of acrylic acid to succinic anhydride was unlocked, thanks to mild reaction conditions (90°C, 16 bar).[6] Screening of several reaction parameters such as gas phase pressure and composition, ligands, and temperature, enabled us to propose some mechanistic hypotheses to rationalize the trends observed during this challenging carbonylative ring-closure.

FIGURES

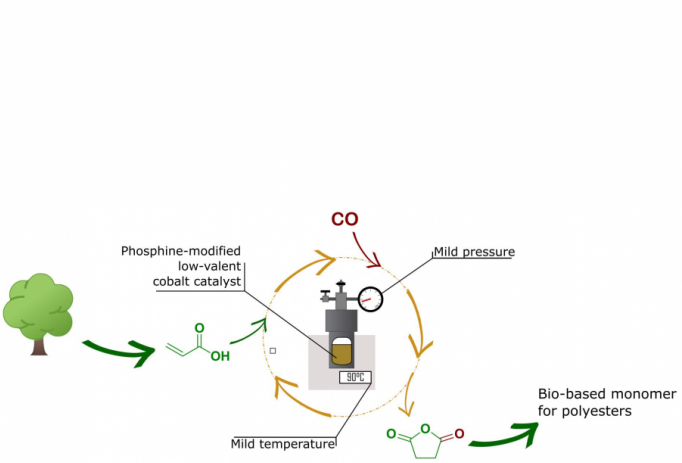

FIGURE 1

Catalytic carbonylation of acrylic acid to succinic anhydride: en route to the synthesis of a bio-based monomer

By designing a selective low-valent cobalt complex supported by phosphine ligands, the production of acrylic acid to succinic anhydride was unlocked, thanks to mild reaction conditions (90°C, 16 bar).

FIGURE 2

KEYWORDS

homogenous catalysis | carbonylation | monomer | plastics

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