



HAL
open science

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

Marie-Hélène Pietraru, Louise Ponsard, Nicolas Lentz, Emmanuel Nicolas, Thibault Cantat

► To cite this version:

Marie-Hélène Pietraru, Louise Ponsard, Nicolas Lentz, Emmanuel Nicolas, Thibault Cantat. Catalytic carbonylation of acrylic acid to succinic anhydride: en route to the synthesis of a bio-based monomer. Symposium International sur la chimie durable (ISGC 2022), May 2022, La Rochelle, France. cea-03675178

HAL Id: cea-03675178

<https://cea.hal.science/cea-03675178>

Submitted on 23 May 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

N°823 / OC

TOPIC(s) : Waste and side streams valorization / Homogenous, heterogenous and biocatalysis

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

AUTHORS

Marie-Hélène PIETRARU / CEA SACLAY, IRAMIS/NIMBE/LCMCE BATIMENT 125, GIF-SUR-YVETTE CEDEX

Louise PONSARD / CEA SACLAY, IRAMIS/NIMBE/LCMCE BATIMENT 125, GIF-SUR-YVETTE CEDEX

Nicolas LENTZ / CEA SACLAY, IRAMIS/NIMBE/LCMCE BATIMENT 125, GIF-SUR-YVETTE CEDEX

Emmanuel NICOLAS / CEA SACLAY, IRAMIS/NIMBE/LCMCE BATIMENT 125, GIF-SUR-YVETTE CEDEX

Thibault CANTAT / CEA SACLAY, IRAMIS/NIMBE/LCMCE BATIMENT 125, GIF-SUR-YVETTE CEDEX

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

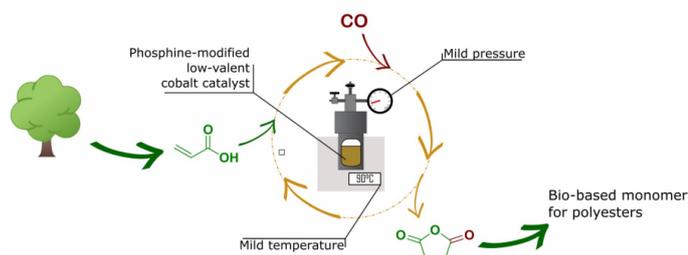


FIGURE 1

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

BIBLIOGRAPHY

- [1] Lange J.-P., *Energy Environ. Sci.* 2021, 14, 4358-4376.
- [2] Fumagalli C., *Succinic acid and succinic anhydride*. Kirk-Othmer Encyclopedia of Chemical Technology. 2000.
- [3] Nasr Allah T., Ponsard L., Nicolas E. & Cantat T. *Green Chem.* 2021, 23, 723-739.
- [4] T. Ohara, T. Sato, N. Shimizu, G. Prescher, H. Schwind, O. Weiberg, K. Marten, H. Greim, T. D. Shaffer & P. Nandi, *Acrylic Acid and Derivatives*. Ullmann's Encyclopedia of Industrial Chemistry. Wiley-VCH, Weinheim, 2020.
- [5] a) Falbe J., *Carbon Monoxide in Organic Synthesis*. Springer, Berlin, Heidelberg, 1970; b) Mori, Y. & Tsuji, J.; *J. Bull. Chem. Soc. Jpn.* 1969, 42 (3), 777-779; c) Dessole, G., Marchetti, M., & Taddei, M. *J. Comb. Chem.* 2003, 5(3), 198-200.
- [6] Pietraru M.-H., Lentz N., Ponsard L., Nicolas E. & Cantat T. Patent submitted on November 12th, 2021, FR2111996.