

Closing the Carbon Cycle – Catalytic Conversion of Alternative Feedstocks for the Chemical Value Chain

W. Leitner

Max Planck Institute for Chemical Energy Conversion, Mülheim a.d.R., RWTH Aachen University, Germany

Abstract

The industrial transformation of carbon-based raw materials into valuable products forms the basis of today's global economy and modern societies. With products ranging from energy carriers, through plastics and advanced materials, to biologically active compounds, chemistry is essential to cope with the global challenges of our time. Moving towards a more sustainable future, there is an increasing need for broadening the raw material basis by developing and using non-fossil resources together with the deployment of carbon-free energy technologies. The present contribution will discuss the opportunities and challenges of this approach and present examples of new products and processes based on it. In particular, it will highlight how catalysis science and technology can promote this development in particular through industrial-academic collaborations.

The examples comprise the utilization of carbon dioxide as a new building block for the polymer industry,¹ the exploitation of off-gases from the steel industry as feedstock for chemical processes,² new opportunities for bulk chemicals and fuels from biomass,³ and the combination of fluctuating electrical energy from carbon-free sources with renewable carbon sources ("power-to-X").⁴ Progress in science and technology together with insights from life cycle assessment will be analyzed and critically discussed.

[1] a) <https://www.co2-dreams.covestro.com>; b) *Carbon dioxide (CO₂) as sustainable feedstock for polyurethane production*, J. Langanke, A. Wolf, J. Hofmann, K. Böhm, M. A. Subhani, T. E. Müller, W. Leitner, C. Gürtler, *Green Chem.* **2014**, *16*, 1865–1870.

[2] a) <https://www.thyssenkrupp.com/de/carbon2chem>; b) *Sustainable conversion of carbon dioxide: An integrated review of catalysis and life cycle assessment*, W. Leitner, A. Bardow, et al. *Chem. Rev.* **2018**, *118*, 434–504.

[3] a) <http://www.fuelcenter.rwth-aachen.de>; b) *Advanced Biofuels and Beyond: Chemistry Solutions for Propulsion and Production*, W. Leitner, J. Klankermayer, S. Pischinger, H. Pitsch, K. Kohse-Höinghaus, *Angew. Chem. Int. Ed.* **2017**, *56*, 5412-5452.

[4] a) <https://www.kopernikus-projekte.de/projekte/power-to-x>; b) *Selective Catalytic Synthesis Using the Combination of Carbon Dioxide and Hydrogen: Catalytic Chess at the Interface of Energy and Chemistry*, J. Klankermayer, S. Wesselbaum, K. Beydoun, W. Leitner, *Angew. Chem. Int. Ed.* **2016**, *55*, 7296-7343.