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"Metha-Cycle": Methanol cycle for storage of renewable energy

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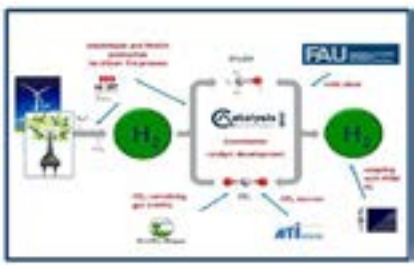
Here we present the renewable energy project "Metha-Cycle". The aim of this project is the technological development of energy and hydrogen storage in methanol. This technology also enables the carbon dioxide based chemical storage of renewable energies as well as a decentralized supply of energy and hydrogen.

Statement of the Problem: The concept of "hydrogen economy" in the renewable energy field is an attractive developing topic, since hydrogen is being viewed as environmentally benign energy carrier. Storage of hydrogen is a challenge, because its liquefaction is rather costly and has its challenges. That is why the chemical storage of hydrogen in liquid organic compounds and its release on demand is currently in focus. Presently there are many systems under investigation (formic acid, methanol, LOHC). Methanol, having high gravimetric and volumetric hydrogen content under ambient conditions and long term stability, is viewed as very promising for this purpose.

Methodology & Theoretical Orientation: The aim of the project is the technological development of energy and hydrogen storage in methanol via CO_2 neutral cycle. The aim of the LIKAT sub-project is the development of suitable catalysts for hydrogen production. The obtained data and catalysts should serve as the basis for operation of a miniplant in FAU Erlangen-Nurnberg. The aim of ZBT Duisburg subproject is the development of a polymer electrolyte (PEM) fuel cell system for the efficient conversion of H_2 produced from MeOH while simultaneously providing the reaction enthalpy necessary for the catalytic splitting of methanol. A second focus of the LIKAT subproject is the development of catalysts for low-temperature methanol production by direct hydrogenation of CO_2. The aim of HOST subproject is a modular simulation of the entire system of methanol production and reconversion by wind and solar power. The present interdisciplinary project enables indirect storage of wind energy in the form of methanol, and further methanol conversion into electrical energy via low-temperature hydrogen release in a fuel cell.

Findings: For LIKAT subproject we report an improved bi-catalytic system for methanol dehydrogenation, using two ruthenium-based PNP pincer complexes at mild conditions (TON > 17000). The proposed system exhibits synergistic activity under significantly reduced base amount. For low scale reaction at least 120 h of continuous hydrogen generation is achieved with good product selectivity.



Recent Publications

1. D. Mellmann, P. Spronholz, H. Junge, M. Beller. Formic acid as a hydrogen storage material – development of homogeneous catalysts for selective hydrogen release. Chem. Soc. Rev., 2016, 45, 3954.

2. M. Nielsen, E. Alberico, W. Baumann, H.-J. Drexler, H. Junge, S. Gladiali, M. Beller. Low-temperature aqueous-phase methanol dehydrogenation to hydrogen and carbon dioxide. Nature, 2013, 495, 85.
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4. K. Sordakis, A. Tsurusaki, M. Iguchi, H. Kawanami, Y. Himeda, G. Laurenczy. Carbon dioxide to methanol: the aqueous catalytic way at room temperature. Chem. Eur. J., 2016, 22, 15605.
5. M. Nielsen, A. Kammer, D. Cozzula, H. Junge, S. Gladiali, M. Beller. Efficient hydrogen production from alcohols under mild reaction conditions. Angew. Chem. Int. Ed., 2011, 50, 9593.
6. A. Boddien, B. Loges, H. Junge, M. Beller. Hydrogen generation at ambient conditions: application in fuel cells. ChemSusChem, 2008, 1, 751.
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Biography

Anastasiya Agapova graduated from Lomonosov State University with chemistry degree. She is working now in Leibniz Institut für Katalyse (Rostock, Germany) on her PhD thesis in the group "Catalysis for Energy" under supervision of Prof. M. Beller.

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