

Catalysts for Hydrogen Storage based on Liquid Organic Hydrogen Carriers

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Abstract

Establishing a sustainable hydrogen economy can decisively contribute to a successful transition of the energy system. A safe and easy technology to store and transport hydrogen reversibly is provided by liquid organic hydrogen carriers (LOHC): Hydrogen is bonded to the hydrogen-lean compound (LOHC⁻) in a catalytic hydrogenation forming the hydrogen-rich LOHC⁺, which can be stored or transported *via* the existing infrastructure. As soon as H₂ is required, it is released in the catalytic dehydrogenation and the LOHC⁻ can be reused.¹

Attractive LOHC systems are provided by established heat transfer oils like benzyltoluene (BT). Additionally, alternative LOHC compounds can be obtained *via* plastic recycling or from biomass.² Suitable catalysts enable selective implementation of the desired hydrogenation and dehydrogenation with high productivity while preventing undesired side reactions.³

This work focuses on the design, development and optimization of catalyst materials that are suitable for both hydrogenation and dehydrogenation of LOHC compounds. This enables dynamic changes between hydrogen loading and release only by adjusting the hydrogen pressure.^{3,4,5} To realize the intended multiple cycling of LOHC, the stability of the catalyst over many storage cycles is relevant. Based on present challenges of the LOHC process, potential optimization approaches are identified.^{4,5}

For the attractive LOHC system based on BT, optimization of the catalyst as well as potential overcomes of current difficulties for the application of the LOHC technology were investigated. We present possibilities to avoid the formation of undesired side products as well as the need for high temperatures during dehydrogenation. Additionally, the hydrogen release from BT-based species with different degrees of hydrogenation was studied mimicking partial loading during the application of LOHC technology. Furthermore, the optimized catalysts were investigated in the hydrogenation and dehydrogenation of different LOHC systems to obtain further insights into eligible catalytic materials for various LOHC compounds.^{4,5}

Associated References

- 1: D. Teichmann, W. Arlt, P. Wasserscheid *et al.*, *Energy Environ. Sci.* **2011**, *4*, 2767.
- 2: M. Markiewicz, Y. Q. Zhang, A. Bösmann *et al.*, *Energy Environ. Sci.* **2015**, *8*, 1035.
- 3: J. Oh, Y. Jo, T. W. Kim *et al.*, *Appl. Catal., B* **2022**, *305*, 121061.
- 5: B. Bong, C. Mebrahtu, D. Jurado *et al.*, *ACS Eng. Au* **2024**, *4*, 359.
- 4: B. Bong, W. A. Kopp, T. Nevolianis *et al.*, *Chem. Eng. Technol.* **2025**, *48*, 1.

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