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Convenient and Sustainable Hydrogen Storage using Liquid Organic Hydrogen Carrier (LOHC) Technologies

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Hydrogen is an attractive vector in the transition of the energy sector from a high dependence on fossil fuels to an increasing amount of energy from renewable and sustainable sources. Hydrogen can be produced from water electrolysis using green energy sources like solar and wind energy, which reduces CO_2 emission and thus the contribution to anthropogenic climate change. By storing hydrogen, it can compensate for the intermittent nature of renewable energy sources in order to sustain a continuous energy supply.

Conventional hydrogen storage involves compressed gaseous hydrogen and cryogenic liquid hydrogen, which both are expensive technologies involving technical challenges. An alternative storage technology is s the use of Liquid Organic Hydrogen Carriers (LOHCs). In LOHCs, hydrogen is chemically bound via a catalytic hydrogenation reaction in times of overproduction and cheap energy, and later transported and released through a catalytic dehydrogenation reaction at the time and place of energy need [1].

Hydrogen in LOHCs are stored under ambient conditions, which simplifies their handling and enables transport and storage using already existing infrastructure for liquid fuels resulting in reduced investment cost for implementation. Commercially available LOHC systems are typically based on aromatic hydrocarbons, which exhibit favorable (eco)toxicity profiles. However, due to high dehydrogenation enthalpies reactions are often performed above 300 °C, which possess a challenge for heat integration with state-of-the-art PEM fuels for clean energy production [2]. Hence, alternative LOHC systems, which can operate under significantly milder conditions, are attractive.

In this work, reversible catalytic hydrogenation/dehydrogenation of N-functionalized heterocycles are demonstrated as efficient LOHC systems operating as low as 120 °C. The dehydrogenation has been performed with a homogeneous hydrogenation iridium catalyst in biphasic reaction mode using a molten salt as catalyst immobilization phase. This approach facilitated easy catalyst separation and required only a small amount of catalyst phase to store large amounts of hydrogen, which is beneficial for future large-scale continuous hydrogen storage and release.

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