LIQUID STORAGE OF SOLAR ENERGY

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A research team from Chalmers University of Technology in Gothenburg, Sweden, has shown that it is possible to directly convert solar energy into energy stored in the bonds of a chemical fluid – a molecular solar thermal system. The chemical liquid allows the stored solar energy to be stored, transported, and released on demand with the complete recovery of the storage medium.

The process is based on the organic compound norbornadiene which – when exposed to light – is converted into the quadricycle. "This technique means we can store solar energy in chemical bonds and release it as heat whenever we need it," explains Professor Kasper Moth-Poulsen (Liquid storage of solar energy – more effective than ever before, 2024), who leads the research team. Designing a more efficient hydrogen storage will improve the inclusion and acceptance of this fuel in society.

In this way, the production of hydrogen from renewable sources (green hydrogen) will allow us to take a big step forward in reducing greenhouse gas emissions. However, the integration of hydrogen into the energy system cannot be done completely and immediately due to the existence of important economic, technological, and institutional obstacles that must be overcome.

One such technological hurdle that has been receiving attention recently is the improvement of liquid organic hydrogen carrier (LOHC) storage. It is important to note that although LOHC research on hydrogen storage has only recently started, these chemical reactions involving hydrogen have been used in industry for decades, e.g. for the modification of vegetable oils and petroleum products (LOHC – Liquid Organic Hydrogen Carrier, 2023). The research project was launched at Chalmers more than six years ago, and in 2013 the research team contributed to an initial demonstration of the concept. At that time, the solar energy conversion efficiency

was 0.01 per cent and ruthenium – an expensive element – played a major role in the composition.

Now, years later, the system stores 1.1 per cent of incoming sunlight as latent chemical energy, an improvement of 100. In addition, ruthenium has been replaced by much cheaper carbon-based elements. A hydrogenation reaction involves the addition of hydrogen to a compound. Typically, this happens reversibly, meaning that it is possible to achieve the initial reaction by releasing the incorporated gas through the reverse reaction, called dehydrogenation (Fig. 1).

Also, during this process, energy compensation occurs. The hydrogenation reaction is an exothermic reaction, while the dehydrogenation is endothermic. This means that the energy released during the first reaction is equal to the energy that must be added for the second reaction to occur, ideally achieving an energy requirement of zero.

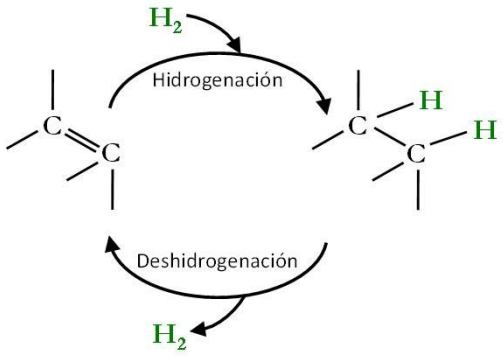

Fig. 1

Liquid organic hydrogen carriers (LOHC) can be used for long-term storage and long-range transportation of hydrogen. LOHCs are organic molecules that can be reversibly hydrogenated and dehydrogenated to release H_2. Due to their easy transportation and their adaptability to existing infrastructures, they are attracting more and more interest in the research landscape. However, despite their flexibility, LOHCs have not been exploited as a means of large-scale energy storage/transportation due to their prohibitive costs (Liquid storage of solar energy – more effective than ever before, 2024). In this sense, this work aims to carry out a detailed technological-economic evaluation of H_2 distribution by means of toluene as LOHC.

Currently, different scenarios are being studied at different distances travelled by sea transport, and the costs of services and raw materials are being examined, as well, to identify weaknesses in the overall value chain and know where to focus research efforts to improve existing technologies. The research is funded by the Swedish Foundation for Strategic Research and the Knut and Alice Wallenberg Foundation.

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