Challenges for Hydrogen Storage and Handling

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Storage and handling are still a bottleneck for the full implementation of hydrogen technologies. After production by a variety of techniques (e.g. from electrolysis or biomasses) and before the use in different applicatioins, hydrogen may need to be purified, transported, compressed and stored. The impact of different steps strongly depends on application, but they are often interconnected. For mobile and stationary applications, the gravimetric and volumetric density is a key performance parameter for hydrogen storage. In addition, the energy efficiency of the whole hydrogen management has to be taken into account. As an example, compression of hydrogen up to 700 bar for FCEV is a highly energy demanding process. For transportation, the cyclability and the practical aspects in loading and unloading have to be managed. In any case, safety and cost are main drivers for the selection of best solutions, even if environmental impacts of the whole life cycle are nowadays also to be considered.

An overview on the state of the art of current technologies for hydrogen storage and handling will be provided. The characteristics of tanks for storing hydrogen in the gas phase will be outlined, focusing on material challenges for both mobile and stationary applications. The handling of hydrogen in the liquid phase at low temperatures will be shortly described, pointing out advantages and drawbacks. The use of carriers for the hydrogen storage and transportation has been widely investigated in the last years. Both absorption and adsorption in solid state will be described, considering various classes of materials (e.g. metal and complex hydrides, porous media). Hydrogen compression by suitable thermal cycles with metal hydrides, currently proposed as an efficient approach, will be described. More recently, hydrogen transportation by liquid organic hydrogen carriers has been suggested and their main characteristics will be presented.

Some case studies using metal hydrides as hydrogen carrier will be presented. A small scale H_2 refueling station developed to provide hydrogen for a FC-driven drone will be presented. Hydrogen is produced at 30 bar by an electrolyzer, driven by photovoltaic panels, and then it is compressed up to 250 bar by a two-stage metal hydride compressor and a booster. The HyCARE project, funded by FCH JU - H2020, focus on the development of an efficient metal hydride-based system for the storage of renewables energies, with a planned quantity of 50 kg of stored hydrogen. The storage module will be integrated with an electrolyzer and fuel cells. The Life Cycle Assessment (LCA) methodology to evaluate the environmental impacts associated with developed systems will be shortly presented. The goal is to identify the main environmental hotspots, in order to quantify the actual benefits and drawbacks of hydrogen handling systems. Finally, main open challenges will be outlined, suggesting possible approaches for their overcoming.

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