Safety of hydrogen storage in aqueous formate solution

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ABSTRACT

Next future hydrogen economy is expected to contribute to about 15-20 % of the total decarbonization process foreseen by 2050. The scientific and industrial community has already recognized the versatility of hydrogen as an enabler of sustainable processes, a fuel, and an energy vector. The main actions to enable a hydrogen economy can be identified in: (i) low-carbon hydrogen production, (ii) development of efficient and safe distribution and storage facilities and technologies, and (iii) development of cheap and efficient utilizers. Low-carbon hydrogen production processes such as blue and green hydrogen are already mature and commercially available technologies, the main limitation being represented by the actual costs. However, projections show that these will decrease in the next future, making sustainable hydrogen production a viable industrial option. One of the main bottlenecks is still represented by the availability of a distribution and storage technology that is energetically efficient, cheap, and safety. State-of-the-art hydrogen technologies, i.e. compressed hydrogen at 350-700 bar and cryogenic liquid hydrogen down to -253 °C, are characterized by the required extreme conditions, leading to significant costs, a decrease in energetic efficiency, and safety issues. In this framework, safety is a key aspect affecting both policy makers and social acceptance of hydrogen technologies.

In this work, a preliminary safety assessment of a new system for hydrogen storage is presented. The technology is based on the adoption of aqueous solution of cheap and harmless salts such as formate and bicarbonate. Hydrogen release and uptake are based on catalytic dehydrogenation of formate and hydrogenation of bicarbonate at mild conditions, i.e. less than 100 °C and 10 bar. Safety and risk assessment shows that the system is intrinsically safer than traditional hydrogen storage not only under normal operating conditions but also when significant deviation from normal operations occurs, as in the case of a fire in proximity of the storage vessels. Risk is reduced by both lower frequency of occurrence and less severe outcome consequences. Interestingly, reduced risk is due not only to the milder initial conditions, but also to the presence of water vapor, reducing the flammability range of hydrogen and thermal transmittance of air.