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Crystalline Porous Materials for Efficient Hydrogen Isotope Separation and Hydrogen Transportation Application

Crystalline porous materials have emerged as a promising class of materials for efficient hydrogen isotope separation. These frameworks have various structure-property relations owing to their ordered porous structure with ultra-high surface area, tunable porosity, and functionality. As a result, they have garnered a lot of interest in many applications, such as gas storage, separation, biomedical applications, sensor technology, and catalysis. Two particular applications that have great potential for this ordered porous structure are 1) hydrogen isotope separation by quantum sieving and 2) crystalline adsorbent in LH2 transportation application.

Part I: Separating gaseous mixtures that consist of very similar particles is a challenge in modern separation technology, particularly isotope separation due to shared size, shape, and thermodynamic properties. Recently, Quantum Sieving (QS) in confined space has received increased attention as an efficient method for hydrogen isotope separation. In this presentation, the feasibility of the microporous frameworks as isotope sieves is outlined through the experimental results obtained by low-pressure high-resolution isotherms and cryogenic thermal desorption spectroscopy (TDS) directly on isotope mixtures. For that, various strategies for satisfying industrial requirements (*e.g.* working temperature or pressure) are introduced by exploiting the Gating, Breathing effect, or Specific Isotope-Responsive system.

Part II: Liquid hydrogen (LH2) has many benefits for the hydrogen infrastructure; its high density allows minimum costs for distribution (e.g. a liquid H_2 trailer is almost five times cheaper per kg than a high-pressure gas trailer), its high payload and short transfer times ease the delivery logistics, and its low temperature provides very low potential burst energy. Those benefits are translated into a significant reduction in the expenses for hydrogen transportation and refuelling station operations. However, using LH2 has a few challenges: liquefying H_2 is an energy-intensive process (more than three times the energy of compression to 700 bar), the setback distances are more stringent for LH2, and particularly boil-off losses along the LH2 pathway may occur. In order to overcome boil-off losses, a new/simple approach is proposed that combines two storage technologies (hybrid; liquefaction at 20 K and cryo-adsorption). Our experimental results reveal that cry-adsorbed H_2 density with specific adsorbent is more than the density of LH2 at 20 K, evidenced by observing the peak for solid H_2 in neutron scattering analysis. In this talk, a new strategy for suppressing the boil-off loss is introduced by exploiting such a high adsorption density on the advanced porous materials.

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