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Progress and problems in hydrogen storage methods

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Abstract

A technique of hydrogen storage has to meet the DOE criterion for the volumetric and gravimetric density of the stored hydrogen and the reversibility criterion for the charging/discharging processes. There are basically five candidate methods that have attracted the common interest: compression, liquefaction, physisorption, metallic hydrides, and complex hydrides. An overview was given for the storage methods available today with respect to the progress made recently and problems still there.

Keywords: Hydrogen; Storage; State; Overview

Contents

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1. Introduction

Hydrogen is shown to be the future fuel from the point of view of human fuel evolution. The fuel evolution experienced the history from coal through petroleum to natural gas following the direction of increasing the content of hydrogen, therefore, it must finally reach the destination of pure hydrogen. Every step of the fuel evolution initiated a progress in human civilization, therefore, the large-scale utilization of hydrogen fuel will certainly elevate the human civilization to a higher horizon. Hydrogen is the cleanest fuel, and has a heating value three times higher than petroleum. However, it is not a natural source, but a man-made fuel; therefore, hydrogen bears a manufacture cost, which made it costing three times higher than the petroleum products. Therefore, any method of storage is not allowed to considerably increase the cost of hydrogen fuel. There are still problems in the realization of the renewed hydrogen from water, but the market supply and the cost of hydrogen do not constitute the bottleneck of hydrogen vehicles today although the hydrogen used presently may not be renewed. There is only one bottleneck for the hydrogen vehicle program, the storage of hydrogen. Just think about as large as 49 m^3 that 4 kg hydrogen occupies, which is required for a practical driving distance, one can imagine how difficult is the job of hydrogen storage. Storage basically implies to reduce the enormous volume of the hydrogen gas. The reversibility of the hydrogen uptake and release excludes all covalent hydrocarbon compounds as hydrogen carriers because the hydrogen is only released from the compounds if being heated to temperatures above 800 °C. The methods of interest include compression, liquefaction, physisorption, metallic hydrides, and complex hydrides, which are commented with respect to the technical state and the viability in future application.

2. Compression

It might be the simplest way to store hydrogen in a cylinder of pressure up to 20 MPa, but the energy density is too low to satisfy the fuel demand of driving practice. About four times higher pressure is needed to meet the driving purpose, however, such industrial cylinders have not been commercially available. Industry sets up a goal to manufacture cylinders capable of withstanding pressure up to 70 MPa with a weight 110 kg to reach a gravimetric density 6%; and volumetric density 30 kg/m^3. The hydrogen density as such is remarkably lower than the cryoadsorption method, and the high cost of compression and the cylinder might hinder the method to be accepted commercially. The isothermal