

# Optimal adsorption energy for physical hydrogen storage

What is adsorption based solid hydrogen storage?

The adsorption-based solid hydrogen storage has attracted increasing attentions owing to high safety, large storage volumetric density, and fast adsorption and desorption kinetics [ 9, 10 ]. Carbon nanotubes [ 11] and metal-organic frameworks (MOFs) [ 12] can store hydrogen via physisorption or chemisorption.

What is the optimal adsorption duration?

Optimal adsorption duration depended fin configurations are identified through machine learning and genetic algorithm. At the adsorption duration of 400s,the hydrogen storage amount is augmented by 12.8%. Adsorption hydrogen storage paves an alternative way for reliable hydrogen storage.

What is the maximum storage capacity of hydrogen adsorption?

Hydrogen adsorption measurements confirmed an excess uptake of about 5 wt%, therefore reaching already values comparable to the best activated carbons, i.e., 4.5 wt% on activated carbon . At 77 K and high pressures above 20 bar, the maximum storage capacities are closely related to the specific surface area accessible to H<sub>2</sub> molecules.

What is the hydrogen storage amount of a 10-finned adsorption bed?

The hydrogen storage amount for 10-finned bed at a dimensionless height of 0.8 is 5.2% more than that at a dimensionless height of 0.2 at the adsorption duration of 800 s. The hydrogen storage amount of the 10-finned bed is higher than that of the 5-finned adsorption bed due to better heat and mass transfer performance.

Can adsorbents enhance hydrogen storage?

This paper reviews recent advances in physically adsorbed hydrogen storage materials,emphasizing solid-state options like carbon adsorbents,metal-organic frameworks,covalent organic frameworks,graphene,and zeolites. These materials have been synthesized and modified to enhance hydrogen storage.

Can physical adsorption achieve fast reversible hydrogen storage?

Author to whom correspondence should be addressed. Physical adsorption remains a promising methodfor achieving fast,reversible hydrogen storage at both ambient and cryogenic conditions.

The isotherms of molecular hydrogen adsorption in slit pores have been calculated at room temperature ( $T = 298$  K) for various pore sizes, from 0.6 nm to 2.5 nm.The pressure has been varied from 0 to 120 bar (12 MPa).The wall surface has been characterized by different values of the adsorption energy, from 3 to 25 kJ/mol.The provided raw data give the number of ...

Several approaches to hydrogen storage are available: (i) high-pressure tanks, (ii) cryogenic liquefaction of molecular hydrogen, (iii) chemical solid storage materials, and iv) physically adsorbing porous materials [1], [2], [7].High-pressure tanks require pressures of 350-700 bar for hydrogen compression, however, even at

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such high pressures, the energy ...

The increasing global emphasis on sustainable energy alternatives, driven by concerns about climate change, has resulted in a deeper examination of hydrogen as a viable and ecologically safe energy carrier. The review paper analyzes the recent advancements achieved in materials used for storing hydrogen in solid-state, focusing particularly on the improvements ...

Hydrogen has the highest energy content per unit mass (120 MJ/kg H<sub>2</sub>), but its volumetric energy density is quite low owing to its extremely low density at ordinary temperature and pressure conditions. At standard atmospheric pressure and 25 °C, under ideal gas conditions, the density of hydrogen is only 0.0824 kg/m<sup>3</sup> where the air density under the same conditions ...

The depletion of reliable energy sources and the environmental and climatic repercussions of polluting energy sources have become global challenges. Hence, many countries have adopted various renewable energy sources including hydrogen. Hydrogen is a future energy carrier in the global energy system and has the potential to produce zero carbon ...

Cryogenic adsorption using microporous materials is one of the emerging technologies for hydrogen storage in fuel cell vehicles. Metal-organic frameworks have been identified as suitable adsorbents exhibiting large ...

The experimental data on hydrogen adsorption on five nanoporous activated carbons (ACs) of various origins measured over the temperature range of 303-363 K and pressures up to 20 MPa were compared with the predictions ...

Hydrogen stands as a promising energy carrier, owing to its potential for production from renewable resources [7] s numerous advantages, such as low mass density, high energy density, ease of production, versatility, and abundance, position it as a preferred choice for a sustainable energy future [8, 9]. When hydrogen is combusted, only water vapor is ...

An optimal hydrogen storage property is achieved for  $\rho \sim 0.5 \text{ g/cm}^3$ , yielding a 350% increase in volumetric H<sub>2</sub> density, reaching up to 42 g H<sub>2</sub> L<sup>-1</sup>. A total volumetric H<sub>2</sub> ...

The optimal sites of H<sub>2</sub> storage (adsorption) with the most negative adsorption energy change  $\Delta E$  (Supplementary Figs. 2-5) or the minimum adsorption Gibbs free energy ...

Two-dimensional (2D) material families hold the potential for energy conversion and hydrogen storage. This material has innovative physical and chemical properties and a vast surface area [24]. The unique family of 2D materials with magnetic properties, occurrences, and possible uses came to the forefront and underwent intense research after graphene was ...

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Hydrogen adsorption on activated carbons (ACs) is a promising alternative to compression and liquefaction for storing hydrogen. Herein, we have studied hydrogen adsorption on six commercial ACs (CACs) with surface ...

Research in this area has recently shifted to focus primarily on the volumetric ( $H_2$  stored/delivered per volume) gains achieved within an adsorptive storage system over that of ...

The adsorption-based solid hydrogen storage has attracted increasing attentions owing to high safety, large storage volumetric density, and fast adsorption and desorption ...

Adsorptive hydrogen storage has enjoyed growing interest to address these aforementioned problems, with many types of nanoporous materials (NPMs) explored including zeolites (), carbon-based materials (), and metal-organic ...

Hydrogen is currently stored in vehicles as a gas in high pressure cylinders (at up to 700 bar) or as a liquid at 20 K in cryogenic reservoirs. According to the DOE, the maximum storage densities that have been achieved so far using these storage technologies are 1.2 kW h l<sup>-1</sup> and 1.7 kW h kg<sup>-1</sup> for liquid and 0.8 kW h l<sup>-1</sup> and 1.6 kW h kg<sup>-1</sup> for high pressure [2].

Developing optimal physisorbents for high-capacity hydrogen storage has essentially addressed three parameters, namely, the intrinsic binding energy between the hydrogen molecule and adsorbent, the accessible adsorption surface, and the ...

The optimal sites of  $H_2$  storage (adsorption) with the most negative adsorption energy change  $\Delta E$  (Supplementary Figs. 2-5) or the minimum adsorption Gibbs free energy change  $\Delta G_{H_2^*}$  (Fig. 1b ...

Because material composition has been demonstrated to have a direct influence on hydrogen gravimetric capacity, the most common type of hydrogen storage material has been two-dimensional structures composed of light components [16, 17]. However, research has revealed that most pristine 2D materials possess poor hydrogen adsorption energy and low ...

Among various storage methods, adsorption-based has prospects and has lately been of interest, judging from recent publications [6], [7], [8]. This approach involves Vander Waals' forces, electrostatic, and orbital interaction and proceeds by meticulously tailoring materials with a porous structure to host the hydrogen molecules preferentially physically (there is a high chance of ...

A series of porous crystalline materials known as metal-organic materials are prepared, and a full sorption study shows that controlled pore size (rather than large surface area) coupled with ...

The mass and energy balances of a zero-dimensional model for hydrogen storage by adsorption is studied. The

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model is solved with an in-house MATLAB code and validated with three experimental case studies from the ...

This review examines the research progress of carbon-based and novel porous materials for hydrogen storage via physical adsorption. It discusses potential applications and ...

In contrast, physical adsorption presents several advantages, including a rapid hydrogen adsorption and release process, lower activation energy, and the amount of hydrogen adsorbed being solely influenced by the physical structure of the storage materials [22, 23]. As a result, it is regarded as a highly promising approach for hydrogen storage.

There is much current interest in the storage of hydrogen in porous materials for mobile energy applications. Despite significant hydrogen storage capacities having been observed recently for some synthesised materials, the identification of optimal operating conditions (pressure and temperature) is perhaps an even more important consideration from an ...

Solid-state hydrogen storage is a significant branch in the field of hydrogen storage [[28], [29], [30]]. Solid-state hydrogen storage materials demonstrate excellent hydrogen storage capacity, high energy conversion efficiency, outstanding safety, and good reversibility, presenting a promising prospect and a bright future for the commercial operation of hydrogen energy ...

The first one, system-based storage, or physical modes of storing hydrogen, includes the use of high-pressure cylinders into which the hydrogen is stored either in a gaseous state under extremely high pressures approximately up to 800 bars, or in a liquid state by maintaining the temperature at 21 K. Storing hydrogen as a gas under high ...

With the chemical formula  $H_2$ , hydrogen is one of the simplest molecules known and possesses a much higher gravimetric yet lower volumetric energy density compared with gasoline (120 MJ kg<sup>-1</sup> and 8 MJ L<sup>-1</sup> for liquid hydrogen versus 44 MJ kg<sup>-1</sup> and 32 MJ L<sup>-1</sup> for gasoline). Despite this favorable energy density, an efficient hydrogen storage system is one ...

**Hydrogen Storage Materials** 1.1 Introduction Hydrogen has drawn attention as a next-generation energy carrier for mobile and stationary power sources [1]. It has a number of advantages over other chemical energy carriers. First, the energy conversion process is a clean one, with water as the waste product. Sec-

The goal is to provide adequate hydrogen storage to meet the U.S. Department of Energy (DOE) hydrogen storage targets for onboard light-duty vehicle, material-handling equipment, and portable power applications. By ...

In this work, we critically review the literature in order to determine universal trends in volumetric hydrogen

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storage and delivery across three prominent classes of adsorptive storage materials in order to clarify best ...

An advanced statistical physics model has been applied to study the hydrogen adsorption isotherm on two modified types of activated carbon, namely granular coal activated carbon (AC (GC)) and ...

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