Porous Materials for Hydrogen Storage at Low Temperatures: A Review

Maria-Sophie Günther[1, S], Xiaoxian Yang[1], Daniel Zipplies[1] and Markus Richter[1, C]

[1]*Applied Thermodynamics, Chemnitz University of Technology, Chemnitz, Germany*
m.richter@mb.tu-chemnitz.de

The goal of emissions neutrality requires rethinking energy supply in all sectors of society and industry. Against this background, a promising approach lies in hydrogen production and efficient storage [1]. In addition to established technologies, adsorptive hydrogen storage offers significant potential, as it substantially increases volume-based storage density at comparatively low pressures [2-3]. Furthermore, adsorption is a largely reversible process, enabling easy and loss-free release of hydrogen when needed [4]. While numerous adsorbents have been examined for their suitability, a comprehensive investigation of their temperature-dependent behavior, particularly at low temperatures, is notably lacking. Research on hydrogen adsorption continues to be in high demand, and much data continues to be published. In this context, the present work aims to provide an essential overview of the current state of research in this field. Based on extensive literature research on hydrogen adsorption behavior in various porous materials and subsequent data analysis, characteristic behaviors within material groups are identified. The focus here is primarily on the temperature range down to 77 K and pressures up to 100 bar, as comparatively less energy is required for cooling and compression under these conditions. In addition to the adsorption potential of the different materials and underlying thermodynamics, this review mainly focuses on hydrogen adsorption measurement and the role of computational modeling and simulations. In conclusion, this literature review summarized the current knowledge on hydrogen adsorption on porous materials, highlighting the potential of these materials for efficient hydrogen storage. It also identifies gaps in the existing research and outlines future directions to accelerate the development of practical hydrogen storage solutions to facilitate the transition towards a sustainable energy future.

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