Study of H_2 Storage in Ultramicroporous Carbon Materials Synthesized from Peat Precursor with $ZnCl_2$ activation

Egert Möller[1,*], Rasmus Palm[1,2], Kenneth Tuul[1], Meelis Härmas[1], Miriam Koppel[1], Jaan Aruväli[3], Marian Külaviir[3], Enn Lust[1]

[1]*Institute of Chemistry, University of Tartu, Ravila 14a, 50411 Tartu, Estonia*
[2]*Department of Applied Physics, KTH Royal Institute of Technology, SE-106 91 Stockholm, Sweden*
[3]*Institute of Ecology and Earth Sciences, University of Tartu, J. Liivi 2, 50409 Tartu, Estonia*
**egert.moller@ut.ee*

Confinement of gaseous hydrogen through physical adsorption in a porous adsorbent, such as activated carbon materials, is a promising mechanism for hydrogen storage. The main requirements for hydrogen storage materials are high hydrogen uptake capacity, low material density, safety of use, and bulk price of production and system operation. A desired pore size distribution within the material, more specifically a large degree of microporosity, allows for a higher hydrogen storage capacity per pore volume, so it must also be considered.[1] Peat-derived $ZnCl_2$-activated carbon materials combine the low cost and ease-of-use of biomass pyrolysis with the high specific surface area (SSA) and configurable pore size distribution of chemical activation.

Peat was combined with $ZnCl_2$ in six different mass ratios and used to synthesize activated carbon materials through pyrolysis in an Ar environment. The chemical compositions of the activated carbon materials were determined with X-ray fluorescence and energy dispersive X-ray spectrometry, the microstructures were characterized via scanning electron microscopy, crystalline impurity phases were determined with X-ray diffraction, and porosity properties were determined with N_2 and CO_2 gas adsorption methods. The effectiveness of the used synthesis route for the production of high SSA and highly microporous carbon materials was additionally verified through H_2 gas adsorption measurements for suitable H_2 storage properties.[2] The strong H_2 adsorption capability of ultramicropores in a peat-derived carbon material activated with low amounts of $ZnCl_2$ is presented.

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References

1 Y. Gogotsi, C. Portet, S. Osswald, J. M. Simmons, T. Yildirim, G. Laudisio and J. E. Fischer, Importance of pore size in high-pressure hydrogen storage by porous carbons, *International Journal of Hydrogen Energy*, 2009, **34**, 6314–6319.

2 E. Möller, R. Palm, K. Tuul, M. Härmas, M. Koppel, J. Aruväli, M. Külaviir and E. Lust, Peat-Derived ZnCl2-Activated Ultramicroporous Carbon Materials for Hydrogen Adsorption, *Nanomaterials*, 2023, **13**, 2883.