BÖLÜM 6

Storage of Hydrogen on Metals and Porous Systems

Yavuz SÜMER[1]
Afşin GÜNGÖR[2]

1. Introduction

The increasing population in our globalized world has allowed the use of energy and natural resources to change over time, irresponsibly consuming energy resources and increasing environmental problems. Fossil fuels, which supply the majority of the world's energy, are depleting, resulting in catastrophic environmental and air pollution. The use of fossil fuels adversely affects the global ozone layer's acid rain and global warming. The most important feature of fossil fuels with hydrocarbon content, which is the stored form of solar energy, is the lack of renewable resources and limited reserves. There are a variety of methods of generating energy, and methods of getting more energy from renewable energy sources due to global warming are among the particular interests today. Hydrogen energy is considered a state-of-the-art technology that can meet the world's growing energy needs without polluting the environment [1-3]

[1] M.S, Pamukkale University, Çardak OSB Vocational School, Department of Mechatronics Denizli, Turkey, e-mail: ysumer@pau.edu.tr
[2] Prof. Dr., Akdeniz University, Faculty of Engineering, Mechanical Engineering, Antalya, Turkey e-mail: afsingungor@akdeniz.edu.tr

REFERENCES

1. Kumaş, K., Akyüz, A., Zaman, M., Güngör, A.(2019). Carbon Footprint Determination for a Sustainable Environment: MAKÜ Bucak School of Health Example" ElCezerî Journal of Science and Engineering, 2019, 6 (1), 108-117. https://doi.org/10.31202/ecjse.459478
2. Kumaş, K., Temiz, D., Akyüz, A.Ö., Güngör, A. (2019) Biomass to Energy: The Potential of Biogas in Turkey and World. Mesleki Bilimler Dergisi (MBD), 8 (2): 70 – 77. https://dergipark.org.tr/tr/pub/mbd
3. Kumaş, K., Akyüz, A. (2020). An overview on the use of nanotechnology in the renewable energy field, International Journal of Energy Applications and Technologies,7(4),143-148.
4. İnan, O., Kumaş, K., Akyüz, A. Ö., Güngör, A. (2019). A Robust Fuzzy Model for Wind Energy Potential Estimation. Engineering Research Papers, ed. Erol PEHLİVAN vd. Gece Kitaplığı, 305-315. ISBN: 978-625-7958-55-4
5. Godula-Jopek, A., Jehle, W., & Wellnitz, J. (2012). Hydrogen Storage Technologies: New Materials, Transport, and Infrastructure (1st ed.). Wiley-VCH.
6. Adamson, Kerry-Ann & Pearson, Peter. (2000). Hydrogen and methanol: A comparison of safety, economics, efficiencies and emissions. Journal of Power Sources. 86. 548-555. 10.1016/S0378-7753(99)00404-8.
7. Hake, J.-F & Linssen, Jochen & Walbeck, M.. (2006). Prospects for hydrogen in the German energy system. Energy Policy. 34. 1271-1283. 10.1016/j.enpol.2005.12.015.
8. Zhao, X., Xiao, B., Fletcher, A. J., Thomas, K. M., Bradshaw, D., & Rosseinsky, M. J. (2004). Hysteretic adsorption and desorption of hydrogen by nanoporous metal-organic frameworks. Science (New York, N.Y.), 306(5698), 1012–1015. 10.1126/science.1101982
9. Morris, R. and Wheatley, P. (2008), Gas Storage in Nanoporous Materials. Angewandte Chemie International Edition, 47: 4966-4981. 10.1002/anie.200703934
10. Ren, Jianwei & Langmi, Henrietta W & North, Brian & Mathe, Mkhulu. (2014). Review on processing of metal–organic framework (MOF) materials towards system integration for hydrogen storage. International Journal of Energy Research. 39. 10.1002/er.3255.
11. Stetson N. (2012) An overview of U.S. DOE's activities for hydrogen fuel cell technologies. Clearwater, Florida, America, 2/27/2012.
12. Bo Xiao, Paul S. Wheatley, Xuebo Zhao, Ashleigh J. Fletcher, Sarah Fox, Adriano G. Rossi, Ian L. Megson, S. Bordiga, L. Regli, K. Mark Thomas, and Russell E. Morris. (2007) Journal of the American Chemical Society 129 (5), 1203-1209 DOI: 10.1021/ja066098k
13. J. Wegrzyn, H. Wisemann, and T. Lee.(1992) Low pressure storage of natural gas on activated carbon, in SAE Proc. of Annual Automotive Technology Development, pp. 1–11.
14. Yang, S. , Jung, H. , Kim, T. , & Park, C. (2012). Recent advances in hydrogen storage technologies based on nanoporous carbon materials. Progress in Natural Science: Materials International, 22 (6). 10.1016/j.pnsc.2012.11.006
15. von Ardenne M, Musiol G, Reball S (1990) Effekte der Physik. Verlag Harry Deutsch, pp 712–715

16. Züttel, Andreas. (2004). Hydrogen storage methods. Die Naturwissenschaften. 91. 157-72. 10.1007/s00114-004-0516-x.
17. Sandrock, G. A panoramic overview of hydrogen storage alloys from a gas reaction point of view. Switzerland. 10.1016/S0925-8388(99)00384-9
18. Sandrock, G., & Thomas, G. (2001). The IEA/DOE/SNL on-line hydride databases. Applied Physics A, 72(2), 153-155.
19. Cejka, J., Bekkum, H. V., Corma, A., & Schueth, F. (2007). Introduction to Zeolite Molecular Sieves (ISSN Book 168) (3rd ed.). Elsevier Science.
20. Zhou, Li, 2005. "Progress and problems in hydrogen storage methods," Renewable and Sustainable Energy Reviews, Elsevier, vol. 9(4), pages 395-408
21. Xu, R., Pang, W., Yu, J., Huo, Q., & Chen, J. (2007). Chemistry of Zeolites and Related Porous Materials: Synthesis and Structure (1st ed.). Wiley-Interscience.
22. Yürüm, Y., Taralp, A., & Veziroglu, T. N. (2009). Storage of hydrogen in nanostructured carbon materials. International Journal of Hydrogen Energy, 34(9), 3784–3798. 10.1016/j.ijhydene.2009.03.001
23. Ren, J., Langmi, H. W., North, B. C. and Mathe, M. (2015), Review on processing of metal–organic framework (MOF) materials towards system integration for hydrogen storage. Int. J. Energy Res., 39: 607– 620. 10.1002/er.3255.
24. Hirscher, Michael & Panella, Barbara. (2007). Hydrogen storage in metal–organic frameworks. Scripta Materialia. 56. 809-812. 10.1016/j.scriptamat.2007.01.005.
25. Suh, M. P., Park, H. J., Prasad, T. K., & Lim, D. W. (2012). Hydrogen storage in metal-organic frameworks. Chemical reviews, 112(2), 782–835. 10.1021/cr200274s
26. Latroche, M., Surblé, S., Serre, C., Mellot-Draznieks, C., Llewellyn, P. L., Lee, J. H., Chang, J. S., Jhung, S. H., & Férey, G. (2006). Hydrogen storage in the giant-pore metal-organic frameworks MIL-100 and MIL-101. Angewandte Chemie (International ed. in English), 45(48), 8227–8231. 10.1002/anie.200600105
27. Frost, H., & Snurr, R. Q. (2007). Design Requirements for Metal-Organic Frameworks as Hydrogen Storage Materials. The Journal of Physical Chemistry C, 111(50), 18794–18803. https://doi.org/10.1021/jp076657p