iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 **Issue:** X **Month of publication:** October 2022

DOI: https://doi.org/10.22214/ijraset.2022.46931

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue X Oct 2022- Available at www.ijraset.com

Bimetal Decorated Carbon Nano Materials (CNMs) Synthesized from Plant Waste Materials as An Excellent Hydrogen Storage Material

Suyash S. Prasad[1], Shyambabu K. Sainik[2], Manoj D. Basutkar[3], Bholanath T. Mukherjee[4]
[1, 2, 3, 4]*DSPM'S K.V. Pendharkar College, Dombivli, Maharashtra, India*

Abstract: In this study, Carbon nanomaterials (CNMs) were synthesized from plant filaments and were investigated for the hydrogen adsorption capacity. Synthesis was carried out using Bagasse-a plant waste materials by pyrolyzing at high temperature of 700°C in an inert atmosphere and were activated by different alkali solutions. The activated carbon fibres were further loaded with nano size bimetal particles. The SEM images show highly porous carbon nano structures impregnated with different combinations of metals. The EDAX and SEM confirmed the presence of bimetals. Raman spectra and X-ray diffraction indicates the presence of crystalline and amorphous carbon material. The designed carbon nanomaterial with bimetal particles has the higher specific surface area (SSA) than the carbon obtained without activation which was confirmed by the BET analysis. This makes it a front runner for its utilization in hydrogen adsorption among numerous others. The adsorption was studied using a Sievert's apparatus.
Keywords: Carbon nanomaterials (CNMs), Bagasse, Bimetal, Activated carbon fibres, Hydrogen adsorption, Sievert's apparatus.

I. INTRODUCTION

The abatement in petroleum products has encouraged a huge interest for sustainable power sources having higher energy proficiency. Moreover, this has raised overall endeavours to create elective energizes and innovations.[1]. The contamination because of ignition of petroleum derivatives has added to the radically altering climatic issues. Hence, the need is to create eco-accommodating clean fuels, which, otherwise is very difficult to achieve[2].

Hydrogen is viewed as one of the promising energy fuels for automobiles and its utilization can be additionally stretched out to more modest compact gadget like PCs and cell phones and so forth[3]. Hydrogen is proficient, sustainable and eco- friendly source and can possibly supplant non-inexhaustible petroleum derivatives. The current energy utilization for versatility and transport applications represents 33% of the petroleum derivative being utilized and accordingly utilization of hydrogen will cause diminished carbon dioxide creation as burning of hydrogen will deliver water as by-product [3][4][5].

Till date different materials for storage of hydrogen have been studied, which includes graphene based materials, nanomaterials, complex hydrides, etc. [2][5][6][7][8]. Among the various techniques studied so far for hydrogen adsorption, physi-sorption on carbon material is very encouraging as there is no chemical bond between hydrogen and carbon surface, consequently giving totally reversible hydrogen adsorption and desorption[9][10][11][12]. It is accepted that adsorption at encompassing conditions on materials bearing a pores with feeble Van der Waals connection can satisfy the magnitude that have been set by the U.S. Department of Energy (DOE)[3][13][14]. These materials have varied capacities of adsorption of hydrogen and have inherent limitations as these involve physisorption and chemisorption[15] [16][17] [18]. Researchers have come up with numerous procedure for the preparation of CNMs, utilizing plant-based materials, to study storage of hydrogen[19][20][21].

Porous nanomaterials have long acquired significance as an adsorbent. For instance, adsorbent materials like nano-organized carbonaceous materials which comprises of carbon nanotube, layered structure such as graphene and nanofibers developed from carbon have been created[22][23][24][25]. Carbon nanomaterials (CNMs) because of their high explicit surface region and porous characteristics, notwithstanding its special mechanical property, permit it to be an ideal substrate which can be adjusted through various metals enrichment for expanding hydrogen adsorption[26][27][28][29]. Considering the use of various transition metals in hydrogen adsorption, nickel is favourable in light of the fact that it is plentiful, cheap in comparison with different metals and have comparable hydrogen adsorption properties.[30][19][31]

In this study, attempts were made to study the effect of treatment of bimetals (Nickel in combinations with other metals) on hydrogen adsorption property of CNMs prepared from plant waste materials.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue X Oct 2022- Available at www.ijraset.com

II. EXPERIMENTAL TECHNIQUES

A. Synthesis of Carbon nanomaterials

The bagasse fibers obtained from the plant waste materials was carbonized in a designed Lindberg horizontal quartz tube furnace at 700℃ for 3 hours in inert atmosphere and was activated with alkali solutions of different concentrations. The activated carbon was treated with bimetal solution and annealed in the presence of carbon dioxide (CO_2). This highly porous carbon nanomaterial was utilized for studying the hydrogen adsorption properties using the Sievert’s apparatus.

B. Determination of Hydrogen Adsorption using Sievert’s Apparatus

Adsorption of hydrogen by the CNMs formed was examined by utilizing Sievert’s apparatus at ambient temperature at a pressure of 60 bars. For the study, 10g of CNMs sample was utilized.

TABLE I: HYDROGEN ADSORPTION BY CNMS ENRICHED WITH BIMETALS

Bimetal	BET m^2g^{-1}	Pore Volume cc/g	Adsorption wt%
Ni-Mg	517.875	0.220	4.84

III. RESULTS AND DISCUSSIONS

A. Characterisation of CNMs

The final CNMs obtained by annealing is analysed by X-Ray Diffraction (XRD) techniques [Fig. III(a)]. One Broad peak was obtained at 36.31 two theta value which corresponds to (002) plane and another sharp peak at 43.19 two theta value that corresponds to (100) plane.

B. SEM Images of CNMs

Scanning Electron Microscopy(SEM) provides a vital information regarding the characteristics viz. morphology of samples[32]. In this study, SEM was utilized to investigate the surface morphology of the designed CNMs prepared from bagasse- a plant waste materials. The SEM images obtained, reveals the porous nature of the material [Fig.1], distribution of bimetals and width of the sample was found to be around 424-461nm [Fig.2]

C. EDAX of Sample

EDAX of the sample gives the information regarding the concentration and distribution of the bimetal (Ni and Mg) on the surface of the CNMs. The major elemental composition displayed by EDAX is 81.83% of C and 3.2% of bimetal. [Table 2]

D. Raman Analysis of CNMs

Raman spectrum [Fig. III(b)] indicates the two peaks, one at 2581 cm^{-1} of G band and another at 3173 cm^{-1} of D band that reveals the graphitic carbon materials[33][34] having disorder structure.

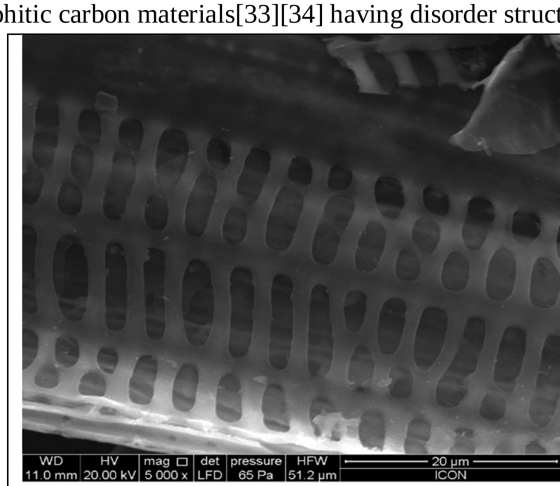


Fig.1 SEM images of Porous Sample

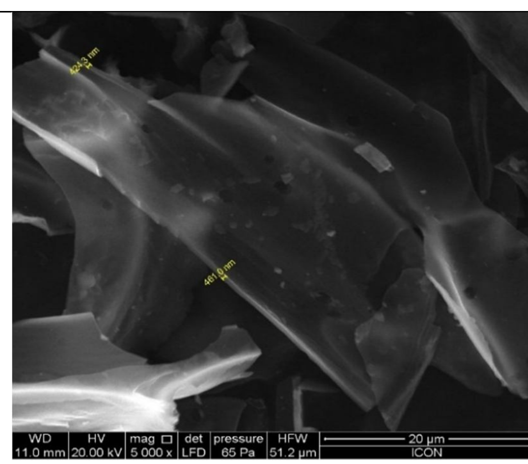
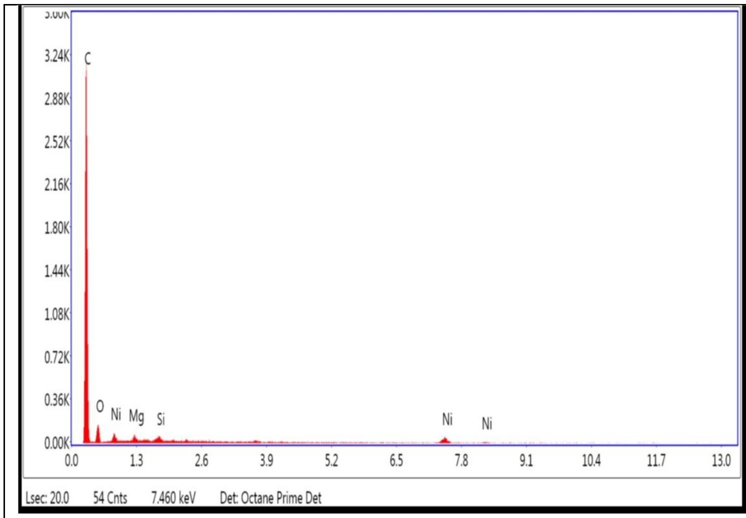
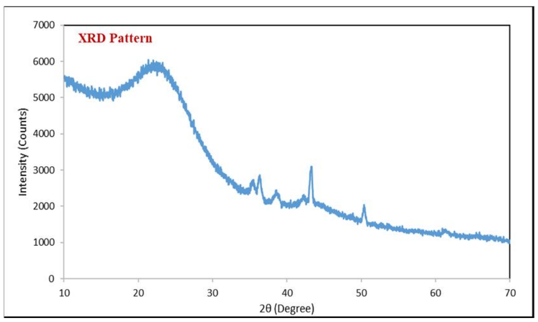


Fig.2 SEM images shows distribution of bimetals and width of the sample

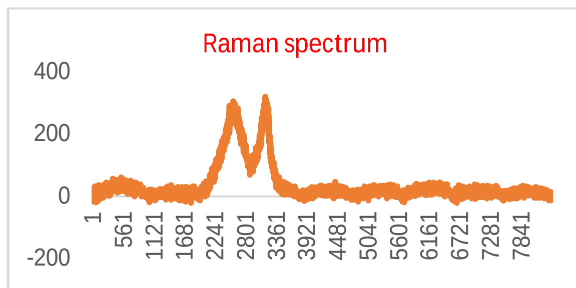
TABLE 2: EDAX of Sample With Elemental Composition



Element	Weight %	Atomic%
C K	81.83	87.29
Ni K	2.68	0.59
Mg K	0.52	0.27
O K	14.56	11.66
Si K	0.42	0.19
Total	100.0	



[Fig. III(a)] X-Ray diffraction of CNMs



[Fig. III(b)] Raman Spectra of CNMs

IV. STUDY OF HYDROGEN ADSORPTION

The CNMs obtained were used to study the hydrogen adsorption at defined temperature as mentioned in Table 1. Adsorption of hydrogen not only count on the SSA of the sample but also depend on the spill-over theory [34]. The adsorption of hydrogen on CNMs was measured as 4.84 wt% at ambient temperature at a pressure of 60 bars. The surface area by BET (Brunauer-Emmett-Teller) analysis was found to be 517.875 m^2g^- with pore volume of 0.220 cc/g. The presence of metal nanoparticles on to the carbon surface is known to increase the hydrogen adsorption by expanding the porosity of carbon materials[30]. These metal particles also aid to separate hydrogen in such that upgrading the hydrogen adsorption limit.

V. CONCLUSION

In summary, pyrolysis of Bagasse- a plant waste material was carried out and hydrogen adsorption was determined at ambient temperature using a sieverts apparatus. The adsorption of hydrogen on CNMs was measured as 4.84 wt% at a pressure of 60 bars. The outcomes reveal the considerable uptake of hydrogen by using 10g of CNMs sample.

REFERENCES

[1] L. Schlapbach and A. Züttel, "Hydrogen-storage materials for mobile applications," Nature, vol. 414, no. 6861, pp. 353–358, 2001, doi: 10.1038/35104634.
[2] K. Spyrou, D. Gournis, and P. Rudolf, "Hydrogen Storage in Graphene-Based Materials: Efforts Towards Enhanced Hydrogen Absorption," ECS J. Solid State Sci. Technol., vol. 2, no. 10, pp. M3160–M3169, 2013, doi: 10.1149/2.018310jss.
[3] G. K. Dimitrakakis, E. Tylianakis, and G. E. Froudakis, "Pillared graphene: a new 3-D network nanostructure for enhanced hydrogen storage," Nano Lett., vol. 8, no. 10, pp. 3166–3170, 2008, doi: 10.1021/nl801417w.
[4] M. Heben and M. J. Heben, "VI . C . 1 DOE Carbon-Based Hydrogen Storage Center of Excellence," no. July, 2014.
[5] M. U. Niemann, S. S. Srinivasan, A. R. Phani, A. Kumar, D. Y. Goswami, and E. K. Stefanakos, "Nanomaterials for hydrogen storage applications: A review," J. Nanomater., vol. 2008, no. 1, 2008, doi: 10.1155/2008/950967.

[6] M. B. Ley et al., “Complex hydrides for hydrogen storage - New perspectives,” Mater. Today, vol. 17, no. 3, pp. 122–128, 2014, doi: 10.1016/j.mattod.2014.02.013.

[7] R. Krishna et al., “Hydrogen Storage for Energy Application,” Hydrog. Storage, 2012, doi: 10.5772/51238.

[8] V. Fierro et al., “Experimental evidence of an upper limit for hydrogen storage at 77 K on activated carbons,” Carbon N. Y., vol. 48, no. 7, pp. 1902–1911, 2010, doi: 10.1016/j.carbon.2010.01.052.

[9] B. Panella, M. Hirscher, and S. Roth, “Hydrogen adsorption in different carbon nanostructures,” Carbon N. Y., vol. 43, no. 10, pp. 2209–2214, 2005, doi: 10.1016/j.carbon.2005.03.037.

[10] S. Sircar, T. C. Golden, and M. B. Rao, “Activated carbon for gas separation and storage,” Carbon N. Y., vol. 34, no. 1, pp. 1–12, 1996, doi: 10.1016/0008-6223(95)00128-X.

[11] M. Rzepka, P. Lamp, and M. A. De La Casa-Lillo, “Physisorption of hydrogen on microporous carbon and carbon nanotubes,” J. Phys. Chem. B, vol. 102, no. 52, pp. 10894–10898, 1998, doi: 10.1021/jp9829602.

[12] P. Bénard and R. Chahine, “Storage of hydrogen by physisorption on carbon and nanostructured materials,” Scr. Mater., vol. 56, no. 10, pp. 803–808, 2007, doi: 10.1016/j.scriptamat.2007.01.008.

[13] K. Sumida et al., “Impact of metal and anion substitutions on the hydrogen storage properties of M-BTT metal-organic frameworks,” J. Am. Chem. Soc., vol. 135, no. 3, pp. 1083–1091, 2013, doi: 10.1021/ja310173e.

[14] M. A. Salam, S. Sufian, and T. Murugesan, “Hydrogen storage investigation of fixed bed of nano-crystalline Mg-Ni-Cr mixed oxides,” Adv. Mater. Res., vol. 701, pp. 179–183, 2013, doi: 10.4028/www.scientific.net/AMR.701.179.

[15] M. Sharon et al., “Hydrogen storage by carbon materials synthesized from oil seeds and fibrous plant materials,” Int. J. Hydrogen Energy, vol. 32, no. 17, pp. 4238–4249, 2007, doi: 10.1016/j.ijhydene.2007.05.038.

[16] M. Doğan, P. Sabaz, Z. Bicil, B. Koçer Kizilduman, and Y. Turhan, “Activated carbon synthesis from tangerine peel and its use in hydrogen storage,” J. Energy Inst., vol. 93, no. 6, pp. 2176–2185, 2020, doi: 10.1016/j.joei.2020.05.011.

[17] L. L. Vasiliev, L. E. Kanonchik, A. G. Kulakov, and D. A. Mishkinis, “Activated carbon and hydrogen adsorption storage,” NATO Secur. through Sci. Ser. A Chem. Biol., pp. 633–651, 2007, doi: 10.1007/978-1-4020-5514-0_80.

[18] V. Dhand, J. S. Prasad, K. Y. Rhee, and Y. Anjaneyulu, “Fabrication of high pressure hydrogen adsorption/desorption unit-Adsorption study on flame synthesized carbon nanofibers,” J. Ind. Eng. Chem., vol. 19, no. 3, pp. 944–949, 2013, doi: 10.1016/j.jiec.2012.11.013.

[19] N. A. Fathy, “Carbon nanotubes synthesis using carbonization of pretreated rice straw through chemical vapor deposition of camphor,” RSC Adv., vol. 7, no. 45, pp. 28535–28541, 2017, doi: 10.1039/c7ra04882c.

[20] M. Sharon, S. Bhardwaj, S. Jaybhaye, D. Sathiyamoorthy, K. Dasgupta, and M. Sharon, “Hydrogen Adsorption by Carbon Nanomaterials from Natural Source,” vol. 21, no. 2, 2007.

[21] N. U. Sawai and F. W. Harun, “Hydrogen Adsorption on Agricultural-Based Activated Templated-Carbons and Clay-Based Materials ; A Review Carbons , Zeolite,” J. Indutrial Eng. Res., vol. 1, no. 5, pp. 1–7, 2015.

[22] G. E. Froudakis, “Hydrogen storage in nanotubes & nanostructures,” Mater. Today, vol. 14, no. 7–8, pp. 324–328, 2011, doi: 10.1016/S1369-7021(11)70162-6.

[23] H. M. Cheng, Q. H. Yang, and C. Liu, “Hydrogen storage in carbon nanotubes,” Carbon N. Y., vol. 39, no. 10, pp. 1447–1454, 2001, doi: 10.1016/S0008-6223(00)00306-7.

[24] C. Li, J. Li, F. Wu, S. S. Li, J. B. Xia, and L. W. Wang, “High capacity hydrogen storage in Ca decorated graphyne: A first-principles study,” J. Phys. Chem. C, vol. 115, no. 46, pp. 23221–23225, 2011, doi: 10.1021/jp208423y.

[25] H. G. Schimmel, G. J. Kearley, M. G. Nijkamp, C. T. Visser, K. P. De Jong, and F. M. Mulder, “Hydrogen adsorption in carbon nanostructures: Comparison of nanotubes, fibers, and coals,” Chem. - A Eur. J., vol. 9, no. 19, pp. 4764–4770, 2003, doi: 10.1002/chem.200304845.

[26] E. Yoo, T. Habe, and J. Nakamura, “Possibilities of atomic hydrogen storage by carbon nanotubes or graphite materials,” Sci. Technol. Adv. Mater., vol. 6, no. 6, pp. 615–619, 2005, doi: 10.1016/j.stam.2005.04.008.

[27] H. Liu and Y. Li, “Modified carbon nanotubes for hydrogen storage at moderate pressure and room temperature,” Fullerenes Nanotub. Carbon Nanostructures, vol. 28, no. 8, pp. 663–670, 2020, doi: 10.1080/1536383X.2020.1738396.

[28] K. hsiung Young and J. Nei, “The current status of hydrogen storage alloy development for electrochemical applications,” Materials (Basel)., vol. 6, no. 10, pp. 4574–4608, 2013, doi: 10.3390/ma6104574.

[29] J. Jin, J. Ouyang, and H. Yang, “Pd Nanoparticles and MOFs Synergistically Hybridized Halloysite Nanotubes for Hydrogen Storage,” Nanoscale Res. Lett., vol. 12, no. 1, 2017, doi: 10.1186/s11671-017-2000-5.

[30] B. Mukherjee, G. Kalita, M. Sharon, and M. Sharon, “Hydrogen storage by carbon fibers from cotton,” QScience Connect, no. 2013, p. 45, 2013, doi: 10.5339/connect.2013.45.

[31] V. J. Surya, K. Iyakutti, N. Venkataramanan, H. Mizuseki, and Y. Kawazoe, “The role of Li and Ni metals in the adsorbate complex and their effect on the hydrogen storage capacity of single walled carbon nanotubes coated with metal hydrides, LiH and NiH2,” Int. J. Hydrogen Energy, vol. 35, no. 6, pp. 2368–2376, 2010, doi: 10.1016/j.ijhydene.2010.01.001.

[32] G. Thomas, “Modern electron microscopy for materials characterization,” J. Electron Microsc. Tech., vol. 3, no. 1, pp. 95–108, 1986, doi: 10.1002/jemt.1060030109.

[33] B. T. Mukherjee, S. K. Sainik, and K. R. Jagdeo, “Microwave absorption by CNM decorated with nickel nano particles .,” vol. 6, no. 9, pp. 77–80, 2017.

[34] R. Zacharia, K. Y. Kim, A. K. M. Fazle Kibria, and K. S. Nahm, “Enhancement of hydrogen storage capacity of carbon nanotubes via spill-over from vanadium and palladium nanoparticles,” Chem. Phys. Lett., vol. 412, no. 4–6, pp. 369–375, 2005, doi: 10.1016/j.cplett.2005.07.020.