

Review of Hydrogen mass storage using Ammonia Borane

Mrs. Anupama Mathapati

Department of Mechanical Engineering
Shivajirao S Jondhle College of Engineering And Technology
Asangaon 421601
mathapatianupama@gmail.com

Prof. S.V. Devkare

Department of Mechanical Engineering
Shivajirao S Jondhle College of Engineering And Technology
Asangaon 421601
santosh.devkare@gmail.com

Abstract :-This work is a study of use of boron for hydrogen stockpiling. Boron is a promising component for hydrogen stockpiling with its concoction hydrides and nanostructural shapes. It is additionally utilized as an added substance as a part of nickel metal hydride battery frameworks to improve hydrogen similarity and execution. This present study will be a brief synopsis of hydrogen stockpiling innovation all in all and spotlight on conceivable employments of boron and its mixes.

Keywords: *Hydrogen storage; Boron compounds; Thermal decomposition, Iso thermal, Non isothermal.*

I. INTRODUCTION

From the earliest starting point of industrialization, mankind has been devouring normal assets without considering the natural effect and conceivable results of their weariness. A noteworthy impact of utilizing fossil fuels is a dangerous atmospheric deviation, which causes many passings in warm atmosphere nations, expanding levels of ocean water worldwide which undermines shoreline urban areas, and various other characteristic debacles, for example, surges, sea tempests, backwoods flames, et cetera. As of right now we need to think which approach to pick: stop the weariness of assets, quicken the move to renewable energies, or keep devouring fossil powers and quicken the world toward an awful end.

We trust we pick the main alternative. Clean vitality advances, in particular, sun based vitality, wind power, hydro power, biomass vitality, geothermal vitality, tidal vitality and wave power advances are enhancing quickly. The principle issue with these advances is that vitality created from these sources is hard to store or transport. Critical measures of power are lost while moving long separations on electric electrical cables. It is evident that a vitality transporter is required for these vitality sources, which will be hydrogen, giving its name to the new period coming soon—The Hydrogen Era.

Hydrogen can be delivered by various procedures, with no discharge of poisons and nursery gasses by any stretch of the imagination, and the expenses will be focused as the innovation enhances [1]. Hydrogen can convey vitality with no misfortune for many kilometers, requiring just a little pumping influence. There are a couple of various methodologies for hydrogen transportation and capacity. Traditional capacity frameworks comprise of established high-weight tanks and protected fluid hydrogen frameworks. Additionally hydrogen stockpiling in hydrocarbons is a customary strategy, yet it is out of our degree as it makes carbon dioxide emanation. Utilizing metal hydrides as a part of

Electrochemical batteries is an old and quickly enhancing strategy for hydrogen stockpiling. They are equipped for retaining and desorbing hydrogen with little weight varieties. usage of hydrides

is additionally a promising method for on-board hydrogen stockpiling. Another technique is the utilization of nanostructure materials, for example, carbon and boron nitride nanotubes, which are known not the property to store gasses inside their structure. The principle extent of this paper is to introduce the conceivable use of boron for hydrogen stockpiling.

II. LITERATURE REVIEW

The initially distributed exploration depicting the properties of these AB hydrogen rich materials was supported by extensive part by U.S. government organizations intrigued by boron based plane fuel. Ammonia borane was initially orchestrated and portrayed by Sheldon Shore in the 1950s amid his proposition research in Richard Parry's lab at the University of Michigan. They performed arrangement of shrewd test configuration to recognize the "puzzling" B₂N₂H₆ adduct, the supposed diammoniate of diborane (DADB), formed when smelling salts was blended with diborane. The same adduct to be shaped when an ammonium salt was blended with metal borohydride in fluid alkali. Past work had recommended that the response created an ammonium cation and the comparing diborane anion [NH₂(BH₃)₂]⁻ [NH₄]⁺.

III. METHODOLOGY

Ammonia Borane (AB, NH₃BH₃) is considered to be one of the most promising candidates for onboard hydrogen storage as it contains 19.6 wt% of hydrogen and is stable under ambient conditions. It decomposes thermally as well as hydrolytically [6] [7]. It thermally decomposes between 70°C and 112°C to yield polyiminoborane [NH₂BH₂]_n and hydrogen. In turn polyiminoborane decomposes over a broad temperature range about 110°C to approximately 200°C with further hydrogen loss, forming polyiminoborane [NHBH]_n and a small fraction of borazine [N₃B₃H₆]. The decomposition of [NHBH]_n to BN occurs at temperatures in excess of 500°C as such this final step is not considered for practical applications for hydrogen storage. The problems associated with AB are listed below.

1. Decomposition temperature of 100 °C which is slightly higher than the target value of 90 °C (Operating temperature of PEMFC [8])
2. Slow kinetics with long induction or warm-up period
3. Formation of unwanted species
4. Regeneration of AB from its decomposition products

Therefore it was decided to study thermal decomposition of AB initially to understand the problems associated with it and then develop an efficient method to lower the temperature of decomposition, enhance the kinetics and uppress the unwanted species formed during the decomposition.

Thermal decomposition of ammonia borane was studied at isothermal and non-isothermal conditions. Non-isothermal experiments were performed in a TG-DTA system whereas the isothermal experiments were performed in an indigenously developed Sievert's type apparatus [9]. Characterization of ammonia borane and the decomposition products was carried out using various techniques like XRD, FTIR, in situ GC-MS, GC. Further, zeolite-X, Cs exchanged K-chabazite, silicon nanoparticles and misch metal nanoparticles were added to AB as catalyst. The catalysts were characterized by various techniques like XRD, FTIR, HRTEM, Raman and UV-Visible spectroscopy. The decomposition of AB was then studied in the presence of these catalysts. The dehydrogenation behaviour of AB was improved on addition of these catalysts and the kinetics was also enhanced. The detailed kinetic analysis of thermal decomposition of AB was undertaken and a kinetic model for the same was proposed. The conclusions that are drawn from the experimental studies are listed below.

When AB was decomposed under non-isothermal conditions in a TG-DTA system, it was observed that it melts in the temperature range of 100 °C and 120 °C depending on the heating rate and decomposes forming solid residue and gaseous products. Figure 1 shows the TG and DTA curve for AB at various heating rates. The melting of the sample was seen as an endothermic event which shifted to higher temperature as the heating rate increased. Mass loss of the samples in TG-DTA studies was significantly more than the amount of hydrogen present in AB. In situ GC-MS results shown in figure 2 confirmed the formation of ammonia, borazine and some other volatile species along with hydrogen. Also it was seen that the decomposition of AB largely depends on the heating rate. Overall it was found that the decomposition of AB is an exothermic reaction.

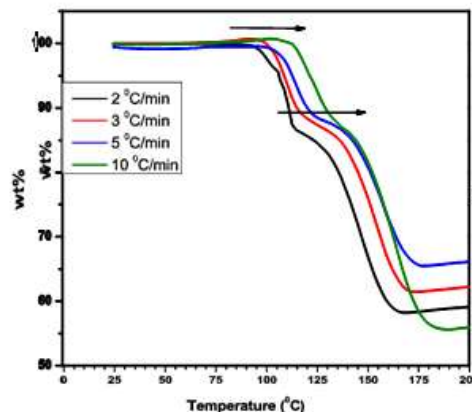


FIG 1 A: TGA of AB at different heating rates.

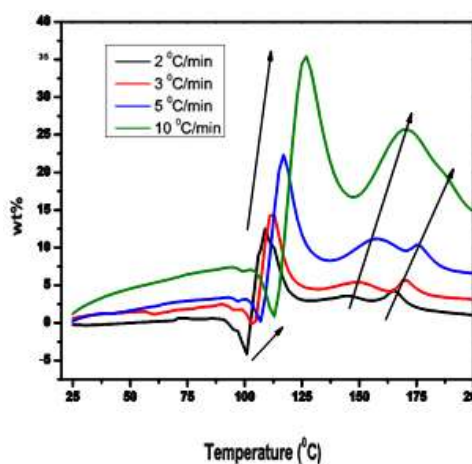


FIG 1 B: DTA of AB at different heating rates.

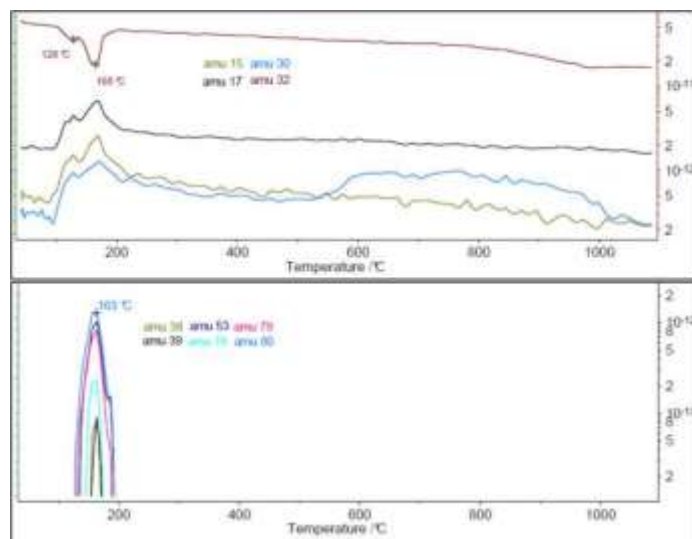


Figure 2 Mass Spectrum of evolved gases during TG of AB

Isothermal decomposition experiments on pristine AB were performed in the standard Sievert's type apparatus at various temperatures ranging from 90 °C to 180 °C. Long induction period of 125 min was observed in the isothermal decomposition of AB at 90 °C. At higher temperatures the induction period was negligible. At a fixed temperature the amount of gas released increased with time. Maximum amount of gas released in the isothermal experiments was 13.6 wt% for the experiment conducted at 180 °C. This amount is in well agreement with the theoretical expected value of about 13.5 wt%. Also it was observed that as the temperature increases the amount of gas released also increases. Figure 3 shows the isothermal decomposition curves for AB at various temperatures. It was confirmed by FTIR and GC that the gas released in isothermal experiments is hydrogen only and the

formation of ammonia, borazine and other volatile species observed in TG-DTA experiments was completely suppressed.

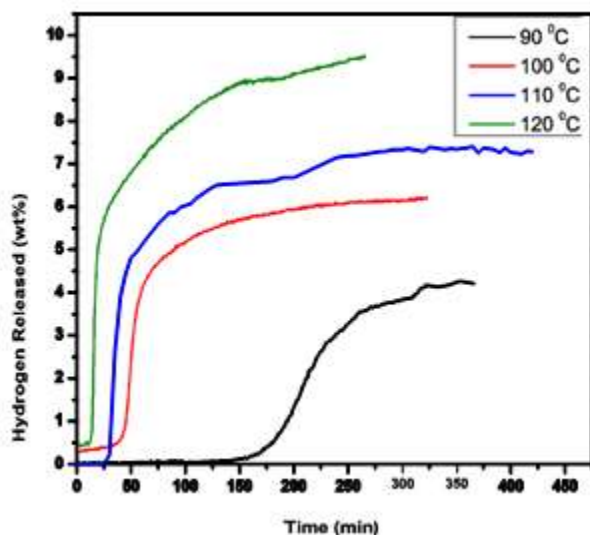


Fig 3 Isothermal decomposition curves for AB at various temperature.

One major conclusion that can be drawn from the decomposition studies of AB is that the isothermal experiments carried out in constant volume system produces only hydrogen. In the TG-DTA system the products of decomposition are immediately swept away by the purge gas and thus there is no time for chain branching or polymerization and thus the cyclization is favoured over these reactions and formation of borazine is observed. On the contrary, in case of isothermal decomposition carried out in a closed volume apparatus, the solid products of decomposition as well as the gaseous species remain in the same reactor and thus there is enough time for chain formation or polymerization releasing only hydrogen.

IV. CONCLUSION

1. Isothermal against non-isothermal decomposition

It is experimentally proven that isothermal decomposition of AB in a closed system produces only hydrogen and the formation of other volatile species, observed in case of non-isothermal decomposition, is completely suppressed.

2. Use of zeolites as catalyst

Usually zeolites are used as the templates for loading catalyst. This is the first ever report of using zeolite as a catalyst.

Future Scope:

1) Synthesis of silicon nanoparticles and use of silicon nanoparticles as catalyst

Successful synthesis of silicon nanoparticles by ball milling of silicon thin films is reported for the first time. Use of silicon nanoparticles as a decomposition catalyst is proposed and the results obtained are quite encouraging.

2) Silicon nanoparticles as hydrogen storage material

It is experimentally proven that silicon nanoparticles can be used as hydrogen storage material.

3) New kinetic model for thermal decomposition of ammonia borane

A new kinetic model is proposed for the thermal decomposition of ammonia borane. The model is based on the experimental data and the fundamental kinetic equations. It is proven that the proposed model best describes the kinetic behaviour of AB thermolysis

V. ACKNOWLEDGMENT

We pay our immense pleasure to acknowledge our President of Vignaharta Trust's Dr. Shivajirao S. Jondhle & Mrs. Geeta Khare for their great support as they provided us with huge facilities and also gave us such a great opportunity to express ourselves. We also like to appreciate our Prof. S V. Devkare as he inspired and motivated us at each and every step.

REFERENCE:

- [1] Shaijumona M M, Bejoy N, Ramaprabhu S., 2005, Catalytic growth of carbon nanotubes over Ni/Cr hydrotalcite-type anionic clay and their hydrogen storage properties. *Appl. Surf. Sci.*, Vol. 242, pp. 192-198.
- [2] Muthukumar P, Prakash M M, Murthy S S, Experiments on a metal hydride-based hydrogen storage device. *Int. J. Hydrogen Energy*, Vol. 30, pp. 1569-1581.
- [3] Vijay R, Sundaresan R, Maiya M P, Murthy S S., 2007, Application of nanostructured Mg-x wt% MnNi5 (x=10-70) composites in a hydrogen storage device. *Int. J. Hydrogen Energy*, Vol. 32, pp. 2390-2399.
- [4] Jain I P, Jain P, Jain A., 2010, Novel hydrogen storage materials: A review of lightweight complex hydrides. *J. Alloys. Compd.*, Vol. 503, pp. 303-339.
- [5] Gregory D H. 2008, Lithium Nitrides, Imides and Amides as Lightweight, Reversible Hydrogen Stores. *J. Mater. Chem.*, Vol. 18, p. 2321.
- [6] Brockman A, Zheng Y, Gore J., 2010, A study of catalytic hydrolysis of concentrated ammonia borane solutions. *Int J Hydrogen Energy*, Vol. 35, pp. 7350-7356.
- [7] Patel N, Fernandes R, Edla R, Lihitkar P B, Kothari D C, Miotello A., 2012, Superior hydrogen production rate by catalytic hydrolysis of ammonia borane using Co-B

- nanoparticles supported over mesoporous silica particles. Catal. Commun., Vol. 23, pp. 39-42.
- [8] Vishwanathan B, Scibioh M A., Fuel Cells. Hyderabad : Universities Press, 2006.
- [9] Ramaprabhu S, Natarajan R, Alaruch W,. 1998, Design and development of hydrogen absorption/desorption high pressure apparatus on pressure reduction method. Int J Hydrogen Energy, Vol. 23, pp. 797-801.
- [10] Jensen CM, Zidan R, Mariels N, Hee A, Hagen C. Int J Hydrogen Energy 1999;24:461-5.
- [11] Meisner GP, Tibbetts GG, Pinkerton FE, Olk CH, Balogh MP. J Alloys Compounds 2002;337:254-63.
- [12] Artz GD, Grant LR. US Pat. 4468263, August 28, 1984.
- [13] Ayers OE, Patrick RE. US Pat. 3948699, April 6, 1976.
- [14] Chew WM, Ayers OE, Murfree JA, Martignoni P. US Pat. 4061512, December 20, 1977.
- [15] Chew WM, Ayers OE, Murfree JA, Martignoni P. US Pat. 4064225.
- [16] Beckert WF, Barber WH, Dengel OH. US Pat. 4231891, November 4, 1980.
- [17] English WD, Chew WM. US Pat. 4315786, February 16, 1982.
- [18] Chew WM, Murfree JA, Martignoni P, Nappier HA, Ayers OE. US Pat. 4157927, June 12, 1979.
- [19] Cavalleri RJ. Hydrogen Energy Part B. Proceedings of Hydrogen Economy Miami Energy Conference, Florida, 1975. p. 677-84.
- [20] Hu MG, Geanangel RA, Wendlandt WW. Thermochem Acta 1978;23:249-55.
- [21] Wolf G, Baumann J, Baitalow F, Hoffmann FP. Thermochem Acta 2000;343:19-25.
- [22] Shore SG, Parry RW. J Am Chem Soc 1957;77:60845.
- [23] Shore SG, Parry RW. J Am Chem Soc 1958;80:12-5.
- [24] Schlesinger HI, Brown HC, Finholt AE, Gilbreath JR, Hoekstra HR, Hyde EK. J Am Chem Soc 1953;75:215-9.
- [25] Aiello R, Matthews MA, Reger DL, Collins JE. Int J Hydrogen Energy 1998;23(12):1103-8.
- [26] Kong VCY, Foulkes FR, Kirk DW, Hinatsu JT. Int J Hydrogen Energy 1999;24:665-75.
- [27] Amendola SC, Sharp-Goldman SL, Janjua MS, Spencer MS, Kelly MT, Petillo PJ, Binder M. Int J Hydrogen Energy 2000;25:969-75.
- [28] Amendola SC, Sharp-Goldman SL, Janjua MS, Spencer NS, Kelly MT, Petillo PJ, Binder M. J Power Sources 2000;85:186-9.
- [29] Aiello R, Sharp JH, Matthews MA. Int J Hydrogen Energy 1999;24:1123-30.
- [30] Huot, Liang G, Schulz R. J Alloys Compounds 2003;353: L12-5.