Quest Journals
Journal of Research in Environmental and Earth Science
Volume 5~ Issue 1 (2019) pp: 56-58
ISSN(Online) : 2348-2532
www.questjournals.org

Research Paper

Implementing Fuel Cells in Vehicles by Using Nanotechnology to Store Hydrogen

Aryaman Darda

Received 10 July, 2019; Accepted 28 July, 2019
Published with open access at www.questjournals.org

I. INTRODUCTION

As the natural energy sources deplete at an increasing rate, we need to rapidly materialize more sustainable sources of energy which can also be easily replenished. These new energy obtaining mechanisms include hydroelectricity, solar power, wind energy… But alongside energy generation methods, we need to develop energy storage mechanisms. Effectively and efficiently storing energy is as important as generating it sustainably.

Electric batteries currently serve as the most common means of storing energy for use in daily life. Low pollution cars – usually electric cars –employ batteries to story charge and later use these batteries to run their multiple systems. These batteries, however, pose numerous challenges – pollution while manufacturing, short life-span, below requirement power capacity, defects in electrodes, overused electrolytes, etc.

The hunt for energy storage mechanisms which can address the drawbacks of electric batteries brings us to fuel cells – electrochemical cells which use a fuel from storage (hydrogen in most cases) and convert the chemical energy stored in this fuel to more usable forms through redox reactions. These redox reactions, of course, require an oxidizing agent from the atmosphere.

Using fuel cells in energy efficient cars is a complex model currently under research. One of the barriers to the easy implementation of fuel cells in daily life is storing the fuel (hydrogen) – as hydrogen storage can be risky and costly. Another barrier is retrieving this stored fuel and oxidizing it in the cell.

As I looked for a solution to these problems, I came across nanomaterials, which have proven to be effective in addressing the barriers to implementation of sustainable energy. Thus, over the course of this paper, I plan to explore how we can effectively use nanomaterials to store hydrogen for fuel cells. This paper will primarily deal with methods of synthesizing those nanomaterials, how hydrogen can be stored in them, and how these materials will make it easier to retrieve the stored hydrogen and oxidize it in the cell.

Synthesis of Required Nanomaterials

Some of the nanomaterials from which hydrogen storage mechanisms can be synthesized are carbon nanotubes, nano-magnesium based hydrides, complex hydride/carbon nanocomposites, boron nitride nanotubes, alanates, polymer nanocomposites, metal organic frameworks, and lithium nitride. I will elaborate upon the important ones in this section.

Carbon nanotubes are gaining increasing importance in the materials industry so I will address the process of their synthesis. Carbon nanotubes can be most easily synthesized using chemical vapour deposition – CVD. However, as CVD may sometimes be polluting due to release of harmful gases, non-catalytic methods of making carbon nanotubes are gaining increasing importance.

Advanced complex hydrides are other materials which can be used to store hydrogen especially for use in vehicles. Lithium nitride particles are also popular. [1]

These nanomaterials should be in the form of tubes of high surface area. Hydrogen should be easily retrievable from them. For doing this, we should be able to control the sorption characteristics of nanomaterials as we use them.

To synthesize such materials, the most common technique is to use a solvent (liquid ammonia in most cases) for introducing metals and nitrogen into carbon nanoparticle pockets and make nano-confined lithium nitride particles. Other features that need to be controlled while manufacturing are storage capacity, enhancing bulk absorption of hydrogen, and easy retrieval. By using catalytic doping, it is possible to increase the hydrogen storage capacity and reduce the temperature at which it can be retrieved form the tubes, thus making reaction kinetics easier and more feasible.[2]

Mechanism of Hydrogen Storage in Nanomaterials

According to the results of the experiments carried out at Sandia National Laboratories, nano-confinement is the best and easiest method to increase hydrogen storage capacity in nanomaterials. Their research has shown that lithium nitride absorbed hydrogen and also released it faster than other bulk materials used to store hydrogen.

The phenomenon of hydrogen storage can be simply explained using the concepts of surface chemistry. The hydrogen gets adsorbed on the surface of the nanomaterials. More the surface area, more the amount of hydrogen stored. Under proper thermokinetic conditions, we can initiate the process of desorption, which will erode hydrogen from the surface and implement it in fuel cells. [3]

However, the mechanism to do so may sometimes be complicated and may result in reduced efficiency. Currently, low metal surface temperature is needed for adsorption and high metal surface temperature is needed for desorption. Poor heat transfer in these storage metals also leads to interrupted and uncontrolled gas release which leads to improper functioning of the fuel cell.

However, I came across an efficient alternative mechanism to implement this idea.Nanomaterials shorten diffusion distances for hydrogen particles and make the exchange easier. The heat transfer capacity improves as discontinuity in nanomaterials decreases. Nanomaterials also result in increased porosity and have smaller size. As a result, the new surface energies due to nanoscale properties lower release temperature. This makes it cheaper and easier to store and retrieve hydrogen for burning in fuel cells in vehicles. [Ibid (2)]

How this Idea Can Improve Vehicles

The biggest issue with manufacturing sustainable cars – and sustainable vehicles by extension – is the weight of the fuel used, which ultimately adds to the weight of the vehicle. A large part of a vehicle's storage capacity is lost as one compensates for the weight of the fuel.

Hydrogen, however, is a light weight gas. The nanomaterials based storage tanks will also be light. And since the other half fuel (besides hydrogen) of the fuel cell – oxygen – doesn't need to be stored as it is directly captured from the atmosphere, the storage weight is considerably reduced, making fuel cell vehicles – cars and buses – more cost effective and efficient. [4]

Other benefits of fuel cell based vehicles over electric vehicles include reduced maintenance requirements. The average life of a fuel cell and nanomaterial based hydrogen storage tank is way longer than that of a battery used to run motors in electric cars and buses.

When compared to internal combustion engine vehicles, fuel cells don't release harmful gases and thus make transportation more sustainable. [Ibid (1)]

Working Mechanism of Fuel Cells

$$H_2 + \frac{1}{2}O_2 \rightarrow H_2O + \text{Electricity} + \text{Heat.}$$

Fuel cells comprise of anodes, cathodes, and electrolytes. For the fuel cell installed in a car, the anode will take up oxygen from the air, use it to oxidize the hydrogen retrieved from the nanomaterials storage, and split the hydrogen into protons and electrons. The protons would move toward the cathode, while the electrons can flow through the external car systems and produce enough electricity to run them. [Ibid (2)]

II. CONCLUSION

Developing sustainable mechanisms to usein daily life is an important part of addressing the global climate catastrophe. Electric vehicles which operate on batteries can reduce emissions but simultaneously pose challenges like insufficient charge storage capacity and high maintenance costs. Fuel cells clearly have the potential to solve this problem along with addressing the other problems.

Fuel cells will provide more energy than batteries and make electric vehicles lighter. The core issue of using fuel cells – hydrogen storage – can be addressed by using nanomaterials to store hydrogen.

DOCS FOR CITATION

[1]. “Researchers use confined nanoparticles to improve hydrogen storage materials performance”, by Sandia National Laboratories, February 24, 2017,https://phys.org/news/2017-02-confined-nanoparticles-hydrogen-storage-materials.html
[2]. “Nanomaterials for Hydrogen Storage Applications: A Review”by Michael U. Niemann, Sesha S. Srinivasan, Ayala R. Phani,Ashok Kumar, D. Yogi Goswami, and Elias K. Stefanakos, September 21, 2008, https://www.hindawi.com/journals/jnm/2008/950967/
[3]. “Nanomaterials for Hydrogen Storage” by CS Sunandana https://www.ias.ac.in/article/fulltext/reso/012/05/0031-0036
[4]. “Production and Storage of Hydrogen Using Nanotechnology” by Will Soutter, August 7, 2012, https://www.azonano.com/article.aspx?ArticleID=3067

Aryaman Darda" Implementing Fuel Cells in Vehicles by Using Nanotechnology to Store Hydrogen" Quest Journals Journal of Research in Environmental and Earth Science, vol. 05, no. 01, 2019, pp. 56-58