

Storage Of Hydrogen Through Carbon Nanotubes

*Prof. Dileepkumar K. Nayak, **Mrs. Usha Raghavan

V.P.M.'s Polytechnic, 'Jnanadweepa', Chendani, Bunder Road, Thane – 400601, MS, India.

dknayak_vpm@rediffmail.com, usha63mr@yahoo.com

ABSTRACT

The ever-growing demand for energy and rising concern of environmental pollution caused by the use of conventional fossil fuels, call for new and clean fuels. Among all kinds of energy sources, hydrogen is the best choice as a clean fuel. The advantages of hydrogen as energy sources lies in the fact that its byproduct is water, and it can be easily regenerated. Unfortunately, owing to the lack of a suitable storage system satisfying a combination of both volume and weight limitations, the use of hydrogen energy technology has been restricted from automobile application. Therefore, to implement hydrogen energy for electrical vehicles, the first step is to look for an economical and safe hydrogen-storage medium. Recent reports on very high and reversible adsorption of hydrogen in nano- structured carbon materials such as carbon nanotubes, graphite nanofibers, and alkali-doped nanotubes have stimulated many experimental works and theoretical calculations worldwide. Experimental results demonstrate that nanostructured carbon materials have relatively high gravimetric hydrogen storage capacity; however, owing to the low apparent density of carbon nanotubes and nanofibers, one doubts whether their volumetric hydrogen storage capacity could meet the volumetric target value.

1. INTRODUCTION

As technology is advancing, consumption of power is steadily rising. In this advanced technical era, with the programmes of large scale industrialization, increased agricultural activities, increased and intensive use of electrical and electronic gadgets, mechanization of manufacturing processes, the demand of power in our country is increasing at a rapid rate and there is a large gap between demand for and supply of power. Coupled with this, the increased use of sophisticated electrical and electronic equipments, quality based control systems have forced us to think seriously about **Power Quality** and **Energy Conservation**.

At present most of the energy demands are met by fossil, hydel and nuclear fuels. Fossil energy sources are finite and excess use of it is environmentally hazardous. Nuclear energy is seen as a long term, clean, attractive, high technology solution to the world's energy problems. The nuclear waste disposal threat of accidents has raised doubts and fear about its large-scale use alternative to fossil fuels.

The undesirable effects of pollution both from burning fossil fuels and from nuclear waste by-products has in turn led to many problems being found today such as ozone depletion and global warming.

The increased power demand, depleting fossil fuel resources and growing environmental pollution have led energy hungry world to think seriously for other sources of energy for future survival and for reducing environmental pollution.

* Principal, V.P.M.'s Polytechnic, Thane

** The author is doing research in nanotechnology at National Chemical Laboratory, Pune with Dr. Murali Sastry as the Guide.

While energy surrounds us in all aspects of life, the ability to harness it and use it for constructive and economically is the challenge before mankind. Therefore, alternative energy sources such as solar, wind, tidal, biomass, fuel cell; etc. have become very much important and relevant in today's world.

Since India is one of the few countries with over 300 sunny days annually and plenty of sunshine, the areas where high intensity of solar radiations are available, solar power plant is a good option for electrification. It can be used variedly for domestic, street lighting, cooking, heating, drying, etc. Energy can also be extracted from tides and wind. Biogas derived from biomass is expected to become one of the key energy resources for global sustainable development. It is particularly useful for village household that have their own cattle as well serves fuel for cooking. Fuel cells, directly convert hydrogen or hydrogen-rich fuel into electricity without combustion. Hydrogen being a clean fuel and efficient energy carrier, it should be considered to be a potential alternative to fossil fuels. It provides a clean electricity and heat energy. Small hydropower can serve energy needs to rural areas independently.

2. ENERGY SCENARIO – INDIAN CONTEXT

Existing Energy Supply

Thermal	70%
Hydro Power	24%
Nuclear	2.50%
Renewable Sources	3.50%

For a progressive country, the annual power requirement increases by 10%. With the cost components and project developments involved the process of meeting increased demands is becoming difficult.

The above energy scenario indicates that there is a need for alternate energy sources. Research is going on to explore the other efficient source and one of them is Hydrogen. Hydrogen economy will mean a world where all the pollution problem are solved and where our need for abundant and affordable energy is secure.

Dr. Ed Bittner explains, if hydrogen gas becomes the fuel of the future, it will be better for the environment because when it is burned, the product is water.

In this presentation we would like to highlight, the storage of Hydrogen through carbon nano tubes. Hydrogen is the lightest and most abundant element in the universe. In its pure form, hydrogen is colorless and odourless gas. It is an energy carrier, not an energy source it stores and delivers energy in usable form. However, since it combines easily with other elements, hydrogen is rarely found by itself in nature.

2.1 Production Of Hydrogen

The various technologies that are involved in the production of hydrogen are

- Thermo Chemical process.
- Electrolytic process.
- Photolytic process.

Thermo Chemical Process:

- 1) Steam Methane Reforming: - High temperature steam is used to extract hydrogen from any methane source. This is the most common method of producing hydrogen.
- 2) Partial Oxidation: - Methods are being explored in which simultaneously oxygen is separated from air and partially oxidizing methane to produce hydrogen.
- 3) Splitting water using heat from a solar concentrator.
- 4) Burning to generate gas, which is then reformed to produce hydrogen.

Electrolytic Process:

Electricity is used to separate water (H₂O) into hydrogen and oxygen.

Photolytic Process:

In this, Sunlight is used to split water. Two photolytic processes are being studied.

- 1) Photo biological methods: - This involves the exposure of microbes to Sunlight, split water to produce Hydrogen.
- 2) Photo Electrolysis: - Here, Semiconductors, when exposed to Sunlight & immersed in water, generates enough electricity to produce hydrogen by splitting water.

Thus Hydrogen can be produced in large scale and transported or locally produced depending on the method used. The delivery infrastructure for hydrogen will require high-pressure compressors for gaseous hydrogen and liquefaction for Cryogenic Hydrogen. These methods have significant capital and operating costs. They also have energy inefficiency associated with them.

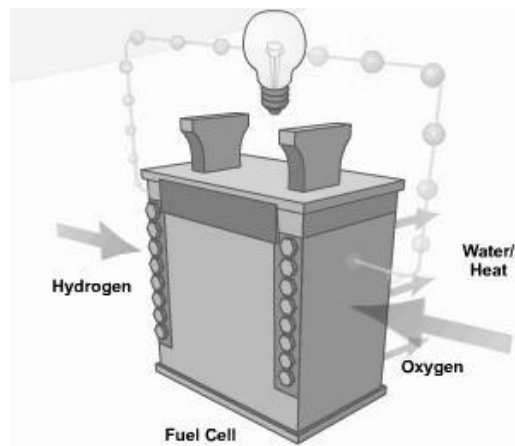


Figure 1: Fuel Cell

2.2 Storage Of Hydrogen

- Various technologies are available for the storage of hydrogen.
- High pressure tanks: Hydrogen gas can be compressed and stored in storage tanks at high pressure. These tanks must be strong, durable, light weight and compact.
- Liquid Hydrogen: It can be stored as liquid but has to be kept at cold.
- Hydrogen combines with some metals which can result in higher storage capacity compared to high pressure gas or liquid.

- Carbon Nanotubes can store hydrogen.

2.3 Challenges

For transportation, the overloading technical challenge for hydrogen storage is how to store the amount of hydrogen required for a conventional driving range, within the vehicular constraints of weight, volume efficiency, safety and cost. The performance lifetime durability of these systems must also be verified and validated. The main challenges are:

- **Weight & Volume:** - The weight and volume of hydrogen storage systems are presently too high.
- **Efficiency:** - Energy efficiency is a challenge for all hydrogen storage approaches.
- **Durability:** - Materials and components are needed that allow hydrogen storage systems with a lifetime of 1500 cycles.
- **Refueling Time:** - There is a need to develop hydrogen storage systems with refueling times being very low.
- **Codes and Standards:** - Codes and Standards for hydrogen storage systems and interface technologies which will help commercialization and implementation on a large scale and assure safety, have not been established.

2.4 Carbon Nanotube Fabrication

Many new methods use carbon as a storage medium and bring us a step closer to the widespread use of hydrogen as a fuel source. Scientists are using various approaches to shape carbon into microscopic cylindrical structures known as nanotubes.

The first method of producing nanotubes uses an electric arc to vaporize a metal-impregnated carbon electrode. The second method uses a laser to vaporize a heated carbon target that has been treated with a metal such as nickel, cobalt or iron.

The third method is known as catalytic chemical vapor deposition (CCVD), and researchers at Washington University in St. Louis believe this is the most promising approach. In the CCVD technique, a heated metal element breaks down a hydrocarbon gas (such as methane, ethylene, acetylene, etc.) into carbon and hydrogen. The hydrogen gas is released while the carbon is extruded as a nanofiber. The advantage of CCVD is that it is a low-temperature technique and is suitable for large-scale production.

2.5 Storage Of Hydrogen In Carbon Nanotube

One of the critical factors in nanotubes' usefulness as a hydrogen storage medium is the ratio of stored hydrogen to carbon. According to the US Department of Energy, a carbon material needs to store 6.5% of its own weight in hydrogen to make fuel cells practical in cars. Such fuel cell cars could then travel 300 miles between refueling stops.

Researchers at MIT claim to have produced nanotube clusters with the ability to store 4.2% of their own weight in hydrogen. In recent months, scientists from the National University of Singapore have released figures for nanotubes and nanofibers that can store 10-20% of their weight in hydrogen. These results, when combined with new car manufacturing technologies have the potential of transforming our transportation industries.

Single-walled carbon nanotubes are remarkable forms of elemental carbon. Their unique properties have stimulated the imaginations of many scientists and engineers to propose a wide range of applications.

Nanotubes do have a dramatic visual impact. If beauty rests on symmetry, nanotubes have inherent beauty. Further, their cylindrical structures led to suggestions that they would be ideal gas storage materials. The appearance of these potential storage materials conveniently coincided with the revivification of interest in the hydrogen economy. The potential for coupling carbon-based storage materials to supply pure hydrogen to automotive fuel cell power plants was quickly seen. Initial reports of experiments showing high levels of hydrogen storage were encouraging. Theoreticians were then quick to calculate the possible amounts of hydrogen that could be stored using arrays of tubes of various sizes and packing parameters. Since the appearance of the initial reports, the results have been varied and controversial. Some are higher, some lower; some imply physisorption, and some chemisorption. It is clear that storage is a complex issue, partly because the materials are more far complex than the visual comprehension of the single ideal nanotube would allow.

Studies have been conducted and it has been found that purified Multi walled carbon nanotubes (MWNT) can be used for bulk storage of hydrogen. Multi walled carbon nanotubes have been synthesised by catalytic decomposition of hydrocarbon using a floating catalyst method. The mean diameter of the MWNTs was found to be 5.1 nm. The MWNTs are then purified and hydrogen storage techniques are used. It is found that the gravimetric hydrogen storage capacity of purified MWNTs is much higher than that of as-prepared one which means that purification process is very important for hydrogen storage. This could be attributed to the fact that there is more exposure to more surfaces of the multiwalled nanotubes. The ends were seen to be opened up. This allowed hydrogen to more easily move into the hollow core of MWNTs.

XPS spectra of C1s of the purified sample is narrower and has no notable peak in the range of high electron binding energy. This indicates that the sample is in simple chemical state. This simple chemical state of C and lower oxygen contained groups correspond higher hydrogen storage capacity of carbon nanotubes.

There are many questions that must still be answered regarding nanotube hydrogen storage: How do we make the process more efficient at lower temperatures in order to increase supply and decrease cost? What is the capacity loss with each storage cycle? Can other forms of carbon produce the same results just as effectively? What additional applications can increase demand and research into nanotubes?

REFERENCES

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