CHAPTER I
INTRODUCTION

Main problems of fossil fuel are that they are non-renewable energy and create pollutant emissions. Therefore, new energy sources have been the topic of interests in last decade. Hydrogen, one of those interests, is a promising alternative fuel since it can be used completely pollution-free and can also be found in numerous materials, *e.g.* natural gas, methanol, coal, biomass and water. It can be used to provide energy either combustion or chemical reaction, as in the case of the hydrogen fuel cell.

Fuel cell vehicles can run cleanly and efficiently on hydrogen, however, supplies of that hydrogen fuel are not widely available like fuel gas and gasoline. For fuel cells to be accepted throughout the global market, end-consumers need to fill up their fuel tank conveniently as they used to be. Consequently, the technology to produce high-capacity hydrogen storage systems has been the subject of extensive research, but a critical problem of hydrogen storage is its low energy density.

There are several hydrogen storage methods, for examples, in the forms of compressed gaseous hydrogen, metal hydrides and liquid hydrogen. However, these techniques are too bulky, heavy, dangerous and/or expensive for practical transport applications and also do not achieved the target of the Department of Energy (DOE) in the USA. DOE has set the target for on-board hydrogen energy density on a fuel cell vehicles at 6.5 wt% H_2 and 62 kgH_2/m^3, or about 3.1 kg of H_2 for a 500 km/fill-up (Deluchi, 1992). Recently, there is a new medium acquired a massive of interest of researchers and scientists. It is carbon nanotubes that may offer a potential solution to this problem.

Carbon nanotubes are long, thin and hollow cylinders, which can be viewed as rolling up seamlessly of graphite layers. They can be either multi-walled tubes or single-walled tubes. They have a unique structure that is very high strength in the combination with low weight and high thermal stability. Depending on the carbon atom arrangement, nanotubes can be whether insulators, semi-conductors or conductors. Potential applications include gas storage materials, materials for manipulation of nanostructures, filler for conductive plastics and high power electrochemical capacitors.

More recently, carbon nanotubes have been reported to be a more effective material for H_2 uptake, *i.e.* they come close to the target densities and operate near room temperature. There are several procedures to uptake H_2 on treated or untreated carbon nanotubes requiring high pressure or sub-ambient temperatures such as alkali-doped or unpurified carbon nanotubes. Nevertheless, the DOE energy density target has not been reached yet. Furthermore, high values of sorption from many groups are the controversial topic on reliability regarding numerous possible errors in experiments and lacking of complete information on experimental methods.

In this study, a constant volumetric isothermal adsorption apparatus for hydrogen was set up. The volumes of manifold and sample cylinder of the apparatus were determined. Two different carbon materials, multi-wall carbon nanotubes and activated carbon, were used as adsorbents and references to study and verify the potential of carbon nanotubes as a hydrogen adsorbent, at pressure ranging from 140 psia to 1040 psia and a constant temperature of 298 K. The effect of the difference in amount of adsorbent, calculated equilibrium time and measuring procedure were examined. Moreover, to make trustworthy sorption values, correction of actual pressure readings with feasible leaking hydrogen, controlling temperature during experiments and standard deviation of calculated data must be attended and reported in this study. The BET, TEM, XRD and Raman spectroscopy were also employed to characterize the carbon materials in order to relate between the nanostructure and hydrogen storage efficiency.