

# ON THE HIGH DENSITY HYDROGEN FILMS ADSORBED IN CARBON NANOSPACES

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## ABSTRACT

The commercialization of hydrogen-powered fuel cell cars, with their environmentally friendly emissions, provides an opportunity to replace current gasoline powered vehicles.

The main drawback of hydrogen as a fuel is the low density at ambient temperatures. The gas needs to be compressed to high pressure or kept under cryogenic temperatures to achieve reasonably long driving ranges. These obstacles can be overcome if the tanks are filled with a porous material that adsorbs a high volume of hydrogen. Many materials are put forward for this purpose, such as metal organic frameworks (MOFs) and engineered carbon nanospaces (synthetic carbon). To get a better understanding of the materials performance, an attempt was made to analyze the properties of the adsorbed hydrogen film. High pressure hydrogen isotherms at cryogenic temperatures (77 K, 50 K) have been studied to estimate adsorbed film properties such as density and thickness. Furthermore, how isosteric heat of adsorption, surface chemistry, and pore size distribution affect the adsorbed film has been investigated. At supercritical temperatures and high pressures, a film density 20% higher than liquid hydrogen at 1 bar and 20 K was obtained. These densities are independent of the isosteric heat of adsorption or pore size distribution. The adsorbed film densities behave similarly for all carbon-based surfaces at 77 K.

Additionally a new method was developed to estimate specific surface areas of gas storage materials from high pressure isotherms and tested against the BET theory. The new

method does not require knowledge of the packing fraction or cross-sectional area of an adsorbed molecule in the film. In most cases the new method leads to surface areas comparable to those found using BET theory if cryogenic high pressure isotherms are used.

A new manometric (Sieverts type) adsorption instrument was designed and test, capable of measuring sub- and supercritical hydrogen isotherms at high pressure.