INVESTIGATION OF ELECTROCHEMICALLY HYDROGENATED CARBON NANOTUBES

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Introduction

The fundamental problem of hydrogen energy is connected with creation of effective systems for hydrogen storage. Therefore, searching of the new materials capable to interact reversibly in a wide interval of temperatures, pressures and electrochemical potentials with hydrogen is necessary. Hydrogen sorption by carbon nanotubes (CNT), which are chemically stable, have a great surface area, insignificant weight and are rather inexpensive, is one of the ways to solve this problem. The above-mentioned properties make them an ideal material for hydrogen storage [1, 2]. Besides, carbon nanomaterials possess internal cavities which can be filled by hydrogen under certain conditions. In this case, not only superficial, but also volumetric sorption takes place that leads to increase in a degree of filling of a material by gaseous substance. Experimental works show a basic opportunity of hydrogen storage by carbon structures [3]. At present time intensive searches of ways of increase hydrogen-carbon ratio take place, in order to proceed at accumulation up to practically comprehensible level, for application in fuel cells for vehicles or the big and small stationary power.

The majority of experiments on filling carbon nanostructures is spent at high gas pressures [4, 5]. It is necessary to provide penetration of molecules of hydrogen into the smallest pores in carbon nanostructures. The alternative way of filling of carbon nanostructures is connected with the use of electrochemical processes [6]. In that case, penetration of molecules into pores is provided due to the influence of an electric field on the charged particle. It is known, that using an electrochemical method, lithium was intercalated into carbon [7]. Considering, that the size of atom of hydrogen is comparable to that of atom of lithium, it is possible to assume that use of an electrochemical method will allow filling interplane spaces of multiwalled CNT, that can give the additional contribution to absorbing capacity of carbon nanotubes.

Results and discussion

In the given work results of investigation of hydrogen interaction with carbon nanotubes during their electrolytic hydrogenation in a water solution of a sulfuric acid are presented. Carbon nanotubes were synthesized by catalytic pyrolysis of the granulated polyethylene in helium atmosphere on a nickel plate [8]. The morphology and geometrical parameters of carbon nanomaterial were investigated by TEM. It has been established, that during synthesis “bamboo”- type and “fish bone”-type carbon nanotubes are formed (Fig.1). Nanotubes are a few microns in length, with outer diameter ranging between 40 – 50 nm and inner channels varying between 9 - 20 nanometers. HREM images obtained from nanotube walls reveal that these consist of open ended conic segments. The fringe spacing is 0,34 nm. The main feature of these type of nanotubes is that the majority of their external and internal edges are open, that can essentially simplify process of hydrogen intercalation and other elements (for example, Li, K, Ca) in interplane space of nanotubes.

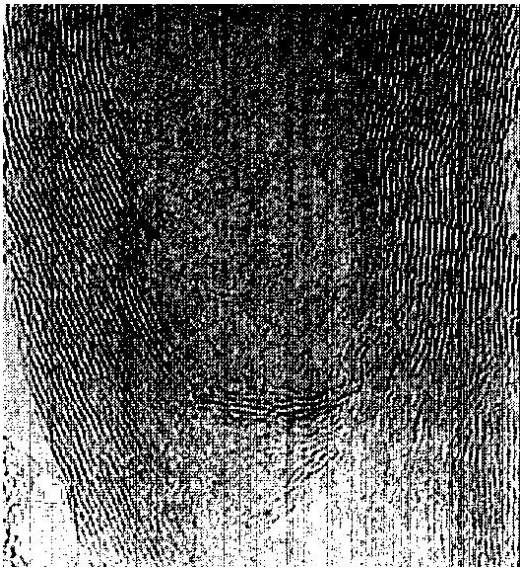

Fig.1. Fragment of carbon nanotube.

Hydrogenation of CNT was carried out by the electrochemical method in a three-electrode cell on the basis of potentiometric complex Ecotest-VA. As a working electrode the sample with carbon nanotubes grown up on a nickel plate was used. The platinum foil served as an auxiliary electrode, Ag/AgCl electrode was used as a reference electrode. The NMR-method was applied to study the obtained samples. It has been found, that hydrogen adsorption on the surface of carbon nanotubes from hydrocarbonic plasma occurs directly during their growth (Fig.2). Besides, the essential increase of amplitude of a signal after electrochemical filling of carbon nanotubes by hydrogen was observed. The application of a method of electrochemical hydrogenation of CNT for their use as accumulators of hydrogen is discussed.

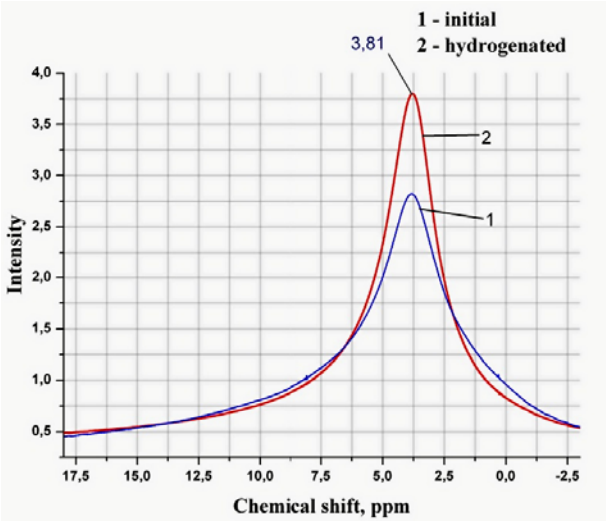

Fig. 2. NMR - spectrums of initial and hydrogenated CNT.

Acknowledgements

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