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Cobalt Carbide Nanofibers Produced by Mechanosynthesis and Quenching

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Introduction.

Interest in applications of carbon nanotubes has been growing since the apparition of these macromolecules.

It has been known for a long time **[1]**, that carbon filaments are grown from carbon containing gases in the presence of metal particles as a consequence of a catalytic reaction.

In the last decade several researchers look for a method to produce big amounts of carbon nanofibers and to control their properties in order to use them, mainly in petroleum and electronic industries **[1]**.

In most important studies in the area **[2]**, several metals, like Fe, Co, Ni, Mo, were used to catalyze the growth of carbon nanofibers, and the conclusion of some of these works was that the formation of them, depends upon a nucleation and growth process from a metal carbide. However, in the quoted works, no mention has been made about crystalline structure of metal carbides involved in the catalytic process.

Another important conclusion was **[2]** that metal particles used in these experiments, must be nanosized and with a strong magnetic properties.

Although the carbon is comparatively inert at room temperature, at higher temperatures it forms carbides with many elements, particularly with metals and metals like elements.

The purpose of the present work was to produce nanocrystalline cobalt carbide by metallurgical methods and to study the possibility of using such carbide for production of carbon nanofibers.

Mechanical Alloying was used to prepare cobalt carbide. Microstructure characterization of samples was performed by XRD and TEM methods. The cobalt carbide was quenched during 10 minutes at 800°C in order to produce cobalt carbide nanofibers.

The X-ray diffraction patterns (XRD) of elementary, mechanically alloyed and heat treated powders are shown in Fig. 1. The starting powder of cobalt is a mixture of the fcc and hcp structure i (figure 1a). The structure of carbon is cubic and an amorphous region is present too (figure 1b).

In figure 1c) XRD pattern of 15h milled powders is observed. In this pattern an orthorhombic structure is present, and a cobalt carbide is formed with a stoichiometry Co_3C.

In figure 1d), the XRD pattern of heat-treated sample is observed, peaks corresponding to carbon and cobalt are separated from those of orthorhombic cobalt carbide. This fact indicate the nucleation of metallic particles as well as the formation of some carbonic structures. It is particularly important to notice that in the case of cubic carbon peaks, planes (220) and (422) appear at 800°C and 1000°C, but they are not present in figure 1b).

Figure 2a) illustrate bright field electron transmission micrographs of cobalt carbide produced by MA and in figure 2b) the corresponding electron diffraction pattern.

The carbide heat treated at 800°C can be observed in figures 3a)and 3b). In this sample a small amount of nanosized cobalt carbide fibers was present. An important characteristic in those nanofibers is the fact that cobalt nanocrystals covered its surface

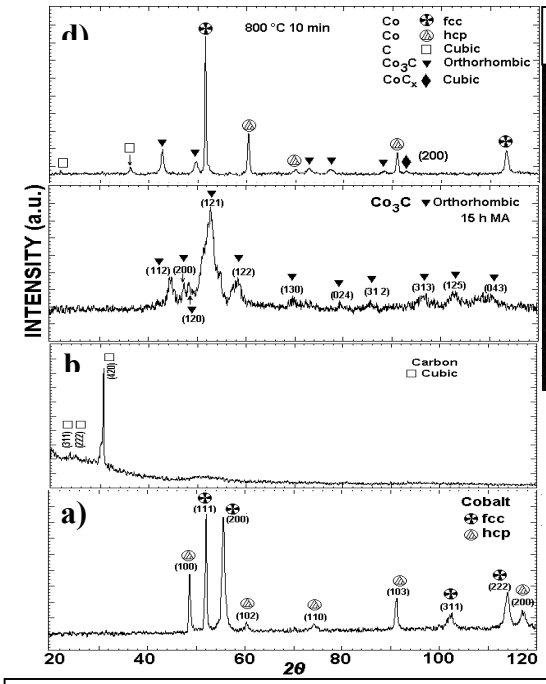

Figure 1. X-ray diffraction patterns of :
a) elementary **, b)** mechanically alloyed and **d)** heat treated powders.

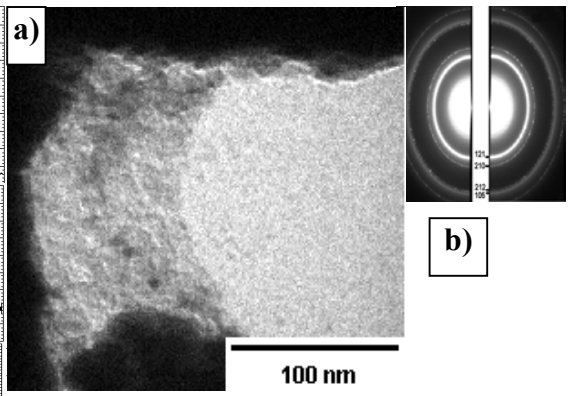

Figure 2. a) The orthorrombic cobalt carbide produced by mechanical alloying and **b)** the corresponding electron diffraction pattern

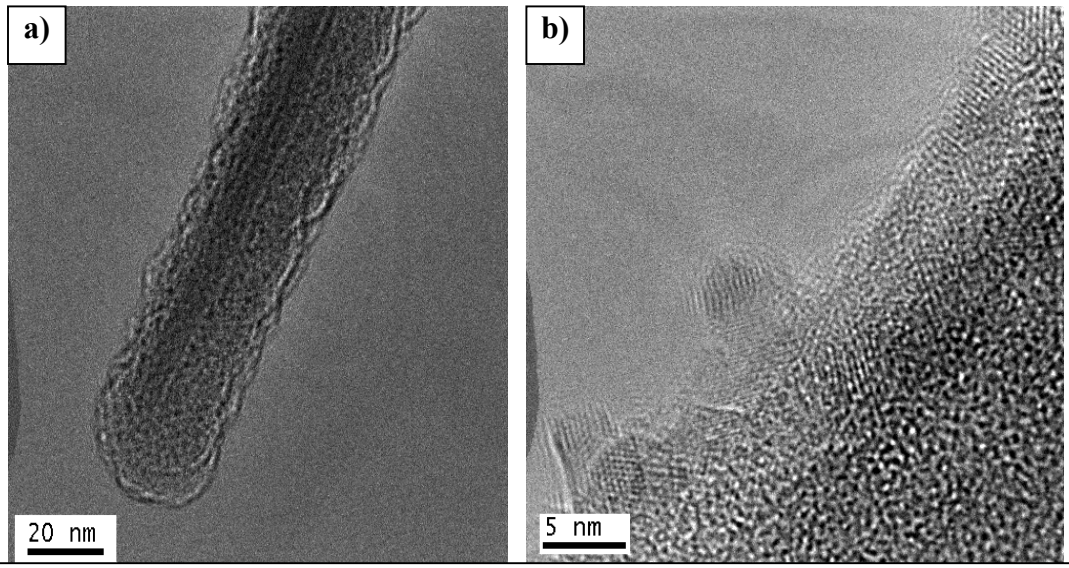

Figure 3. a) Cobalt carbide nanofiber and **b)** its surface. Cobalt crystals were observed.

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