SYNTHESIS OF CARBON NANOTUBES ON THE SURFACE OF CARBON FIBERS

Bogolepov V.A., Schur D.V., Adeev V.M., Golovchenko T.N., Voronaya T.V., Kotko A.V., Lysenko E.A.*

Institute for Problems of Materials Science of NASU,
3, Krzhyzhanovsky st., Kyiv, 03142 Ukraine
Fax: 38(044) 424-0381; E-mail:shurzag@ipms.kiev.ua

Introduction

Pyrolytic method is the most widespread technique of carbon nanostructures synthesis. Simplicity of technological equipment, significant deposition rate, low fabrication cost, control over properties and chemical flexibility are a driving force of this method. Synthesis of various nanoproducts is successfully performed by the pyrolytic method.

The size and shape of synthesized particles are of essential fundamental and applied interest as they define micro (electron and quantum) as well as bulk behavior of the system. Dependence of these parameters on the process conditions is crucial in optimization of the generated structures. Critical parameters of the process are profiles of chemical, dynamical and thermal properties of reacting gases (type of gas, composition, flow rate, gas pressure, direction of convective streams, angle of the reactor axis relative to horizon and temperature gradient in the reactor) and chemical composition of a catalyst. The latter affects chemical composition of the product. The product purification from metallic catalysts is a serious problem.

In the present work authors have synthesized carbon nanotubes (CNT) on the non-metallic substrate by the pyrolytic method using nonmetallic catalysts.

Results and discussion

The studies were performed on a pyrolytic setup with a vertical reactor. This installation makes it possible to install the reactor at any angle to horizon.

The change in the angle of the reactor position (γ) allows the change in the effect that processes conditioned by both convection and gravitation has on the nanostructures formation.

Carbon microfibers 5-15 μm in diameter were used as a nonmetallic substrate. Before synthesis these fibers were saturated with metal-free catalysts. Gas mixture of acetylene and helium was used as a precursor. The synthesis was carried out in the temperature range from 350 to 800 ^{o}C.

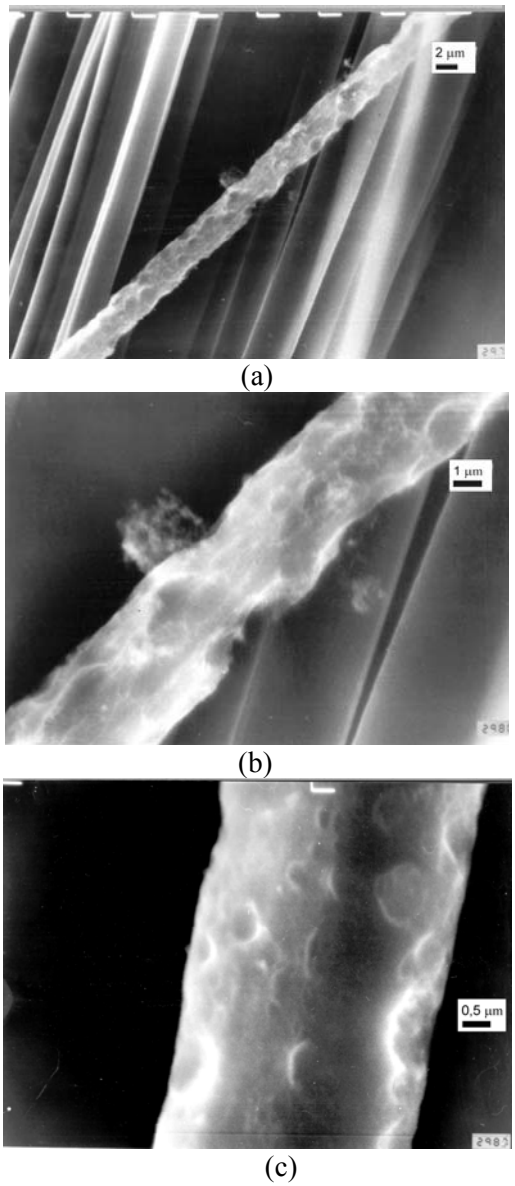


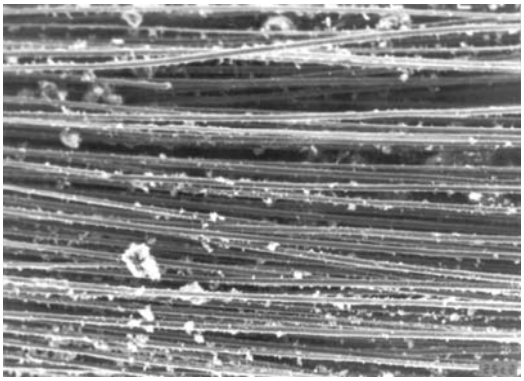
Fig.1. Carbon fibers with surface defects formed as a result of action of unfortunate choice catalyst (a – ×5000; b – ×10000; c – ×20000).

Different organic compounds, their mixtures and fullerene solutions were used as nonmetallic catalysts. The mixture 2355 containing up to 2 g of fullerenes per liter of toluene with other admixtures proved to be optimal. The use of this composition did not cause the fibers erosion (Fig.1) and allowed the control over geometric

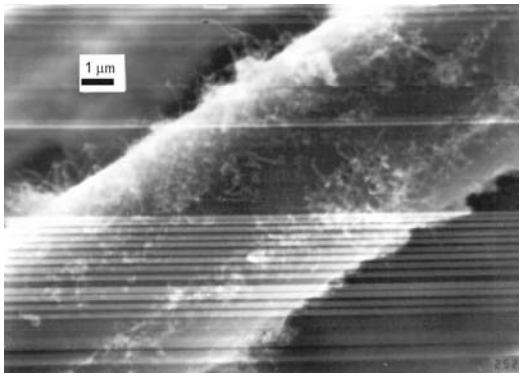
sizes (Fig.2) of carbon nanotubes and fibers (Fig.3) using technological conditions.

The prolonged process of synthesis brings about the formation of nanofibers up to 100-200 nm in diameter and tens of micrometers in length.

Our design of the reactor makes it possible to pass continuously a fiber through the reaction zone at a specified velocity. In this case a bunch of fibers is rewound from one cassette to another.

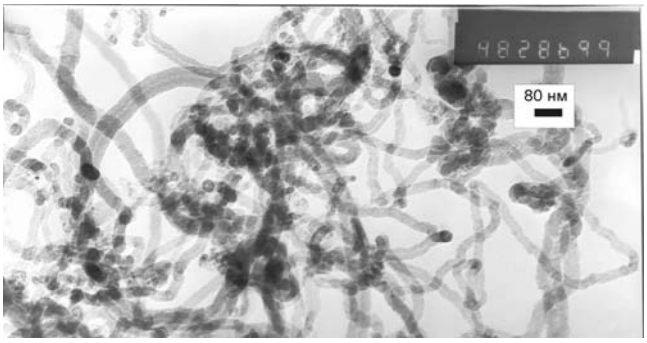


(a)

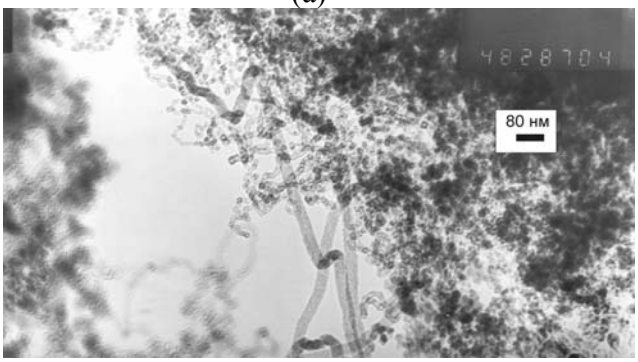


(b)

Fig. 2. Carbon microfibers after synthesis of carbon nanotubes and nanofibers on them: (a) – fibers bundle; (b) – individual fiber with carbon nanostructures on the surface.



(a)



(b)

Fig. 3. Fragments of bundles of carbon nanotubes synthesized on the surfaces of carbon microfibers.

Conclusions

Carbon microfibers synthesized under optimal conditions (T = 630 ^{o}C, γ = 50^{o}) have carbon nanotubes 5-25 nm in diameter and up to 1-2 μm in length present on their surface.

It has been shown that fullerene molecules are possible to use as a nonmetallic catalyst.

The pyrolytic setup has been designed for continuous synthesis of carbon nanotubes on the surface of carbon fibers.