Nitrogen-doped MWNCTs under low catalyst concentrations

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Introduction

Carbon nanomaterials have experienced a notable advance over recent years, especially carbon nanotubes (CNTs) due to their excellent mechanical, electrical, and thermal properties that allow them to be used in different applications. Nitrogen doping improves the conductivity in CNTs[1], modifies its structure, leads to large surface areas and a high density of defects[2]. An important factor for the growth of CNTs is the catalyst, the most used have been Fe, Ni, and Co[3]. Ferrocene as a catalyst has been shown to be efficient for the growth of NTC. In particular, the effect of the concentration of the catalyst on the CNTs has been studied intensively[4], since it has been mentioned that, by using a high concentration of catalyst to obtain a higher production, the catalytic particles formed during the decomposition of the Precursors can be deposited in the walls or cavities of carbon nanotubes and it is almost impossible to eliminate them effectively without damaging the order[4]. On the contrary, when it is used under catalyst, it is not necessary to carry out subsequent purification treatments, it has been thought that the appropriate minimum is 0.5-1.0% by weight[5,6]. As mentioned above, the importance of the concentration of the catalyst lies in obtaining nanotubes without adhered particles. In the literature studies have been reported with low concentrations of catalyst, however, the growth mechanism has not been studied with the incorporation of nitrogen in smaller percentages of catalyst, as well as the effect on performance. Therefore, very low concentrations of ferrocene will be used in the present work. It is also intended to study some electrochemical properties of these materials because recently excellent electrochemical properties of carbon nanotubes have been reported for supercapacitor applications for energy storage devices [7]. For this purpose, the flow and temperature conditions will be varied, in such a way that we determine their effect on the morphology and electrochemical properties.

Materials and Methods

The synthesis method used was the chemical vapor deposition technique assisted by aerosol (AACVD). This method consists of a quartz tube 90 cm long and 2.54 cm in diameter, placed inside two tubular furnaces (Thermo scientific Tube Furnace 21100) of 40 cm length, the entrance of the tube was connected to a key in "Y" shape to control the flow input. This key in turn was connected to a nebulizer working with signals synchronized to piezoelectric with cooling system and interface to the external frequency generator. The concentration used was a mixture of 0.05% by weight of ferrocene in benzylamine. The drag and temperature flow parameters varied from 2.4-3.6 L / min with 800 and 850 º C, respectively.

Results and Discussion

In Figure 1, the micrographs of samples synthesized at 800 ºC and 850 ºC are observed for three values of the flow of entrainment. Note that as the flow grows, the diameter of N-MWCNTs increases. In all cases, the N-MWCNTs presented a clean and free surface of nanoparticles adhered to their surfaces.

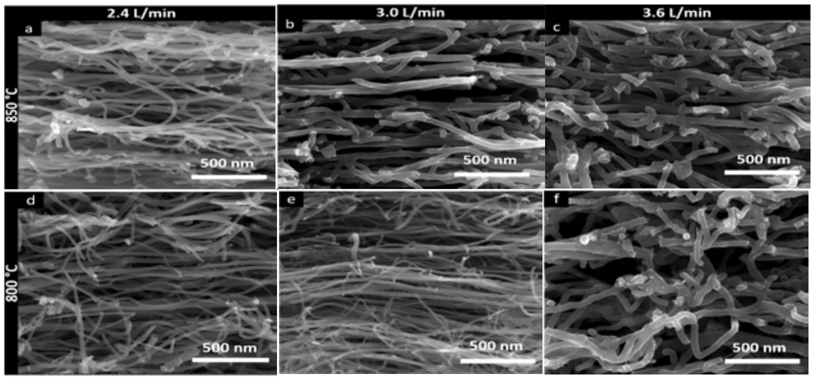

Figure 1. Images of SEM for N-MWCNTs grown at 800 ºC and 850 ºC for three different entrainment flows.

Conclusions

In this paper, we demonstrate that it is possible to produce carbon nanotubes without adhering particles using very low concentrations of catalyst.

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