J. Basic. Appl. Sci. Res., 3(6)1108-1111, 2013

ISSN 2090-4304
Journal of Basic and Applied Scientific Research
www.textroad.com

An Investigation of the Presence and Absence of Catalyst in the Carbon Nanotubes Synthesis Trough CVD Method

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ABSTRACT

In this work, we sought the effects of catalyst on carbon nanotubes growth using Chemical Vapor Deposition (CVD) method. Doing so, we synthesized carbon nanotubes first by using Fe nanoparticles as catalyst, and second without the presence of any catalyst on quartz substrate. In addition, in the process of synthesizing carbon nanotubes, we applied pyrolysis of ethylene gas molecules as the carbon source at a temperature of 925°, as well as argon as the carrier gas. XRD spectra and SEM images were used to investigate the characteristics, morphology and structure of carbon's products.
KEYWORDS: Carbon Nanotubes; Chemical Vapor Deposition; SEM; XRD

INTRODUCTION

The unique combination of characteristic such as, low density, large aspect ratio, structural diversity, excellent mechanical strength and remarkable electronic properties make carbon nanotubes an attractive field of discovery for a wide range of applications, from reinforcing materials in the form of Nano composites to microelectronic devices such as FED, LED, molecular sensors and detectors [1, 2, and 3]. The immediate problems regarding the application of these nanostructured materials is in fabricating reliable and reproducibility of synthesizing procedures. The reason is the large number of parameters affecting carbon nanotubes growth mechanism and the characteristics of the products [4, 5]. Amongst the various methods of synthesizing, Chemical Vapor Deposition (CVD) can improve and control the carbon nanotubes growth mechanism and also favors the problems mentioned above to some extent [6, 7, and 8]. In this work, we will show that catalyst has significant role in the synthesis of carbon nanotubes using CVD method, and without the presence of catalyst, there is indeed no possibility to produce structures of carbon nanotubes by CVD method.

Experimental procedure

Our experimental processes were done in two stages. Initially, carbon nanotubes were grown on quartz substrate without the presence of growth catalyst. In the second stage, we sprayed iron nanoparticles, as catalysts, on quartz substrate and carried out the synthesis process of nanotubes. Details of these stages are described as follows:

1) In this stage, we initially heated the furnace of CVD, in the presence of argon inert gas, to reach 925°. Then, when carbon resource of ethylene gas started to flow, we led quartz substrate to the center of furnace without the presence of catalyst. After fifteen minutes, we ended the synthesis process.

2) In this stage of our experimental work, we carried out the synthesis process with the presence of Fe nanoparticles as catalyst. Doing so, after the furnace of CVD was heated to 925° in the presence of argon inert gas, the relatively moist quartz substrate was impregnated with Fe nanoparticles and inserted into the center of furnace. We stopped the synthesis process after fifteen minutes.

RESULT AND DISCUSSION

The results obtained from XRD and SEM images, figures 1 and 2, show that the structures of nanotubes cannot be seen if the synthesis is done without the presence of catalyst. However, if Fe nanoparticles are present in the synthesis process, we can see that in XRD spectrum (Figure 3), the peaks related to carbon nanotubes are well appeared, which is clearly recognizable in SEM images (Figure 4).

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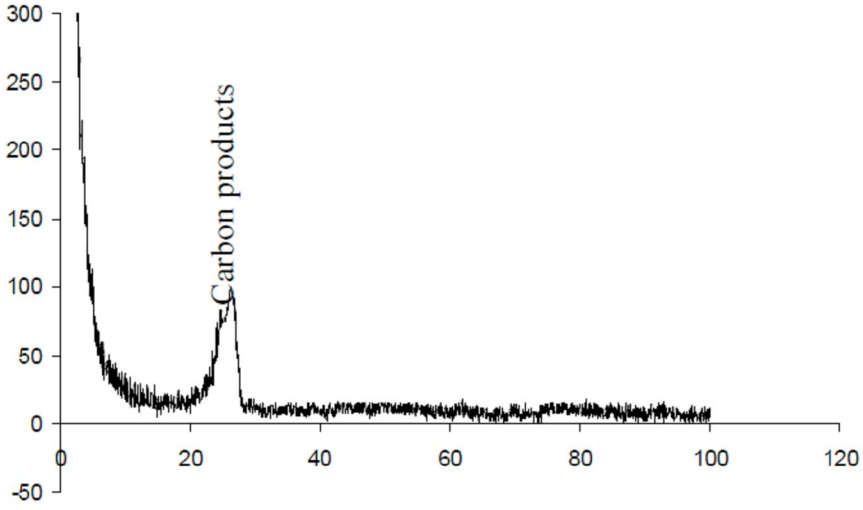

Fig. 1- XRD pattern of the as-grown carbon products (without the presence of catalyst)

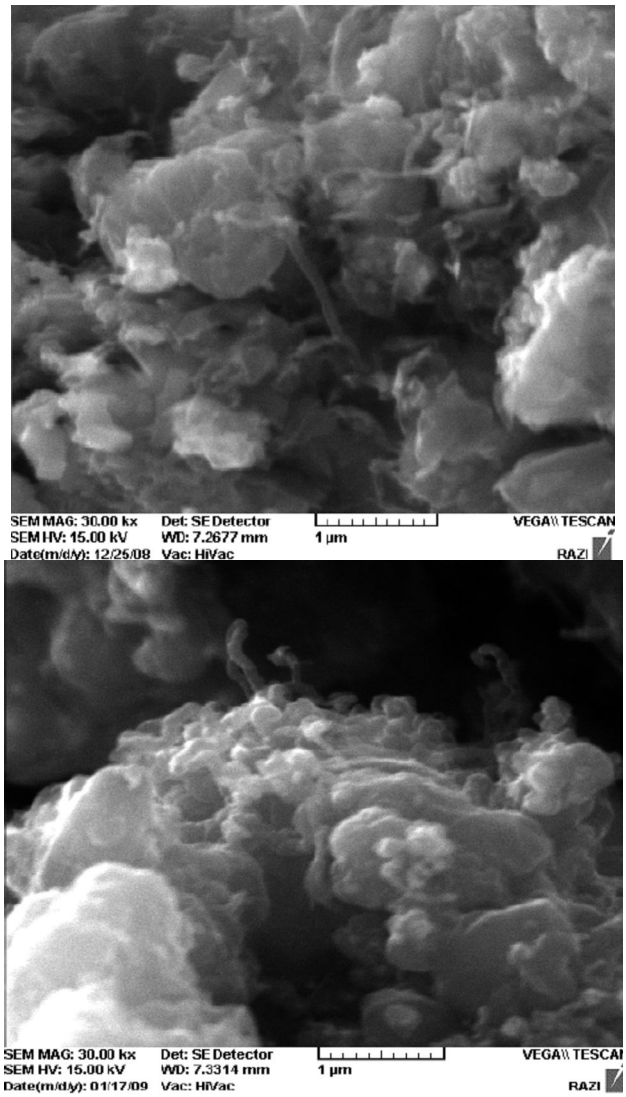

Fig. 2- SEM image of the raw carbon product (without the presence of catalyst)

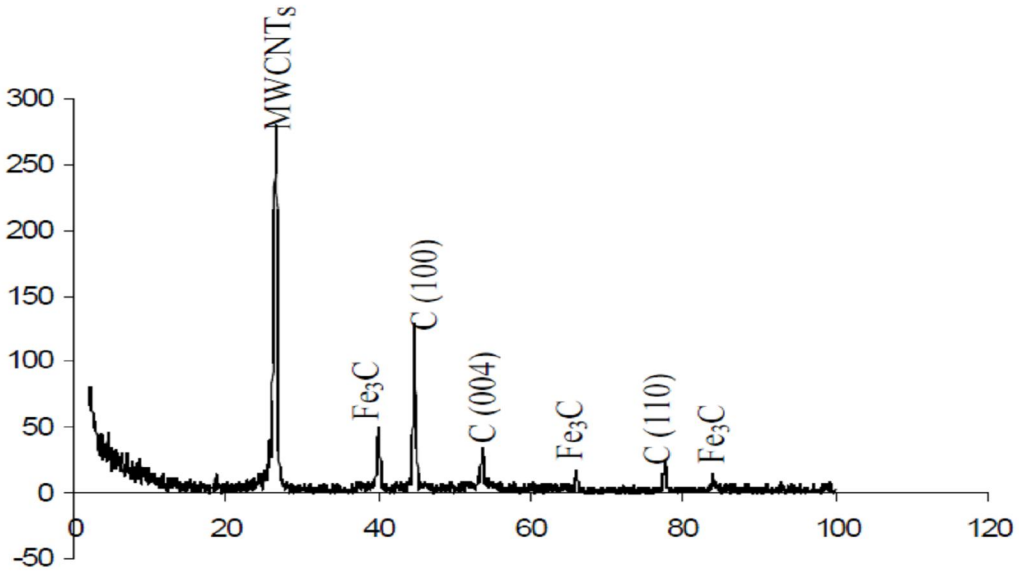

Fig. 3- XRD pattern of the as-grown carbon nanotubes (with the presence of catalyst)

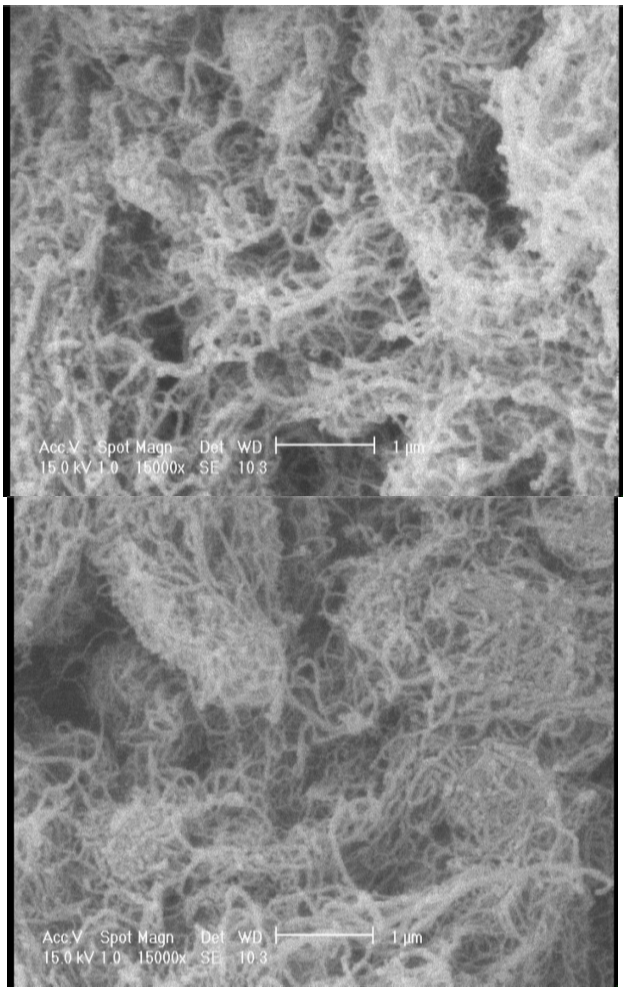

Fig. 4- SEM image of the raw carbon nanotubes (with the presence of catalyst)

CONCLUSIONS

In this work, we reviewed the role of catalyst, which is one of the most important factors in the synthesis of carbon nanotubes, by CVD. The results show that the synthesis of carbon nanotubes by using CVD method, and without the presence of catalyst will practically be useless and wasteful; while, in the presence of catalyst, carbon nanotubes would appear widely.

Acknowledgement

The authors would like to acknowledge University of Mazandaran and Iranian Nano Technology Initiative Council (INIC), for the financial support.

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