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Powder Synthesis and Characterization for CNTs/Metal/Al_2O_3 Nanocomposites by Thermal CVD

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Carbon nanaotubes (CNTs) have unique electronic, mechanical, and thermal properties including ballistic conduction and the highest known tensile strength and thermal conductivity [1]. CNTs are considered to be of technological importance due to its numerous applications, such as field emission displays, potential molecular quantum wire, tip of microscope, hydrogen storage, etc [2]. Recently, the synthesis of CNTs using CVD method has attracted lots of attentions because of many advantages such as high purity, high yield, controlled growth, and vertical alignment. In the CVD process, transition metal catalysts such as Fe and Ni play an essential role in the nucleation and growth of aligned CNTs. The peculiarability of these metals was suggested to relate to the catalytic activity for the decomposition of carbon precursors, the formation of metal-stable carbides, the diffusion of carbons, etc [3,4]. Despite tremendous progress in synthesizing CNTs, the systematic study of the catalyst effect on the CNT growth is still not much reported yet. It is well known that the size of the catalytic particles control the size of CNTs. Also, the yield and length of the CNTs can be determined by varying the amount of metal catalyst. The exact understanding of the catalyst activity would lead eventually a controlled growth of CNTs, which is prerequisite for various potential applications. Therefore, in this work, we used Fe and Ni metal catalytic materials and investigate effects of different catalytic materials on the growth characteristics of CNTs. The CNTs with different amount of metal catalyst were also studied and compared.

Starting materials were prepared from the followings: α-Al_2O_3 powder as a matrix material, Fe-nitrate or Ni-nitrate as a source of Fe or Ni catalytic metals, respectively. The weighing was aimed at having final compositions of Al_2O_3/2 and 5vol.% Fe or Ni, respectively. After Al_2O_3 powders and Fe or Ni-nitride were mixed in ethanol using hot plate at 40°C for 30 min, wet milling with Al_2O_3 powders for 24 h was proceeding. The slurries were dried and calcined. Also, the prepared oxide/Al_2O_3 powders were selectively reduced by raising the temperature up to 600°C for 1 h in hydrogen atmosphere to prepare metal/Al_2O_3 nanocomposite catalyst. A mixture of C_2H_2, H_2 and Ar gases passed, which flow rate of C_2H_2, H_2, and Ar gases were 10, 20, and 1000 sccm, respectively. Subsequently, after the system was heated up to 800°C for

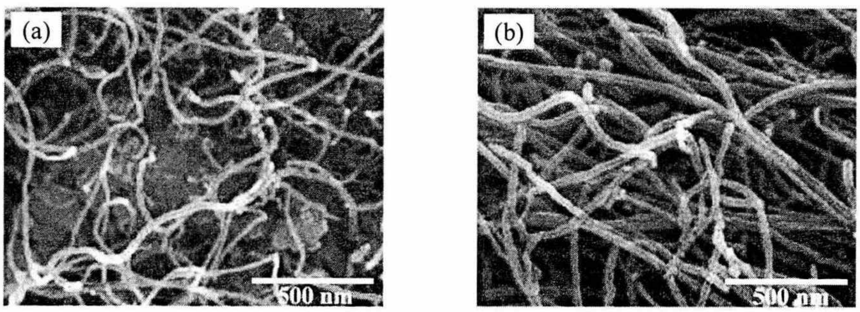

Fig. 1 FESEM images of CNTs synthesized by thermal CVD using (a)2vol% Ni/Al_2O_3 (b)2vol% Fe/Al_2O_3 nanocomposite catalyst.

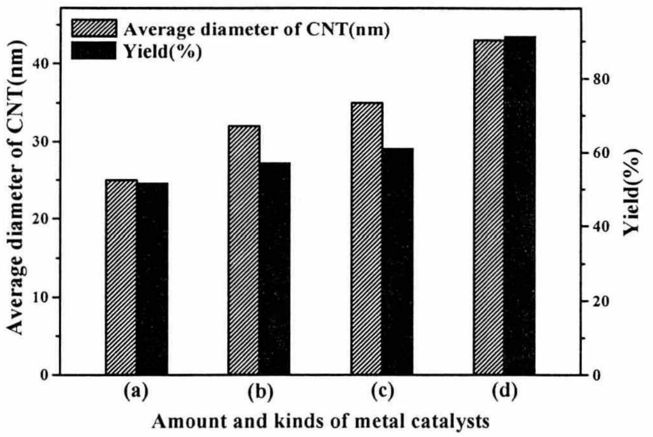

Fig. 2 Average diameter and yield of CNTs with the amount and kinds of metal catalysts. (a) 2vol% Ni/Al_2O_3 (b) 5vol% Ni/Al_2O_3 (c) 2vol% Fe/Al_2O_3 (d) 5vol% Fe/Al_2O_3 nanocomposite catalyst.

20 min, the system was cooled to room temperature. For evaluation of this $CNTs/Metal/Al_2O_3$ composite, characterization methods such as X-ray diffraction (XRD), field emission scanning electron microscopy (FESEM), and FT-Raman analysis were performed. By the FESEM characterization, it can be explained that in the senses of considering the change of CNTs diameter, the particle size of iron was greater than that of nickel even though at the same amount of metal catalyst and same reduction temperature as shown Fig. 1. More significantly it should be considered that Fe/Al_2O_3 nanocomposite catalyst yields more CNTs that Ni/Al_2O_3 nanocomposite catalyst. Also, Fig. 2 represented that the increase of the particle size the yield and diameter of CNTs can be explained in terms of the size and kinds of metal catalyst.

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