The effects of MgO source for substrate preparation on the growth of carbon nanotubes by catalytic chemical vapor deposition

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Abstrract

The Carbon nanotubes (CNTs) growth process by Catalytic chemical vapor deposition (CCVD) method involves heating a catalyst material to high temperatures in a tube furnace and flowing a hydrocarbon gas over a period of time. MgO as a catalytic support has an advantage over alumina and silica, because MgO can be easily dissolved in acid. In this paper we investigate the influence of MgO source as substrate on the growth of carbon nanotubes. The two catalyst was prepared with $Mg(NO_3)_2$ and MgO. Production of CNTs was carried out in a tube furnace by passing CH_4 with flow rate of 6 lit/min. The supported catalysts and grown CNTs were investigated by Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), X-Ray Diffraction (XRD) and FT-Raman spectroscopy. The characterization showed that both substrates grew primarily multi-wall CNTs. Results revealed that catalyst prepared with MgO showed much better activity than catalyst synthesized with $Mg(NO_3)_2$.

Introduction

Carbon nanotubes (CNTs) have aroused a great deal of research interest due to their unique electrical and mechanical properties, and a wider range of potential applications have been proposed. Catalytic chemical vapor deposition (CCVD) method is the best possibility for large-scale production at lower reaction temperature. The growth process by CVD involves heating a catalyst material to high temperatures in a tube furnace and flowing a hydrocarbon gas over a period of time. As far as the porous materials including silica and alumina are efficient supporters of catalyst particles. Bet removal of these materials from CNTs may waste much time and efforts. MgO as a catalytic support has an advantage over alumina and silica, because MgO can be easily dissolved in acid. In this paper we investigate the influence of MgO source as substrate on the growth of carbon nanotubes.

Experimental Procedure

The first catalyst was prepared by impregnation method. MgO powders was mixed with the $FeSO_4$ solution in ethanol and stirred at 90°C. The second catalyst was prepared at room temperature by sol-gel method from a mixture $FeSO_4$ and $Mg(NO_3)_2$ in aqueous solution and citric acid as precipitating agent. The weight ratio of Fe to MgO was 15% in both catalysts. Production of CNTs was carried out in a quartz tube reactor mounted in a horizontal tube furnace. 0.3 g of the catalyst was put into a quartz

boat at the center of the reactor tube. The tube reactor was first heated to 900°C in N_2 atmosphere and then CH_4 with flow rate of 6 lit/min. was introduced into the reactor for CNT preparation. After 30 min., the reactor was cooled to room temperature in N_2 atmosphere. The supported catalysts and grown CNTs were investigated by Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM) and X-Ray Diffraction (XRD). To obtain the overall information of the synthesized carbon materials, the product was further analyzed by FT-Raman spectroscopy.

Results and Discussion

SEM pictures indicated that prepared supports with $Mg(NO_3)_2$ were nonporous (Fig. 1). Thus CNTs growth rate was weak. On the other hand supports synthesized with MgO showed much better CNTs growth rate because of porosity in the support (Fig. 2).

Figure 3 and 4 show FT-Raman results in prepared sample with MgO and $Mg(NO_3)_2$ respectivly. It is revealed that at Figure 4, G-band is stronger than D-band. In general, a ratio of I(D)/I(G) can be used as an indicator of extent of disorder within the nanotubes. The ratio of I(D)/I(G) showed in Figures 3 and 4 illustrate that the defect level in the CNTs synthesized on supports prepared with MgO is low in comparison of those synthesized on supports prepared with $Mg(NO_3)_2$, indicating that high-quality CNTs are produced by MgO precursor.

Based on TEM observation of CNTs synthesized on prepared support with MgO (Fig.5), it is found the sample includes single wall carbon nanotubes and multi wall carbon nanotubes and some impurities can be seen on the CNTs.

Conclusion

The characterization showed that both substrates grew primarily multi-wall CNTs. Results revealed that catalyst prepared with MgO showed much better activity than catalyst synthesized with $Mg(NO_3)_2$.

Figures:

Fig1. SEM picture of CNTs synthesized on prepared support with $Mg(NO_3)_2$

Fig2. SEM picture of CNTs synthesized on prepared support with MgO

Fig3. FT-Raman spectroscopy of CNTs synthesized on prepared support with $Mg(NO_3)_2$

Fig4. FT-Raman spectroscopy of CNTs synthesized on prepared support with MgO

Fig5. TEM picture of CNTs synthesized on prepared support with MgO

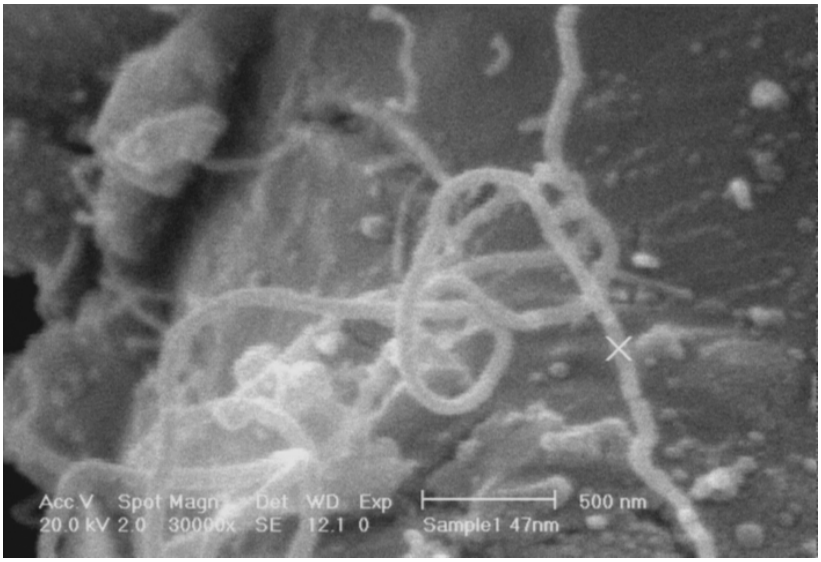
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Fig1.

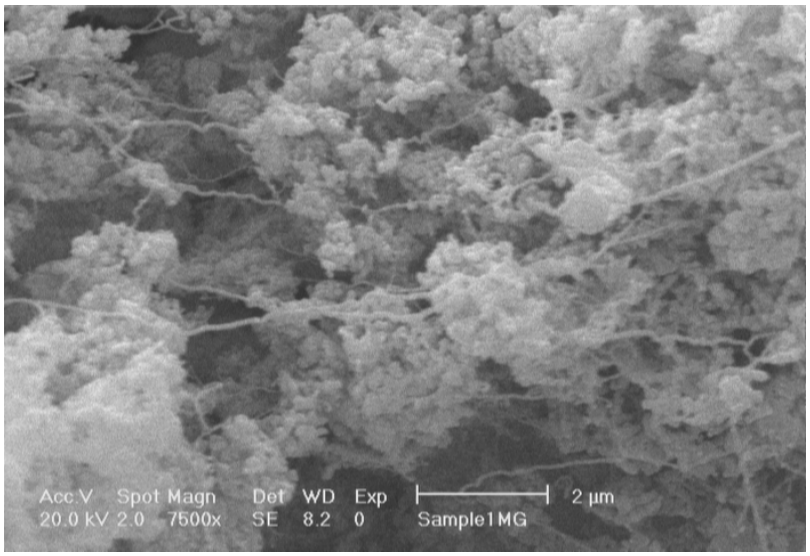
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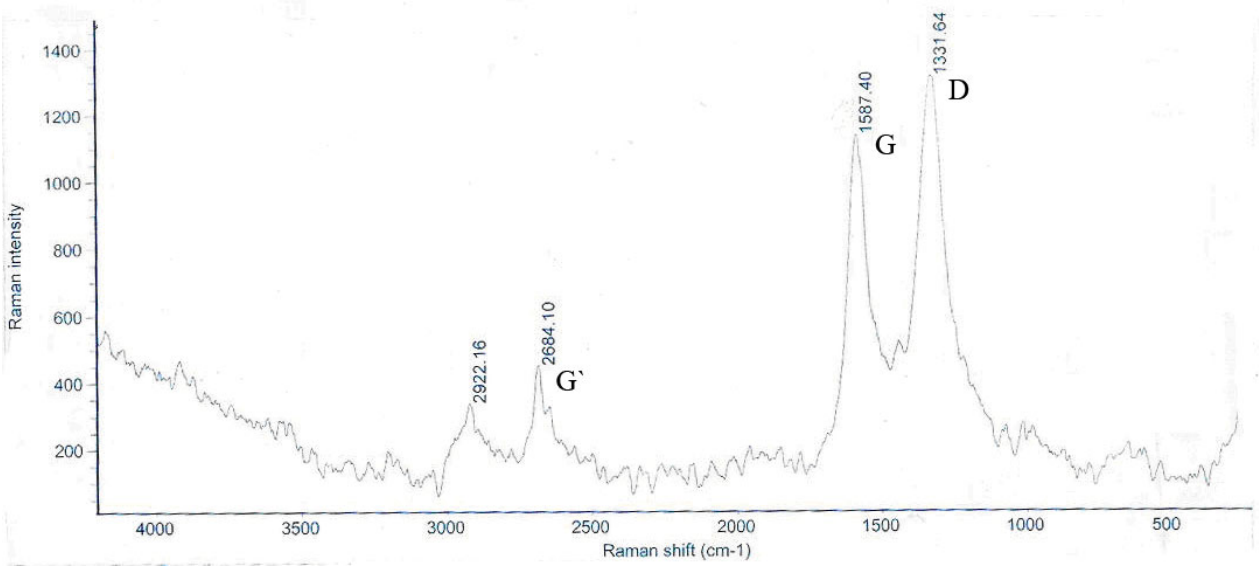
Fig2.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G
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D
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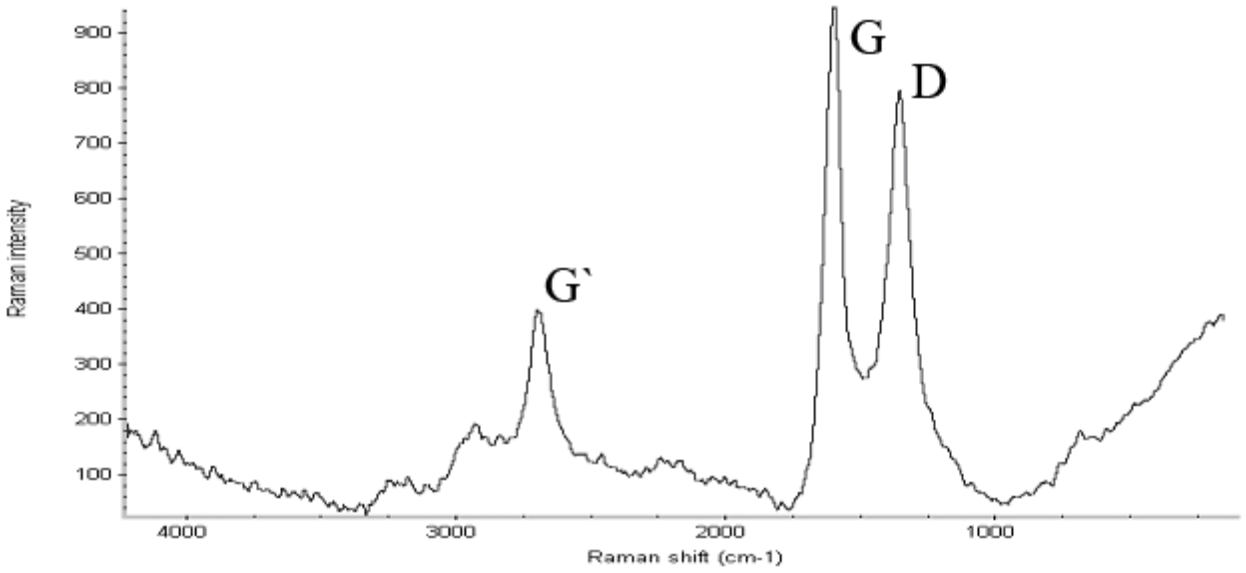
3500
3000
2500
2000
1500
1000
500
Raman shift (cm-1)

Fig3.


Raman intensity
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800
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G`
G
D
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Raman shift (cm-1)

Fig4.

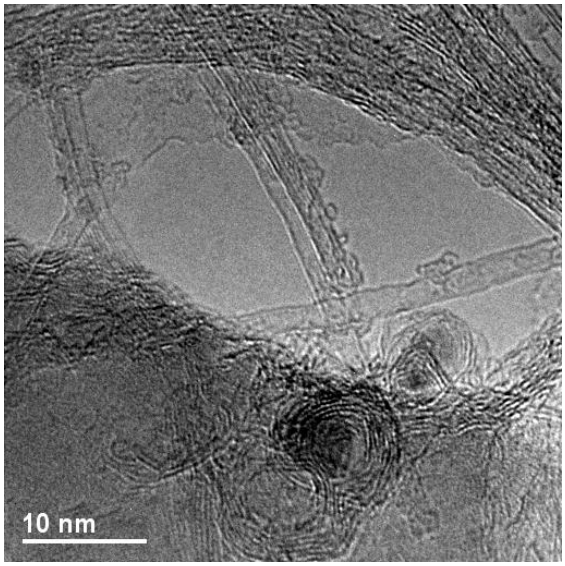

Fig5.