Synthesis and Characterization of Single-Walled Carbon Nanotubes using Alcohol as the Carbon Source

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Single-walled carbon nanotubes have been the subject of focused multi-disciplinary studies due to their unique electrical and mechanical properties. In general, the catalytic decomposition of hydrocarbon gases such as methane, ethylene and acetylene in the chemical vapor deposition (CVD) system is used to synthesize single-walled carbon nanotubes. In this study, we investigated the catalytic decomposition of ethanol as the carbon source for the synthesis of single-walled carbon nanotubes[1,2].

The technique of using alcohol as the carbon source is based on the facts that at high temperatures, ethanol vapor decomposes into many different reactive radicals such as $CH_3\cdot$, $CH_3CH_2\cdot$,$\cdot CH_2OH$, $OH\cdot$, etc. These radicals in turn undergo a series of reactions with each other and other molecules of ethanol. One intermediate reaction is:

$$CH_3\cdot + CH_3CH_2OH \rightarrow CH_4 + CH_3CH\cdot OH$$

Methane gas generated from this reaction undergoes decomposition into elemental carbon which generates single-walled carbon nanotubes. The reaction of methyl radical with another molecule of ethanol is exothermic and it increases the local temperature at the growth site. Therefore it provides thermal energy which allows carbon nanotubes to grow at lower reaction temperatures. Other radicals such as $OH\cdot$, acting as etching agents, react with amorphous carbon on the catalyst surface and suppress such morphologies as multi-walled nanotubes. The technique of utilizing alcohol as the carbon source is inexpensive and efficient as well as safe and environmentally friendly. It can guarantee easy scale-up production at lower cost.

During this study, two catalysts were investigated including iron powder catalyst and cobalt/molybdenum catalyst[3]. Figures 1 and 2 show the SEM and TEM images of single walled carbon nanotubes grown with iron catalyst. The SEM and TEM images reveal bundles of single-walled carbon nanotubes with 7-10 nm in diameter. TEM images also confirm absence of multi-walled carbon nanotubes. Synthesis of carbon nanotubes from cobalt/molybdenum catalyst was also successful. The single-walled nanotubes grown from cobalt/molybdenum catalysts were present in high yield as shown in Figure 3.

In this report, a series of experimental results with respect to the growth mechanisms of single-walled carbon nanotubes will be discussed and field emission properties of synthesized carbon nanotubes will be presented.

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References:

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[2] Y. Murakami et al., Chem. Phys. Lett. **377**, 49 (2003).
[3] Y.Murakami et al., Chem. Phys. Lett. **385**, 298 (2004).

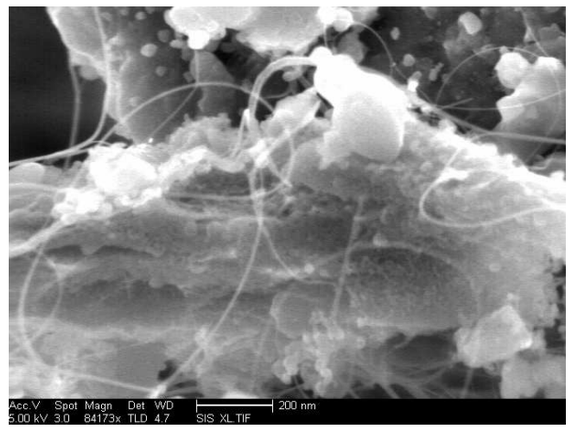

Figure 1. SEM image of single-walled carbon nanotubes grown from Fe powder catalyst

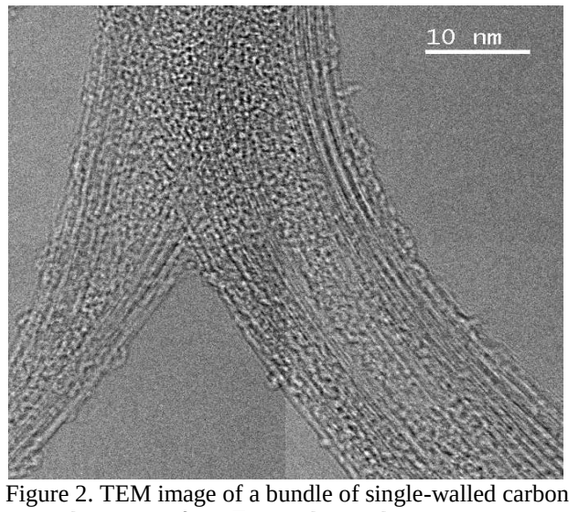

Figure 2. TEM image of a bundle of single-walled carbon nanotubes grown from Fe powder catalyst

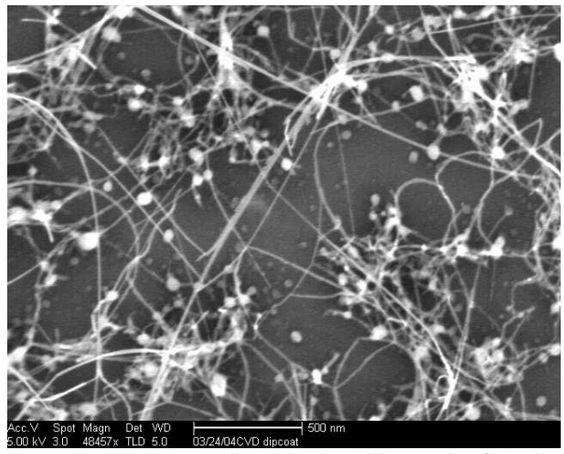

Figure 3. SEM image shows high yield growth of single-walled carbon nanotubes from cobalt/molybdenum catalyst