Ethanol pyrolytic synthesis of carbon nanotubes using a novel Ni/(NiO+Y_2O_3) catalyst

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When carbon nanotubes (CNTs) are producing using the chemical vapor deposition method, the process of nanoscale catalyst particle (CP) formation plays an important role. The CPs can be efficiently obtained using a sol-gel technique allowing the obtaintion of a catalyst material with high specific area, containing previously fabricated metal nanoparticles with the desired size.

The prospects of using sol-gel technology for the manufacturing of the catalyst is rendered feasible by the possibility of preparing a material containing metal nanoparticles of predetermined and uniform size that subsequently determines the homogeneity of the CNTs fabricated.

The catalyst was synthesized by a modified sol-gel technique from $Ni(NO_3)_2$ and $Y(NO_3)_3$ using polyvinyl alcohol. The resulting material consisted of agglomerates of platelets (about 10 nm × 2 μ × 2 μ) which were nanostructured and contained the mixture NiO+Y_2O_3 (weight ratio ~ 4/1) with Ni inclusions in the form of nanoparticles (>3 nm in diameter).

Before synthesis, the catalyst was pre-treated by ultrasound in ethanol, then deposited on a quartz substrate, dried and placed in the reactor. Carbon nanostructures were synthesized by ethanol pyrolysis under both atmospheric and reduced (0.2 atm) pressure. The experimental temperature was varied from 600°C to 800°C. The carbon deposit was analyzed using scanning and transmission electron microscopy and X-ray diffraction.

All fabricated samples contained few-walled CNTs (mostly 10-20 nm in diameter) and carbon nanofibres. The specific microstructure of the new catalyst and optimized thermodynamic conditions of synthesis led to a high yield of CNTs with a low content of non-crystalline carbon.

The influence of both catalyst microstructure and synthesis parameters on the structure and morphology of the carbon deposit will be presented. The X-ray diffraction analysis of the deposit from different temperature zones of the pyrolysis furnace was carried out. The probable mechanism of formation of carbon nanotubes and nanofibres on the catalyst will be proposed.