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Controlled Syntheses of Multi-walled Carbon Nanotubes from Bimetallic Fe–Co Catalyst Supported on Kaolin by Chemical Vapour Deposition Method

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Abstract

Multi-walled carbon nanotubes (MWCNTs) were synthesized via acetylene gas deposition over bimetallic Fe–Co/kaolin catalyst by chemical vapour deposition method. The effects of synthesis parameters such as calcination temperatures, reaction time, argon and acetylene flow rates on the CNTs yield were examined using 2424 full factorial experimental design. The as-prepared nanomaterials were characterized by HRSEM/EDS, HRTEM, TGA, DLS, XRD, XPS and BET. The HRSEM/TGA revealed well dispersion of the metallic particles on the kaolin support with high thermal stability. XRD analysis of the catalyst confirmed the formation of mixed oxides of different intensities which can favour the growth of MWCNTs. The optimum conditions to obtain high catalyst yield of 88.9% were: mixing ratio of 1.6, stirring speed 1000 rpm, calcination temperature 500◦C500◦C and calcination time 14 h. The HRSEM, HRTEM and XRD analyses showed that optimal controlled conditions to obtain homogeneous growth of high-quality graphitic MWCNTs of different inner and outer diameters were: reaction temperature of 700◦C700◦C, growing time 55 min, argon flow rate 220 mL/min and acetylene flow rate 180 mL/min. The BET analysis showed that the surface area of unpurified MWCNTs was 275.5 m2/g275.5 m2/g while pure MWCNTs increased to 330.6 m2/g330.6 m2/g after acid treatment. The statistical analysis showed

that deposition temperature and acetylene flow rate positively exerted significant influence on the CNTs yield than other synthesis parameters, an evidence of thermodynamic-controlled mechanism. This study demonstrated that kaolin can act as an excellent substrate for MWCNTs growth compared to other commercial supports such as $CaCO_3$, MgO, Al_2O_3, SiO_2.

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