Microwave synthesis and characterisation of tin dioxide (SnO_2) coated multi-walled carbon nanotubes

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INTRODUCTION

Metal nanoparticles coated onto carbon nanotubes (CNTs) provide a way to obtain novel materials with useful properties for gas sensing and catalyst application. Metal oxides are well-known materials suitable for detecting a wide spectrum of gases with enough sensitivity. Among the materials functionalised by CNTs, intensive attention is on Tin Dioxide (SnO_2) because of its unique properties such as high optical transparency, electrical conductivity and chemical sensitivity, which made it become an attractive material for application in solar cells, field effect transistors, catalysis and gas-sensing[1-3]. Nanostructured composite materials of carbon nanotubes and metal oxides promise superior performance over conventional approaches due to the ability to direct the selective uptake of gaseous species based on their controlled pore size and chemical properties, increased adsorptive capacity due to their increased surface area, and the effectiveness of carbon nanotubes as matrix materials for gas and vapour detection. In addition, CNTs can be functionalised, doped with catalysts and mixed with polymers accordingly to achieve the selectivity.

In this research, microwave irradiation was used in the fabrication of nanocomposites as a novel technique to disperse SnO_2 nanoparticles uniformly on multi-walled carbon nanotubes (MWCNTs) surface to composite properties. The advantage of using microwave irradiation is the rapid volumetric heating, higher reaction rate, reducing reaction time, uniform surface decoration and smaller particle size. This method of preparation was compared with the conventional technique 'wet impregnation'. Characterisation of the composites was done using techniques such Raman, transmission electron microscopy (TEM) and scanning electron microscopy (SEM).

EXPERIMENTAL

Synthesis

MWCNTs were refluxed with 5M nitric acid (HNO_3) at 120 °C for 2 hours, filtered and then washed with distilled water until the pH of the solution was neutral. The MWCNTs were then dried at 110 degree Celsius for 12 hours. Subsequently, tin (II) chloride (SnCl2) was dissolved in distilled water and then a certain amount of concentrated hydrochloric acid (HCl) (37%) was added. The acid treated MWCNTs were dispersed in the above solution. This mixture was sonicated for 5-10 minutes and then stirred for 60 minutes at room temperature. The precipitate was then separated from the mother liquor by centrifugation and was washed with distilled H_2O several times, and then dried at 110 degree Celsius for 12 hours. Part of the final product was calcined at 500 degree Celsius for 2 hours.

Characterisation

The morphology and microstructure of CNTs were characterised by TEM and SEM. For TEM and SEM sample preparation, the CNTs were dispersed in ethanol by ultrasonic to form a suspension. After about 3 minutes, one or two droplets were dropped onto a carbon-coated copper grid. Raman spectra were also observed for the identification degree of graphitisation of CNTs and identification of disorder in the material.

RESULTS

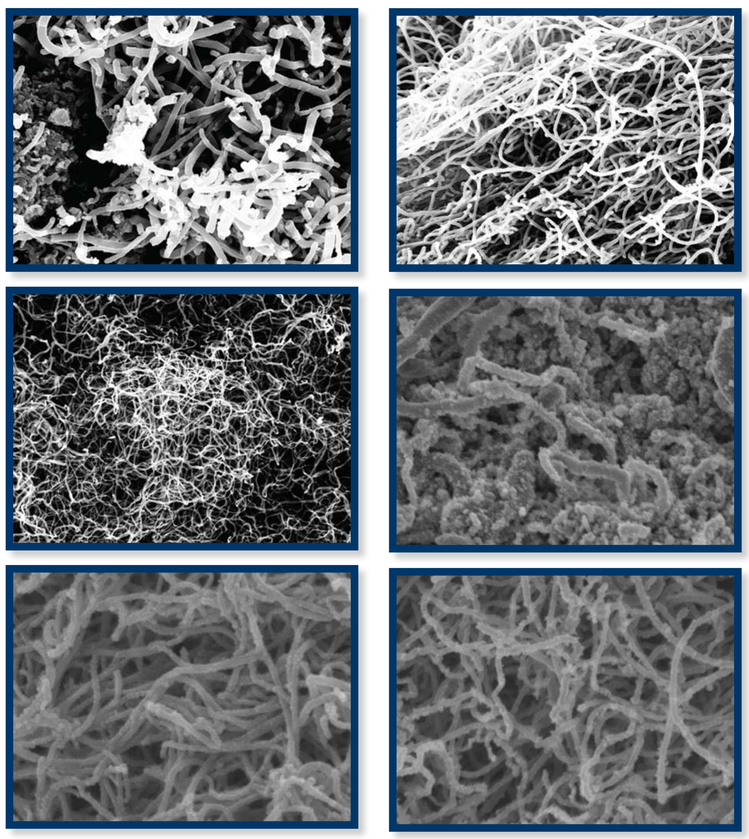
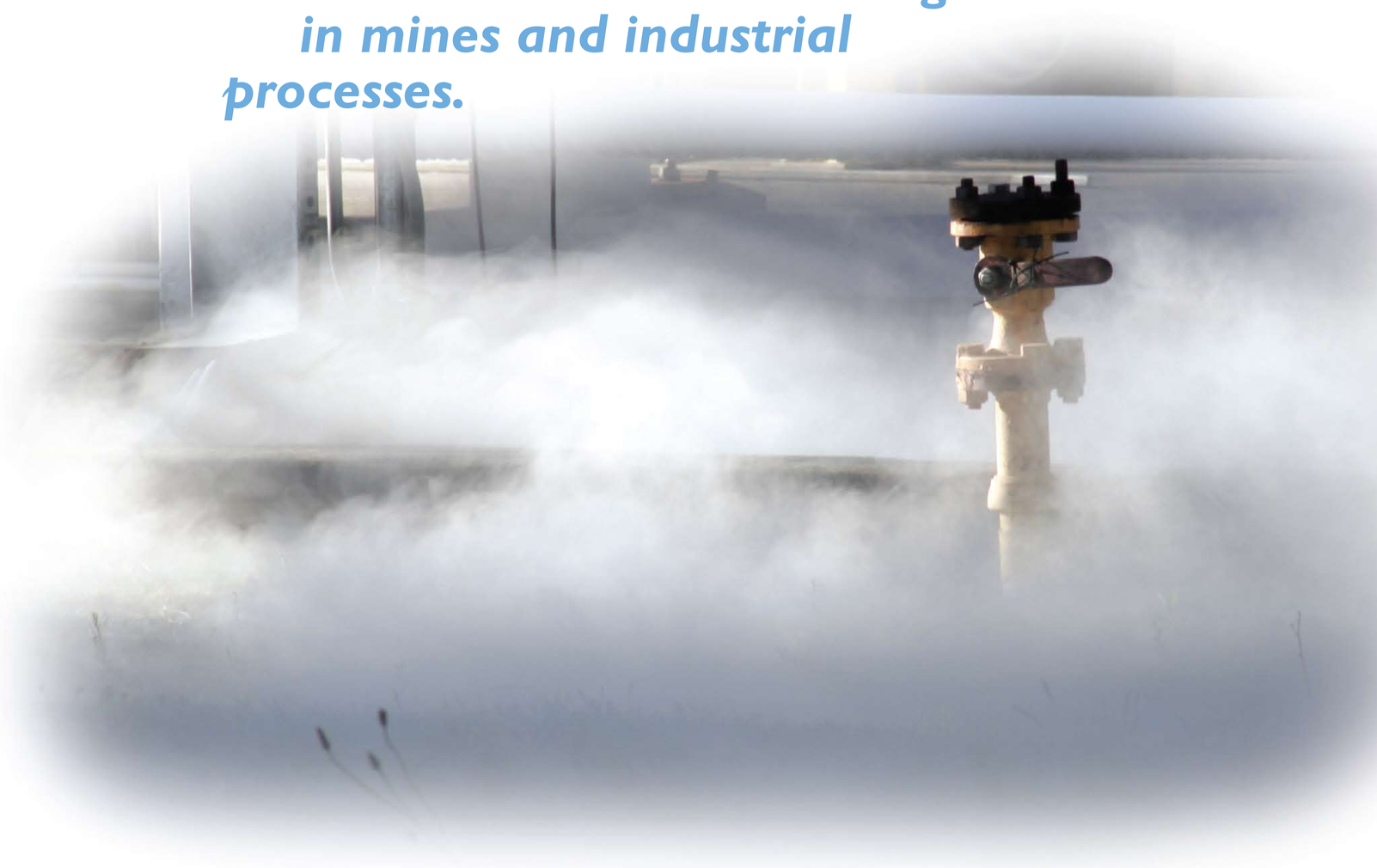


Figure 1: Scanning electron microscopy images of pure and carbon nanotubes densely coated with tin dioxide nanoparticles which are observed to be uniform around the carbon nanotubes

Developing devices through nanotechnology that detects hazardous gasses in mines and industrial processes.



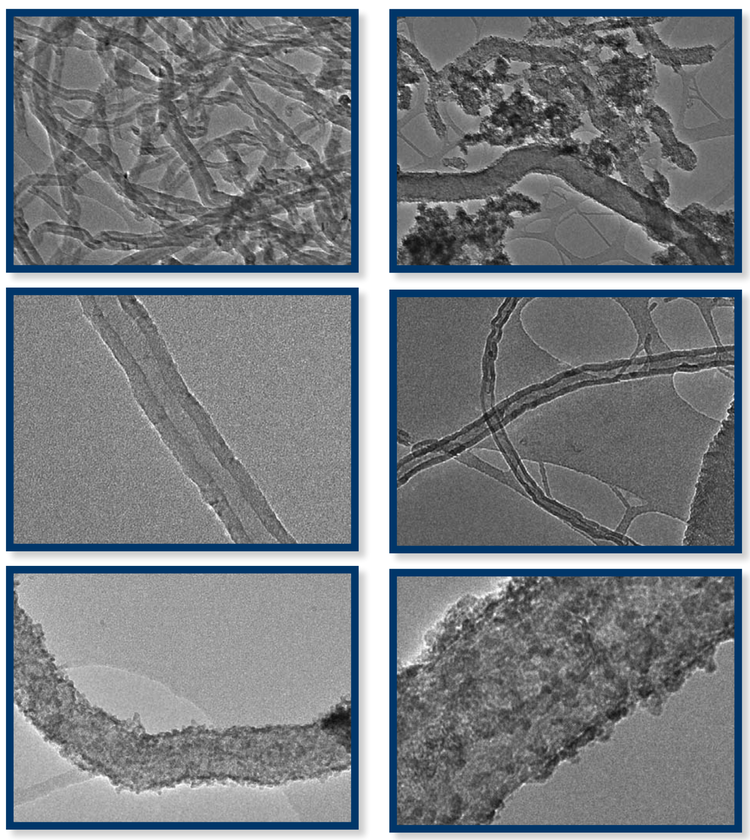
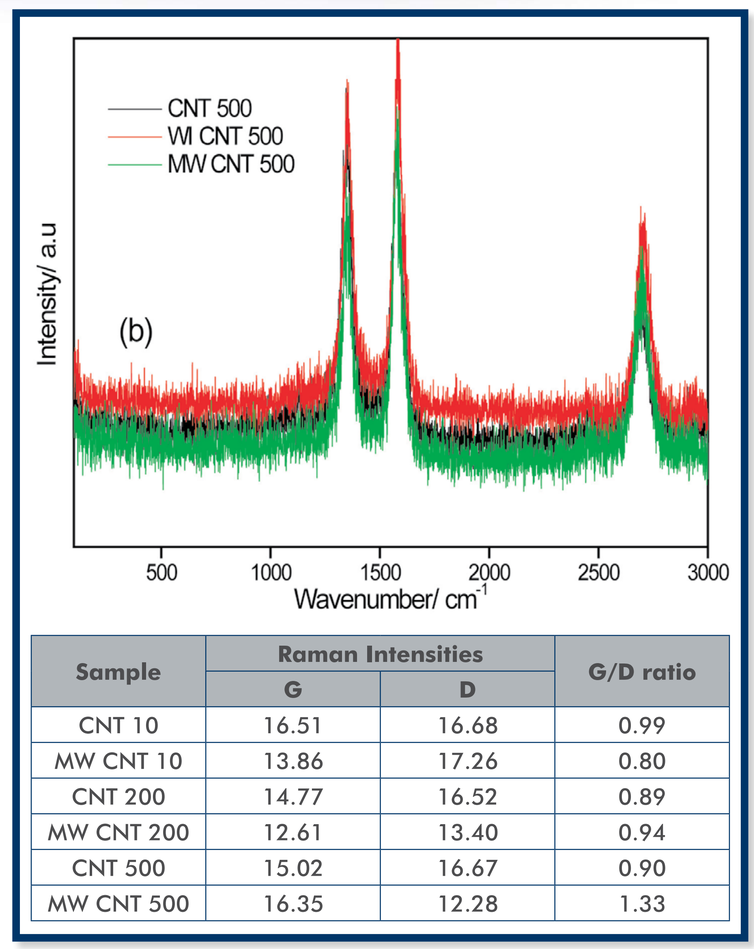


Figure 2: Transmission electron microscopy images of pure and tin dioxide coated carbon nanotubes. Tin dioxide nanoparticles deposition appears to be uniform on the surface and inside the tubes



Sample	Raman Intensities		G/D ratio
	G	D	
CNT 10	16.51	16.68	0.99
MW CNT 10	13.86	17.26	0.80
CNT 200	14.77	16.52	0.89
MW CNT 200	12.61	13.40	0.94
CNT 500	15.02	16.67	0.90
MW CNT 500	16.35	12.28	1.33

Figure 3: Raman spectra recorded for the pure carbon nanotube and SnO_2-MWCNTs composites. The decrease in G/D intensity ratio (refer to the Table) after surface modification is due to the interaction between tin dioxide nanoparticles and the surface groups of multi-walled carbon nanotubes.

CONCLUSION

The SnO_2 decorated MWCNTs were successfully prepared by the microwave irradiation method and compared with the wet impregnation method and the objectives of the project were met.

REFERENCES

1. Wei, B.Y., *et al.*, 2004. A novel SnO_2 gas sensor doped with carbon nanotubes operating at room temperature. Journal of Sensors & Actuators B 101, 2004, pp. 81-89.
2. Liu, Y.L. ,*et al.*,2006.Gas sensing properties of tin dioxide coated onto multi-walled carbon nanotubes.Thin Solid Films. 497, 355-360.
3. Han, W.Q. and Zettl, A, 2003. Coating Single-Walled Carbon Nanotubes with Tin Oxide.Nano Letters, 3,pp. 681-683