One-step Synthesis and Characterization of CoS-Nanoparticles Decorated Multi-Walled Carbon Nanotubes

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INTRODUCTION

The organization of metal or semiconductor nanoparticles like quantum dots (QDs) on carbon nanotubes (CNTs) is one good example motivated by the desire to combine the properties of two functional nanoscale materials to achieve a wider range of applications.[1] The CNT/QD hybrid nanostructures attract more and more interest since they are believed to be useful for building blocks for optoelectronic devices, solar energy conversion and photocatalysis.[2,3] The preservation of the electronic properties of CNTs is also of fundamental importance for these applications since the main function of CNTs in these hybrids is to speed up the transfer of photogenerated electrons. For these purposes, it is vital to develop efficient methods to attach quantum dots onto the sidewalls of CNTs whose structures have been preserved intact. In this study, a simple and facile one-step synthesis approach for the in situ mineralisation of CoS-QDs on the surface of non-pre-treated multi-walled carbon nanotubes (MWCNTs) in ethylene diamine (EDA) medium is attempted.

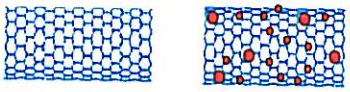

Figure1: Computer generated images of Left: CNT Right: QD decorated CNT

EXPERIMENTAL

CoS precursor was prepared by adding a hot solution of tetramethylthiuram disulfide (4.16 mmol) in methanol (20 ml) to a heated solution of cobalt chloride (2.08 mmol) in methanol (15 ml). The mixture was stirred and refluxed for 1 h. The precipitate was filtered, washed twice with methanol and dried under vacuum. $CoCl_2$ [SC $(N(CH_3)_2)$ SS $(N(CH_3)_2)$ CS]: Yield 80.2 %; m. p. 363.5 °C. Anal. Calcd. C, 19.49; H, 3.03; N, 7.58. Found: C, 19.46; H 3.27; N 7.57. IR (nujol mull)/cm^{-1}: 1387 (s), 1254 (s), 1245 (s), 1124 (s), 1044 (s), 1022 (s), 978 (s), 893 (m), 780 (w), 673 (m), 576 (s), 439 (s).

200 mg of tetramethylthiuram disulphide precursor was then dispersed in 5 ml of TOPO and added to 100 ml of EDA at 100 °C under nitrogen atmosphere. Upon observation of a colour change (nucleation is occurring), 100 mg of MWCNTs (Sigma Aldrich, 95% purity, inner diameter-7-10 nm, outer diameter-20 nm, length-0.5 to 200 μm) was added. The reaction mixture was further refluxed for 1 h at 100 °C. The resultant solution was then allowed to cool to 70 °C and methanol was added in order to flocculate the particles. The particles were separated through centrifugation and washed several times with methanol and acetone. Yield: 73.6%

The CoS-MWCNT heterostructures have been characterized by scanning electron microscopy (SEM), high-resolution transmission electron microscopy (HR-TEM), X-ray photoelectron spectroscopy (XPS), UV-VIS spectroscopy and Photoluminescence (PL) spectroscopy.

RESULTS

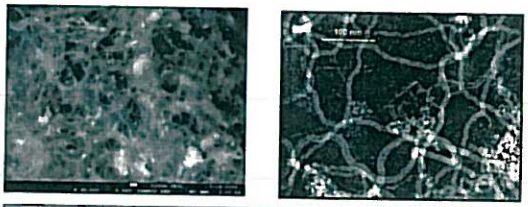

Figure 2: Electron micrographs of CoS-MWCNT structures Left: SEM Right: TEM

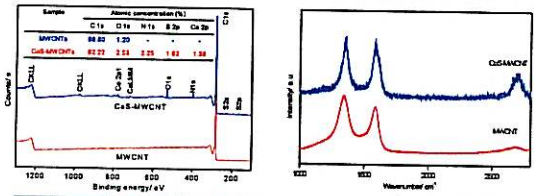

Figure 3: XPS (left) and Raman spectra (right) of MWCNT & CoS-MWCNT

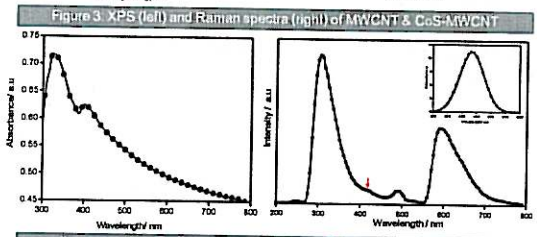

Figure 4: UV-Vis (left) and PL (right) spectra of CoS-MWCNT structures

CONCLUSIONS

SEM and TEM images reveal the presence of CoS nanoparticles on the surface of MWCNTs. The XPS spectrum of the heterostucture the presence of S, Co, O, N and C which confirmed the existence of CoS nanoparticles on the CNT surface. In the UV-VIS spectrum of CoS-MWCNT, the first excitonic peak at 329 nm is blue-shifted when compared to the bulk CoS (388 nm) showing the nanosized nature of the CoS particles. The shoulder peak at 425 nm in PL spectrum is due to the CoS nanoparticles (insert – PL of typical CoS-QD).

ACKNOWLEDGEMENT

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