Carbon nanotube based composite thin film coatings for stray light control space applications

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By

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Abstract

Research on carbon materials such as carbon nanoscrolls (CNS), graphitic sheets (GS), carbon nanotubes (CNTs) etc. based thin films with low light reflectance has received paramount importance in order to have high absorber coatings for stray light control applications. CNS, a one dimensional (1D) helical form of carbon has received enormous attention recently due to their unique structure, superior properties and potential applications. In this work, radial merging of high pressure carbon monoxide (HiPCO) single-walled carbon nanotube (SWCNT) bundles and emergence of CNS are reported following a reflux action involving wet oxidation, HCl wash and annealing at 900°C. We also report a successful demonstration of developing stable thin films comprised of carbon nanomaterials on the aluminium (Al) substrate which exhibits low reflectance of the order of 2-3% in the visible and near-infrared (NIR) spectral band. Changes in structural and chemical compositions to the originally procured SWCNT samples have been analyzed after each subsequent processing step. Spectroscopy, microscopy and microstructural studies demonstrate the emergence of CNS and multi-walled carbon nanotubes (MWCNTs) in the samples due to the sequential chemical processing of the sample. Here, a simple solution based oxidative route for successful merging and exfoliation of SWCNT bundles and subsequent formation of CNS are demonstrated and discussed in view of Fourier transform infrared (FTIR) spectroscopy, X-ray photoelectron spectroscopy (XPS) and transmission electron microscopy (TEM) studies. TEM and scanning electron microscopy (SEM) studies reveal the formation of CNS via curling and folding of the graphene sheets. Microstructural investigations like SEM and atomic force microscopy (AFM) confirm the evidence of microcavities and pores on the film surface. These cavities and pores contribute significantly to the observed low reflectance value of the CNT, CNS compound films by trapping the incident light. Fundamental space environmental simulation tests (SEST) performed on the coated films show promising results with reflectance values almost unaltered in the visible and NIR spectral band which demonstrate the durability of these films as potential candidates to be used in extreme space environmental conditions. The paper describes the preparation, characterization, and testing of the blended CNT and CNS coatings for low-light scatter applications. Direct evidence of emergence of CNS from SWCNTs via synthesis of GS through a simple oxidative is reported for the first time.