Terbium iodide-filled single-walled carbon nanotubes: microscopy, and spectroscopy investigations

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Terbium (III) iodide is an interesting chemical compound with unique chemical properties. The introduction of terbium iodide inside single-walled carbon nanotubes (SWCNTs) is an environment-friendly process, and it leads to the development of new nanocomposites with improved properties. The embedded terbium iodide has new one-dimensional atomic structures inside SWCNTs. Moreover, the electronic properties of filled SWCNTs are modified. Here, the atomic structures of terbium iodide-filled SWCNTs are investigated with high-resolution transmission electron microscopy, and the microstructure, morphology, and filling degrees are studied. The electronic properties of filled SWCNTs are investigated with spectroscopy. Raman spectroscopy provides an information on charge transfer inside filled SWCNTs. The number of transferred electrons, and charge transfer density along the SWCNT axis are estimated from Raman spectra. These data on charge transfer are required for applications of terbium iodide filled SWCNTs in nanoelectronics, thermoelectric power generation, and sensors. The obtained quantitative data reveal high doping efficiencies of SWCNTs with terbium iodide. This is one of the most effective dopants for SWCNTs. The data show strong p-doping of SWCNTs with the charge transfer from SWCNTs to terbium iodide. The data of Raman spectroscopy testify to the shifts of the Fermi level to the valence band of SWCNTs. From these data, the Fermi level shifts are estimated. They are in the range of 0.3-0.4 eV, and are as comparable as the values for SWCNTs filled with other rare-earth metals with environment-friendly processes.