Electrical Properties of Transparent Conductive Films of Single-Walled Carbon Nanotubes with Their Purities

Seungho Lee, Jeungchoon Goak, Chung Yeol Lee, and Naesung Lee*
Faculty of Nanotechnology and Advanced Materials Engineering, Sejong University, Seoul

Abstract : Single-walled carbon nanotubes (SWCNTs) have attracted much attention as a promising material for transparent conducting films (TCFs), due to their superior electrical conductivity, high mechanical strength, and complete flexibility as well as their one-dimensional morphological features of extremely high length-to-diameter ratios. This study investigated three kinds of SWCNTs with different purities: as-produced SWCNTs (AP-SWCNTs), thermally purified SWCNTs (TH-SWCNTs), thermally and acid purified SWCNTs (TA-SWCNTs). The purity of each SWCNT sample was assessed by considering absorption peaks in the semiconducting (S_{22}) and metallic (M_{11}) tubes with UV-Vis NIR spectroscopy and a metal content with thermogravimetric analysis (TGA). The purity increased as proceeding the purification stages from the AP-SWCNTs through the thermal purification to the acid purification. The samples containing different contents of SWCNTs were dispersed in water using sodium dodecyl benzensulfate (SDBS). Aqueous suspensions of different purities of SWCNTs were prepared to have similar absorbances in UV-Vis absorption measurements so that one can make the TCFs possess similar optical transmittances irrespective of the SWCNT purity. Transparent conductive SWCNT networks were formed by spraying an SWCNT suspension onto a poly(ethyleneterephthalate) (PET) substrate. As expected, the TCFs fabricated with AP-SWCNTs showed very high sheet resistances. Interestingly, the TH-SWCNTs gave lower sheet resistances to the TFCs than the TA-SWCNTs although the latter was of higher purity in the SWCNT content than the former. The TA-SWCNTs would be shortened in length and be more bundled by the acid purification, relative to the TH-SWCNTs. For both purified (TH, TA) samples, the subsequent nitric acid (HNO_3) treatment greatly lowered the sheet resistances of the TCFs, but almost eliminated the difference of sheet resistances between them. This seems to be because the electrical conductivity increased not only due to further removal of surfactants but also due to p-type doping upon the acid treatment. The doping effect was likely to overwhelm the effect of surfactant removal. Although the nitric acid treatment resulted in the similar electrical properties to the two samples, the TCFs of TH-SWCNTs showed much lower sheet resistances than those of the TA-SWCNTs prior to the acid treatment.

Keywords : Transparent conductive film, single-walled carbon nanotube, surfactant, purity, nitric acid treatment

† 교신저자) 이내성, e-mail: nslee@sejong.ac.kr, Tel:02-3408-3786
주소: 서울 광진구 군자동 세종대학교 나노신소재공학과