Large Deformable Multiwalled Carbon Nanotube Core–Shell Structure on Polystyrene Beads

Jun-Ho Lee, Youngkwan Lee, Jae-Do Nam

Multiwalled carbon nanotube (MWCNT)-coated polystyrene (PS) beads have been prepared by dispersion polymerization followed by a layer-by-layer self-assembly method. The concentration of carboxylic acid groups on the MWCNTs increased from $1.81 \times 10^{21}$ to $3.43 \times 10^{22}$ COO$^-$ per g as the treatment time was increased from 3 to 9 h. The sulfonated polystyrene (SPS) beads changed from being negatively charged to positively charged when the cationic polyelectrolyte was self-assembled on their surface. The surface morphology of the adsorbed polyelectrolyte was smooth without any aggregation and the thickness of the polyelectrolyte coating on the SPS beads was $\approx 0.6$ μm. The electrical conductivity and resistance of the MWCNT-coated SPS beads were measured to be $4.0 \times 10^{-2}$ S cm$^{-1}$ and $12.8$ Ω at a volume fraction of 91%, respectively.

Introduction

Carbon nanotubes (CNTs) have been among the most exciting new materials since their discovery in 1991.\(^1\) Their remarkable properties have attracted considerable interest from the scientific community and industry. As a result, they have been widely researched for various applications such as actuators, bio/electrochemical materials, sensors, transistors, nanocomposites, and nanometer-scale electronic devices.\(^2\text{–}^6\)

In recent years, metallic layers have been formed on polymer beads by various methods, including multiple electroless deposition, the electroplating method, direct metallization, sputtering, thermal evaporation, and the sol–gel method, to produce conductive beads.\(^7\text{–}^{12}\) For example, Lascelles et al. reported the coating of micro-sized polystyrene (PS) beads with polypyrrole (PPy) by the in-situ polymerization of pyrrole with FeCl$_3$ in aqueous solution.\(^13\) Although many reports have been published on the preparation of metal-coated polymers, there have been few studies of the metal–polymer interface and the metal composition of the shell layers. We previously reported that core–shell conductive beads composed of a PS core and a metallic shell of nickel–gold were prepared by sequential electroless deposition. However, a noisy response of the electrical signals occurs because of the