418f Copper Nanowire-Polymer Composites for Electrostatically Dissipative Nanocomposites

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Polymer nanocomposites are an emerging class of materials that have properties that are often superior to conventional composites, and may be synthesized using surprisingly simple and inexpensive techniques. Layered inorganic clay is the most commonly used nanoscale filler, while carbon black, fullerene nanotubes (eg. MWNT) and metal nanoparticles are less studied but show great promise. High aspect-ratio conductive filler are mixed with polymer to produce a percolated, conducting network at much lower volume fractions than nearly spherical carbon black or metal nanoparticles, enabling the production of conductive or electrostatically dissipative composites without reduction in polymer processiblility or degradation of polymer properties. Herein, we report the gram-scale electrosynthesis of copper nanowires similar in size to MWNTs, modification of their surface chemistry, and preparation of polystyrene matrix nanocomposites displaying similar behavior to MWNT-containing nanocomposites by solution processing.

Porous aluminum oxide (PAO) template was used with an adapted AC deposition technique to produce ~1 g quantities of copper nanowires. PAO templates were grown in sulfuric acid to produce pores 16 nm in diameter and ~20 or ~40 micron in depth. The pores were filled with Cu using a method similar to the ac deposition method of Moskovits, using 200 Hz, 10 Vrms sine-waves, a 0.50 M CuSO4 solution and high purity Cu counter electrodes.

The percolation threshold for the “bare” nanowires in polystyrene is close to 2 vol %. Nanowires were also functionalized using alkyl-thiol. Interestingly, the C18H37SH-functionalized nanowires produced no conductive specimens, even up to 10 vol % loading, despite the better dispersion of the nanowires observed by SEM. These results serve to illustrate that achieving a percolated network at low volume fraction of conductive filler requires not only good dispersion of the nanoparticles into the polymer, but also good contact between the conductive particles. The relatively thick alkyl thiol coating improves dispersion, but also acts as an electrically insulating layer on each wire. Thus, reduced electrical conductivity results due to the insulating nature of the coating.

Further improvements in processing and control of the nanowire surface chemistry to tailor the nanowire-nanowire and nanowire-polymer interactions is required to improve the electrical properties of these composites.