Preparation and electrical properties of a copper-conductive polymer hybrid nanostructure

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Abstract:

Abstract N-(3-pyrrol-1-yl-propyl)-4,4`-bipyridinium hexafluorophosphate (NPPBH) has been synthesized and polymerized in the presence of DNA to produce DNA-templated polymer nanowires (polyNPPBH/DNA). The pyridine group serves as a ligand for Cu(II) and to direct the subsequent electroless deposition of Cu to form Cu/polyNPPBH/DNA nanowires. UV-vis absorption spectra of the hybrid materials show an absorption peak corresponding to the plasmon resonance of Cu0 particles at about 550 nm. AFM observations show that the Cu/polyNPPBH/DNA nanowires have a wide range of diameters, 10□30 nm, but individual nanowires exhibit a uniform and continuous morphology. The electrical properties of the wires were examined by scanned conductance microscopy and conductive AFM. The nanowire conductivity was estimated using the diameter and width of the as-prepared nanowires to calculate the cross-section area (assumed elliptical). We estimate 0.42 ± 0.019 S cm-1 for the Cu/polyNPPBH/DNA nanowire conductivity. This is substantially greater than the polyNPPBH/DNA conductivity (2.1 ± 0.26 x10-2 S cm-1) which indicates that the current pathway is via the copper metallization, however the value is much lower than bulk Cu. Although the AFM images show relatively regular metal coverage of the polymer/DNA wires, the presence of discontinuities or voids along the length of the nanostructure is likely. Such gaps in the metal structure may introduce significant tunneling barriers and a granular metal model is a more appropriate description of the Cu/polyNPPBH/DNA nanowires than a simple metallic nanowire.

Keywords:

copper; DNA; nanowires; poly(N-substituted)pyrrole; conductivity; hybrid nanostructures

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