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Electrical characteristic of single strand of π-conjugated polymer nanotubes and nanowires through conducting atomic force microscope

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π-Conjugated polymer nanotubes and nanowires such as poly (3,4-ethylenedioxythiophene) (PEDOT) and polypyrrole (PPy) were synthesized by using the electrochemical polymerization method with an anodic alumina oxide (Al_2O_3) nanoporous template. A 1-butyl-3-methylimidazolium hexafluorophosphate ($BMIMPF_6$) ionic liquid was used for a dopant in electrolyte. From the SEM and TEM images, we observed the formation of PEDOT and PPy nanotubes and nanowires. The doping level of the polymer nanotubes and nanowires were electrochemically controlled through cyclic voltammetry (CV) in a solution of $BMIMPF_6$ ionic liquid without monomers. To discern the structural and optical properties of the PEDOT and PPy nanotubes and nanowires, we measured FT-IR, micro Raman, and UV/Vis absorbance spectra. The p-p* transition peaks and bipolaron peaks of the PEDOT and PPy nanotubes and nanowires were controlled through the process of repeated reduction by using CV. From the conducting atomic force microscope (AFM), we observed that the current level of the doped samples was higher than that of the de-doped ones. The detail experimental results of the polymer nanotubes and nanowires by using the conducting AFM are presented.