Supporting information

Fully Solution-Processed Transparent Conducting Oxide-Free Counter Electrodes for Dye-sensitized Solar Cells: Spray-Coated Single-Wall Carbon Nanotube Thin Films Loaded with Chemically-Reduced Platinum Nanoparticles

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Figures S1 and S2 are direct evidences for anodic doping and de-doping of SWCNT CEs after nitric- and formic-acid treatments, respectively. In Figure S1, transmittance of an as-deposited SWCNT film clearly shows three absorption bands that correspond to E_{11} and E_{22} transitions of semiconducting SWCNTs and E_{11} transition of metallic SWCNTs, respectively. After nitric acid treatment, the semiconducting E_{11} absorption band disappears almost completely, and the semiconducting E_{22}-band absorption is substantially reduced. Such bleaching of the semiconducting absorption bands is a direct evidence of anodic doping.[1,2] However, the two semiconducting absorption bands are fully recovered after formic acid treatment. Reappearance of the disappeared semiconducting absorption bands is a direct evidence for de-doping. On the contrary to the semiconducting absorption bands there is no discernable change in the metallic absorption band. Inset of Figure S1 is a landscape photo taken through the semi-transparent SWCNT CE decorated with Pt NPs. It is interesting to note that 30~40% transmittance in long visible wavelength range is sufficient to see through such a SWCNT CE.

Figure S2 shows changes in Raman spectra taken at the excitation wavelength of 532 nm. Blue-shifts of G and G′ peaks following the nitric acid treatment are the result of anodic doping.[1–3] On the contrary, formic acid treatment has resulted in red-shifts of G and G′ peaks. The downshifted positions of G and G′ peaks coincide with those of as-deposited SWCNT films. Such identical G- and G′-peak positions are another direct evidence for de-doping.

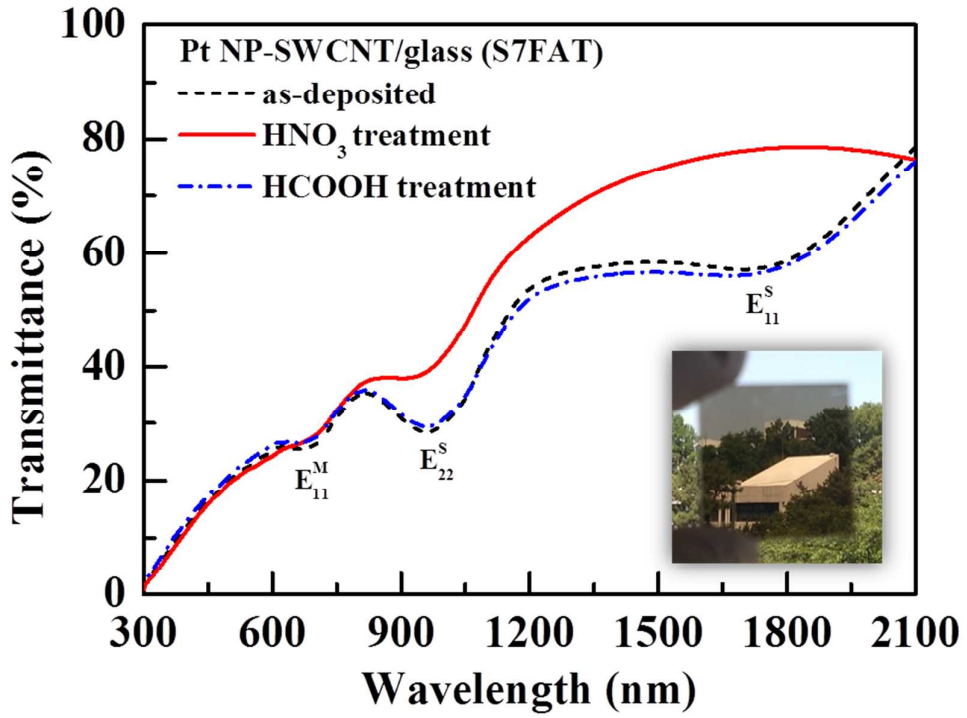

Figure S1. Change in transmittance following nitric- and formic-acid treatments. Three absorption bands that correspond to E_{11} and E_{22} transitions of semiconducting SWCNTs and E_{11} transition of metallic SWCNTs, respectively, are apparent in the transmittance of as-deposited SWCNT films. However, E_{11} and E_{22} absorption bands of semiconducting SWCNTs almost disappear after nitric acid treatment, whereas there is no discernable change in the metallic absorption band. Such bleaching of the semiconducting absorption bands is a direct evidence of anodic doping. Similarly, reappearance of the two semiconducting absorption bands after formic acid treatment is a direct evidence of de-doping. Inset shows a landscape seen through the semi-transparent Pt NP-loaded SWCNT CE.

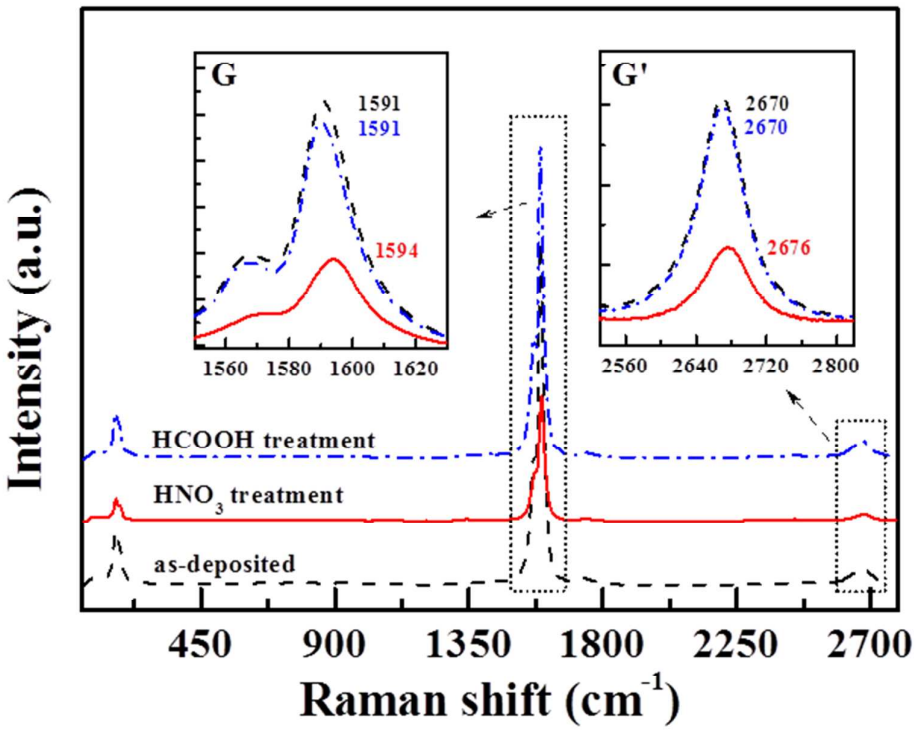

Figure S2. Change in Raman spectra following nitric- and formic-acid treatments. The excitation wavelength is 532 nm. Nitric acid treatment has induced upshifts of G and G′ peaks due to anodic doping. On the contrary, formic acid treatment has resulted in downshifts of G and G′ peaks to the positions that coincide with those of as-deposited SWCNT films. Such identical G- and G′-peak positions are direct evidence for de-doping.

REFERENCES

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