Highly Efficient and Flexible Organic Solar Cells Using Single-Walled Carbon Nanotube Films Doped with Strong and Safe MoO_x Dopant

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As an alternative path to indium based organic solar cells (OSCs), carbon nanotubes (CNTs) and graphenes with excellent mechanical flexibility and earth abundance have emerged as the next generation electrode[1]. Single-walled CNTs (SWCNTs) have advantages in terms of stretchability[2], easier synthesis, direct roll-to-roll deposition onto substrates, and accordingly lower costs. There has been a vigorous research on SWCNTs and its application as transparent conductive film in photovoltaics to date.[3] Here, we propose the most effectively composed ITO-free OSC and its flexible application by applying technologies that are state-of-the-art. Firstly, high quality direct- and dry-deposited aerosol SWCNT was used as anode for the first time. Secondly, MoOx with poly-(3,4-ethylenedioxythiophene)-polystyrenesulfonic (PEDOT:PSS) on top functioning as both dopant and hole-transporting layer (HTL) was discovered and applied. Thirdly, using thieno[3,4-b]thiophene/ benzodithiophene (PTB7), which is highly performing photoactive material with no annealing requirement, flexible application on films are demonstrated. Our record high SWCNT OSC shows a power conversion efficiency (PCE) of 6.04%, which is 83% to its ITO based counterpart with a PCE of 7.48%. (Fig. 1) We anticipate the methodology presented here is not only limited to OSCs but extends to other photovoltaic applications such as emerging perovskite solar cells too. Our finding paves toward fully carbon flexible solar cells by using a facile and stable process. (Fig. 2)

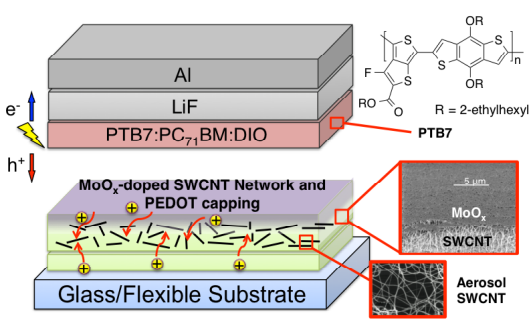

Fig 1. The schematics of our optimized device

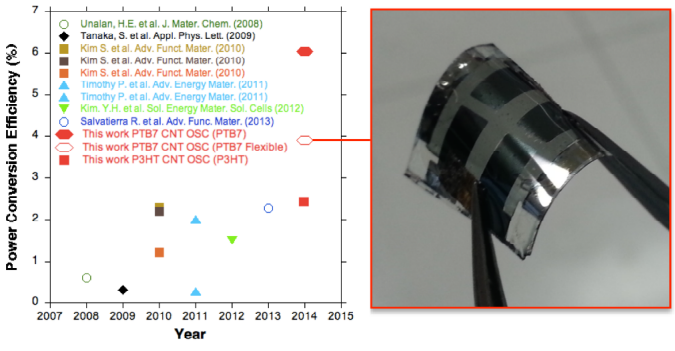

Fig 2. PCEs of SWCNT OSCs on glass (closed) and film (open)

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[2] S. Won et al. Nanoscale **6**, 6057 (2014).

[3] J. Du et al. Adv. Mater. **26**, 1958 (2014).

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