Perovskite Photovoltaics Utilizing a Conductive PCL/CNT Polymer

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Flexible and lightweight electronics and organic photovoltaic devices are highly attractive due to the ability to conform to unconventional locations for applications that range from medical devices to wearable technologies. Electrospinning (ES) provides an attractive platform for fabricating flexible devices due to producing fibrous materials with high surface area, low fabrication cost, and customizable mechanical properties.[1] A conductive electrospun mat with applications in sensing, optics, or energy can be readily produced using a feed polymer composite doped with conductive nanomaterials. Conductivity in polymeric composites has been achieved though the addition of carbon nanotubes.[2] In this work, we utilized single-walled metallic carbon nanotubes (SWMCNTs) and polycaprolactone (PCL) to prepare a conductive polymer composite that will be used to produce low-cost electrodes for flexible electronics and an electrospun photovoltaic cell.

Current progress has produced conductive polymer composite films containing PCL and single-wall carbon nanotubes (SWCNTs) combined with hydroxyl functionalized single-wall carbon nanotubes (OHSWCNTs) with a maximum conductivity of 0.0018 S/cm (*Fig 1*). The composite was used to fabricate two photoactive perovskite cells utilizing the PCL/MWCNTs/OHMWCNTs composite as an electrode (*Fig 2*). Inconsistencies present in the spin coating of the perovskite active layer (*Fig 3*) has led to the deployment of a ligand stabilized $CsPbBr_3$ solution in chloroform.

Presented work will include final conductivity optimization for the PCL/SWMCNTs/OHSWMCNTs composite, ES methodologies for conductive fiber networks, spin coating process development for the chloroform perovskite solution, and fabrication/evaluation of perovskite solar cells and cells utilizing the fabricated composite as an electrode (*Fig 3*). Solar cells will be analyzed layer-by-layer utilizing atomic force microscopy, four-point probe, solar I-V scan, light spectroscopy, Raman spectroscopy, and scanning electron microscopy. In future work, we intend to use the designed composite to fabricate a triaxial ES perovskite solar cell consisting of the conductive polymer composite, a hybrid perovskite active layer, and a polymeric hole transport layer (*Fig 4*).[3]

[1] X.X. Wang, G.F. Yu, J. Zhang, M. Yu, S. Ramakrishna, and Y.Z. Long, Prog Mater Sci **115**, (2021).
[2] G. O'Bryan, E.L. Yang, T. Zifer, K. Wally, J.L. Skinner, and A.L. Vance, J Appl Polym Sci **120**, 1379 (2011).
[3] D. Liu, J. Yang, and T.L. Kelly, J. Am. Chem. Soc **136**, 17116 (2014).

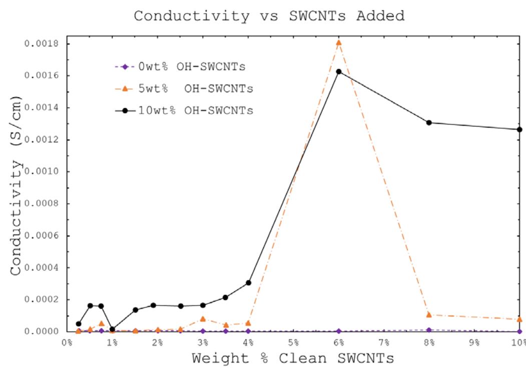

Figure 1. Conductivity plots for each of the PCL/SWCNT/OHSWCNT composites. Showing a drastic increase in conductivity due to the presence of OHSWCNTs in a concentration of five weight %.

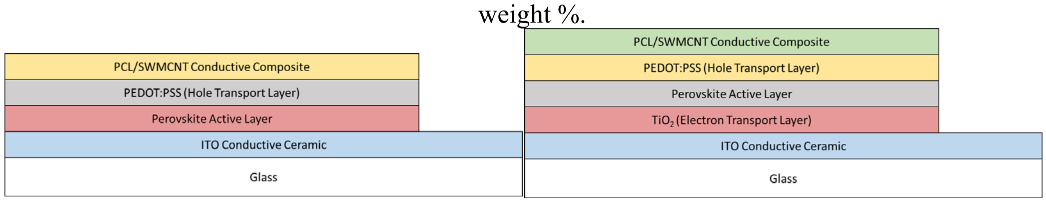

Figure 2: Visual representation of the three-layer and four-layer solar cells that will be modeled, fabricated, and analyzed throughout this work. Each of the cells will have reference cells (in which the PCL/SWMCNTs conductive composite electrode layer will be replaced with sputter deposited metallic electrode.

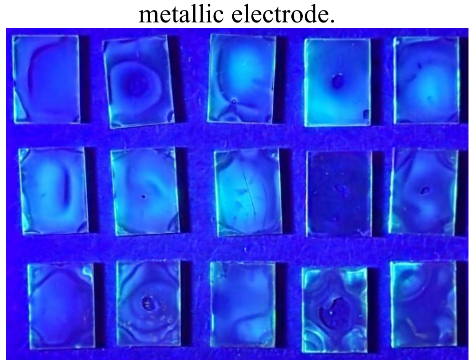

Figure 3: UV illumination of perovskite layers deposited onto glass/ITO substrates deposited via spin coating at various speeds and times. 3000 RPM provided nearly complete coverage with undesirable non-uniform thickness.

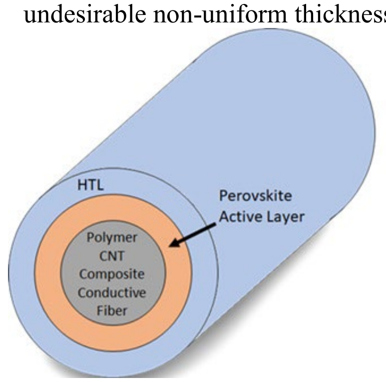

Figure 4: Visualization of the final triaxial electrospun solar cell configuration. The fiber configuration will be placed on a metallic electrode, and the polymer/CNTs conductive composite fiber will be used as the secondary electrode to complete the electrical circuit. We anticipate electrons being generated in the perovskite active layer and transported to the metallic electrode via the hole transport layer.