Conductive Electrospun Fibers for Photovoltaic Applications

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Conductive electrospun (ES) polymer fibers have recently gained interest for their applicability in photovoltaic and flexible electronic applications due to their large surface area, low fabrication cost, and relative mechanical properties.[1] Conductivity is usually achieved in electrospun fibers by directly electrospinning already conductive polymers. However, it has been shown that polymer/carbon nanotube (CNT) composites can also be electrically conductive once the percolation threshold has been reached.[2]

Completed work has yielded and effective process (*Figure 1*) for fabrication conductive polymer/CNT composite films. Ultrasonication (between 1 – 10 min) is used to disperse a blend of multiwalled carbon nanotubes (MWCNT) (0-2.5 weight%) and hydroxyl functionalized multiwalled carbon nanotubes (OHMWCNT) (0 – 7.5 weight%) in a polycaprolactone (PCL) matrix. The resulting PCL/MWCNT/OHMWCNT composite was then drop cast onto glass cover slips to form the composite films. Conductivity of the films were tested via the linear four-point probe technique showing promising conductivity in polymer that was loaded past the percolation threshold (*Figure 2*). Current system models suggest a conductivity of 0.0537 S/cm is possible with 0.15 weight% OHMWCNT and 0.05 weight% MWCNT with a sonication time of one minute.

Presented work will include a design of experiments and conductivity optimization of the PCL/MWCNT/OHMWCNT composite, electrospinning fabrication methods, and ES fiber characterization (size and conductivity). This work will provide the foundational preliminary data for future fabrication of a triaxial ES perovskite solar cell. A triaxial ES process will be utilized to produce a three-layer structure consisting of: (1) a conductive PCL composite, (2) a hybrid perovskite active layer, and (3) a polymeric ETL. Functionality of perovskite solar cells without a hole transport layer has been previously established, and a hole transport layer will not be included in the final design (*Figure 3*).[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).

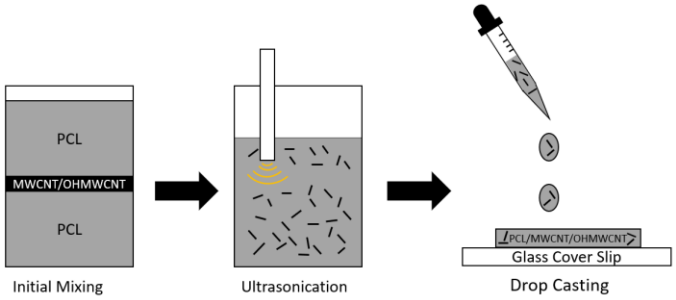

Figure 1. Process flow for the fabrication of PCL/MWCNT/OHMWCNT films. Current fabrication process yields composite films of 240 μm. Varied ultrasonication times and composite compositions affect final conductivity of the films.

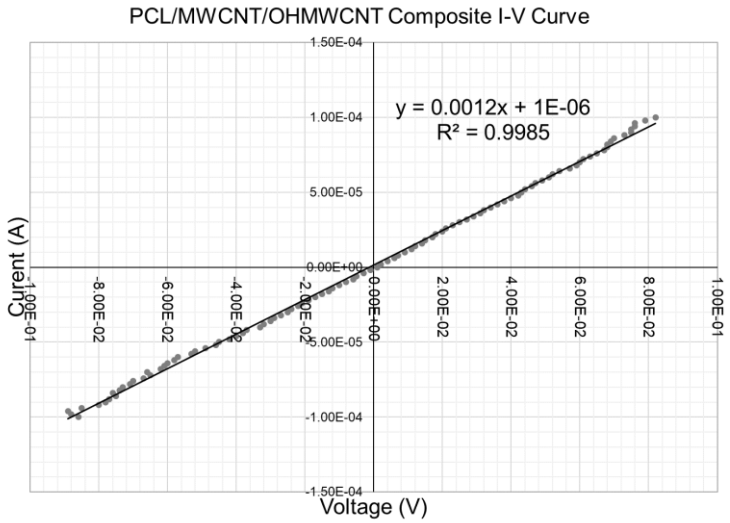

Figure 2. Example I-V curve for one of the fabricated conductive polymer composite films displaying the desired linear relationship between current and voltage. Theoretical maximum conductivity from the current model is 0.0537 S/cm is possible with 0.15 weight% OHMWCNT and 0.05 weight% MWCNT with a sonication time of one minute.

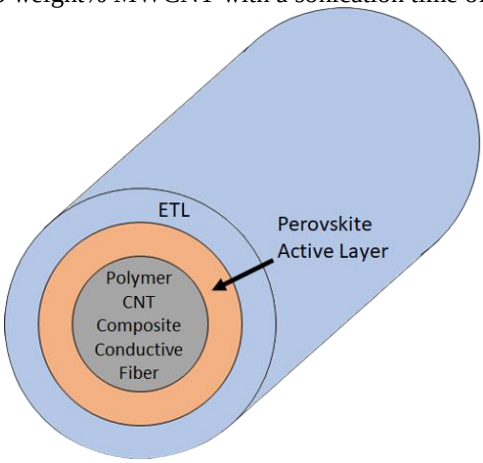

Figure 3. Visualization of the final triaxial electrospun solar cell configuration. Displayed fiber configuration will be placed on a metallic electrode, and the polymer/CNT conductive composite fiber will be used as the secondary electrode to complete the electrical circuit. Electrons will be generated in the perovskite active layer and transported to the metallic electrode via the electron transport layer.