# Conductive Hollow Nanofibers for Buffer Layer of Bulk Heterojunction Solar Cells

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## INTRODUCTION

Nanofibers have occupied an important place in energy-related fields and are used in a variety of applications. The use of nanofibers in renewable energy systems plays an important role today. Solar cells are one of the most suitable sources of renewable energy due to their high-power generation capacity and availability. We have introduced conductive polymeric nanofibers with hollow core as an efficient architecture for organic solar cells. In this design, polyaniline is a conductive polymer used as hole transport layer in the polymer solar cell. It is responsible for the transfer of holes to the anode electrode and prevents the passage of electrons. To evaluate and characterize the polymeric layer, various analyzes such as UV-Vis and FE -SEM and AFM were performed. The increase in electrical conductivity and uniform morphology of the fabricated layer leads to higher efficiencies. The obtained results show that the hollow core structure could be a rational alternative for the hole transfer layer of polymer solar cells.

## PROJECT GOAL

The aim of the research project is to develop conductivity of polymeric buffer layer of polymer solar cells by introducing a hollow-core architecture for this layer, to improve the solar cell photovoltaics parameters, Voc, Jsc as well as efficiency of the polymer solar cell.

## NANOFIBERS

SEM images of PAN, core-shell PANI @PAN and hollow core PANI nanofibers are shown in Figure 1. As you can see, PAN nanofibers have no beads and are geometrically uniform, with an average diameter of 250 nm. PANI @PAN nanofibers show uniform core/shell fibers characterized by the typical textured surface and an average diameter of about 450 nm. According to Figure 1c, the PANI hollow core nanofibers with an inner diameter of about 350 nm have a unique tubular morphology, confirming the removal of the PAN core.

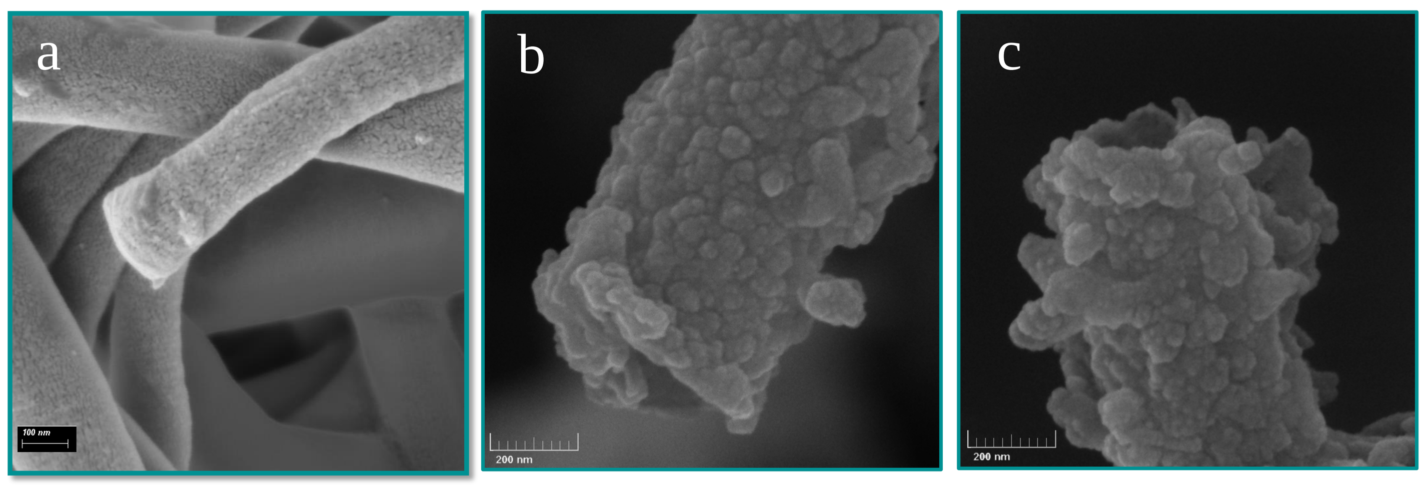


*Figure 1. FE-SEM microscope conducted on nanofibers of a) PAN, b) PANI@PAN and c) hollow core PANI. The cross-sections of the hollow nanofibers clearly show their hollowness.*

## PROPERTIES of NANOFIBERS

The spectrum of the hollow-core nanofiber PANI in Figure 2a shows similar peaks to those of the core-shell PANI@PAN nanofibers, except that the peaks assigned to the cyanide group are not present. The imperceptible peak of the cyanide group in the hollow core nanofibers indicates that the sacrificial template method was performed.

Figure 2b shows a comparison between the conductivities of the different types of PANI used in this research. As can be seen from the graph, PANI with hollow core has the highest conductivity compared to the different types of polyaniline.

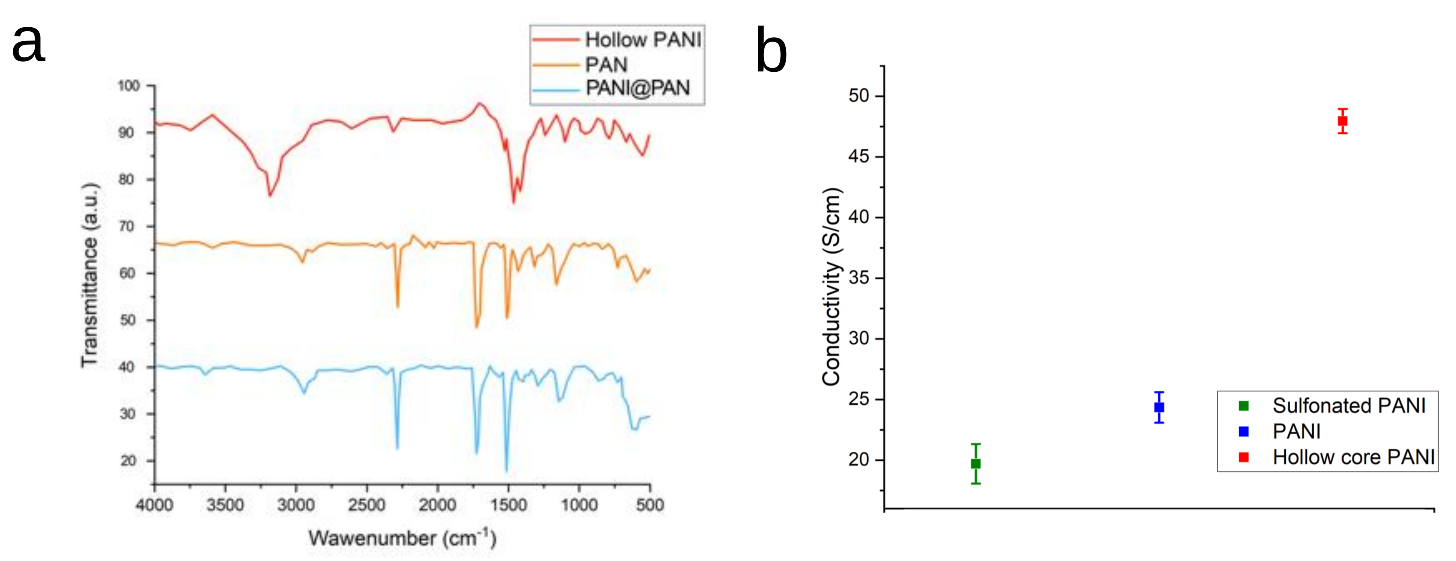


*Figure 2. a) ATR-FTIR spectra of hollow PANI, PAN, and PANI@PAN. b) Conductivity of different types of PANI*

## NANOFIBERS in SOLAR CELLS

A schematic of the solar cells and a comparison of their performances, see Figure 3a. Hollow-core nanofibers can improve efficiency in several ways: by increasing the electrical conductivity of the buffer layer, shortening the hole path to improve hole extraction, reducing the surface roughness of the buffer layers, and improving exciton generation.

The results of the IPCE analysis are shown in Figure 3b to quantify the improvement achieved in terms of Jsc and PCE. As expected, the conversion of photons into current was improved by using PANI hollow core nanofibers. A significant improvement in IPCE in the visible spectrum, corresponding to the wavelength of sunlight, can be observed in the hollow core PANI device, which is attributed to the improvement in optical properties.

The tests were performed using a solar simulator to calculate important solar cell factors such as the efficiency (PCE), open circuit voltage (Voc), short circuit current (Jsc) and fill factor (FF). The photovoltaic parameters of the measured devices are shown in Figure 3c. The reference solar cell with a typical buffer layer of PEDOT:PSS, After using the PANI hollow core buffer layer, Voc remained almost unchanged, while Jsc improved and PCE increased. The reason for this performance improvement could be related to the increase in the optoelectronic properties of the layer, the decrease in its surface roughness and also the increase in conductivity.

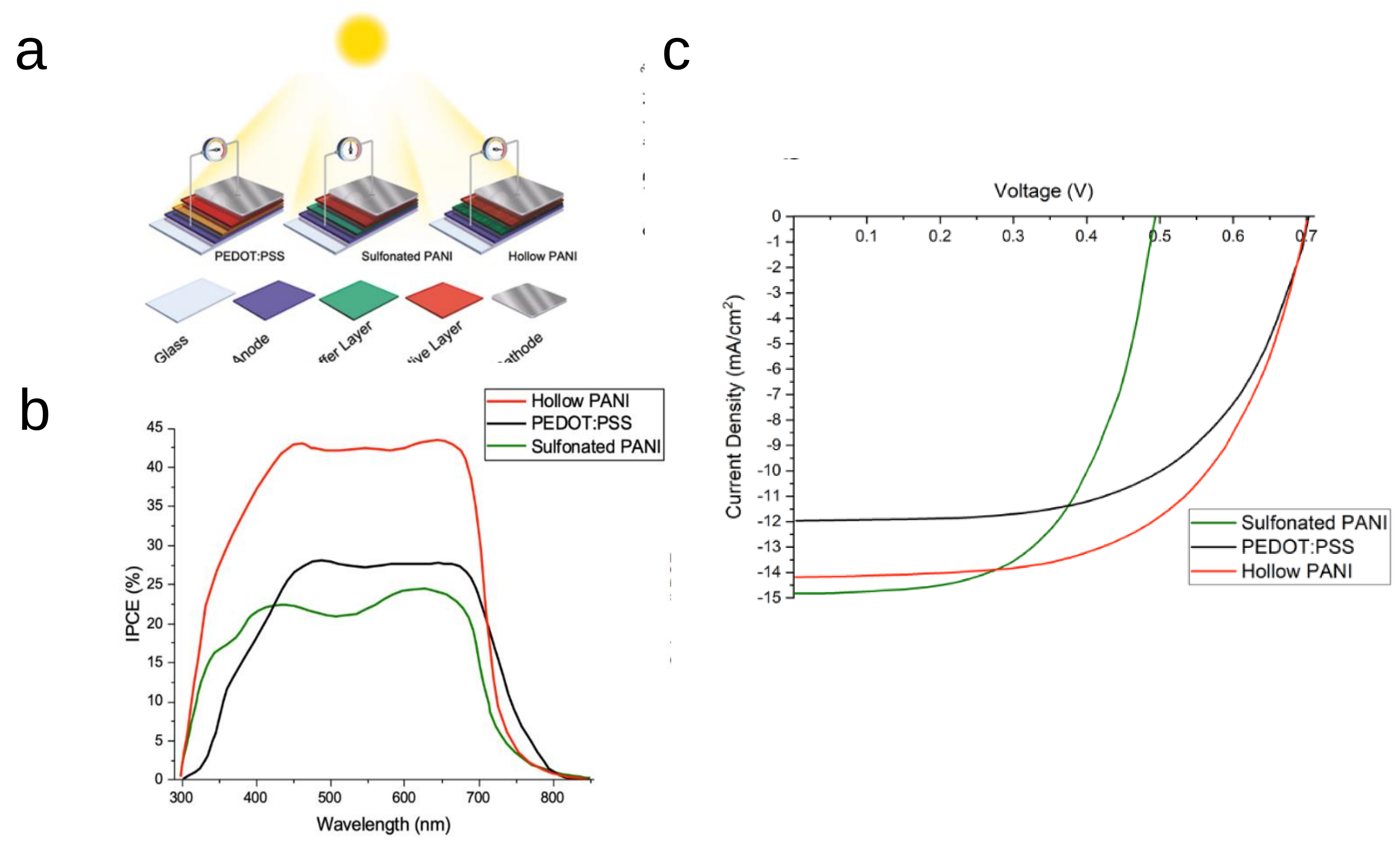


*Figure 3. a) Schematic of the manufactured solar cells b) IPCE spectra of the polymer solar cells fabricated using PANI, PEDOT:PSS and hollow core PANI as buffer layers c) Performance of synthesized buffer layers via J-V characterization of different polymer solar*

## CONCLUSIONS

In summary, well-defined polymer solar cells with a hollow core structure PANI have been successfully fabricated and characterized. The new morphology and nanostructure of PANI hollow core nanofibers showed better conductivity compared to PANI. Moreover, the presence of the novel hierarchical hollow core structure improved the transport of charge carriers while enhancing the efficiency of polymer solar cells. As shown by these results, the hollow core structure of PANI can be efficiently utilized for the fabrication of future high-performance PSCs.

## ACKNOWLEDGMENTS

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