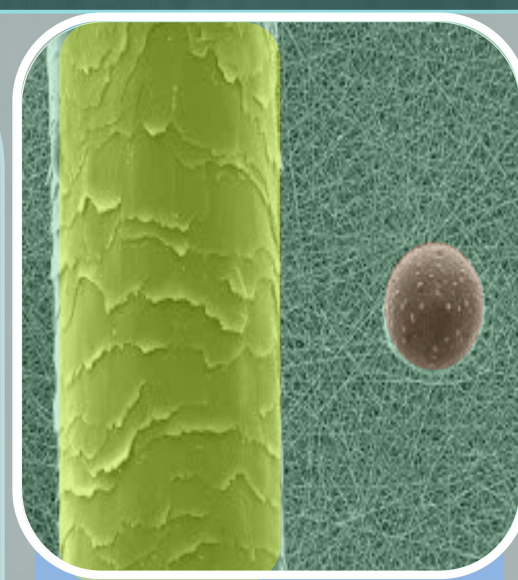
SciTech 2018
Electrospun Transparent Nanofibers For Water Splitting

Elisheva Drillich, Kunal Handa, Svetlana Grigorovich with PhD student Oren Elishav, Prof. Gideon Grader
The Wolfson Faculty of Chemical Engineering

Introduction

Electrospinning is the process of creating polymer nanofibers (referring to a fiber with a diameter less than 100 nanometers) through the use of a high voltage power supply. The applied voltage overcomes the viscous solution surface tension, creating a jet which elongate to create the nanofibers on the collector[1]. In electrospinning, many different collectors can be used, to change the fibers' orientation. For example, a two electrodes array that uses the electric field between the electrodes to align the nanofibers or a rotating drum.



- Human Hair
- Pollen
- Nanofibers

Figure 1. Nanofiber scale

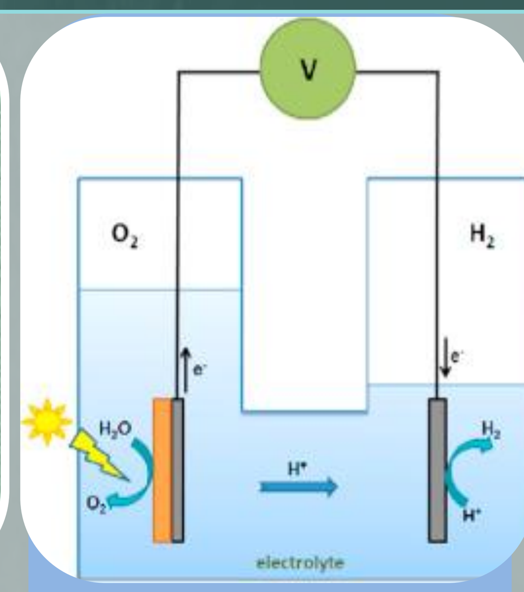


Figure 2. Water splitting cell

Our Goal

Our goal is to create an Indium Tin Oxide (ITO) mat that can be used as an photo-anode in water splitting cell (Fig.2). The nano-fibrous mat needs to be conductive, transparent and vertically aligned. This type of fibers can be used in water splitting reactions because the sunlight can pass through them. Water splitting is currently being researched as a part of a long term energy storage solution because the separated hydrogen can be used as energy storage solution.

Experimental

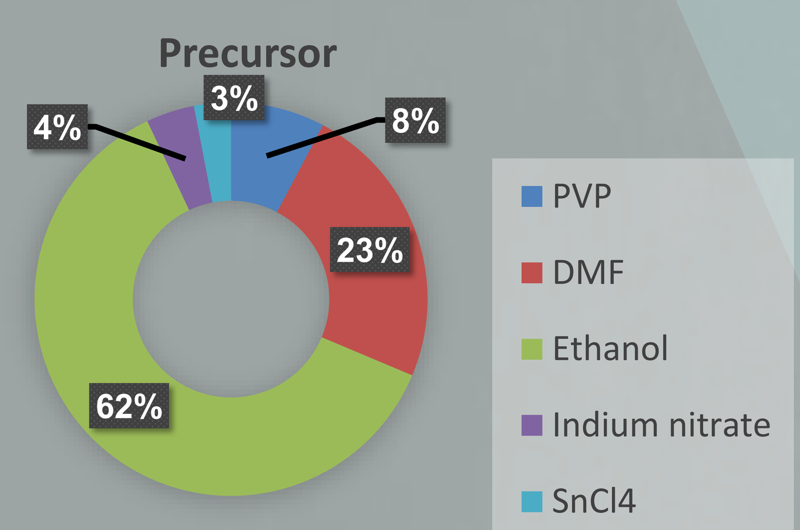


Figure 3. Precursor composition

The first step is to prepare the precursor for electrospinning. The solution is made up of PVP, our polymer, DMF, Ethanol, Indium Nitrate and Tin Chloride as in Figure 3.
After mixing our solution, it's placed into a syringe and into the electrospinning system (Fig. 4). The electrospinning runs for 1.5-4 hours, depending on the collector being used at a constant rate of 0.4 ml·hr^{-1} with a voltage of 30 kV.

Next, the mat is placed in the vacuum to dry from the remaining solvent and water. After the mat is removed from the collector, a piece of the mat is placed in the furnace so all the organic parts and the polymer will be burned. The furnace operates at a low heating rate to preserve the nanofibers' morphology.
The fibrous mat is analyzed using the Scanning Electron Microscope (SEM).

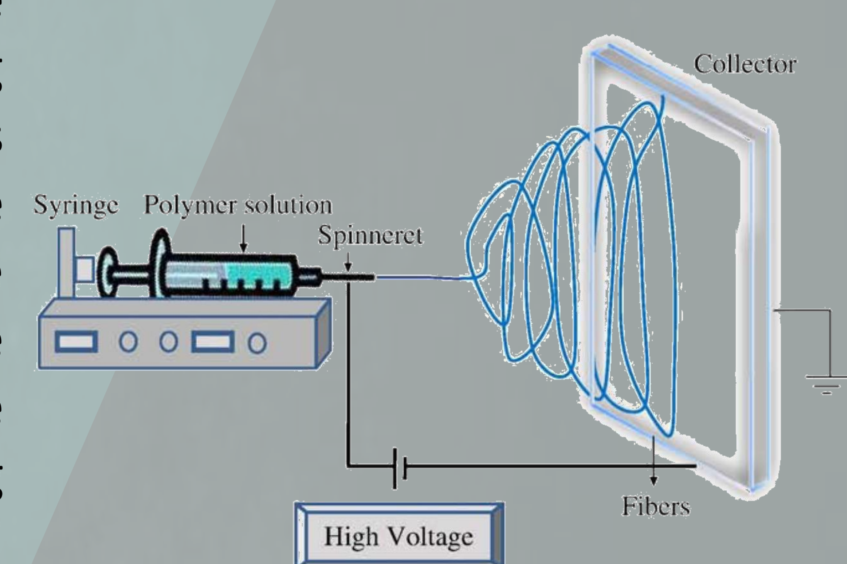
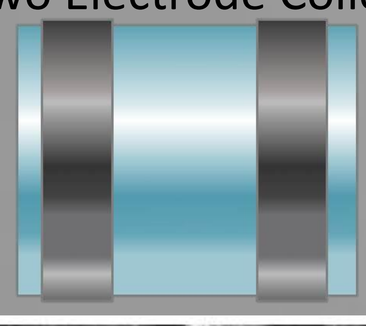


Figure 4. Electrospinning system

Results

Collector design

Two Electrode Collector



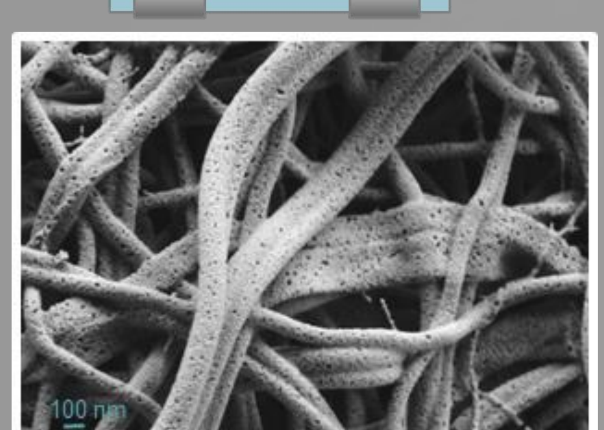
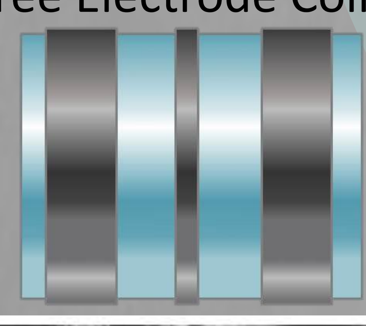


Figure 5. Two Electrode Fibers

Three Electrode Collector



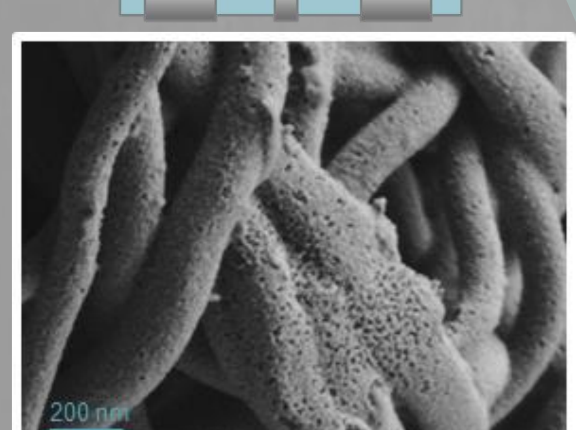
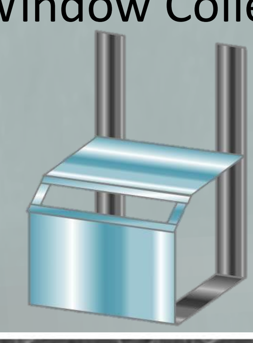


Figure 6. Three electrode Fibers

Window Collector



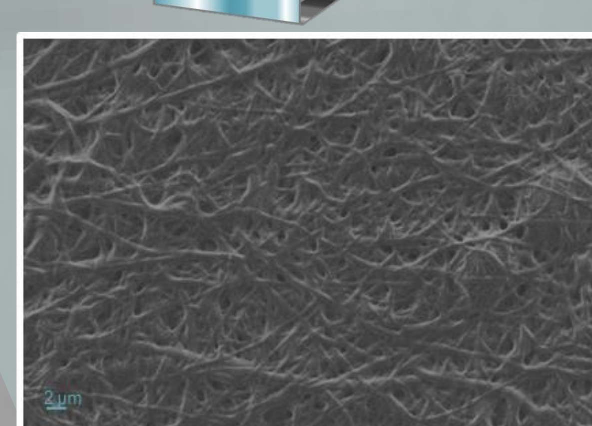
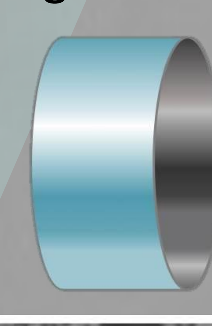


Figure 7. Window Fibers

Rotating Drum Collector



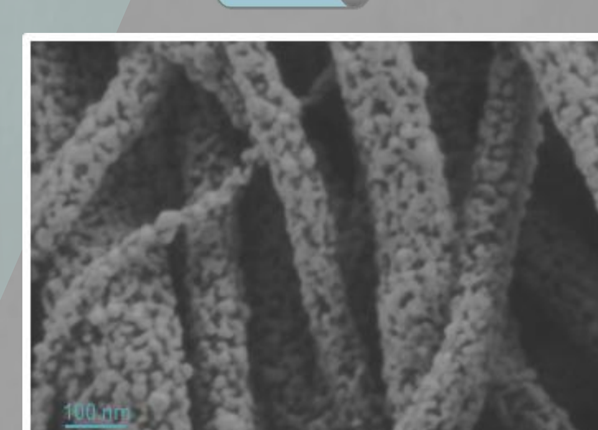
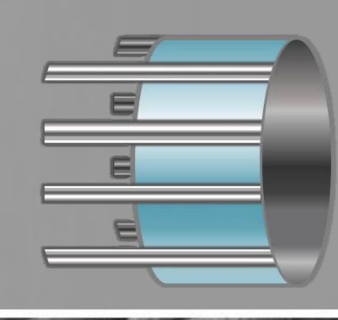


Figure 8. Rotating Drum Fibers

Electrode Drum Collector



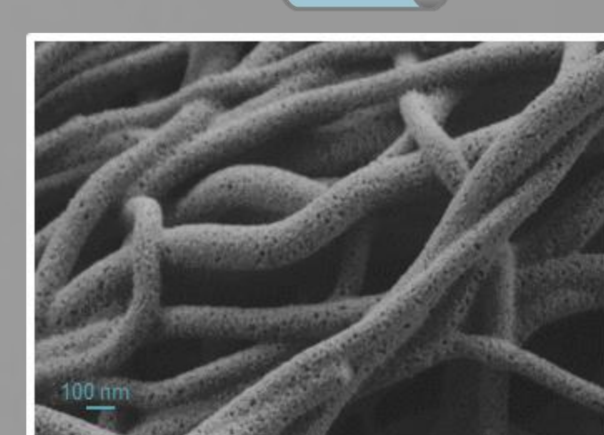


Figure 9. Electrode Drum Fibers

Transparency

Figure 10. Non-transparent Fibers

Figure 11. Semi-Transparent Fibers

Vertically Aligned

After removing the fibers from the rotating drum, they were folded and compressed. This was done to achieve vertical alignment. As seen in Figure 13.

Figure 12. Nanofiber aligning

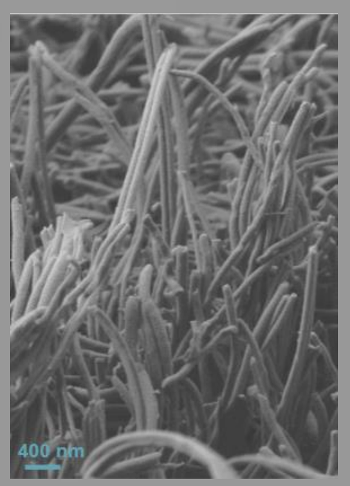


Figure 13. Aligned Folded Fibers

Summary

In conclusion, we did not fulfill all of our ambitious goals but we achieved a lot. We were able to create semi-transparent, vertically aligned nanofibers. In addition, there was not enough time to see if our nanofibers were conductive.
With our collector, we created a new and more efficient collector that produced semi-transparent, vertically aligned fibers.

Looking Forward

Improving the transparency of the fibers suitable for water splitting reaction. In addition, the conductivity of the fibrous mats will be tested. Photocatalysts nanoparticles will be integrated to the mat. The fibrous mat with the nanoparticles will be assembled as photoanode in a water splitting cell.

Acknowledgments

We would like to thank Oren Elishav PhD and Prof. Gideon Grader for hosting and guiding us through our research in his laboratory.

We would also like to thank the foundations and donors for their generous support of the SciTech Program

[1] Lu, Xiaofeng, Ce Wang, and Yen Wei. "One-dimensional composite nanomaterials: synthesis by electrospinning and their applications." Small 5.21 (2009): 2349-2370.