Multi-Walled Carbon Nanotube & Polypyrrole Nanocomposite and its Interactions with AMB-1 Bacteria

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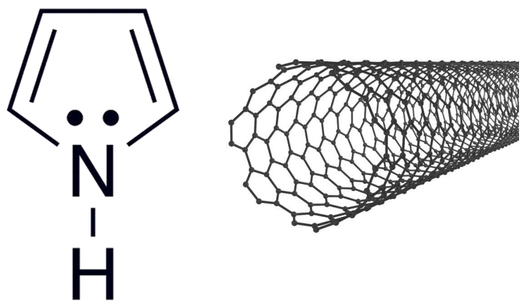


Abstract

Being able to easily manufacture pristine carbon nanotube (CNT) is a difficult problem that we face today. There are many different chirality (twists) that the carbon nanotubes orient themselves in making them either more metallic or semi-conducting in nature. *Being able to separate these two types is very important to electronic industries because semi-conducting carbon nanotubes are better suited for devices such as transistors.* Magnetospirillum *magneticum* (AMB-1) is a bacteria that can be used through magnetotaxis for controlled assembly of CNT based devices. It has been shown that there are favorable interactions between the MSP-1 surface protein and flagellin protein from AMB-1 with only semi-conducting carbon nanotubes[1] through glycine and its flanking residues.

In order to better study this interaction, this work is on the fabrication of a free standing nanocomposite carbon nanotube and polypyrrole (Ppy) film using cyclic voltammetry. This technique electro-polymerizes the pyrrole monomer into Ppy through a series of oxidation and reduction reactions along with multi-walled carbon nanotubes (MWNT) to be deposited on an electrode. It has been shown before that graphene, pyrrole, and carbon nanotubes can form a film together using cyclic voltammetry[2]. In general, carbon nanotubes have a difficult time being suspended in water because they are non-polar (hydrophobic), which challenges the process of making the films containing only CNTs.

The specific aim of this project is to look at the interactions between AMB-1 and MWNT/Ppy film using scanning electron microscopy (SEM), electrochemical impedance spectroscopy (EIS) and atomic force microscopy (AFM). In order to have large number of interactions between AMB-1 and CNT only, we are working to find the least amount of pyrrole needed to make the film containing the most amount of CNTs.

1. Method

1.1 MWNT-Ppy film formation:

We used cyclic voltammetry to co-electro polymerize pyrrole and MWNT to deposit it on a graphite plate.

CV parameters:

- V_{high}= 900mV
- V_{low} = 800mV
- Scan rate = 10 mV/s
- Number of cycles = 100

1.2 Dispersion:

MWNT were suspended in a solution of pyrrole and sodium sulphate. This was done by magnetic stirring and tip sonication.

Figure 1*: Experimental setup to magnetic stir and tip sonicate solution at the same time*

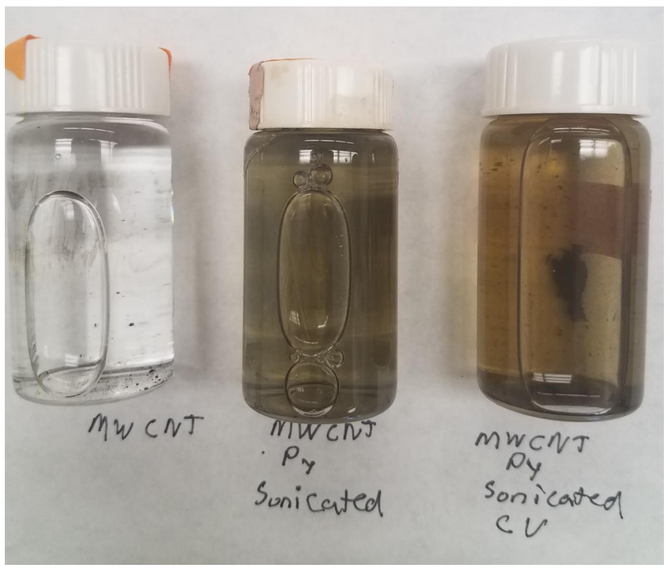
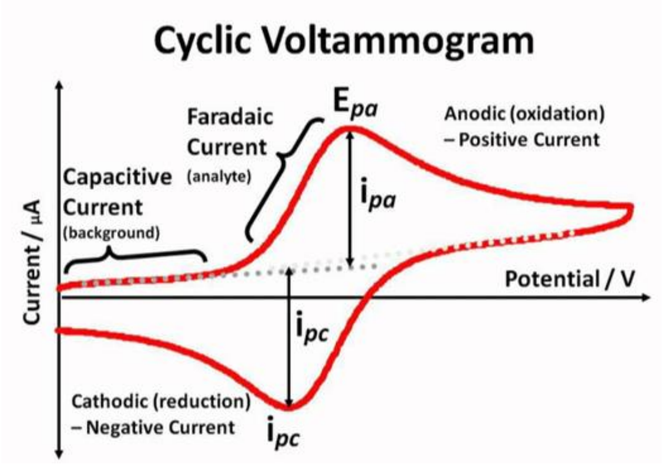


Figure 2*: Comparison of appearance of MWNT after suspension and after cyclic voltammetry*



2. Results

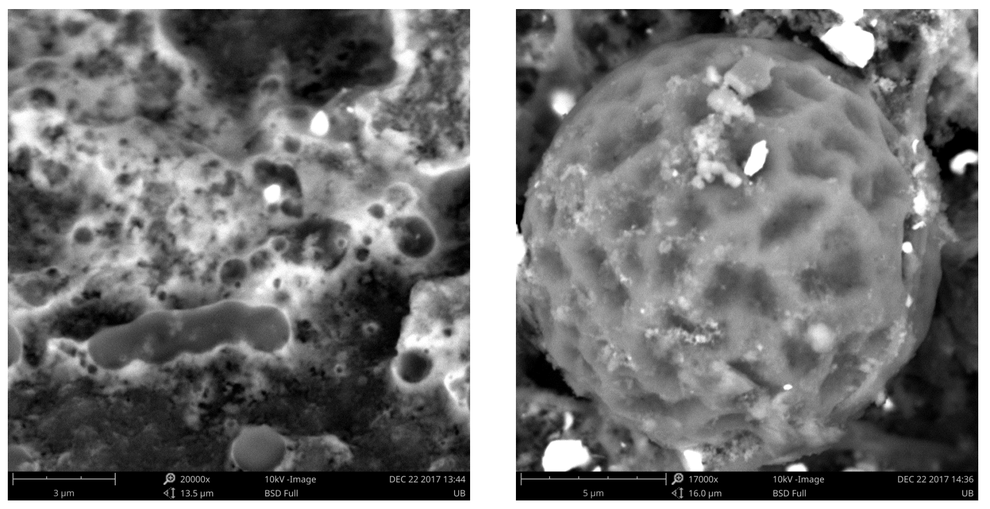
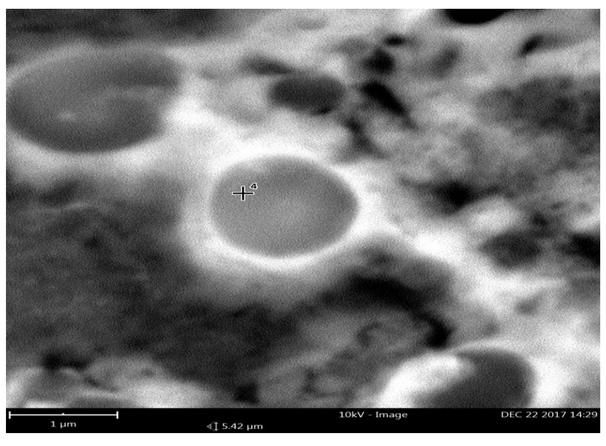


Figure 3*: SEM analysis: Individual pyrrole grains, polypyrrole and MWNT/Ppy nanocompsite surface.*



Element Number	Element Symbol	Element Name	Atomic Conc.	Weight Conc.
6	C	Carbon	43.90	37.65
8	O	Oxygen	29.54	33.75
7	N	Nitrogen	23.41	23.42
11	Na	Sodium	3.15	5.17

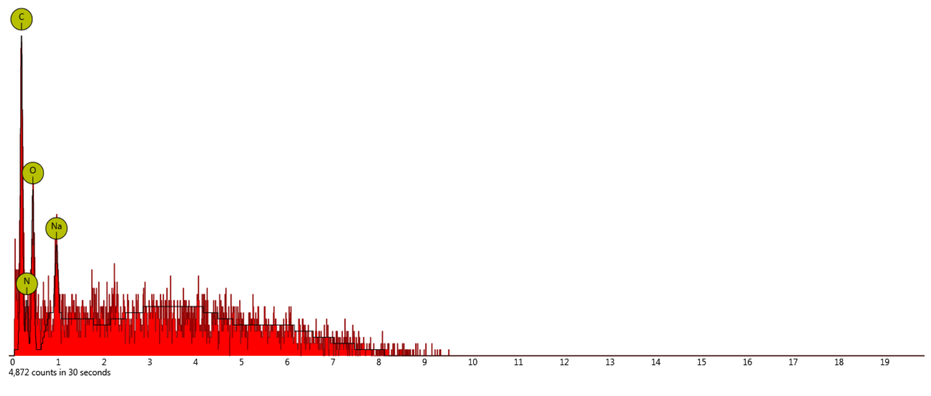


Figure 4: *Energy Dispersive X-ray Spectroscopy of Ppy MWNT sample*

Figure 5*: Ppy film by cyclic voltammetry.*

3. Conclusion and Future work

- We have been able to show that when Ppy is polymerized using cyclic voltammetry, MWNT can be combined to form the composite.
- In order to better suspend the MWNT in solution so that more of it can bind with Ppy, we have been able to use tip sonication to a greater extent but the overall protocol needs to be improved.
- The least amount of pyrrole has been found that is necessary to create 1 by 1 cm film. This is important because the purpose of this research is to later see how proteins on AMB-1 bacteria interact with a free standing MWNT film.
- Next it is planned to use AFM to measure the mechanical forces between AMB-1 and the film and EIS to measure the change in the impedance based on the interactions between the AMB-1 and MWNTs.

4. Acknowledgements

SEM: Fairchild Wheeler high school

Tip Sonication: Dr. Stergios Bibis, Department of Biology.

5. References

1. Sehmus Ozden, Isaac Macwan, et al., 2017. Bacteria as Bio-Template for 3D Carbon Nanotube Architectures, Sci Rep.

2. Ashish Aphale , Krushangi Maisuria, et al., 2015. Hybrid Electrodes by In-Situ Integration of Graphene and Carbon-Nanotubes in Polypyrrole for Supercapacitors