Photocatalytic Photosystem I/PEDOT Composite Films Prepared by Vapor Phase Polymerization

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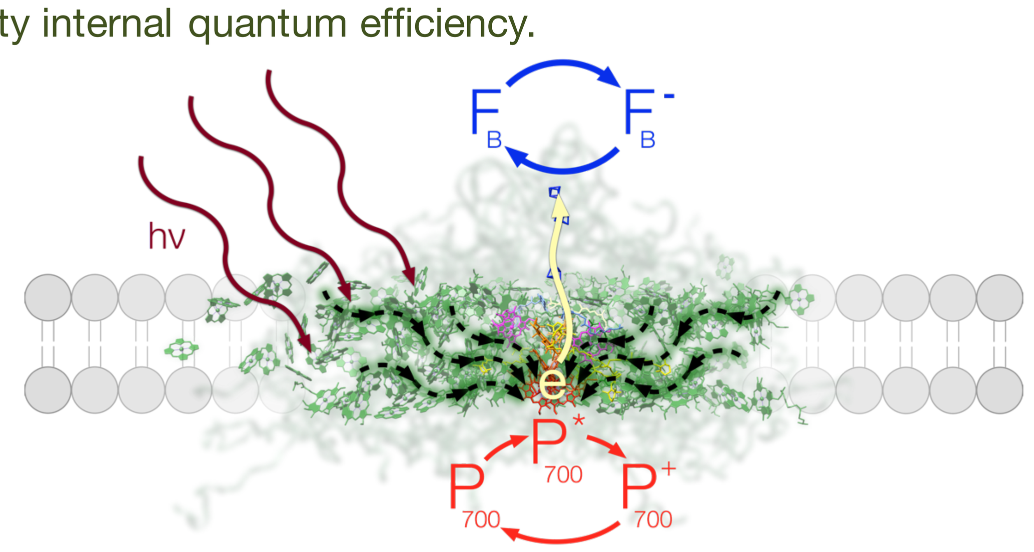
Photosystem I (PSI)

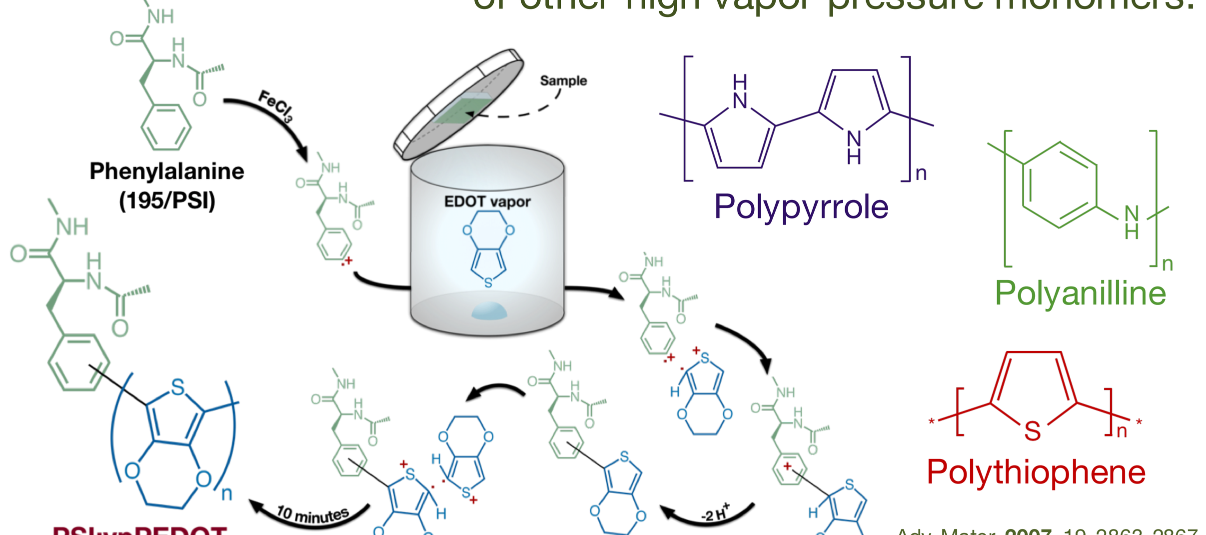
PSI is a globally abundant, photocatalytic protein found in the thylakoid membrane of photosynthetic organisms, with near-unity internal quantum efficiency.



This group currently focuses on maximizing the functionality of PSI within films for solar energy conversion applications.

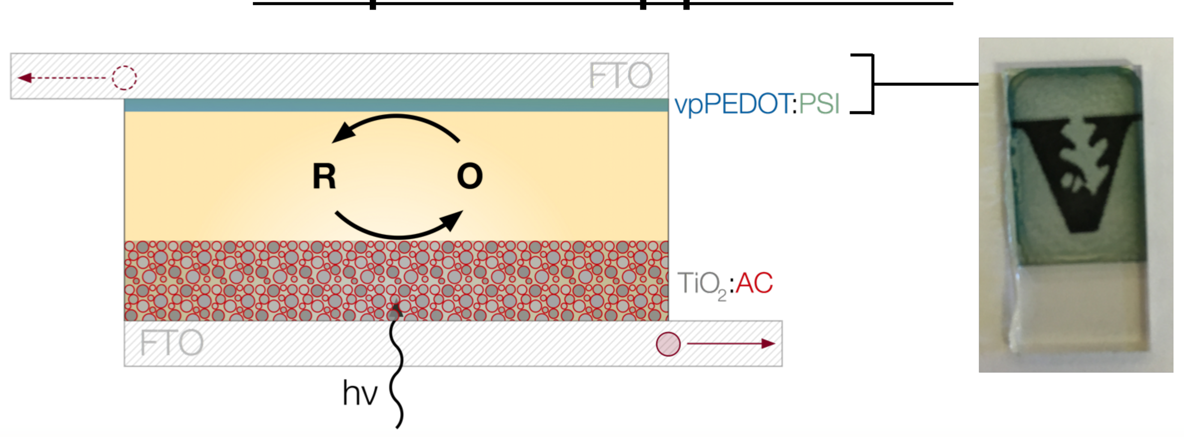
Vapor Phase Polymerization

Electrically conductive polymer films of poly (3,4-ethylenedioxythiophene) (PEDOT) can be grown by free radical polymerization, resulting from the condensation of a high vapor pressure monomer near a Friedel-Crafts catalyst ($FeCl_3$). This technique allows for rapid polymer grafting in a single step, without the use of solvents, and can be expanded to a number of other high vapor pressure monomers.



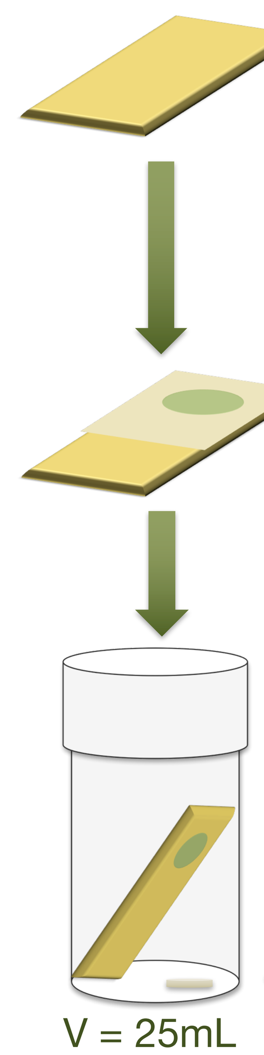
Adv. Mater. 2007, 19, 2863-2867.

Proposed Application



vpPEDOT:PSI is proposed as an alternative to platinum at the counter electrode of dye sensitized solar cells (DSSCs), where PSI allows for the reduction of ions in the mediator solution, reducing resistance to charge transfer.

Film Deposition Process and Characteristics



Drop cast 50µL PSI solution:

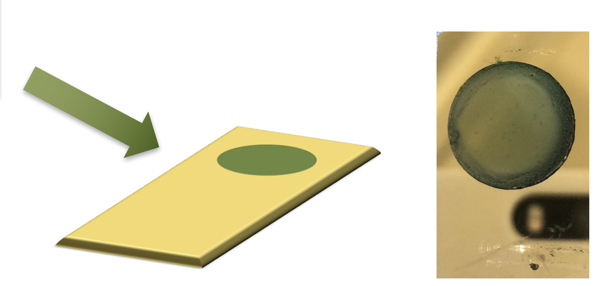
1. PSI
2. 0.025% Triton X-100
3. 10mM $FeCl_3$

into 1cm² mask, vacuum dry

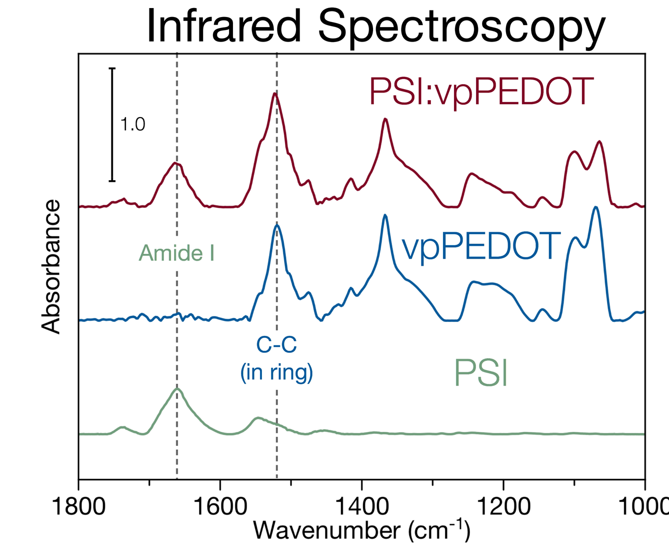
Heat 20µL EDOT at 40°C for 10min for vapor phase polymerization

Rinse to remove residual $FeCl_3$, Triton, PSI

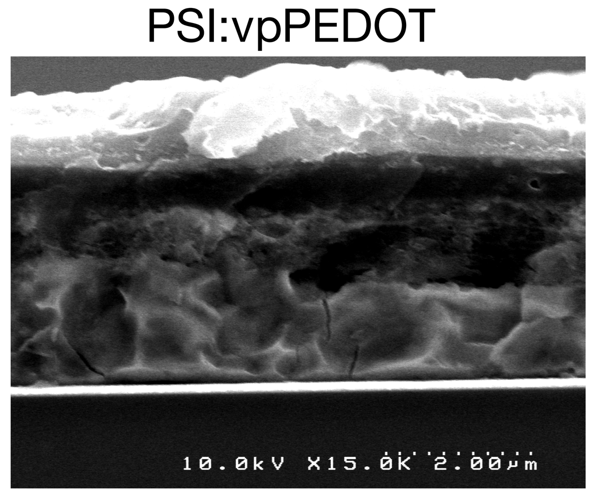
V = 25mL



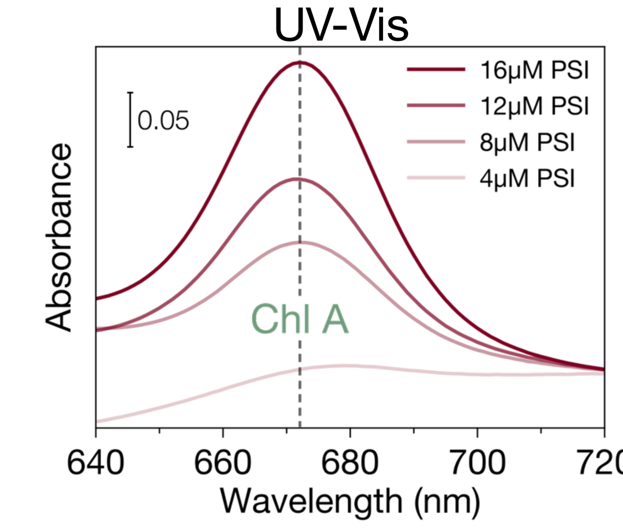
Infrared Spectroscopy



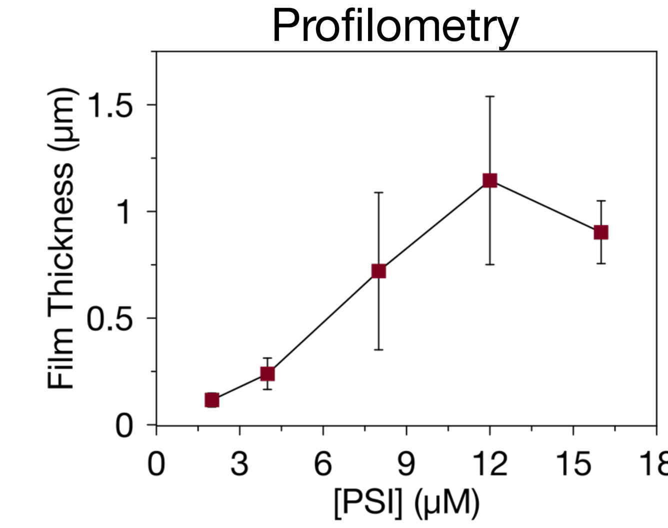
PSI:vpPEDOT



UV-Vis



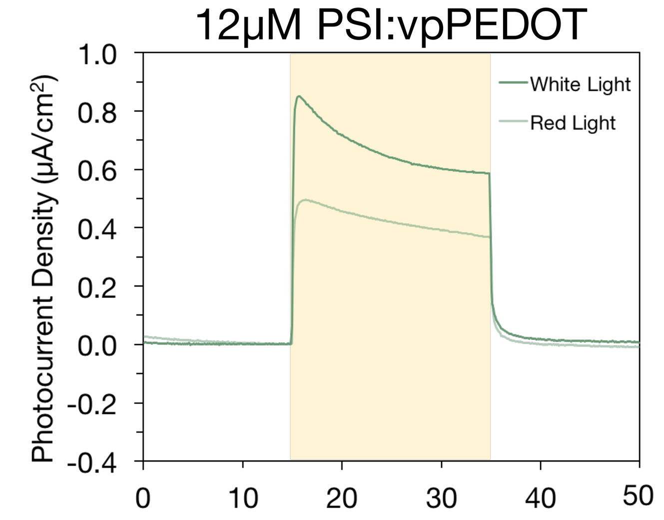
Profilometry



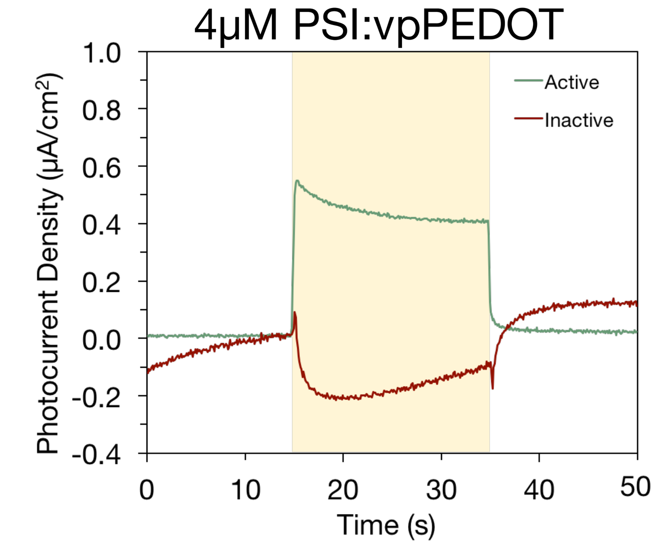
The secondary structure of PSI remains intact with polymer growth throughout the multilayer. Increased protein inclusion reduces encapsulation.

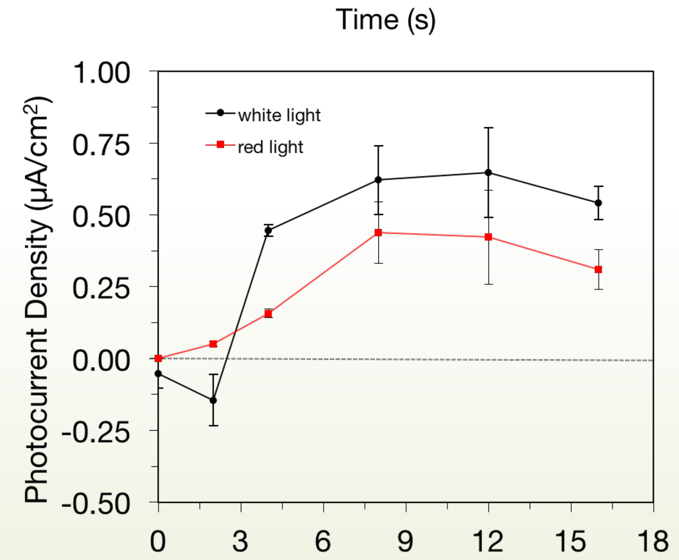
Photocatalytic Performance

12µM PSI:vpPEDOT



4µM PSI:vpPEDOT



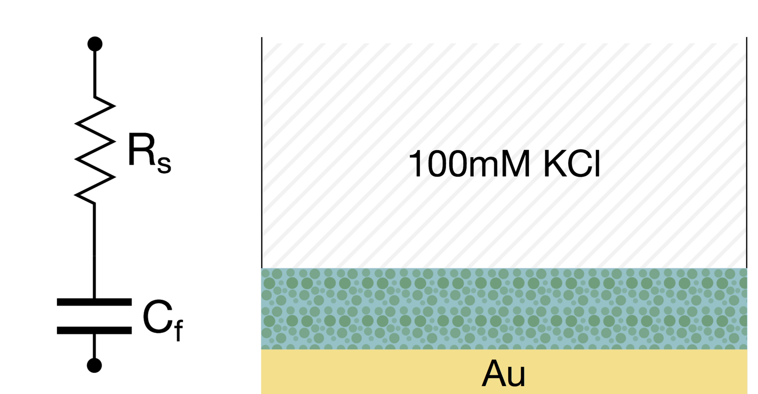


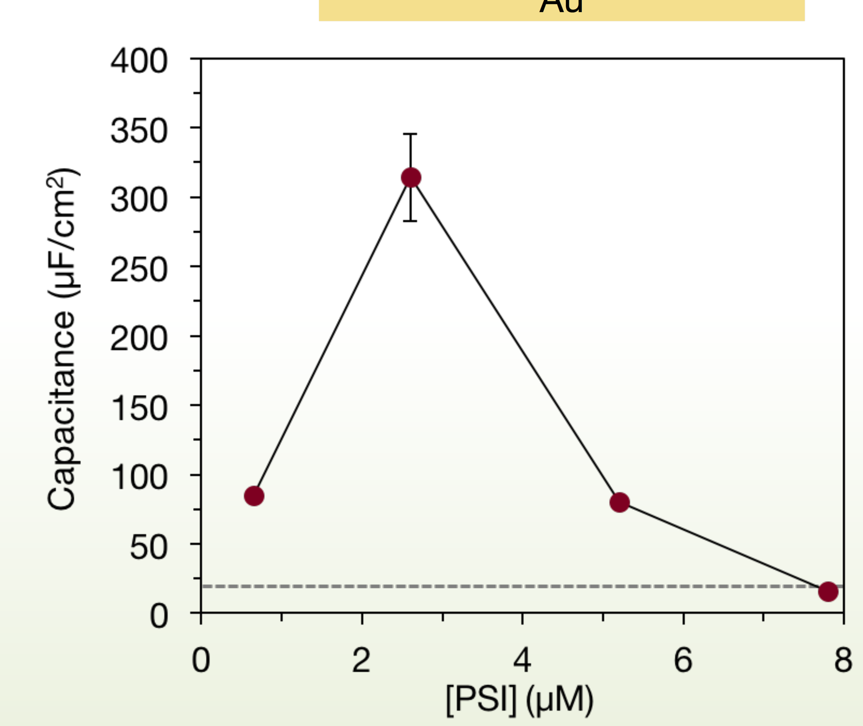
Maximum photocurrent output (~0.65µA/cm²) is achieved when 12 µM concentration of PSI is included in the drop cast solution.

PSI contributes significant red light response of up to 70% of photocurrent density.

Electrolyte Solution: 20mM NaAsc/1mM DCIP/100mM KCl

Electrochemical Impedance Spectroscopy



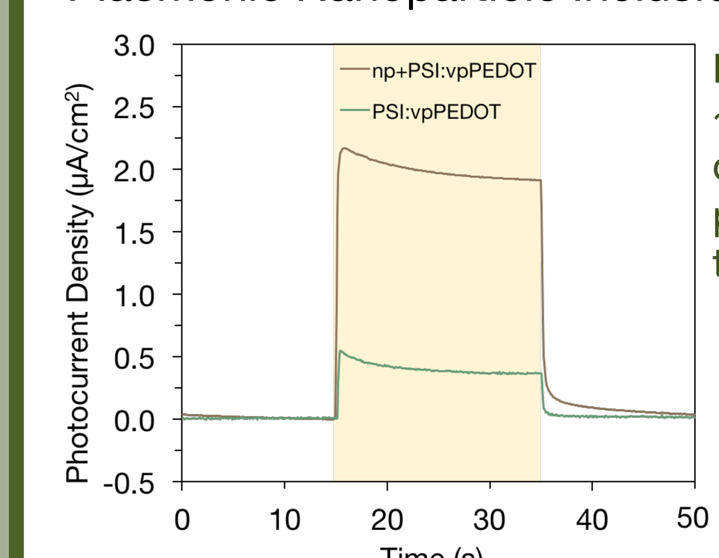


Conclusions

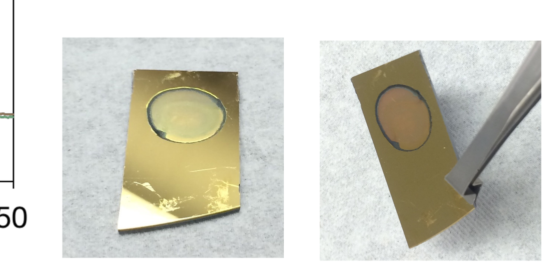
- PSI can be successfully incorporated into a polymer matrix via vapor phase polymerization while retaining its light absorbing properties and secondary structure.
- Polymer inclusion increases the film capacitance to ~25x that of PSI-only films, indicating growth throughout the PSI multilayer.
- Using this technique, PEDOT-encapsulated PSI is found to provide a maximum photocurrent density of ~.65µA/cm².
- At high concentrations of PSI, films are dominated by the protein, which prevents encapsulation within the polymer, leading to film loss after rinsing. This results in thinner and lower performing films with decreased capacitance.

Future Work

Plasmonic Nanoparticle Inclusion



Preliminary results show a ~4x increase in photocurrent density upon the addition of plasmonic nanoparticles in the drop cast solution.



Future work will further investigate the effects of plasmonic nanoparticle inclusion on absorbance and photocurrent output.

References & Acknowledgments

This project was funded by the VINSE NSF REU Grant: DMR-1263182 and the United States Department of Agriculture (2013-67021-21029 USDA). I gratefully acknowledge the support of Evan Gizzie, Faustin Mwambutsa, Ian Njoroge, and the Cliffel and Jennings lab groups as a whole, as well as the Vanderbilt Institute for Nanoscale Science and Engineering.

USDA NSF VINSE