Bridging the Gap: Photosystem I Initiated Polymer Growth For Solid-State Solar Cell Applications

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Introduction

Background:
Photosystem I (PSI) is a photosynthetic protein that drives photosynthesis in green plants. Once extracted, it can be placed on an electrode in order to convert light energy into electrical energy within a biohybrid cell.

Polymerization off of PSI with a semiconducting polymer, polythiophene (PT), would provide a route to more efficient PSI-PT electron transport within the active layer of solid-state devices.

Objective:
1. Grow polymer off of PSI via Surface-Initiated Ring Opening Metathesis Polymerization (SI-ROMP)
2. Explore two different polymer attachments to PSI
   1. Lysine-based from Amin termini
   2. Aspartic and Glutamic Acid-based from Carboxylic Acid termini

SI-ROMP
Lysine-Based Polymerization

Aspartic and Glutamic Acid-Based Polymerization

Monolayer Tests:

pNB6F Growth on PSI Monolayer

pNB6F Growth on PSI Monolayers

Results

Graph 1 shows that both Amide I and Amide II peaks of PSI remain unchanged after exposure to DCM, indicating that the secondary structure of PSI remained intact. SI-ROMP is most efficient in the organic solvent Dichloromethane (DCM). For DCM testing, PSI monolayers were exposed to two 15 minute intervals of DCM to simulate SI-ROMP preparation.

Graph 2 shows that PSI retains photoactivity after DCM exposure.

Monolayer Tests:

DCM Tests:

DCM Effect on PSI Monolayer

Effects of DCM on PSI Monolayer

Graph 3: FTIR results of SI-ROMP progression on PSI

The appearance of C-F stretching peaks from 1300-1100 cm\(^{-1}\) verifies the attachment of the NB6F polymer.

Graph 4: Ellipsometry results of pNB6F growth on PSI

Both attachment methods show polymer growth off of PSI monolayer.

Future Work

- Synthesis of an anchored polythiophene (PT) monomer to a norbornene backbone, providing for a covalently-wired and highly conjugated polymer matrix for efficient PSI-PSI charge mediation.

- Attachment methods initiated from terminal amines or terminal carboxylic acids allow for more consistent polymer growth.

Conclusions

- Successfully polymerized off of PSI via SI-ROMP using two different attachment methods
- Obtained polymer growth from both monolayers and multilayers of PSI
- Characterized polymer films using contact angles, FTIR, ellipsometry, and profilometry
- Discovered that Grubbs Catalyst physisorbs to PSI, effectively growing polymer from the unmodified protein surface
- Attachment methods initiated from terminal amines or terminal carboxylic acids allow for more consistent polymer growth

References & Acknowledgments

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