Controlling the Orientation of Photosynthetic Protein Assembly on Solid Surfaces: a Strategy for Improving Bio-derived Solar Cells

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Introduction

- Photosystem I (PSI) is a membrane-bound protein found in higher order plants that acts as a natural photodiode
- PSI can be used in solar cells as a photodiode which, utilizes light to generate an electron-hole pair

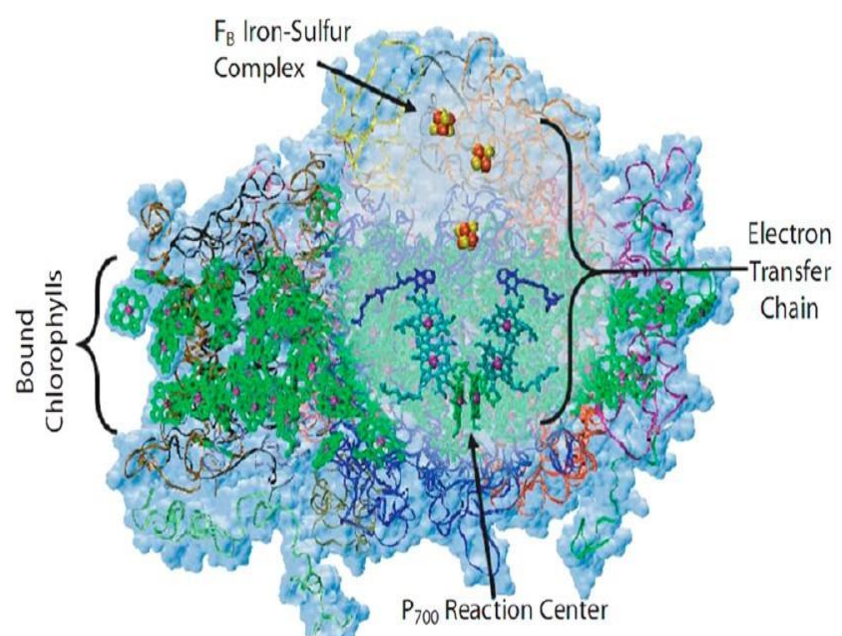
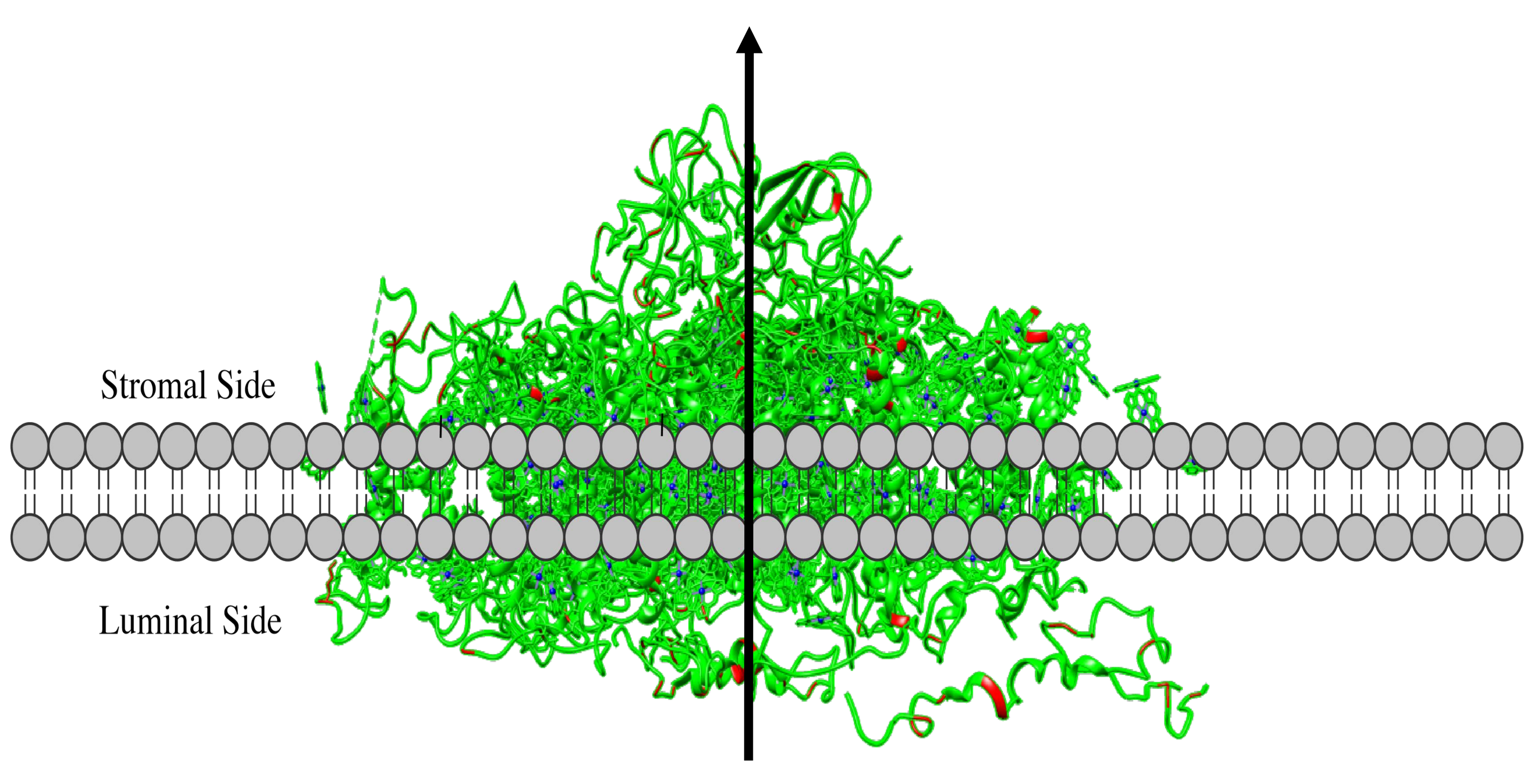


Photo Credit: *(1)*

- Bio-derived solar cells can provide remarkably clean energy and utilizing PSI affords an abundant, low cost material for solar cells

Natural Orientation of Photosystem I

In Nature, Photosystem I is oriented uniformly in the thylakoid membrane found in chloroplasts, and operates by shuttling electrons across the membrane unidirectionally

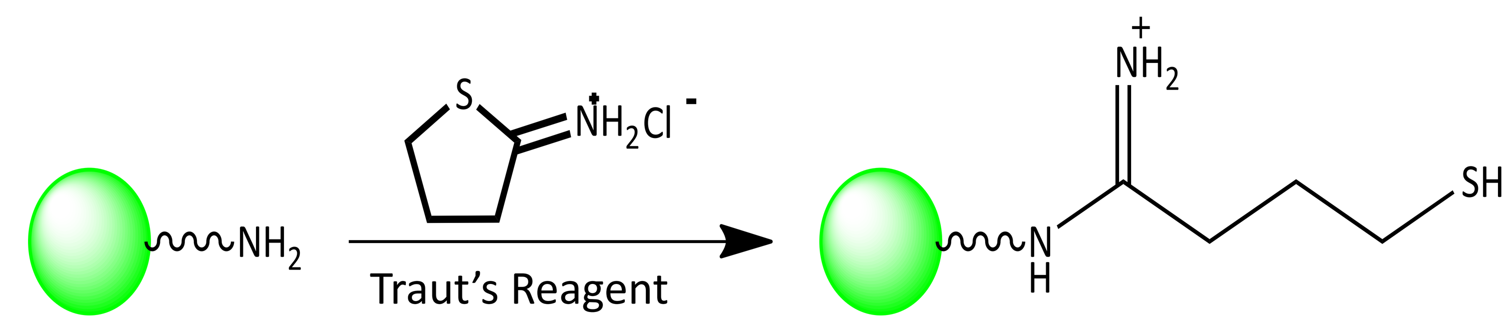


In Vivo
Electron Flow

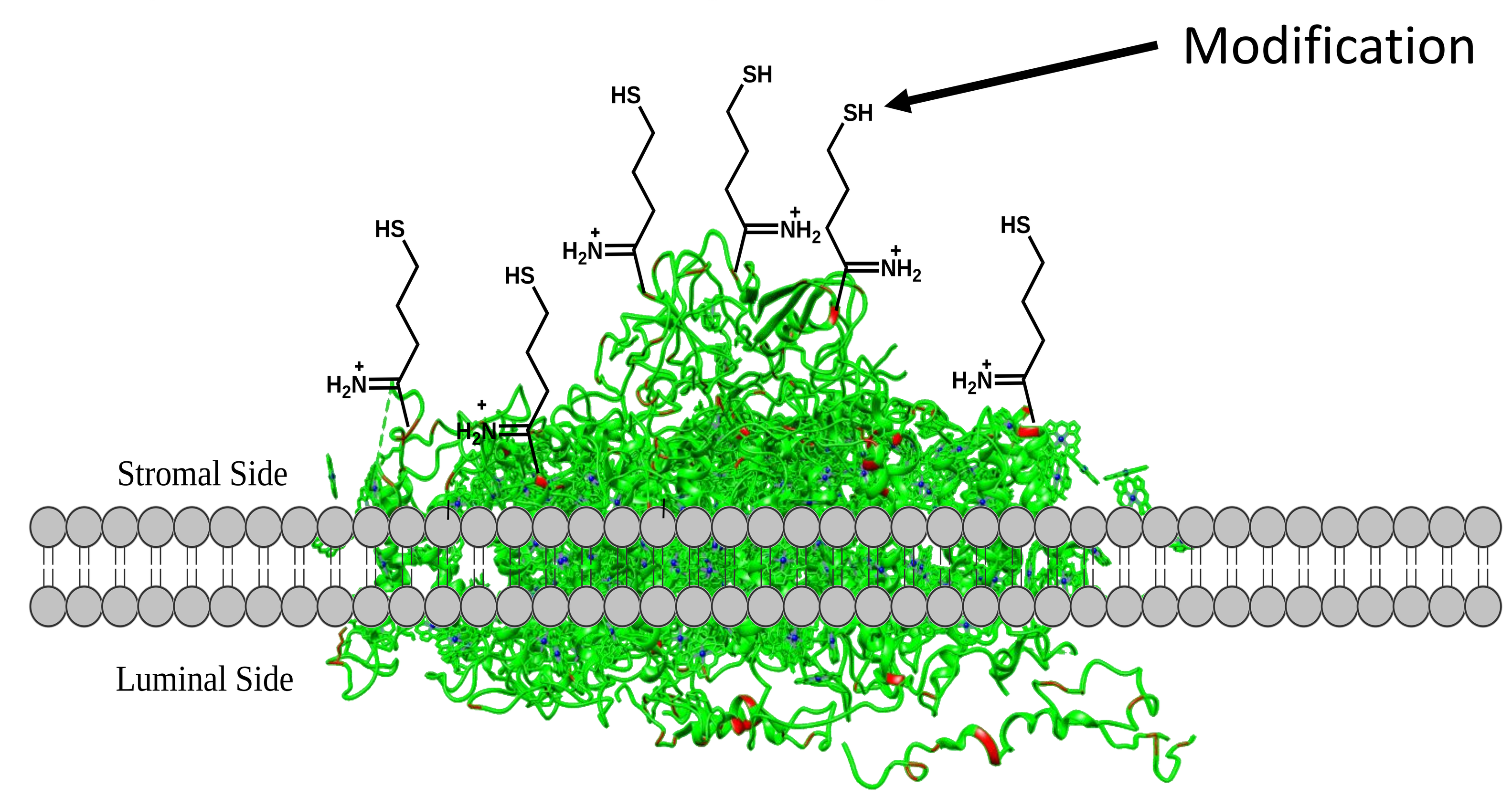
Natural orientation leads to a uniform electron flow across the thylakoid membrane, driving photosynthesis

To achieve maximum current in a solar energy conversion device with PSI, the orientation of PSI must be uniformly controlled

In Situ Modification of Photosystem I



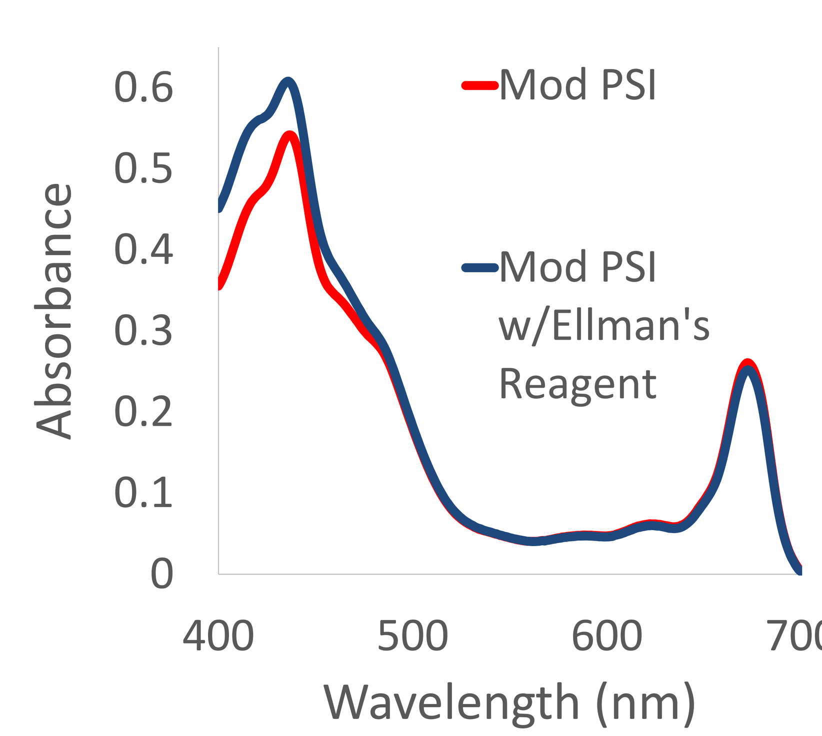
In order to orient PSI, an *in situ* modification was performed using 2-iminothiolane (Traut's Reagent) to modify one side of the protein with the thylakoid membrane acting as a ligand barrier

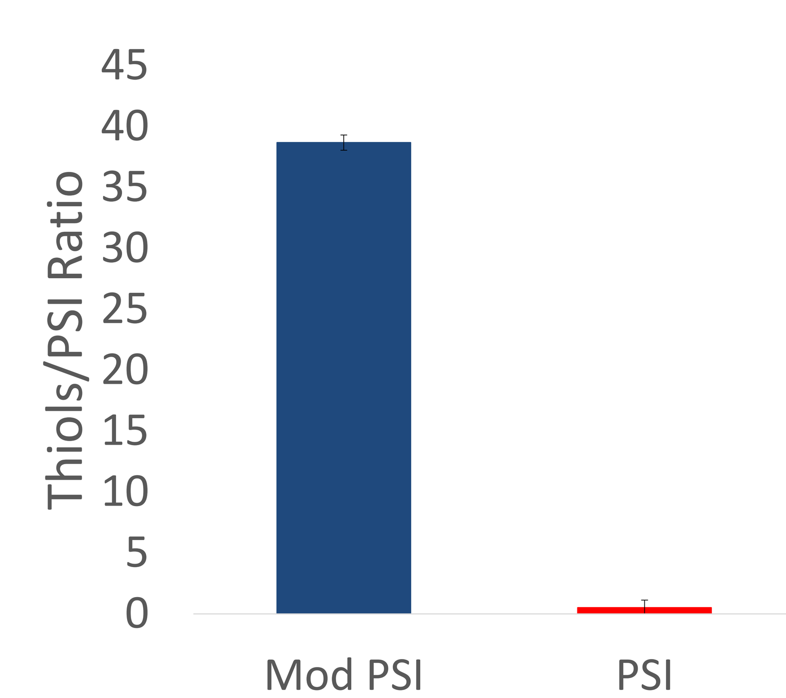


Chemical modification with 2-iminothiolane provides a vector for orientation via gold-thiol interactions

Quantifying Chemical Modification

Ellman's Assay was used to quantify the number of new thiols on PSI via a colorimetric change at 412 nm





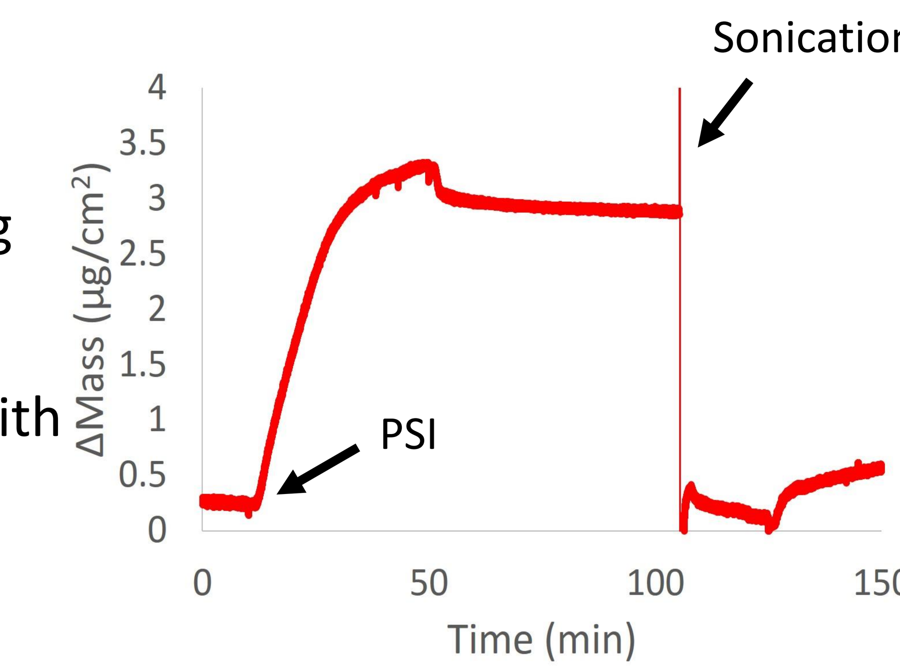
Quantifying the chemical modification indicates extensive thiolation of PSI, allowing a vector for orientation

Quartz Crystal Microbalance (QCM)

QCM can be utilized to show a preferential binding from thiolated PSI via a mass change on the gold crystal surface

- Sonicating the QCM crystal removes the unmodified PSI indicating non-specific binding

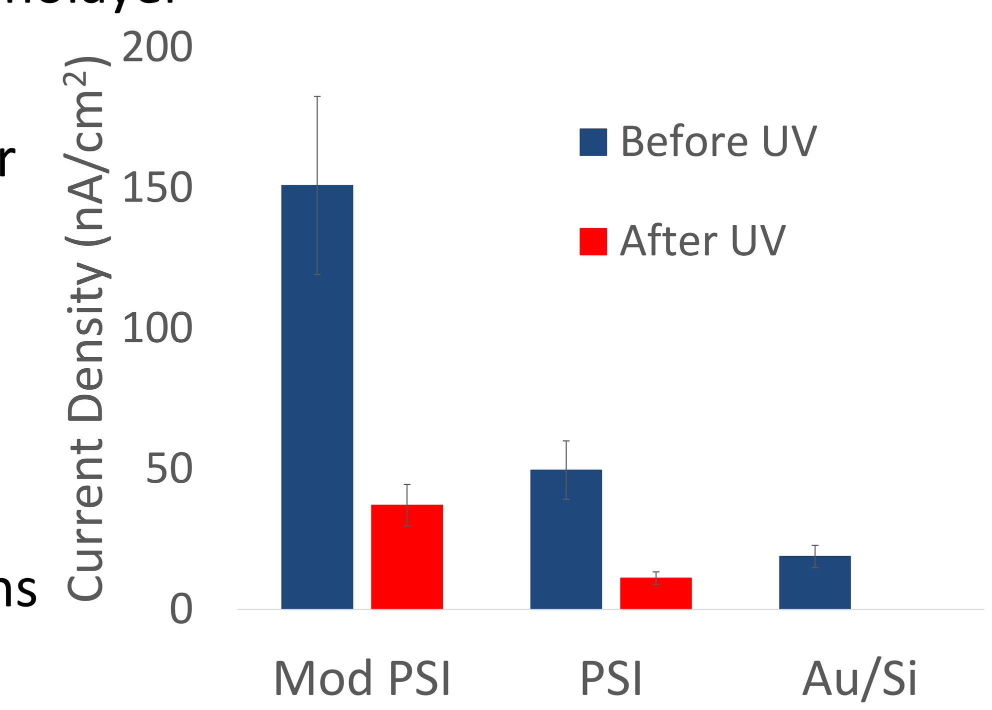
Future QCM experiments with Trauts modified PSI aim to show stronger substrate binding to gold surfaces



Photochronoamperometric Analysis

Electrochemical analysis indicates an increased photocurrent from a modified PSI monolayer

- UV light deactivation provides a control for PSI with similar surface chemistry
- Future research includes optimizing electronic interactions with Trauts modified PSI



Conclusions

- Photosystem I can be modified *in situ* with Traut's Reagent
- Future experiments aim to show that Trauts modified PSI has a stronger gold binding affinity than unmodified PSI
- Electrochemical analysis indicates that Trauts modified PSI has increased photocurrent when compared to unmodified PSI

Acknowledgements and References

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