Systematic Assembly of PSI on Chemically Patterned Substrates

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Background

In nature, plants and algae have evolved an advanced photosynthesis mechanism that harnesses solar energy with nearly 100% quantum efficiency. In doing so the mechanism uses Photosystem I (PS I), a supramolecular protein complex, that functions as a biological photodiode and undergoes photochemical charge separation resulting in unidirectional electron transfer between the reaction center (P700) electron donor on the lumenal side and Fe-S clusters (F_A, F_B, F_X) at the stromal side[1]. The structure and dimensions of PS I being well-characterized[2] (Fig.1), the excellent photo-electrochemical properties of PS I makes it an ideal candidate for incorporation into solid-state bioelectronics or hybrid photovoltaic devices[3-5]. Such devices will be the next generation of high efficiency solar panels, potentially having a huge impact on renewable energy sources.

Purpose

The purpose of this line of research is to characterize the bio-hybrid system of PSI and solid surfaces in order to create the next generation of high efficiency solar panel.

Design/Method

In order to study the system, we have carried out many experiments in both solution and solid phase. The solution phase experiments have been primarily carried out to characterize the interactions of PSI with solvating detergents. These experiments are necessary in order to construct a robust procedure for creating the bio-hybrid devices. Also, many different measurement techniques have been performed on the solid state samples, such as Atomic Force Microscopy and Scanning Electron Microscopy as well as Fourier Transform Infrared Spectroscopy. These techniques have been employed to determine if the protein is systematically attaching to the surface. Our most recent solid state endeavor utilized chemically patterned substrates in order to detect single PSI deposition on gold islands. In order to accomplish this, we had to design a chemical tailoring scheme involving a combination of PEG Silanization as well as Thiolation. Two different methods of Silanization, Majumdau and Gao, were tested. In addition to the techniques I use most often, another graduate student in the same lab works in solid and liquid state to determine the electronic activity of PSI.

Results

In our set of experiments involving chemically patterned substrates (gold nanodots), we obtained stronger protein signatures over the silicone background of our nanopatterned samples when we used the Gao method of Silanization.

Conclusions

From our experiments involving the tailoring of solid surfaces to promote specific attachment of PSI, we can conclude that the combination of Silanization and Thiloation are effective in controlling where PSI attach. Furthermore, we concluded that the Majumdau method of Silanization was more effective. Ultimately, these have been the first steps toward controlling specific attachment of PSI.