DOI: 10.1017/S1431927603440439
Microsc Microanal 9(Suppl 2), 2003

Characterization of Photosystem I/Bio-Engineered Nanoparticle Complex System by Atomic Force Microscopy and Scanning Surface Potential Microscopy

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Atomic force microscope (AFM) [1] and scanning surface potential microscope (SSPM) [2] were used to characterize the construction process and the end-results of Photosystem I (PSI) reaction center/bio-engineered nanoparticle complex system. PSI reaction centers are nanometer-size robust supramolecular structures that can be isolated and purified from green plants. The PSI reaction center is a molecular diode [3] and photovoltaic device [4] made by nature. We have demonstrated that PS I can be selectively oriented by chemical modification of a surface without denatured [5]. The bacterial cell surface layer (s-layer) proteins are two-dimensional protein crystals of the outermost component of bacterial cell envelopes. The S-layer's intrinsic ability to self-assemble allows the formation of protein lattice in suspension, on lipid films, on liposomes, and on solid surfaces, such as silicon wafer, metals, and polymers [6, 7]. The S-layer has been used as a mask to form two-dimensional Au/Pd nanoparticle array on silicon wafer.

In this work, a complex system consists of PSI, 2-mercaptoethanol, Au or Au/Pd nanoparticle, mercaptoethane, and Au{111} substrate was constructed, as shown in FIG. 1. The Au{111} thin film was epitaxially grown on mica substrate and then treated with the mercaptoethane to form a hydrophobic surface. The S-layer was then used as a mask to form 2-dimensional Au or Au/Pd nanoparticle array on top of Au{111}. This substrate was then treated with 2-mercaptoethanol and then immersed in PSI solution. The substrates of both Au and Au/Pd were imaged by AFM before and after the PSI immobilization. Before the PSI immobilization, we observed the particle height of 2nm for both Au and Au/Pd substrate. This is consistent with the evaporation thickness and SEM measurement. While after the PSI immobilization, the particle height became 7 nm for PSI-Au nanoparticle complex system and 6 nm for PSI-Au/Pd nanoparticle complex system. The SSPM was used to measure the light-induced potential change on these complex systems. We observed a 19 mV (as shown in FIG. 2) difference in PSI-Au nanoparticle complex system and a 7 mV difference in PSI-Au/Pd nanoparticle complex system. The variation in photo-induced potential difference between these two systems may be due to the difference in allowed energy states when the electron went through the double-barrier resonant tunneling from the substrate to the PSI.

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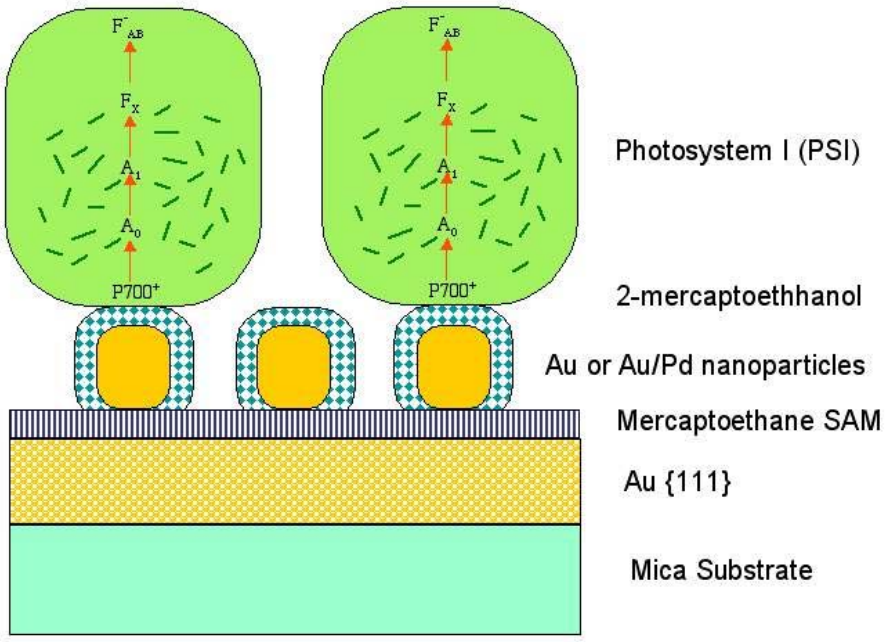

FIG. 1. Photosystem I/Bio-Engineered Nanoparticle Complex System.

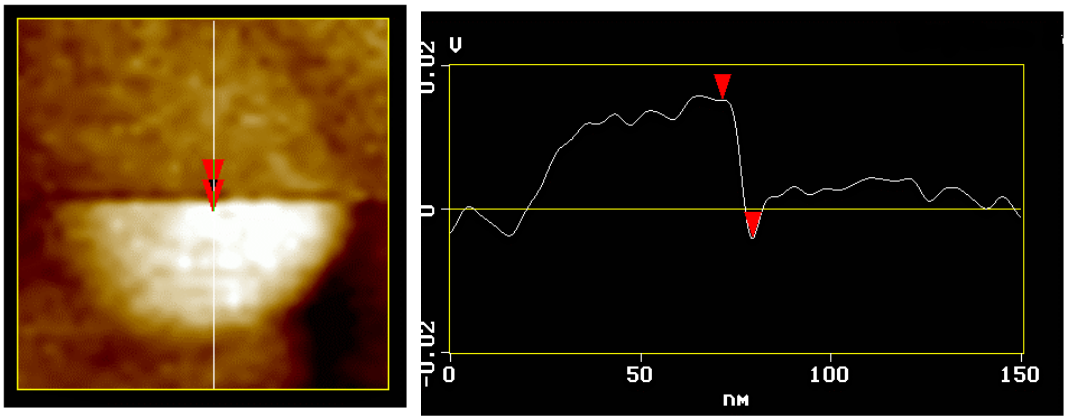

FIG. 2. SSPM measurement of photo-induced potential change in PSI +2-Mercaptoethanol+Nano Au +Mercaptoethane+ Au{111} complex system, The vertical distance between two pointers is 19 mV,

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