

BES Chemical Sciences Division Research Highlight
FWP ERKCT04; KC0302040
Bioelectrochemistry on Nanostructured Surfaces

Molecular Photovoltages and Surface Potentials at the Air-Water Interface
(In press, *J. Phys Chem B*, 2004)

A defining feature of modern bioelectrochemical science is extraction of functional single biomolecules and in vitro reconstitution on patterned surfaces or in defined geometries. Photosynthesis, the bioelectrochemical process of solar energy absorption by green plants and subsequent conversion of light energy for plant growth, uses two nanometer-scale molecular reaction centers operating in series, Photosystems I (PSI) and II (PSII). Photon absorption triggers vectorial electron transfer reactions that generate voltages across the reaction centers and photosynthetic membrane. It is this electrochemical potential that is the source of Gibbs energy for conversion of light energy into chemical energy. The key result of this highlight is that we have demonstrated for the first time that PSI molecules can be oriented by the elementary dipole forces that exist at the air-water interface. Our results indicated that the electron vector points predominantly towards the water. Orientation was demonstrated by measurement of the magnitude and sign of the electrostatic potential above the PSI-containing air-water interface.

We performed original studies of light-induced photovoltages of PSI reaction centers at the air-water interface using scanning surface potential microscopy (SSPM) in combination with microchannel glass. Using the SSPM technique, absolute orientation of the photon-activated electron transport vector can be deduced from the sign of the photovoltage. Moreover, the small pore size of microchannel glass is an ideal sample holder and delivery system for microcantilever sensing of molecules at the gas/water interface. The presence of illuminated PSI reaction centers at the gas/water interface has a dramatic effect on the sign and magnitude of the interfacial surface potential. The results indicate that the new approach will be useful for modeling and understanding dipole forces and interfacial potentials of single molecules at the gas-liquid interface.

Research performed by Elias Greenbaum, Chemical Science Division, Oak Ridge National Laboratory; Ida Lee, Department of Electrical Engineering, University of Tennessee; Brian L. Justus, Optical Sciences Division, Naval Research Laboratory; and James W. Lee, Chemical Science Division, Oak Ridge National Laboratory.

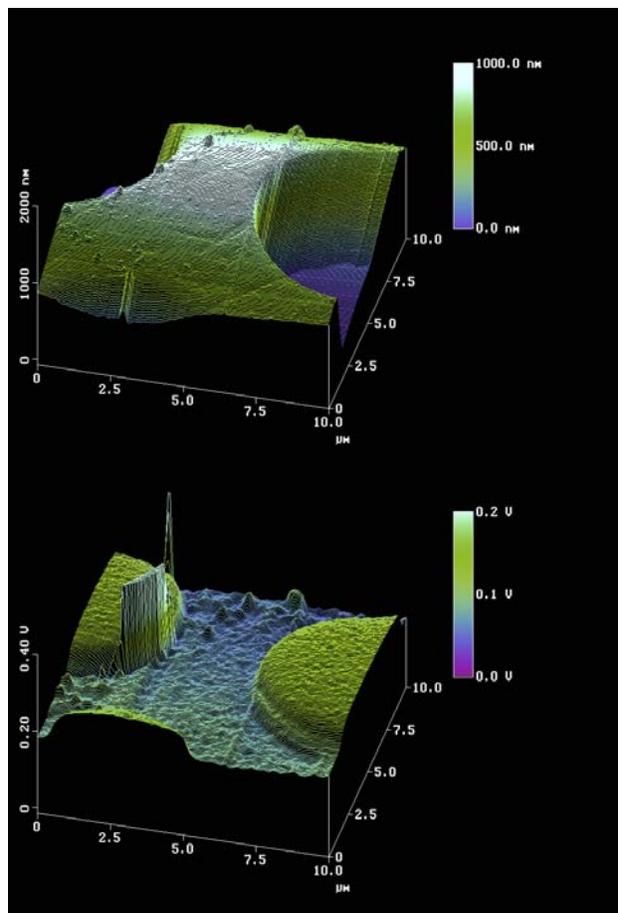


Figure 1 Scanning probe microscopy images of microchannel glass containing PSI. Top: AFM topographic image of microchannel plate with PSI solution inside each microchannel. Note the depression of the “soft” air-water interface and the scale in nanometers. Bottom: The corresponding SSPM potential measurement of the same region. Here the scale is in volts. [I. Lee et al. *J. Phys. Chem B*, in press (2004).