Current Topics in Biophysics 2018, 41 (suppl A), 19-20 DOI: 10.2478/ctb-2018-0004

Posters

IMPROVEMENT OF POWER OUTPUT IN ORIENTED PHOTOSYSTEM I-BASED NANODEVICES

Małgorzata Kiliszek[1], Ersan Harputlu[2], Marcin Szalkowski[3], Dorota Kowalska[3], C. Gokhan Unlu[4], Patrycja Haniewicz[1], Mateusz Abram[1], Kamil Wiwatowski[3], Joanna Niedziółka-Jönsson[5], Sebastian Maćkowski[3], Kasim Ocakoglu[2,6], and Joanna Kargul[1]

[1]Solar Fuels Laboratory, Centre of New Technologies, University of Warsaw, Warsaw, Poland
[2]Advanced Technology Research & Application Centre, Mersin University, Mersin, Turkey
[3]Institute of Physics, Faculty of Physics, Astronomy and Informatics, Nicolaus Copernicus University, Toruń, Poland
[4]Department of Biomedical Engineering, Pamukkale University, Denizli, Turkey
[5]Institute of Physical Chemistry Polish Academy of Sciences, Warsaw, Poland
[6]Department of Energy Systems Engineering, Tarsus Faculty of Technology, Mersin, Turkey

Photosystem I (PSI) pigment-protein complex with its an internal quantum yield close to unity for generation of the primary charge separation state makes this complex one of the most efficient light-harvesting molecular machines for application in energy-converting devices. One of the requirements for efficient application of this biological macromolecule in such devices is the appropriate interface assembly between the photoactive protein and the electrode that ensures optimal electronic communication between both modules.

In this study, the conductive interface between the PSI layer and graphene electrode was provided by an organic self-assembled monolayer (SAM) composed of π-π stacked pyrene functionalized with nitrilotriacetic acid chelated to Ni^{2+} cations (Ni-NTA). Upon specific conjugation of His_6-tagged cytochrome c_{553} (cyt c_{553}) with the graphene-pyrene-Ni-NTA FTO electrode, the PSI photoactive layer was incorporated in an oriented manner, i.e. with its donor (P700) side towards the electrode, taking the advantage of the molecular interaction between PSI and cyt c_{553}. The photoelectrochemical analysis showed mediatorless generation of cathodic photocurrents on the FTO-graphene conductive substrate, even at an open circuit potential, which were further increased upon application of negative overpotential. These results indicate the production of the specific orientation of PSI resulting in the improved direct electron transfer and photocurrent output.

ACKNOWLEDGEMENTS

This research is supported by the grant no. DZP/POLTUR-1/50/2016 funded by the Polish National Centre for Research and Development.

MOLECULAR MECHANISMS OF PHOTOADAPTATION OF THE RED ALGAL PHOTOSYNTHETIC APPARATUS

Patrycja Haniewicz[1], Mateusz Abram[1,2], Lukáš Nosek[3], Joanna Kirkpatrick[4], Eithar El-Mohsnawy[5,6], Julian D. Janna Olmos[1,2], Roman Kouřil[3], Joanna M. Kargul[1]

[1]Solar Fuels Laboratory, Centre of New Technologies, University of Warsaw, Banacha 2C, 02-097 Warsaw, Poland;
[2]Faculty of Biology, University of Warsaw, Miecznikowa 1, 02-096 Warsaw, Poland;
[3]Centre of the Region Haná for Biotechnological and Agricultural Research, Department of Biophysics, Faculty of Science, Palacký University, Šlechtitelů 27, 783 71, Olomouc, Czech Republic;
[4]Leibniz Institute on Aging, Fritz Lipmann Institute, Beutenbergstrasse 11, 07745 Jena, Germany;
[5]Botany Department, Faculty of Science, Kafrelsheikh University, Egypt;
[6]Plant Biochemistry, Faculty of Biology and Biotechnology, Ruhr-University Bochum, Germany.

The monomeric PSI-LHCI supercomplex from an extremophilic red microalga *Cyanidioschyzon merolae* exhibits structural traits of both cyanobacterial and eukaryotic counterparts that places it as an intermediate evolutionary link between them [1, 2]. Our research on extremophilic red algae, led us to the discovery of the molecular mechanisms underlying unprecedented robustness of the C. merolae PSI-LHCI supercomplex upon its exposure to harsh conditions. By the combined use of biochemical, spectroscopic, mass spectrometry and electron microscopy/single particle analyses we characterised three such mechanisms, whose biochemical principles make them independent both at the metabolic and time response levels [3]. The first mechanism consists of the accumulation of a photoprotective carotenoid, zeaxanthin, in both LHCI antenna and PSI reaction centre. The second mechanism involves the structural and functional remodelling of the LHCI antenna. The third mechanism involves the presence of the two PSI-LHCI isomers whose stoichiometric ratio alters in response to dynamic environmental conditions. This process is accompanied by dissociation of the PsaK core subunit, as shown by the quantitative mass spectrometry analysis [3]. Our experiments show that the low light-treated *C.*

merolae PSI-LHCI complex incorporates up to 8 Lhcr antennae subunits which are organized as 2 rows on the PsaF/PsaJ side of the core complex. The spectroscopic and biochemical analyses show no evidence of functional coupling of the phycobilisomes with the PSI-LHCI supercomplex, suggesting that such an interaction does not occur under our experimental conditions [3] in agreement with other studies. [4, 5]

ACKNOWLEDGEMENTS

This research is supported by the grant no. OPUS grant no. 756 UMO-2014/15/B/NZ1/00975, funded by the Polish National Science Centre.

REFERENCES

[1] Adachi, H., Y. Umena, I. Enami, T. Henmi, N. Kamiya, and J.-R. Shen. 2009. Towards structural elucidation of eukaryotic photosystem II: Purification, crystallization and preliminary X-ray diffraction analysis of photosystem II from a red alga. Biochim Biophys Acta. 1787: 121–128.

[2] Krupnik, T., E. Kotabová, L.S. van Bezouwen, R. Mazur, M. Garstka, P.J. Nixon, J. Barber, R. Kaňa, E.J. Boekema, and J. Kargul. 2013. A Reaction Center-dependent Photoprotection Mechanism in a Highly Robust Photosystem II from an Extremophilic Red Alga, *Cyanidioschyzon merolae*. J. Biol. Chem. 288: 23529–23542.

[3] Haniewicz, P., M. Abram, L. Nosek, J. Kirkpatrick, E. El-Mohsnawy, J.D.J. Olmos, R. Kouril, and J.M. Kargul. 2017. Molecular mechanisms of photoadaptation of photosystem I supercomplex of in an evolutionary cyanobacterial/algal intermediate. Plant Physiol: pp.01022.2017.

[4] Cunningham, F.X., R.J. Dennenberg, L. Mustardy, P.A. Jursinic, and E. Gantt. 1989. Stoichiometry of Photosystem I, Photosystem II, and Phycobilisomes in the Red Alga *Porphyridium cruentum* as a Function of Growth Irradiance. Plant Physiology. 91: 1179–1187.

[5] Ueno, Y., S. Aikawa, K. Niwa, T. Abe, A. Murakami, A. Kondo, and S. Akimoto. 2017. Variety in excitation energy transfer processes from phycobilisomes to photosystems I and II. Photosynth Res. 133: 235–243.