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Photoelectrochemical complexes for solar energy conversion that chemically and autonomously regenerate

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Abstract

Naturally occurring photosynthetic systems use elaborate pathways of self-repair to limit the impact of photo-damage. Here, we demonstrate a complex consisting of two recombinant proteins, phospholipids and a carbon nanotube that mimics this process. The components self-assemble into a configuration in which an array of lipid bilayers aggregate on the surface of the carbon nanotube, creating a platform for the attachment of light-converting proteins. The system can disassemble upon the addition of a surfactant and reassemble upon its removal over an indefinite number of cycles. The assembly is thermodynamically metastable and can only transition reversibly if the rate of surfactant removal exceeds a threshold value. Only in the assembled state do the complexes exhibit photoelectrochemical activity. We demonstrate a regeneration cycle that uses surfactant to switch between assembled and disassembled states, resulting in an increased photoconversion efficiency of more than 300% over 168 hours and an indefinite extension of the system lifetime.

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Contributions

M.H.H., J.H.C., A.A.B. and M.S.S. designed the research. M.H.H., J.H.C., A.A.B., R.A.G. and D.A.H. synthesized the complexes. M.H.H. performed the photoelectrochemical experiments. J.H.C. purified the complexes and performed the spectroscopic experiments with A.C.C. A.A.B. performed kinetic modelling of complex formation. E.S.J. performed modelling of the DMPC configuration on the SWNT. A.M. and C.A.W. supplied the photosynthetic reaction centres. Y.V.G. and S.G.S. supplied the membrane scaffold proteins and conducted initial reconstitution experiments. T.H.B., A.S.Z. and K.J.V. performed AFM measurements. E.K.H. performed SANS measurements. M.S.S. originated the concept for the paper. M.H.H., J.H.C., A.A.B. and M.S.S. co-wrote the manuscript with input from S.G.S. and C.A.W.

Competing financial interests

The authors declare no competing financial interests.

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Supplementary information

PDF files

1. Supplementary information (1,181 KB)
   Supplementary information

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