Structural characterization of protein supercomplexes for a bioinspired electrochemical cell

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Photosynthesis is a fundamental natural process capable of converting solar radiation into storable energy-rich carbohydrates. Therefore, it is highly attractive to use this process as an inspiration for the development of photoelectrochemical cells exploiting sustainable energy sources.[1] The primary processes of oxygenic photosynthesis involve the cooperation of several protein-cofactor complexes including photosystems I (PSI) and II (PSII), which can perform the light-induced charge separation. The trimeric PSI from the cyanobacterium Thermosynechococcus elongatus (TePSI) is a remarkably stable intrinsic membrane protein, which converts solar energy into electrical energy with high quantum yield by oxidizing the soluble redox mediator cytochrome c6 (Cyt c6) at the luminal side. PSI can be integrated into an artificial biohybrid electrode.[1] To design electrode surfaces that efficiently interact with PSI, structural characterization of the protein complexes formed by Cyt c6 with PSI is needed. Different approaches of protein supercomplex formation of PSI with Cyt c6 can be effectively verified directly in detergent solution using small-angle neutron scattering (SANS) before high-resolution structures become available.

Recently, we analyzed the interaction of PSI with cyt c6 and the non-native mitochondrial cytochrome from horse heart (Cyt cHH). [2] We found that Cyt cHH is strongly bound to the luminal side of PSI. In contrast, Cyt c6 is also bound, but the binding affinity is weaker than for Cyt cHH. A co-crystal structure of PSI with Cyt c6 or Cyt cHH could not be determined.

In the absence of high-resolution structures, SANS is the technique of choice to investigate the binding of Cyt c6 and Cyt cHH to TePSI in solution – i.e. under the same conditions required for biotechnological applications. We have used SANS at KWS-1 at MLZ before to show that PSI in buffer solution exhibits a structure close to the trimeric crystal structure. [2,3] In the same experiment, we successfully proved a complex formation of TePSI-Cyt cHH consistent with the expected structure. [2] The latter SANS data, the data fit, and the simulated structure of the whole complex are shown in Figure 1.

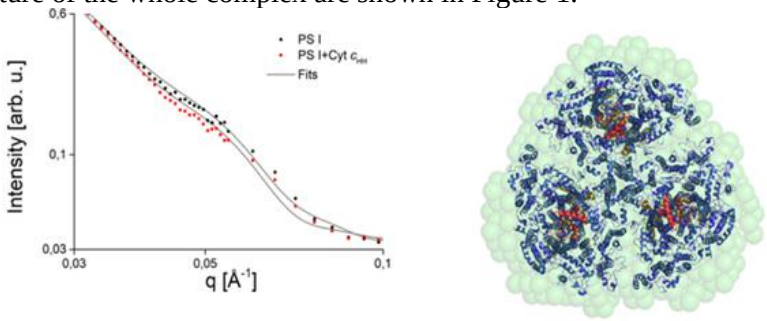

Figure 1: Left: SANS data of *Te*PSI (black dots) and of *Te*PSI-Cyt c_{HH} complexes (red dots) obtained at a contrast of 5% D_2O matching the hydrophobic tails of the detergent. The full lines correspond to simulations based on the *Te*PSI crystal structure and a model for the *Te*PSI-Cyt c_{HH} complex. Right: Comparison of the structure of the *Te*PSI-Cyt c_{HH} complex reconstructed from the SANS data (light blue spheres) with a crystal structure of the PSI-cytochrome complex.

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References

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