

Spectroscopic and Scattering Studies of Photosynthetic Systems Utilizing fs X-ray Pulses

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The recent availability of fs X-ray pulses from XFELs makes it possible to probe the active site of metalloenzymes at room temperature in a time resolved manner without the problems of radiation damage. Conducting such studies, nevertheless is hindered by several technical bottlenecks. These include very limited experimental time available at the few X-ray laser sources currently operating, often very high sample consumption rates and challenges in data collection and processing. When overcoming these bottlenecks XFEL pulses are an ideal tool to study photosynthetic systems due to the possibility to conduct optical laser pumping-x-ray probe experiments. We will present an overview of XFEL studies on photosynthetic systems with a focus on our current progress in XFEL studies of Photosystem II (PSII). PSII is a membrane intrinsic protein complex that catalyzes the light driven oxidation of water to molecular oxygen [1]. To better understand the catalytic mechanism of PSII we were utilizing fs X-ray diffraction and X-ray emission as well as X-ray absorption spectroscopy at the Mn K- and L-edges. Recent results include first undamaged Mn L-edge spectra of PSII in two different illumination states [2], kinetic measurements of Mn oxidation state changes at room temperature using Mn K β emission spectroscopy and time resolved crystallographic determination of the structure of several intermediates in the catalytic cycle of water oxidation [3,4].

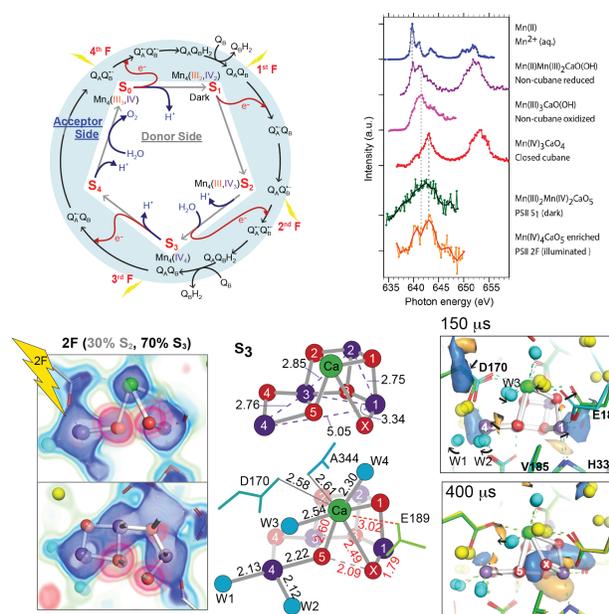


Fig. 1: Reaction cycle of PSII (top left) and Mn L-edge spectra of model compounds and PSII (right). Electron density obtained at RT for the double illuminated state (bottom left) together with structural models and difference electron density obtained for two time points in the transition from the S₂ to the S₃ state (bottom right).

References

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