Contribution ID : **44** Type : **not specified**

Serial femtosecond crystallography of high-valent metal sites and protein radicals

Tuesday, 23 September 2025 10:45 (30)

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High resolution structure determination methods suffer from problems with radiation damage. This is particularly problematic for radiation sensitive states such as high-valent metal sites and radicals. From a chemical perspective this means that some of the most relevant states for catalysis in many enzyme systems are inaccessible to standard structure determination regimes.
In close collaboration with scientists at the LCLS and the LBNL we utilize a conveyor-belt sample injector that allows micrometer-sized crystals to be manipulated in various ways, including oxygen incubation for a defined period of time, before exposure to the free-electron laser X-ray beam [1]. This setup allows varying the time for intermediate trapping while the use of femtosecond XFEL crystallography eliminates the effect of X-ray photoreduction on obtained data. Simultaneous XES also allows in situ oxidation state determination of probed intermediates for metalloprotein systems.
This setup and its use to obtain high-resolution global geometric structures of high-valent intermediates will be discussed, as well as our recent progress defining radiation undamaged structures of methane monooxygenase [2] and ribonucleotide reductase R2 proteins [3,4] including the catalytic radical state [5].

Acknowledgments: This work was funded by the Knut and Alice Wallenberg Foundation, the Swedish Research Council and the European Research Council (ERC).

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Session Classification : Tuesday