Serial femtosecond X-ray crystallography reveals the role of water molecules in the chemistry of compound I reduction in dye-decolorizing peroxidases

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Fe(IV)-oxo species are the core reactive intermediates found in peroxidases, oxidases, mono and dioxygenases as well as halogenases and are central to the redox chemistry and reaction products produced by these enzymes. Deciphering the chemical nature of the ferryl species, called compound I and compound II, amongst these heme enzyme families has been an intensive area of research.[1] Using an X-ray free electron laser (XFEL) we have determined room temperature serial femtosecond X-ray structures of dye-decolorizing peroxidases (DyPs) from *Streptomyces lividans*.[2,3] The application of room temperature XFEL approaches to elucidate metal site structures in metalloenzyme crystals is highly advantageous, as radiation damage that can result in metal centers being rapidly reduced and potentially instigating structural or solvent positional changes that are then not associated with the starting redox state, are eliminated.[4] An emerging theme from our recent XFEL studies is that the presence or absence of resident H_2O molecules in the distal heme pocket of DyPs dictates the reactivity of compound I. In a 'dry' site i.e. a distal heme pocket void of resident H_2O molecules, compound I reduction is rate limited by proton uptake, resulting in a protonated compound II (Fe(IV)-OH), and an apparent two-electron transfer process to the ferric state. In a 'wet' site, proton uptake is alleviated and reduction of compound I via an unprotonated compound II proceeds. From a biological perspective the chemistry of compound I reduction in a 'dry' site is ideally suited to the rapid delivery of two electrons almost simultaneously to a substrate, thus providing a useful clue to seek physiological substrates of 'dry' site DyPs.

References

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