Towards Understanding the $O_2$ Chemistry of Mononuclear Non-Heme Iron Enzymes: Intra- and Extradiol Dioxygenases

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Both intra- and extradiol dioxygenases are found in a number of soil bacteria and participate in the degradation of catecholic rings. However, there is a striking difference in the position of ring cleavage and reaction mechanism. Intradiol dioxygenases employ a Fe$^{3+}$ center which has been proposed to activate substrate for direct attack by $O_2$. In contrast, extradiol dioxygenases use a Fe$^{2+}$ center and substrate binding has been proposed to activate the Fe$^{2+}$ site for $O_2$ binding and reaction.

To identify the factors governing the different chemical behaviour towards $O_2$, we have studied the active site geometric and electronic structures of these two classes of enzymes with a combination of spectroscopic methods, and complemented these spectral studies with DFT calculations. Substrate activation by the Fe$^{3+}$ center in intradiol dioxygenases is investigated through spectroscopic and computational studies on the enzyme-substrate complex. The interaction of $O_2$ with the Fe$^{2+}$ site upon substrate binding in extradiol dioxygenases is probed by binding a small molecule $O_2$ analog, NO, to the enzyme-substrate complex.

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\begin{align*}
\text{Intradiol (ortho), Fe}^{3+} & \quad \text{Extradiol (meta), Fe}^{2+} \\
3,4-\text{PCD; } R=\text{COOH} & \quad 2,3-\text{CTD; } R=\text{H}
\end{align*}
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