Controlling and exploiting intrisic unpaired electrons in metalloproteins

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Redox reactions govern fundamental processes such as respiration and photosynthesis. Controlling the location of unpaired electrons and exploiting the interactions with their environment can provide key mechanistic information into the enzymes that underpin these important reactions. In this talk I will discuss some of our contributions to directing unpaired electrons to mechanistically key locations and using pulse electron paramagnetic resonance (EPR) techniques to probe their nature and role.[1,2]

Respiratory complex I is essential for respiration in all higher organisms, but its mechanism, in particular how electron transfer links to the proton translocation required for ATP synthesis, is not yet fully understood. I will discuss how EPR spectroscopy, in conjunction with other techniques, has enabled us to probe the roles of iron-sulfur electron transfer centres and semiquinones in this enzyme.[3,4] I will then discuss how, with the tools developed for respiratory complex I[5,6] and advances in spin sensitivity,[7] we determined the energetic profile of electron transfer in photosynthetic complex I[8] – the homologous enzymes in plants and cyanobacteria that plays a crucial role in increasing ATP production under stress.

In the final part of my talk, I will provide an overview and outlook of film-electrochemical EPR spectroscopy. With this new technique we have shown that direct and accurate control of the redox state of buried centres in proteins is possible.[9] This opens the door for studying how radicals evolve under well-defined substrate turnover conditions in enzymes, and other catalysts, for which there is currently no other methodology available. FE-EPR thus promises to enhance our understanding of the structure-function relationships of redox-active proteins and enzymes.

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