Proteins prove their metal

July 7 2010, by Pete Wilton

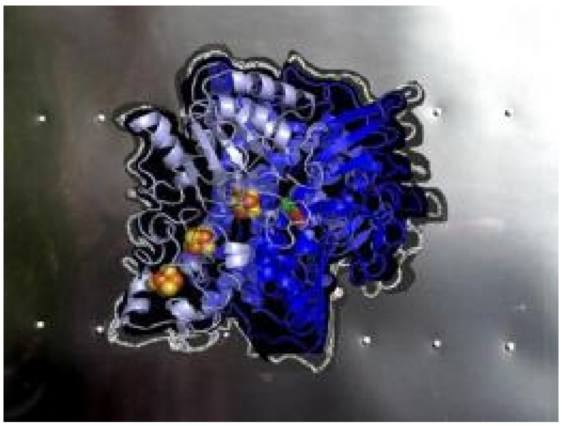

Image: enzymes on their metal. Uses photo from fractalid via Flickr.

(PhysOrg.com) -- The word 'metal' conjures up images of machines and heavy industry but metals are also intimately involved in the biological processes that regulate our bodies and underpin new energy technologies.

‘Nearly half of all enzymes require metals to function in catalysing biological reactions,’ Kylie Vincent, of Oxford University’s Department of Chemistry tells us. ‘Both the metal and the surrounding protein are crucial in tuning the reactivity of metal catalytic centres in enzymes.'

These ‘metal centres’ are hives of industry at a microscopic scale, with metals often held in a special protein environment where they may be assembled into intricate clusters inside proteins.

'Chemists are interested in understanding the effects of the protein environment on the chemistry of the metal centres, and are also fascinated by the synthetic challenges of mimicking the structure and function of metal sites in proteins by smaller molecules,' comments Kylie.

Understanding these effects is important because metal-containing proteins are involved in many biological energy cycling reactions, including the oxidation or production of hydrogen and the conversion of carbon dioxide into organic carbon molecules.

Kylie has written a review of advances in this area of chemistry published in this week's *Philosophical Transactions of the Royal Society A*.

The article explores how chemists are looking beyond X-ray based techniques to find new ways to capture enzymes at work, she explains:

'X-ray crystal structures of metal-containing proteins provide snapshots of the positions of atoms, but proteins are dynamic systems and structural changes are often crucial to their function.'

'Information on the many intermediate states involved in catalysis of complex reactions at metal centres in enzymes is key to understanding enzyme function and for synthesising catalysts that mimic enzyme function.'

Now infrared spectroscopy using lasers is helping to deliver snapshots of chemical changes in enzymes at the pico- or even femto-second scale. These infrared methods should capture fast chemical reactions occurring at metal centres in proteins, revealing information about intermediate species formed during catalytic reactions.

‘Many groups are trying different approaches, but at Oxford we are combining infrared spectroscopy with electrochemistry so that we can control the state of metal-containing proteins at electrodes and, at the same time, measure infrared spectra to obtain information on the structure and function of the protein,’ Kylie tells us.

‘This should provide structural insight into states of metal-containing proteins that are only formed at precise potentials - revealing details of reactions occurring during respiration, metabolism or photosynthesis.’

The knowledge gained from such experiments should help chemists to design new catalysis for ‘green’ electricity generation in fuel cells or the clean production of fuels. And because metal-centres in proteins also bind small molecules that send signals in biological systems, infrared spectroscopic experiments should help us to understand and control these types of processes.

Kylie adds: ‘There is much that we can learn from the way that micro-organisms use readily available metals to carry out these reactions while chemists often require rare and expensive metals for the same chemistry.'

'Advanced infrared spectroscopic experiments should also give us a fresh perspective on fundamental questions about the functioning of metal-containing proteins in biology.’

More information: Royal Society A paper - rsta.royalsocietypublishing.or … 8/1924/3713.abstract

Provided by Oxford University