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What Geochemistry teaches us about Catalyst Design

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One of the greatest challenges of the 21st century will be securing cheap and renewable sources of energy. One of the most promising approaches to this challenge is to design catalysts from earth abundant materials capable of implementing key chemical reactions including splitting water into hydrogen and oxygen ($\text{H}_2\text{O} \rightarrow 2\text{H}^+ + \text{O}_2$); and both the oxidation ($\text{H}_2 \rightarrow 2\text{H}^+$) and reduction ($2\text{H}^+ \rightarrow \text{H}_2$) of hydrogen the reduction of CO_2 hydrocarbons.

Some of the most promising catalyst materials for these reactions are metal oxides and sulfides which commonly exist in nature. Despite the fact that these materials are common, their structures, stability are often poorly understood. This is in part because of the reliance on traditional analytical techniques (particularly X-ray diffraction) for materials characterisation. The molecular structure of functional metal oxide and metal sulfide based catalysts can be probed in situ by combining X-ray Absorption Spectroscopy (XAS) and Transmission Electron Microscopy (TEM) to provide new insights into catalyst structure and function. We find some interesting correlations between these materials in their functional state and the geochemical cycles which form these materials in nature, implicating “kinetic destabilised forms” of these common materials. Our work provides important clues to a possible role these materials may have played in the evolution of metallo-protein type catalysis.

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