Demystifying the CO_2 reduction mechanism in Carbon Monoxide Dehydrogenase: An inspiration for novel carbon capture technologies

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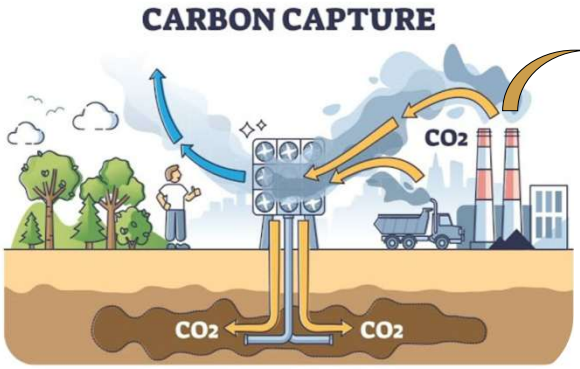
For more information on Vincent Group

The buzz...

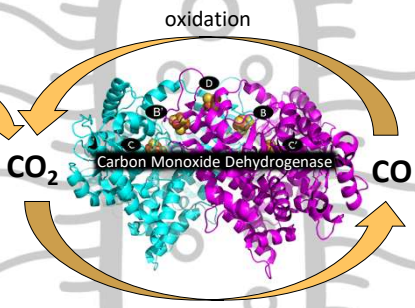
What is carbon capture and why do we need it?



Carbon capture is a process that **traps carbon dioxide (CO_2)** emissions from sources like power plants and industrial facilities before they enter the atmosphere. It is important because it helps **reduce greenhouse gas emissions, slow climate change, and support the transition to cleaner, more sustainable energy systems.**

The mystery...

What's nature bestowed with?



$CO_2 + 2\,e^- + 2\,H^+ \rightleftharpoons CO + H_2O$

Anaerobic microorganisms produce enzymes like **Carbon Monoxide Dehydrogenase (CODH)** which catalyse the **interconversion of CO_2 and CO** (carbon monoxide) as a part of their cellular processes.

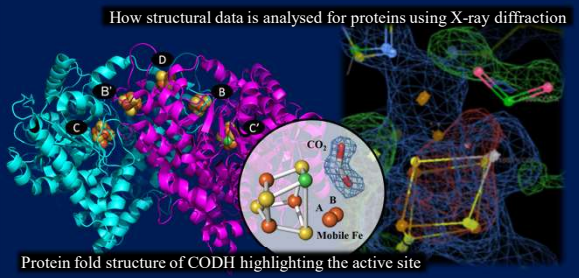
The gift...

That keeps giving.

This catalytic cycle offers double benefits: not only does it open avenues **to inspire novel carbon capture technologies through its CO_2 utilisation mechanism**, but also produces **CO which can be utilised as a pre-cursor to develop green and sustainable fuels and chemicals.**

The scientific approach...

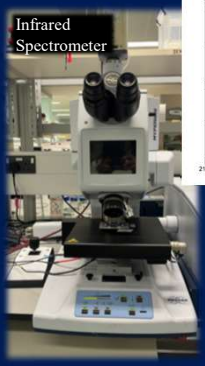
How are we demystifying this enigma of nature?

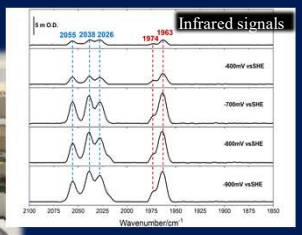


Structural analysis techniques like X-ray diffraction give us a three-dimensional visualisation of the protein molecule, by studying crystals using X-rays at a **synchrotron**.

When Structure met Spectroscopy

The enzyme is first **extracted** from the anaerobic organism, **purified** and **crystallised** for further study.





Spectroscopic methods like Infrared (IR) spectroscopy enable us to observe changes in the enzyme functionality in response to changes in conditions via bond vibrations in the molecule.

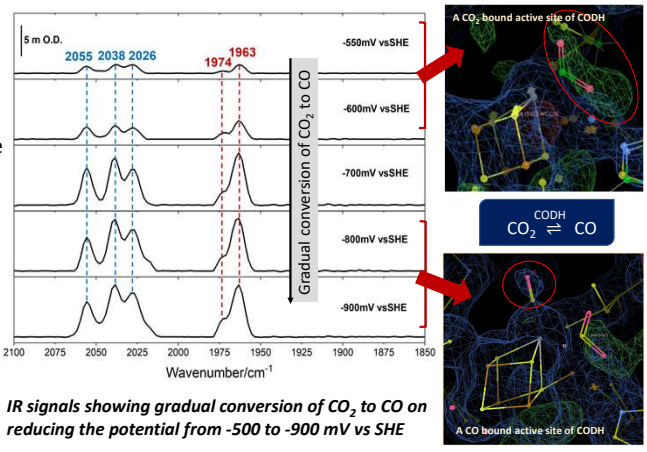
The correlation between these two techniques provides a well-rounded perspective on the enzyme functionality, which can inspire novel catalyst designs to build fine-tuned and efficient carbon capture technologies- ***Learning from nature, FOR nature.***

A promising journey...

The achievements and challenges

Successfully emulating the natural phenomenon in lab: We have been able to observe CO_2 binding to the active site of the enzyme upon exposure, and watch it become reversibly converted to CO under controlled conditions in the lab.

These results not only give us clarity about how mysterious biological processes occur in nature, but **also show promise in attaining a man-made control over its functioning**, a crucial aspect in developing cutting-edge technologies in the future, inspired by nature.



IR signals showing gradual conversion of CO_2 to CO on reducing the potential from -500 to -900 mV vs SHE

Major Challenges

- CODH is **extremely oxygen sensitive**. All the studies are conducted in an anaerobic (O_2-free) atmosphere.
- The **nature of protein crystals can differ from the nature of protein solution**. Due to the close-packed structure of the crystals it can be difficult for chemical solutions to seep in and interact with the protein.
- **The true potential of CODH is still massively unexplored**, offering an exciting and pivotal opportunity to develop CO_2 reducing catalysts learning from nature.

Acknowledgements

UKRI Research Complex at Harwell · University of Michigan · diamond · CatalysisHub