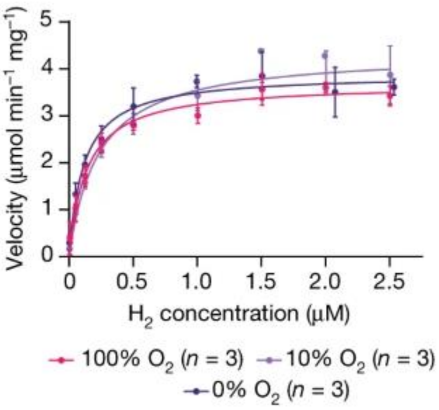
MONASH University

Oxygen-Insensitive Enzyme for Clean Energy Applications

PHYSICAL SCIENCES: Energy Storage and Generation

The Challenge	Current hydrogen fuel cells face significant limitations due to catalyst poisoning by oxygen and carbon monoxide, requiring pure hydrogen fuel streams. This substantially increases system complexity and cost while limiting potential applications. Furthermore, existing hydrogen sensors struggle to detect low concentrations of hydrogen in air, creating challenges for leak detection and industrial monitoring applications. Therefore, the key challenge lies in developing catalysts that can efficiently oxidise even trace quantities hydrogen under ambient conditions.
The Solution	Researchers at Monash University have isolated Huc, a naturally-occuring enzyme complex from soil bacteria that can oxidise hydrogen in ambient air. This unique complex can operate in the presence of oxygen and carbon monoxide without inhibition and demonstrates exceptional sensitivity to hydrogen, even at atmospheric concentrations. When implemented in fuel cells, Huc can generate electricity using a variety of fuel sources, including pure hydrogen, air, or syngas. The system achieves high catalytic efficiency while maintaining stability under ambient conditions, opening new possibilities for simplified fuel cell designs and ultra-sensitive hydrogen detection.
Key Benefits	• Operates effectively in ambient air without oxygen or carbon monoxide inhibition • Demonstrated electricity generation from both air and syngas • Exceptional stability at room temperature • Can be immobilised on electrodes for practical applications • Enables both energy generation and sensing applications
Development Stage	TRL3 Proof of Concept
Brief Description & Differentiation	Conventional fuel cell catalysts require careful isolation from oxygen and other atmospheric contaminants, significantly increasing system complexity. Huc's unique architecture, evolved in soil bacteria to scavenge trace hydrogen, provides inherent resistance to oxygen and carbon monoxide while maintaining high catalytic activity. This enables simplified system designs that can operate in ambient conditions. The complex demonstrates remarkable hydrogen affinity with a Km of 129 nM and can detect hydrogen down to atmospheric concentrations. This combination of sensitivity and stability makes it ideal for both energy generation and sensing applications. When implemented in electrochemical systems, Huc exhibits an advantageous overpotential that optimises it for hydrogen oxidation while preventing unwanted side reactions.
Research Team	Prof Chris Greening, Dr Rhys Grinter, Ashleigh Kropp – Monash Science Prof Huanting Wang, Dr Kaiqiang He – Monash Engineering
Intellectual Property	PCT application filed, WO2024197333
Key Publications	Grinter, R., Kropp, A., Venugopal, H. et al. Structural basis for bacterial energy extraction from atmospheric hydrogen. Nature 615, 541–547 (2023).



Left: Michaelis-Menten kinetics of H_2 oxidation by Huc at varying O_2 levels

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