DAC2BIO: DIRECT AIR CAPTURE-ENABLED SUSTAINABLE BIOMANUFACTURING

Converting atmospheric CO_2 into bioplastics and protein using an integrated DAC2BIO system

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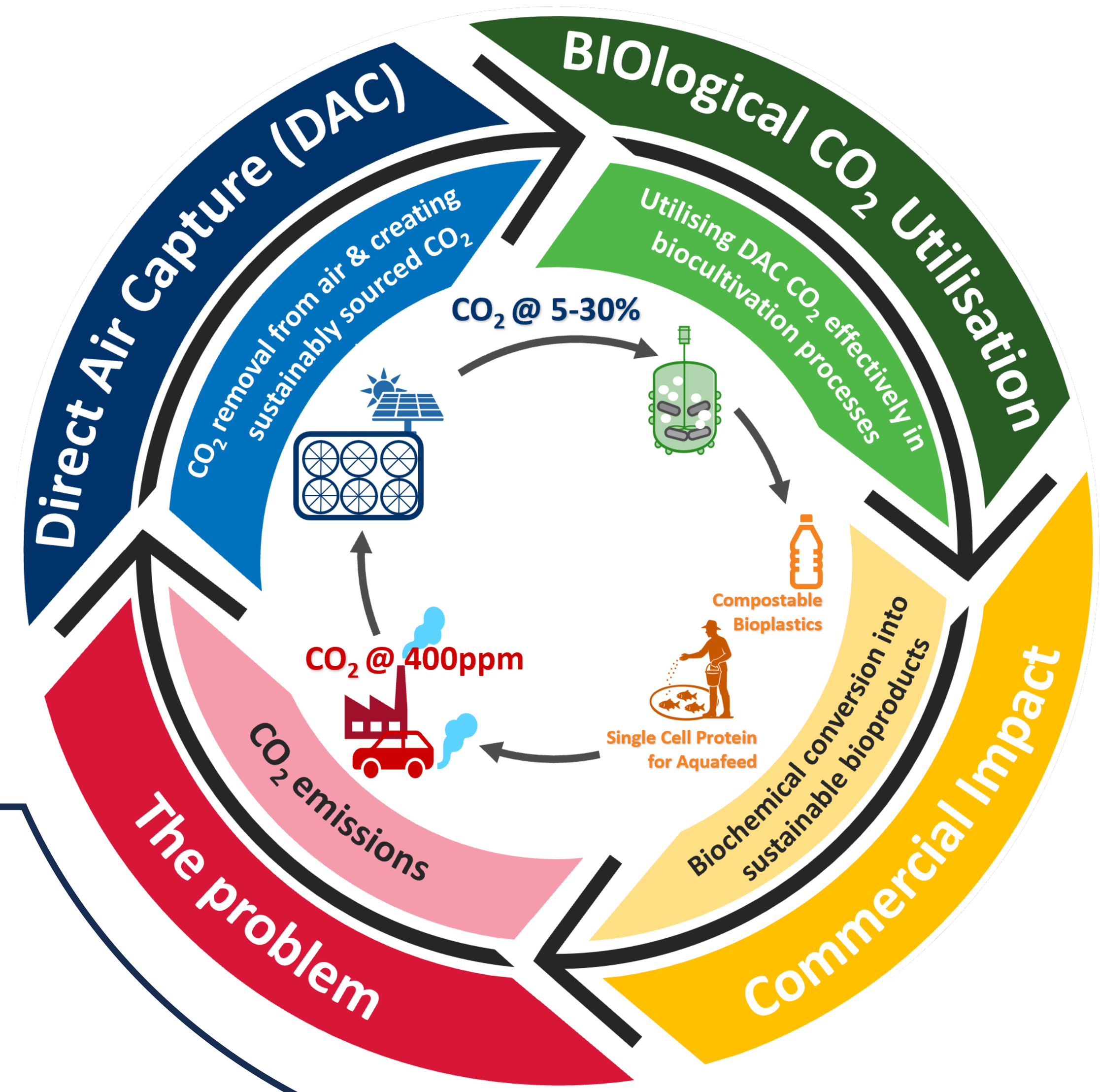
Priority Topic Area: **Waste Valorisation and Circular Economy**

TURNING CO_2 INTO A RESOURCE

Atmospheric CO_2 levels continue to rise globally[1], yet Direct Air Capture (DAC) remains limited by high cost[2] and lack of downstream utilisation. **DAC2BIO addresses this gap by integrating carbon capture with biological conversion**, transforming CO_2 from air into valuable bioproducts including fully biodegradable plastics[3], namely polyhydroxylbuterate (PHB) and single-cell protein (SCP) for aquaculture applications. The system combines modular DAC with controlled gas delivery and microbial fermentation to enable scalable carbon-to-product pathways. **Key innovation** that has been developed is a unified DAC-to-bioprocess (DAC2BIO) platform that converts atmospheric CO_2 into alternative materials and food, improving the economic viability of carbon capture.



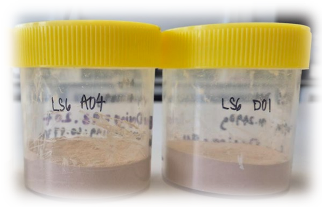
METHODOLOGY

400ppm CO_2 from ambient air

(1) CO_2 captured from ambient air via TVSA* DAC technology

(2) DAC captured CO_2 fed into microbial fermentation of *Cupriavidus necator*

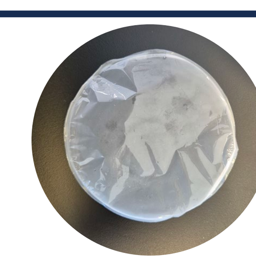
(3) Harvest & Dry



Biomass rich in PHB bioplastics and protein

(4) Solvent Extraction

Product 1: PHB, bioplastics



Pure PHB thin film

(5) Drying

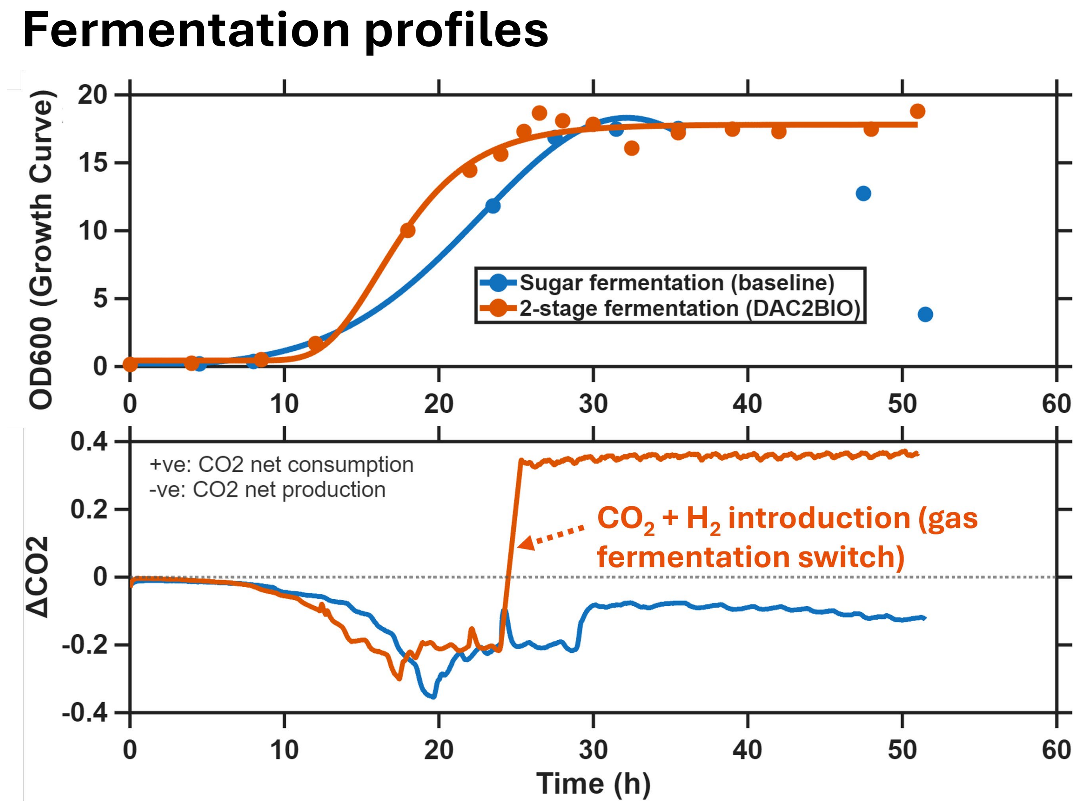
Product 2: SCP for aquafeed

Remaining biomass post-PHB extraction now rich in protein content

**TVSA: Temperature vacuum swing adsorption*

RESULTS: SYSTEM PERFORMANCE & VALIDATION

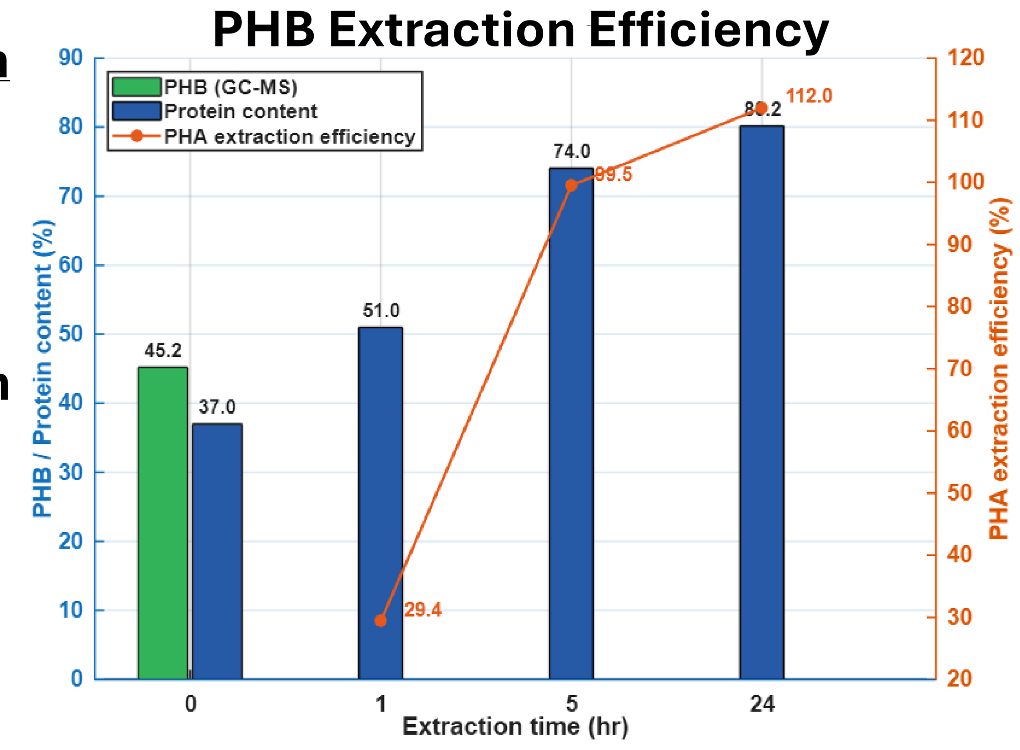
Fermentation profiles



Integrated CO_2 utilisation improves performance

- Demonstrated DAC-bioprocess integration
- Two-stage fermentation enables **transition from CO_2 production to net CO_2 consumption** shifting metabolism toward carbon fixation pathways

PHB & SCP Content + PHB Extraction Efficiency



CO_2 converted into valuable bioproducts

- ~45–60% PHB (bioplastics)
- ~20–37% protein (pre-PHB extraction) suitable for aquafeed applications
- ~75 - 80% protein (post-PHB extraction)
- Demonstrated dual-bioproduct process, **materials (PHB) + protein (SCP)**

SOCIETAL BENEFIT: ENABLING CARBON-TO-VALUE PATHWAYS

SUSTAINABLE DEVELOPMENT GOALS — 13 CLIMATE ACTION, 12 RESPONSIBLE CONSUMPTION AND PRODUCTION, 9 INDUSTRY, INNOVATION AND INFRASTRUCTURE, 2 ZERO HUNGER

🌍 **Climate:** Converts atmospheric CO_2 into useful products, supporting carbon removal and utilisation pathways

🏭 **Industry:** Enables sustainable production of biodegradable plastics (PHB), reducing reliance on fossil-based materials

🍽 **Food systems:** Produces protein-rich microbial biomass for aquafeed, reducing pressure on fisheries and agriculture

♻ **Circular economy:** Transforms waste CO_2 into valuable resources, improving the economic viability of DAC

Enables carbon capture to become economically viable through product generation

FEASIBILITY & DEPLOYMENT

DAC2BIO has been validated at bench scale through successful operation of both Direct Air Capture and microbial bioprocessing systems, as well as their integration into a single platform. The modular design enables decentralised deployment and scalable integration pathways. Larger DAC pilot systems have already been designed, commissioned, and operated by collaborators, providing a clear scale-up pipeline. To date, over $1.5M AUD in government–industry–academia co-investment has been secured, with more co-investment pending evaluation.

NEXT STEPS

Next steps focus on scaling the integrated DAC–bioreactor system to pilot level, transitioning to continuous operation, and optimising gas delivery and fermentation performance. Techno-economic and life cycle assessments will support commercial evaluation, alongside continued industry engagement to enable real-world deployment.

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References

[1] Friedlingstein, P. et al. (2023). *Global Carbon Budget 2023*. Earth System Science Data, 15, 5301–5369.

[2] Energy Analytics Institute (2023). Direct Air Capture (DAC). energyanalytics.org

[3] Koller, M. (2018). Biodegradable and biocompatible polyhydroxyalkanoates (PHA): synthesis, properties, and applications. Materials, 11(7), 1149.

Acknowledgements

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