NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE
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CO_2 CAPTURE VIA NOVEL BIOPROCESS: PURPLE PHOTOTROPHIC BACTERIA (PPB) FOR EMISSION CONTROL AND FOOD SECURITY

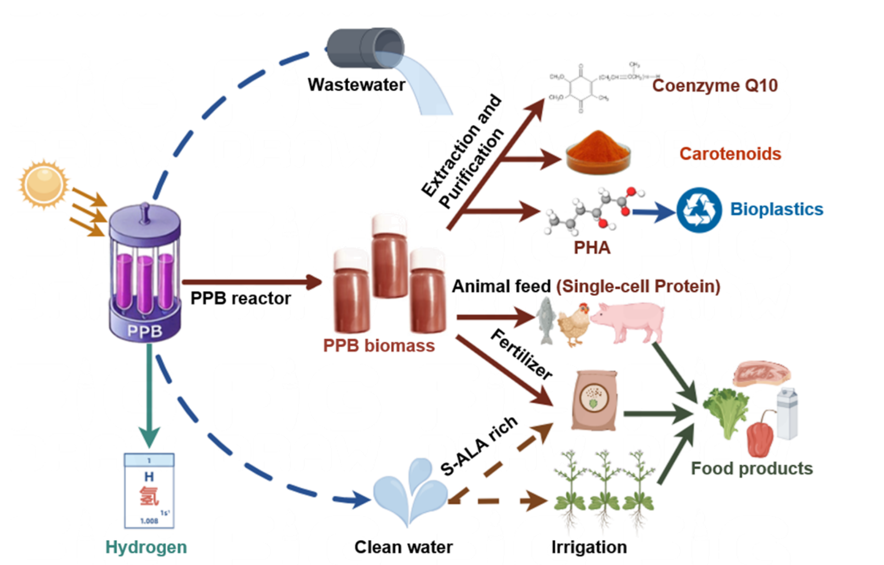
Abstract

This project aims to develop a sustainable bioprocess that captures carbon dioxide (CO_2) from low-concentration emission streams using purple phototrophic bacteria (PPB) and converts it into valuable biomass and bioproducts. The approach leverages PPB's metabolic diversity and ability to utilize multiple electron donors. We hypothesize that by optimizing electron donor availability and growth conditions, PPB can significantly enhance CO_2 fixation into biomass, and that supplying external hydrogen will further boost carbon capture and single-cell protein (SCP) yield. The key objectives and hypotheses are:

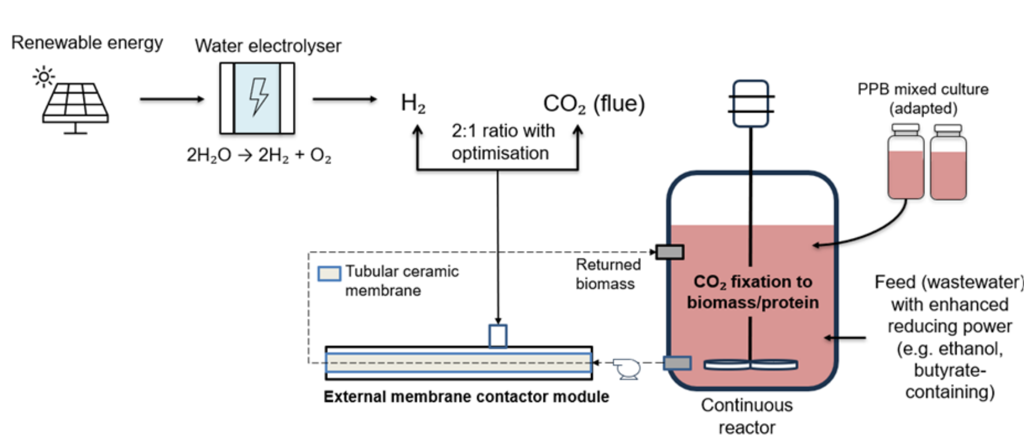
(1) Optimize PPB growth and CO_2 fixation.
Objective: Determine the optimal combinations of electron donor sources (e.g., H_2 gas, ethanol, butyrate) and environmental factors (light intensity, CO_2/H_2 feed ratio, nutrient levels) to maximize PPB growth and CO_2 fixation.
Hypothesis: PPB's versatile metabolism allows it to grow under autotrophic, mixotrophic, and heterotrophic conditions; by tuning electron donor supply and conditions, we can enhance the Calvin–Benson–Bassham (CBB) cycle activity and carbon assimilation.

(2) Integrate novel membrane contactor for enhanced carbon capture and SCP production.
Objective: Incorporate advanced gas delivery module to improve H_2 availability and uptake in PPB cultivation system.
Hypothesis: Incorporating a dedicated H_2 gas contactor (e.g. a membrane diffuser) to the bioreactor will greatly improve hydrogen mass transfer and diffusion into the culture, overcoming gas–liquid transfer limitations. This will allow PPB to utilize H_2 more efficiently as an electron donor, thereby enhancing CO_2 fixation rates and increasing the yield of SCP and value-added products.

Together, these innovations will enable an efficient conversion of dilute CO_2 sources (eg. flue gas) into microbial biomass, demonstrating a hybrid solar-biological route to mitigate emissions while producing protein-rich feed.



Versatility of PPB metabolic pathways and different end products.



Schematic of the proposed integrated lab-scale PPB system

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