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溫室氣體(CO_2)與有機廢水之綠色石化資源化技術開發

Converting Organic Wastewater and Carbon Dioxide to Succinic Acid via Microalgal Biorefinery Technology

國立成功大學 環境工程學系 大學四年級 林佳怡
指導教授：張嘉修 教授

研究重點

Microalgae are considered the third-generation feedstock for biofuels and biorefinery. They have much higher growth rate than that of terrestrial plants and their biomass contains high contents of carbohydrates and lipids, which are suitable raw materials for biofuels and bio-based chemicals production. In this study, carbohydrate-rich microalgal biomass was used as feedstock to develop a CO_2-reutilization platform, taking succinic acid as the target product for the development of the biorefinery process. Succinic acid has the high economic value, and is also considered one of the most valuable bio-refinery products. Since the cost of raw materials accounts for over 60% of the total production cost in bio-succinic acid production, the microalgal biomass feedstock was produced via CO_2 fixation and organic wastewater treatment under mixotrophic conditions. Wastewater from livestock sector with different COD level was used to grow microalgae that could accumulate carbohydrates in their biomass. Using the wastewater with an initial COD of 2027 mg/L COD, the maximum COD, PO_4^+, NO_3^-, and NH_3^+ removal percentages were 88.8, 100, 57.0, and 100%, respectively. In addition, the highest biomass concentration was 3.3 g/L, and the carbohydrates content was 47.9%. Next, the microalgal biomass was hydrolyzed with acid and the hydrolysate was used to produce succinic acid with immobilized cells of *Actinobacillus succinogenes*. The maximum succinic acid concentration, productivity and yield were 21.87 g/l, 1.7 g/l/hr and 5.036 mmol/g COD, respectively. This study demonstrates the feasibility of converting greenhouse gas and environmental pollutants to valuable chemicals via a sustainable biorefinery approach.

研究成果 (I)

	COD mg/L	Phosphate mg/L	NO_3-N mg/L	NH_3-N mg/L	pH
4-fold	1035	6.7	1.5	121.1	7.92
2-fold	2027	13.5	3.0	227.1	7.96
Undiluted	4160	28.1	5.3	470.7	8.04

Table 1. Swine wastewater qualities based on different dilution rates

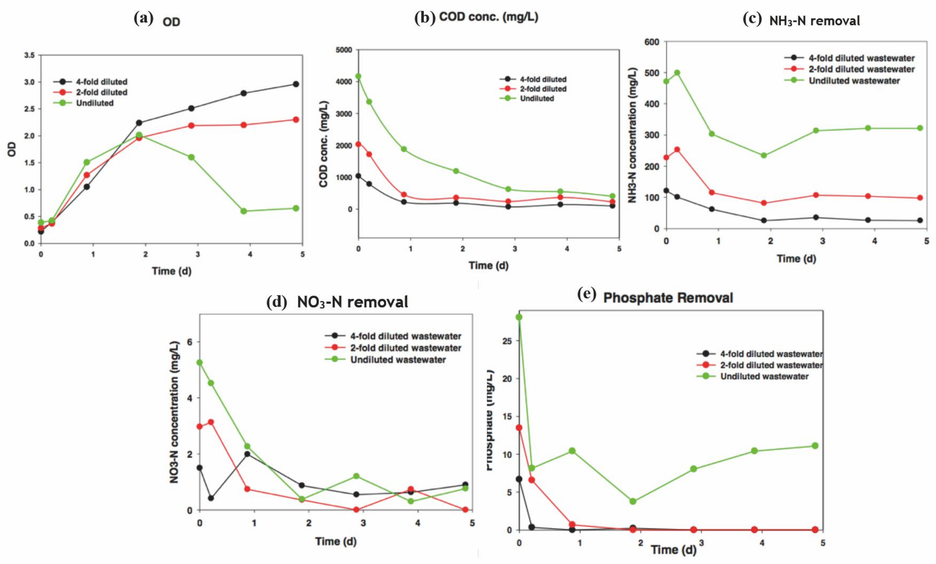

Fig 1. Algae cultivation and nutrients removal in swine wastewater with different dilution rates on a 5-day basis: (a) algal biomass concentration, (b) chemical oxygen demand (mg/L) concentration, (c) NH_3 concentration, (d) NO_3 concentration, and (e) phosphate concentration.

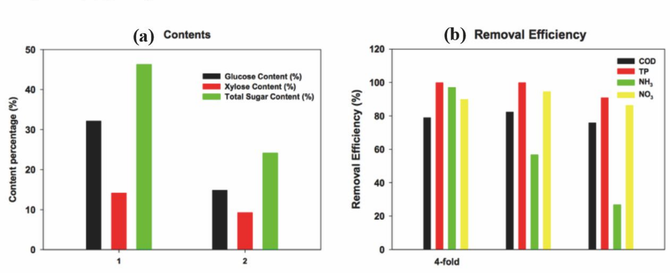

Fig 2. (a) Algae contents and (b) nutrients removal efficiency after 5-day cultivation

研究成果 (II)

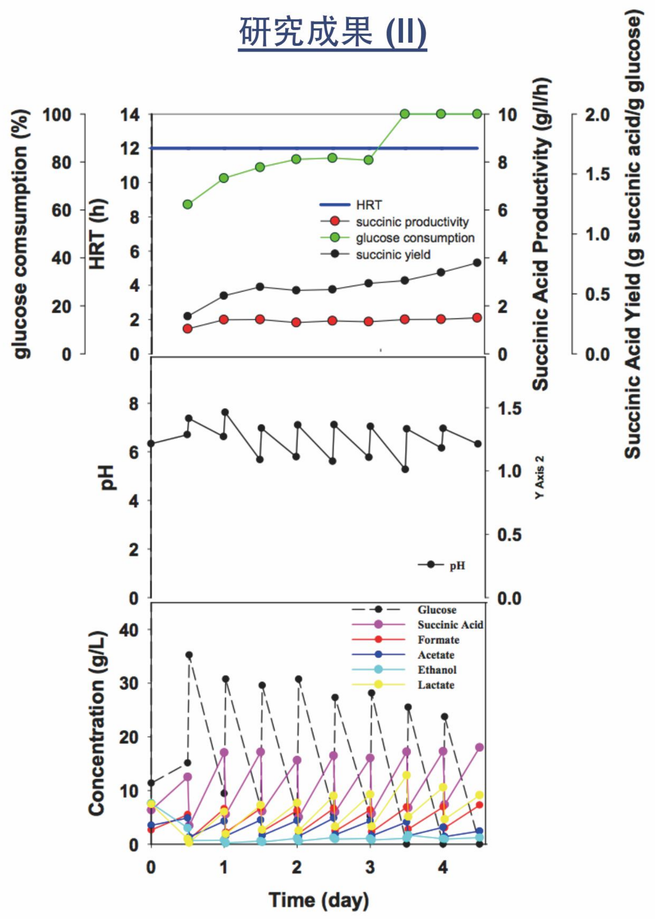

Fig 3. Cultivation and of *Actinobacillus succinogenes* ATCC55618 in semi-batch reactor using medium of 40 g/L glucose, 10 g/L yeast extract, 3 g/L KH_2PO_4, 0.2 g/L $MgCl_2{\cdot}6H_2O$, 1 g/L NaCl, and 30 g/L $MgCO_3$.

Glucose (g/L)	Succinic (g/L)	yield (g/g)	yield (m/m)	Productivity (g/L-hr)	S/A	Acetate (g/L)
37.9	16.3 ±1.62	0.56 ±0.125	0.86 ±0.191	1.3 ±0.13	2.5 ±0.09	6.6 ±0.51

Fig 4. Succinic acid production performance of *Actinobacillus succinogenes* ATCC55618 on semi-batch reactor

研究心得

利用藻類及細菌將廢氣和廢水轉化成具有經濟效益的琥珀酸，這項研究結合了化學工程與環境工程的專業，透過跨學科的方式，嘗試利用創新的方法解決永續發展的問題。藉由在化工系所學加深自己在水處理方面的操作方式，我期望有一天能夠更有效處理環境議題。我希望未來能找到更好的方法，以減輕過去我們對環境所造成的負擔，並創造更加和諧的未來。本構想乃整合微藻混營培養系統處理畜牧業或工業廢水，以單槽式的生物反應器培養微藻，取代以往傳統的雙槽式廢水處理系統，並且進行連續式生質琥珀酸之生產。在反應器內，利用有機廢水與二氧化碳為反應基質，於藻體內累積大量碳水化合物，將藻體回收進行水解，產生的醣類可被*Actinobacillus succinogenes*菌株用來進行醱酵生產琥珀酸。主要目的在於利用環境污染物，經由生物精煉方式將其轉化成有經濟價值的產品，達到零碳低汙染生產製程與永續經營之目的。很幸運能獲得科技創意獎，經過這次的經驗以後，我會進一步拓展我的能力，從不同的角度看待問題，將問體處理的更完善，也將研究計劃提升為實際應用層面。我期望能用持之以恆的熱情去學習新的事物，不斷吸收整合性的知識，以提高我處理問題的能力，讓自己在將來面對環境問題時，不設限於單一種解決方法，盡量嘗試各種可能性。

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