環境科技於循環經濟之應用

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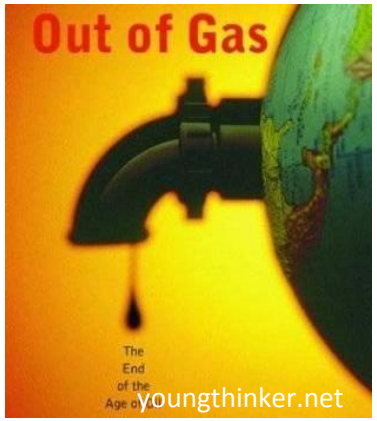
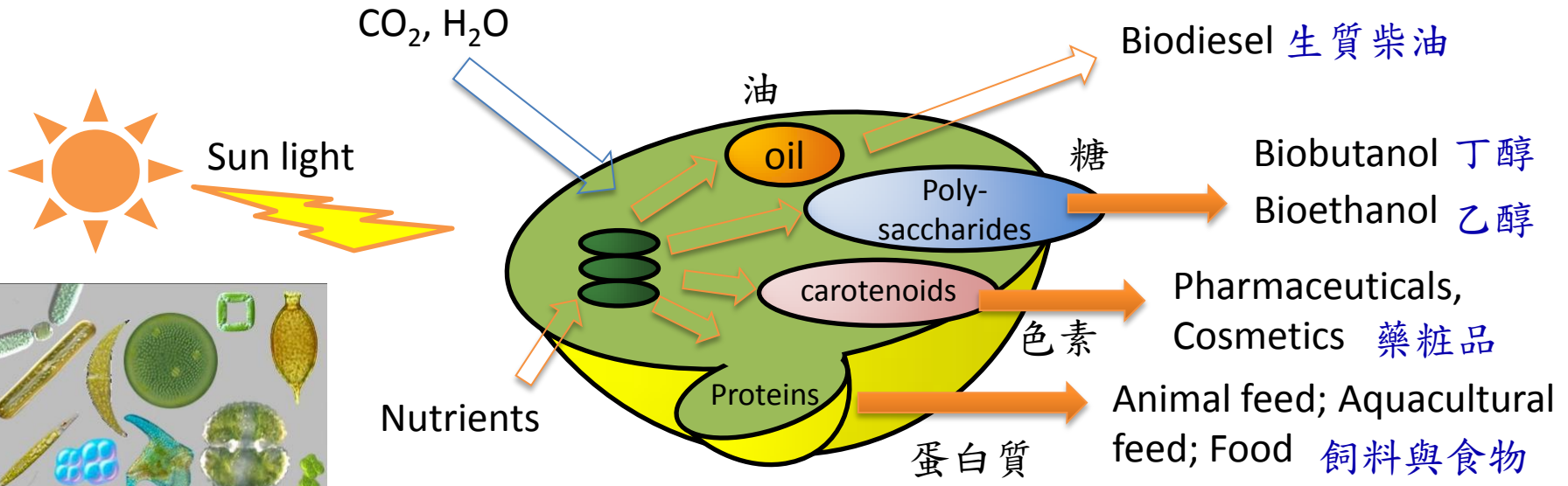
攝影：林柏琪

微藻 Microalgae (Algae =藻類,そうるい)

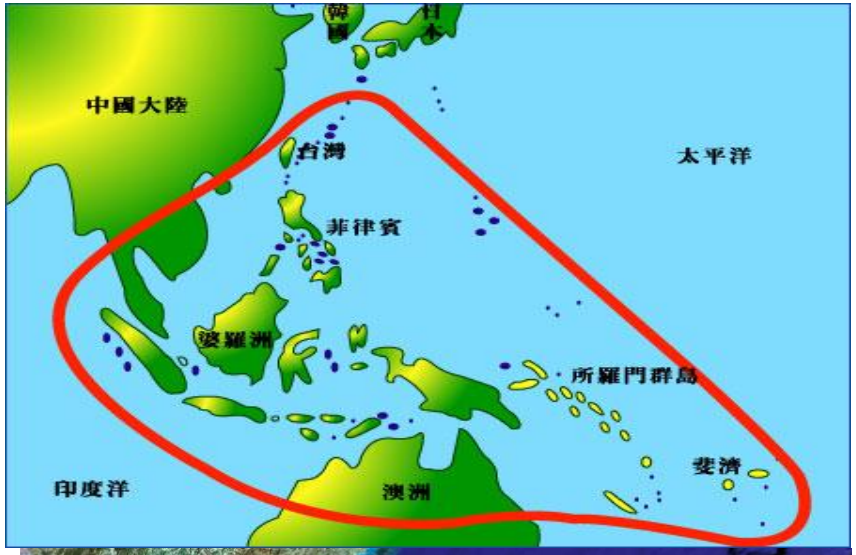
- 藻類可同時解決**全球暖化**與**能源與糧食**的問題

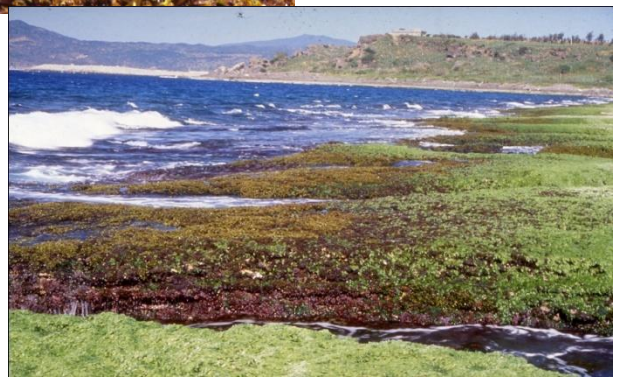


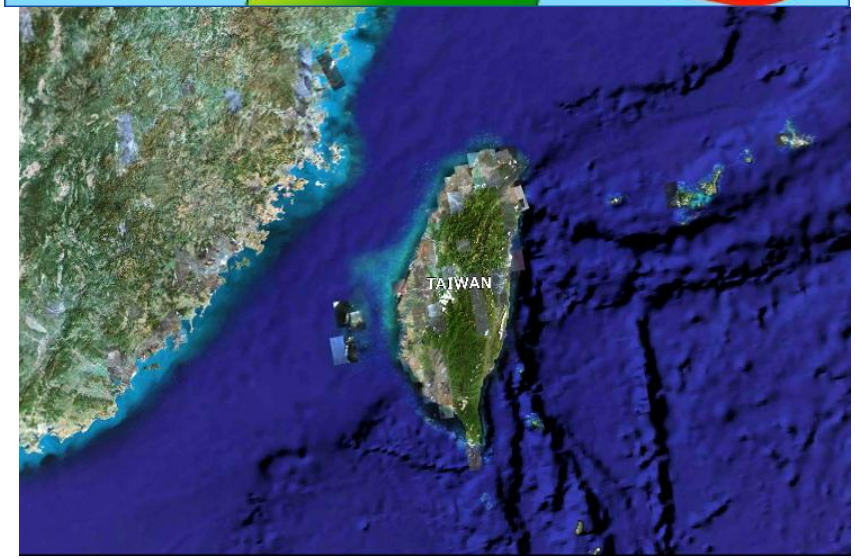


- Posten, C.; Schaub, G., Microalgae and terrestrial biomass as source for fuels--A process view.

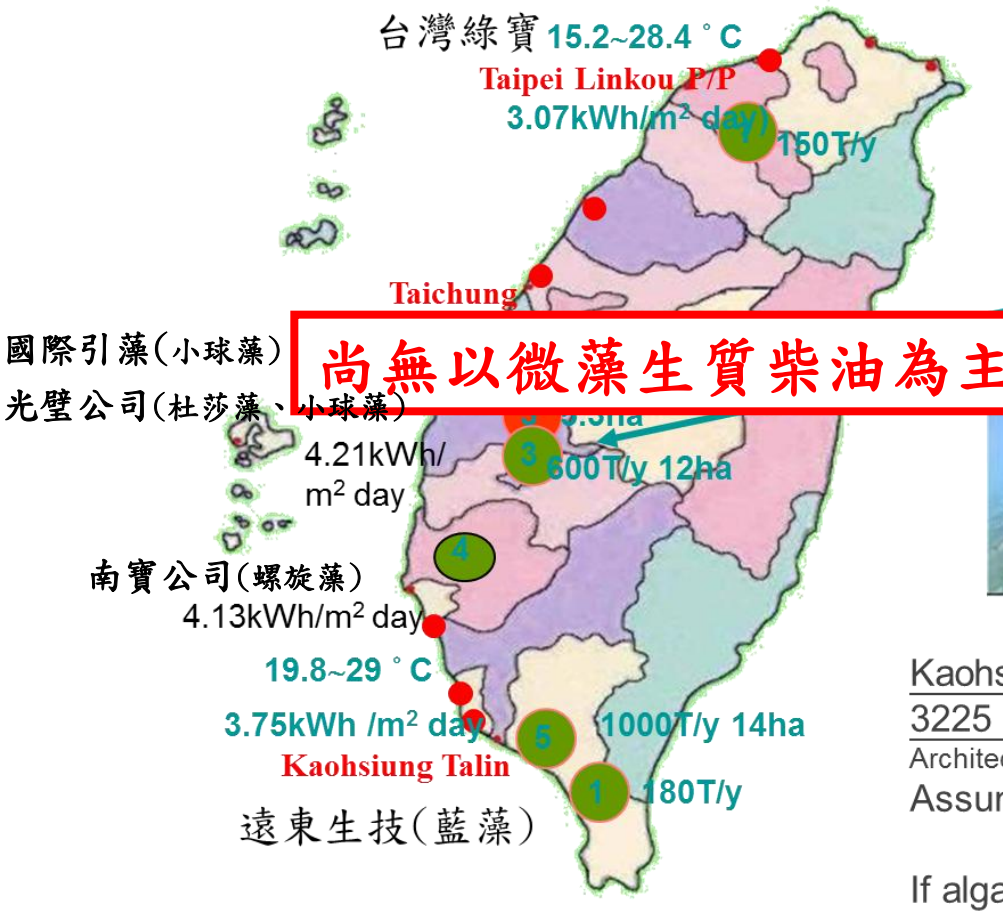
台灣是個培養微藻絕佳的環境





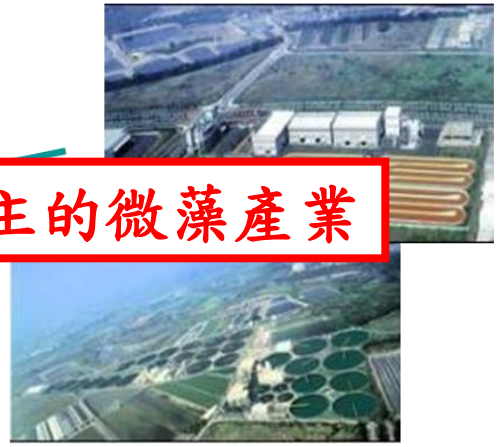


台灣是藻類 (尤其是綠藻)生產的王國



尚無以微藻生質柴油為主的微藻產業

Total capacity： 2,530t/yr dry microalgae (source： google)



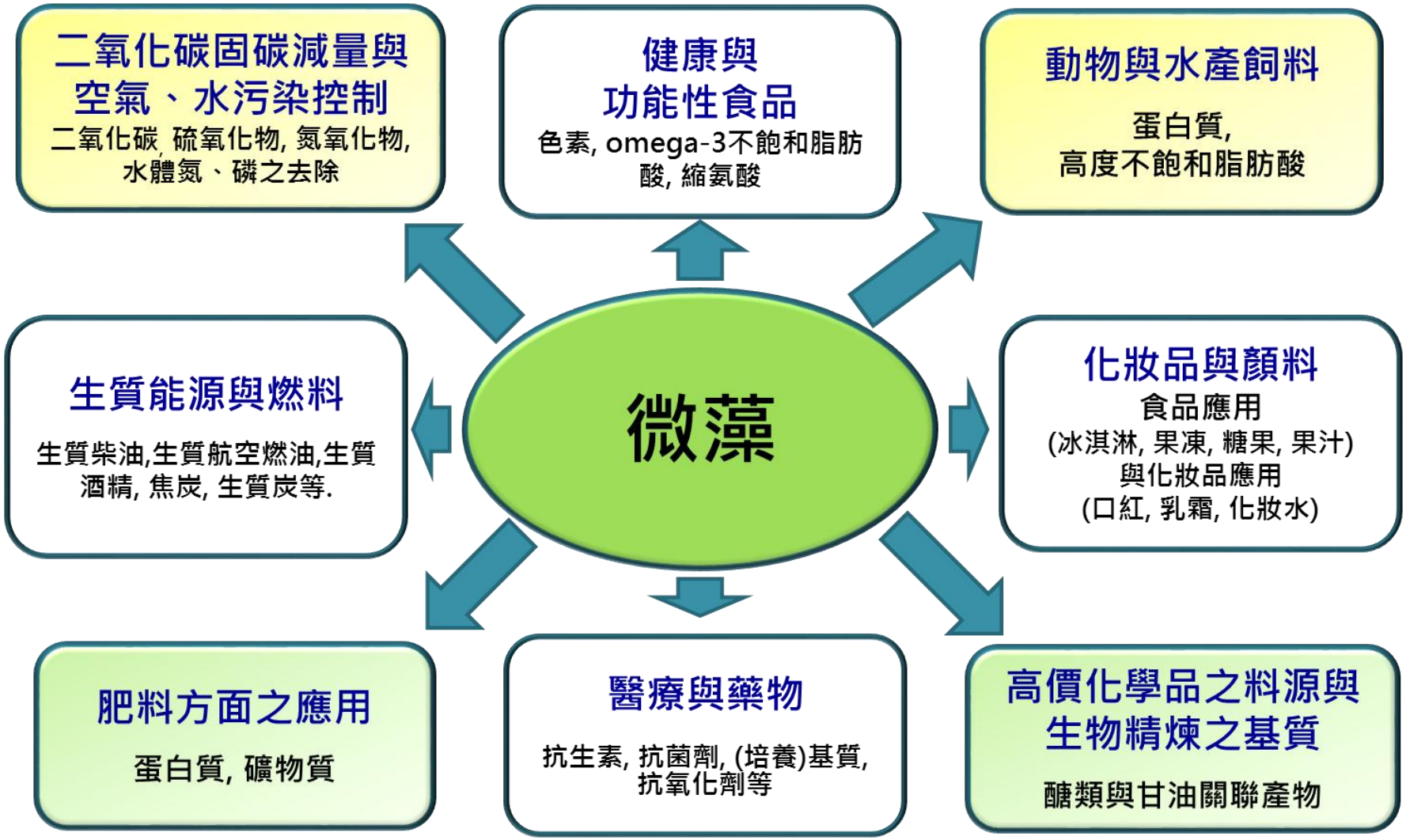
Kaohsiung mean average daily solar radiation: 3225 kcal/m²/day (source： Ou, W-S. et al., Journal of Architecture, No.64, pp.103~118, Jun. 2008)

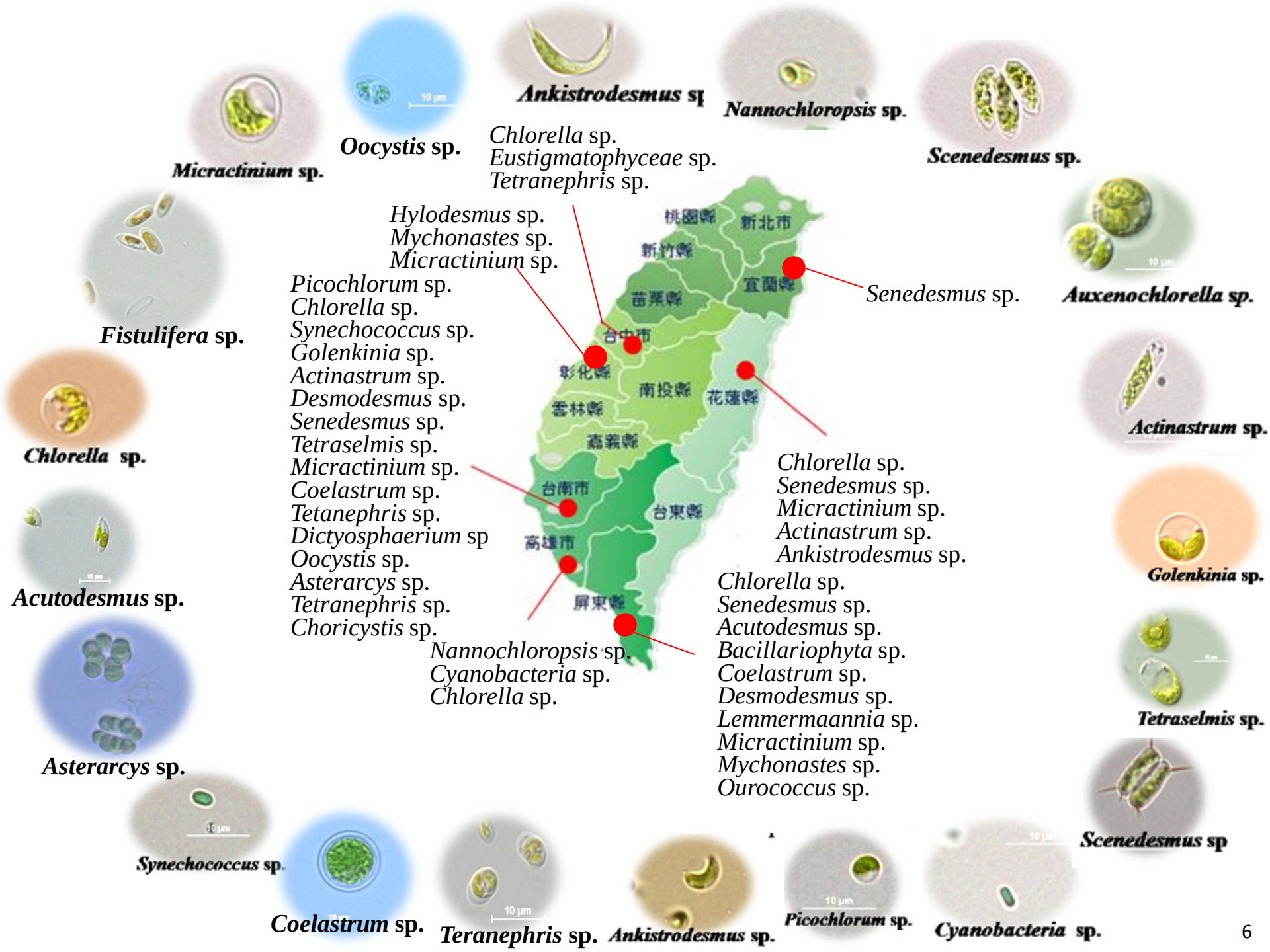
Assume：3% Photosynthetic Efficiency (PE)
≒96.8 kcal/m²/day

If algal caloric value is ~5 kcal/g,

Expected algal biomass productivity: 19.4 g/m²/day

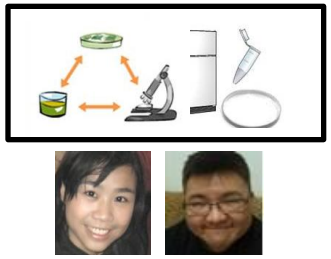
微藻之應用與相關產業


二氧化碳固碳減量與
空氣、水污染控制
二氧化碳, 硫氧化物, 氮氧化物,
水體氮、磷之去除
健康與
功能性食品
色素, omega-3不飽和脂肪
酸, 縮氨酸
動物與水產飼料
蛋白質,
高度不飽和脂肪酸
生質能源與燃料
生質柴油,生質航空燃油,生質
酒精, 焦炭, 生質炭等.
微藻
化妝品與顏料
食品應用
(冰淇淋, 果凍, 糖果, 果汁)
與化妝品應用
(口紅, 乳霜, 化妝水)
肥料方面之應用
蛋白質, 礦物質
醫療與藥物
抗生素, 抗菌劑, (培養)基質,
抗氧化劑等
高價化學品之料源與
生物精煉之基質
醣類與甘油關聯產物

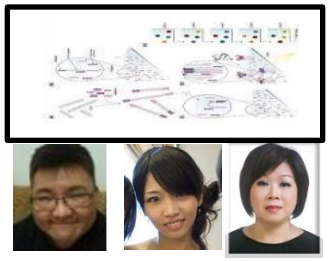

Micractinium sp.
Oocystis sp.
Ankistrodesmus sp.
Nannochloropsis sp.
Scenedesmus sp.
Chlorella sp.
Eustigmatophyceae sp.
Tetranephris sp.
Hylodesmus sp.
Mychonastes sp.
Micractinium sp.
Picochlorum sp.
Chlorella sp.
Synechococcus sp.
Golenkinia sp.
Actinastrum sp.
Desmodesmus sp.
Senedesmus sp.
Tetraselmis sp.
Micractinium sp.
Coelastrum sp.
Tetanephris sp.
Dictyosphaerium sp
Oocystis sp.
Asterarcys sp.
Tetranephris sp.
Choricystis sp.
Nannochloropsis sp.
Cyanobacteria sp.
Chlorella sp.
桃園縣
新北市
新竹縣
宜蘭縣
苗栗縣
台中市
彰化縣
南投縣
花蓮縣
雲林縣
嘉義縣
台南市
台東縣
高雄市
屏東縣
Senedesmus sp.
Chlorella sp.
Senedesmus sp.
Micractinium sp.
Actinastrum sp.
Ankistrodesmus sp.
Chlorella sp.
Senedesmus sp.
Acutodesmus sp.
Bacillariophyta sp.
Coelastrum sp.
Desmodesmus sp.
Lemmermaannia sp.
Micractinium sp.
Mychonastes sp.
Ourococcus sp.
Fistulifera sp.
Chlorella sp.
Acutodesmus sp.
Asterarcys sp.
Synechococcus sp.
Coelastrum sp.
Teranephris sp.
Ankistrodesmus sp.
Picochlorum sp.
Cyanobacteria sp.
Scenedesmus sp
Tetraselmis sp.
Golenkinia sp.
Actinastrum sp.
Auxenochlorella sp.

Core Technology 核心技術

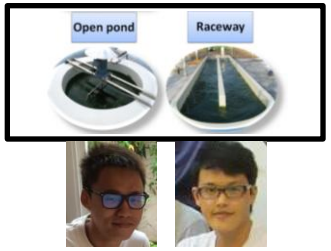
藻類篩選



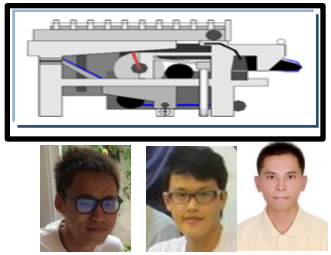
基因工程與突變



戶外大量養殖



藻體收集



有效成分提取

Applications 應用方向

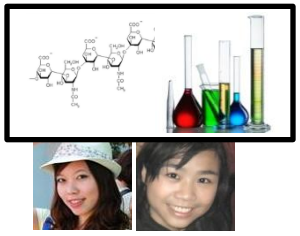
化妝保養品

工廠廢氣固碳

水產養殖飼料

微藻色素

微藻多醣體



DHA/EPA

生質柴油

生物精煉

丁醇, 乙醇,
多元醇, 乳酸,
琥珀酸等

Taiwan's National Energy Project (NEP)

CO_2 fixation and re-utilization using microalgae
二氧化碳固定與再利用

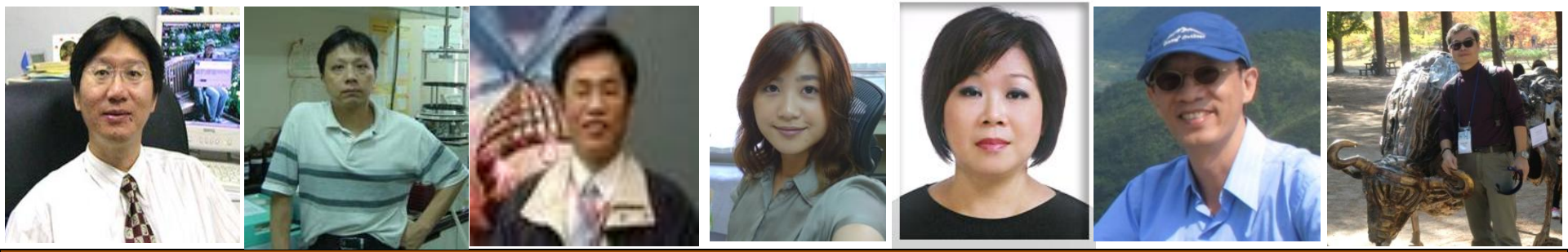
Funding source: Ministry of Science and Technology (MOST)

Project period: 2010-2018

PI: Prof. JS Chang (NCKU)

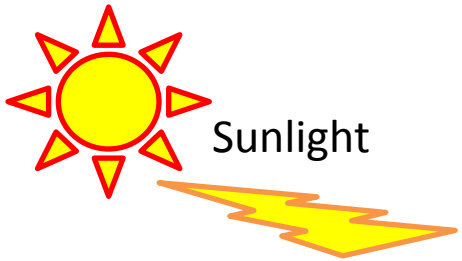
Co-PIs: Prof. TM Lee (NSYSU), Prof. TJ Chou (FYU), Prof. C-S Lin (NCTU)

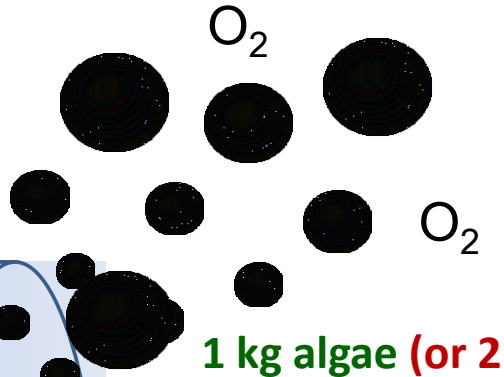
Prof. H-W Yen (THU), Dr. TJ Kou (MIRDC), Prof. HY Wang (NCKU)



微藻固碳及CO_2再利用觀念 公視新聞 video

Flue gas





CO_2

NOx

SOx

CO_2

Microalgae cultivation

1 kg algae (or 2 kg CO_2) = 3-7,000 USD

Wastewater

Biodiesel Succinic acid Cosmetics

2 kg CO_2 + 500 L H_2O (recyclable)
+ tiny amount of nutrients
= 1 kg algae

Lutein Astaxanthin Feed

以微藻固定二氧化碳 - 相關數據

- 微藻固碳速率是陸地植物的20-100倍
- 微藻固碳量如何計算? (碳元素平衡)
- ➔產生1 Kg的微藻約吸收1.6-2.0 Kg的CO_2
- 微藻固碳速率大概有多快？
- ➔ 每年每公頃約吸收200-400 噸的CO_2

  = 100-200 ton algal biomasss/ha/yr

  = $1x10^8$-$2x10^8$ NTD/ha/yr

  (if 1 Kg algal biomass = 1000 NTD)

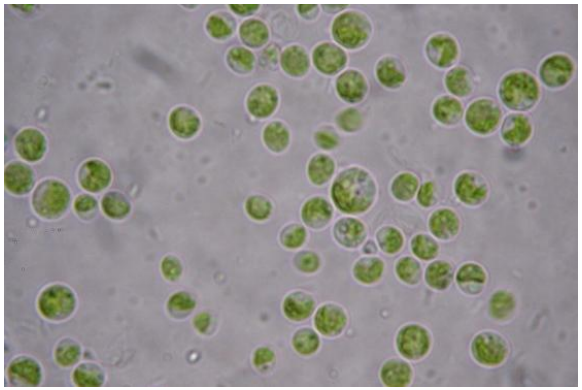
Biofixation of flue gas CO_2 in China Steel Co. using a marine alga

中鋼公司微藻減碳模廠

Flue gas composition:

CO_2: 23.1%; SOx: 85 ppm; NOx: 75 ppm; 230°C

China Steel Co., Taiwan



Microalga: *Chlorella* sp. MT-7

Cultured volume: 40 L/reactor (Total: 6 x 40 = 240 L)

Developing pilot systems for the capture & re-utilization of flue gas CO_2 in China Steel Co.

Circulating tray PBR

Plastic bag-type PBR

Tubular PBR

Ongoing project at CSC:

A 4 ton microalgal CO_2 fixation system will be complete

Microalgae growth using different flue gases (1)

A. Coke oven

B. Blast furnace

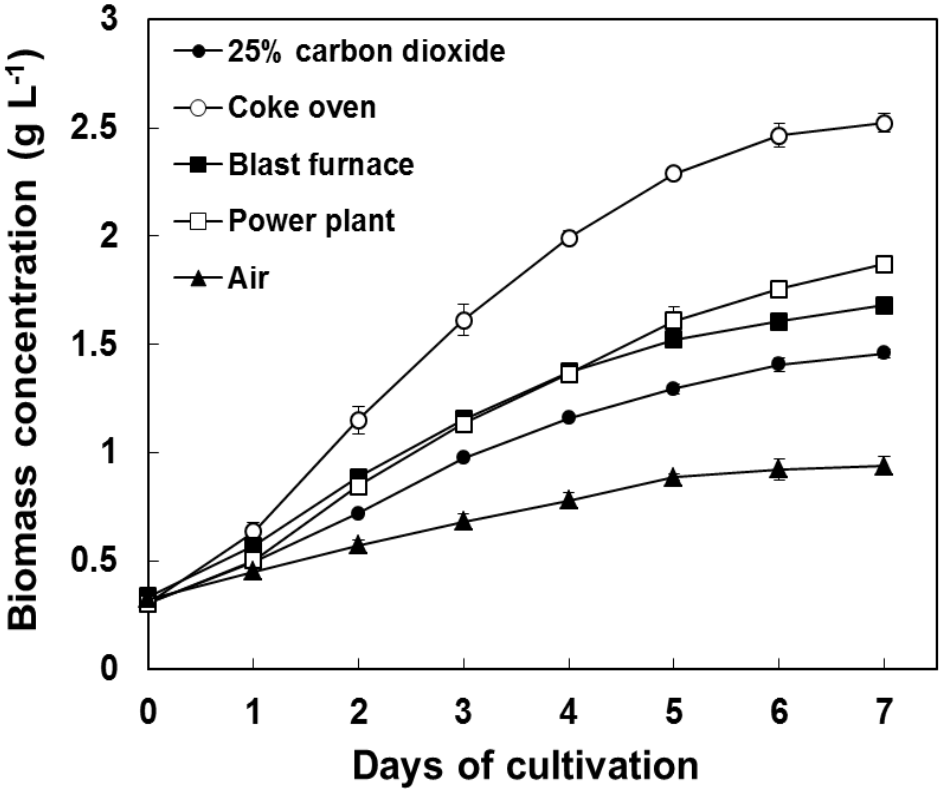
C. Power plant

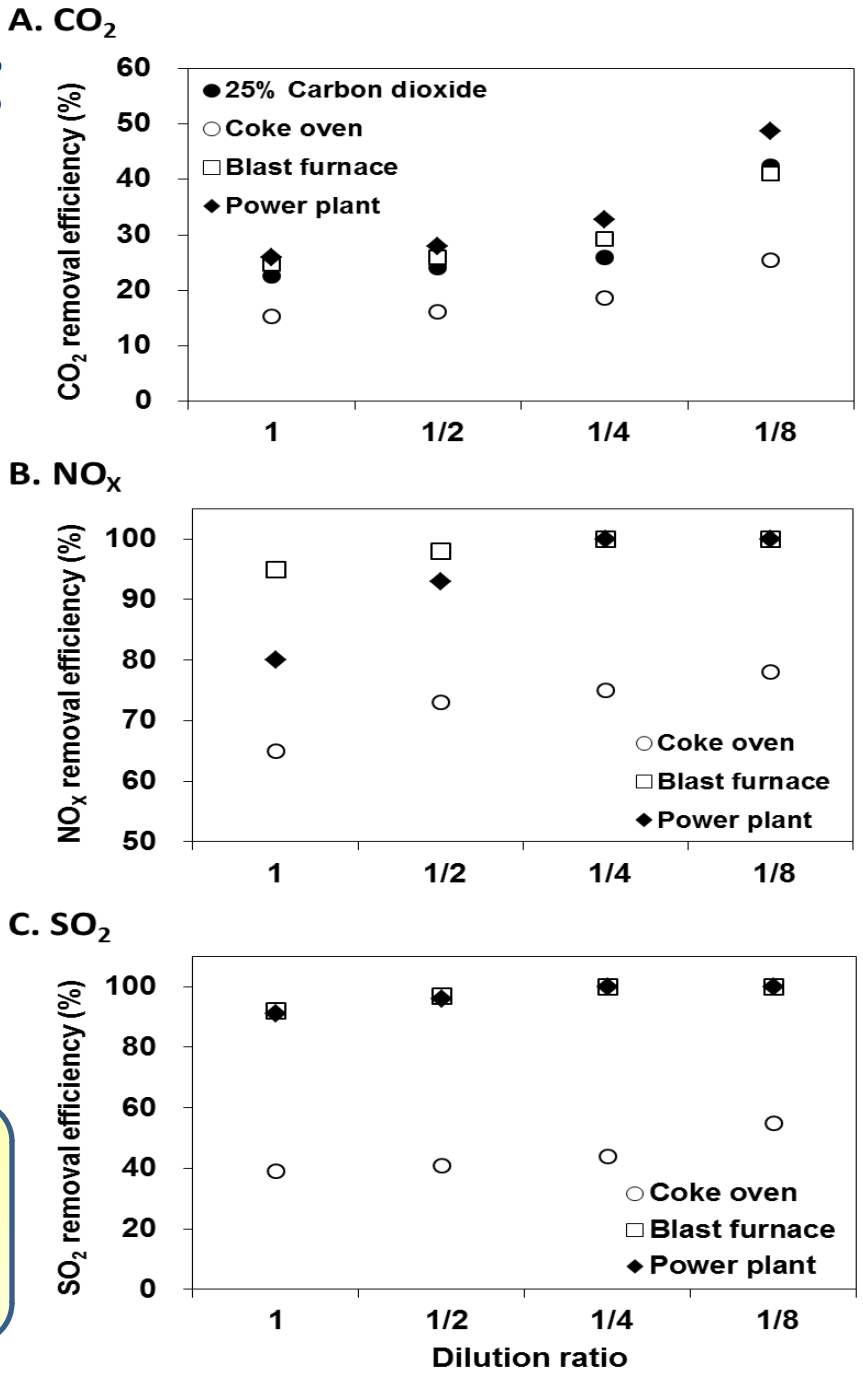
D. Photobioreactor array

Table 1. Major components of different flue gases were collected from the China Steel Corporation in southern Taiwan. Nitrogen oxide (NO_X) is the mixture of nitric oxide (NO) and nitrogen dioxide (NO_2)

	Coke oven	Blast furnace	Power plant
CO_2 (%)	25 (23-27)	26 (24-28)	24 (22-26)
CO (%)	ND [b] (< 0.1)	ND (< 0.1)	ND (< 0.1)
O_2 (%)	7.0	0.4	3.5
NO_X (ppm) [a]	80	10	30
SO_2 (ppm)	90	20	20
Temp. (°C)	200	130	190
Dust (mg m^{-3})	5.8	4.0	--
Gas flow rate (m^3 h^{-1})	175,000	235,000	350,000

Microalgae growth using different flue gases (2)





Lipids content = 21.5 - 41.6%

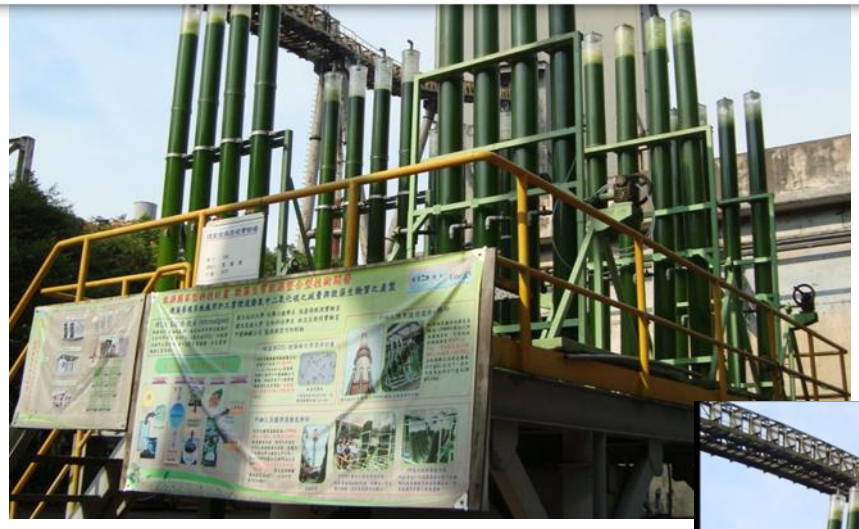
Using coke oven resulted in lower lipid content (due to high NOx content

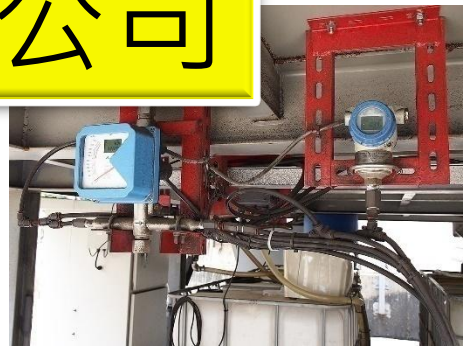
Automation of flue-gas based microalgae cultivation system

Control concept:

Turbidity → Control of fresh medium addition and culture discharge
pH→ Control of flue gas flow rate

此技術已技轉給中鋼公司





台電公司螺旋藻煙道氣固碳模廠

Strain: *Spirulina sp.*

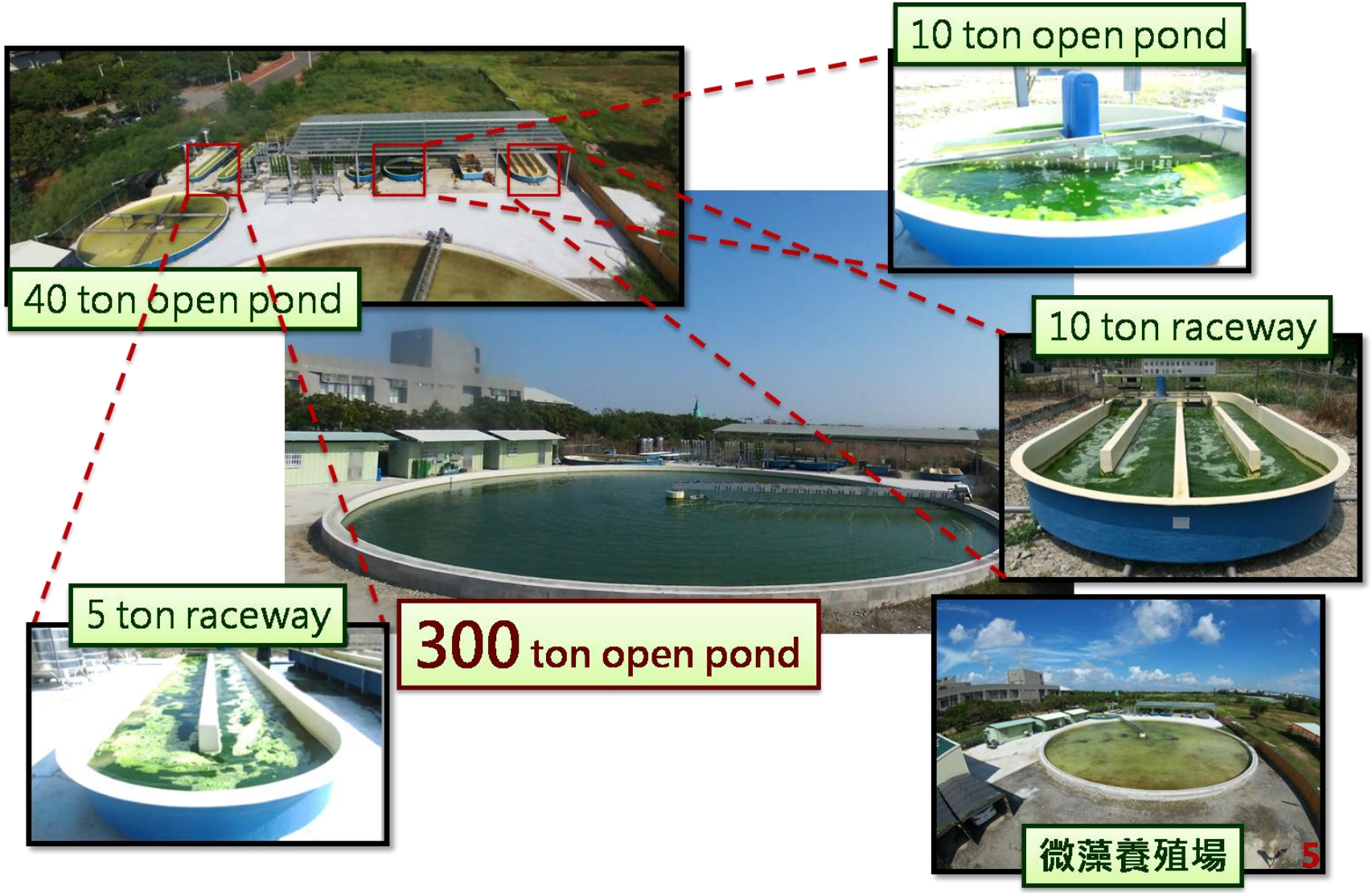
Application of

成功大學綠色永續生物科技示範園區

1. 結合能源科技與策略研究中心、醫學院、工學院、管理學院、生物科技中心等跨領域之研發人才，進行農業生物技術之應用開發與研究
2. 將安南校區打造成全世界第1個結合農業、生態、保健、能源以及民生等領域之**綠色永續生物科技示範園區**。

成功大學安南校區戶外大規模微藻養殖基地

固碳微藻之戶外大規模養殖 (300 ton)

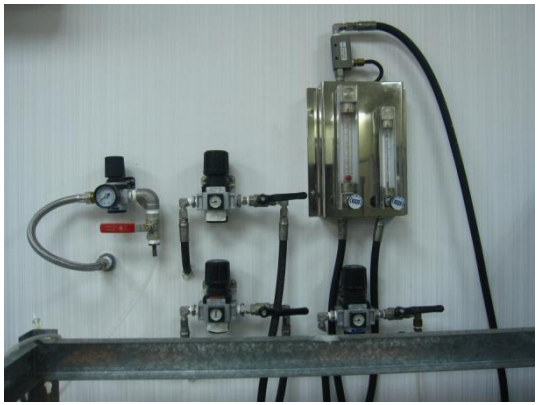


微藻養殖煙道氣來源

成功大學安南校區廢溶劑焚化爐

CO_2

high SOx & NOx

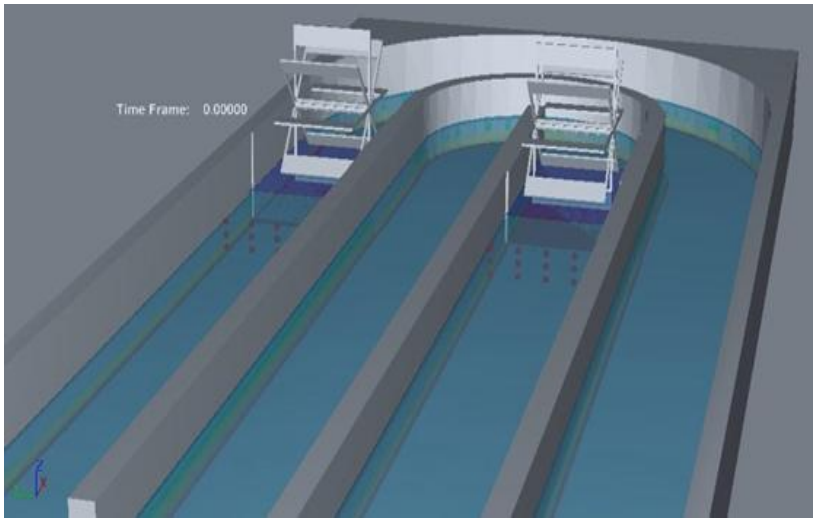


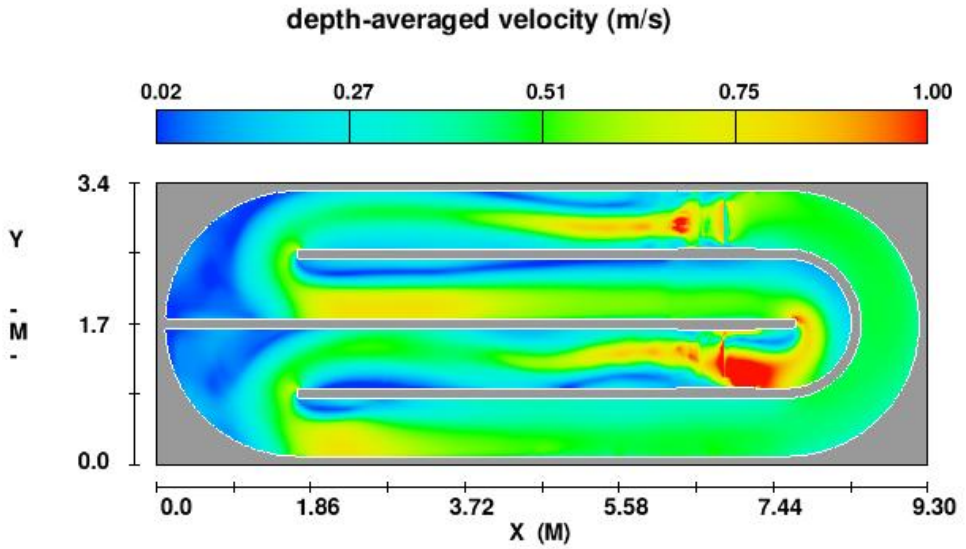
培養微藻之戶外管柱式光生物反應器

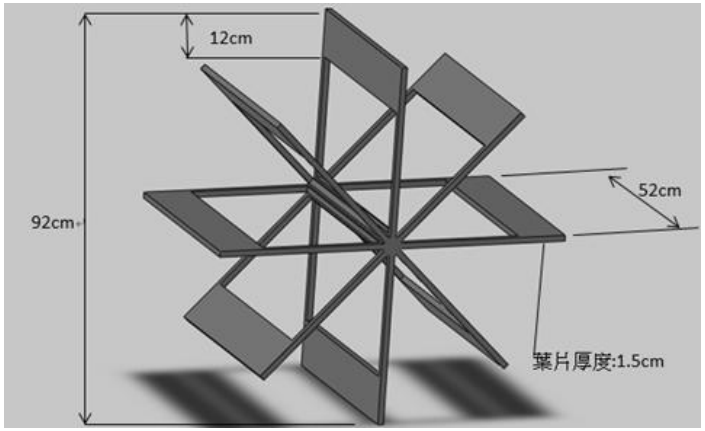
- Photobioreactors (50 L each)

4 channel 跑道式微藻養殖設備

(容量:10-15 ton)





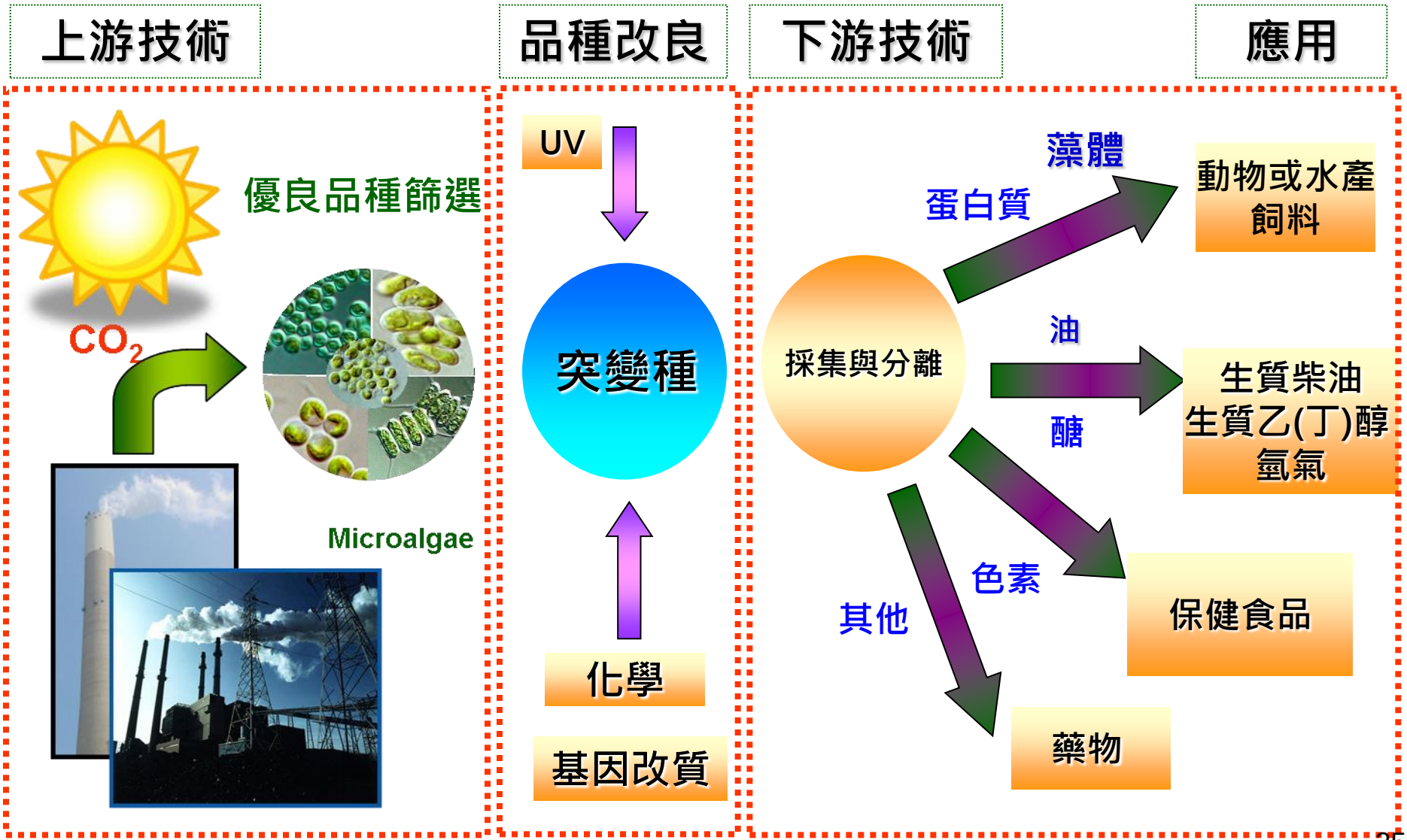


20 ton raceway pond

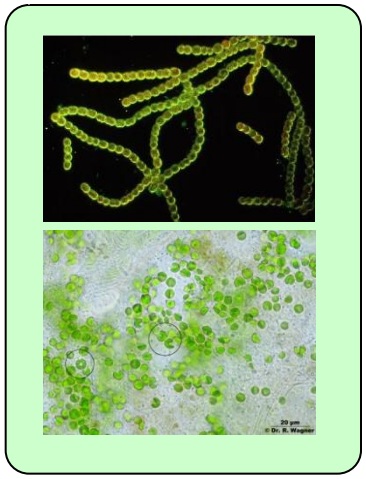

EYELA
900ml
450

成功大學安南校區300公噸商業化規模大型微藻養殖系統 (直徑30 m)

微藻生質能與生物精煉技術整合



微藻生質能源概念



Microalgae

產油藻 → 生質柴油

如：小球藻、葡萄藻

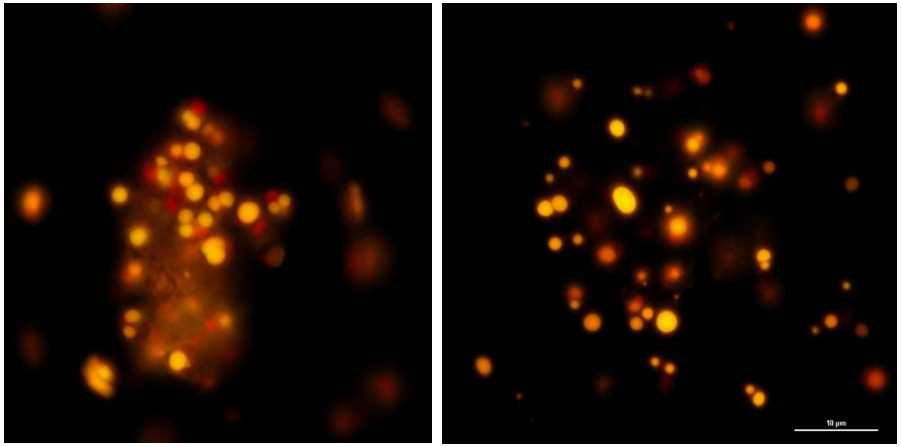
產醣藻 → 乙醇/丁醇/甲烷

如：小球藻、螺旋藻

產氫藻 → 氫氣

如：小球藻、衣藻

以尼羅紅染色法鑑定油脂含量

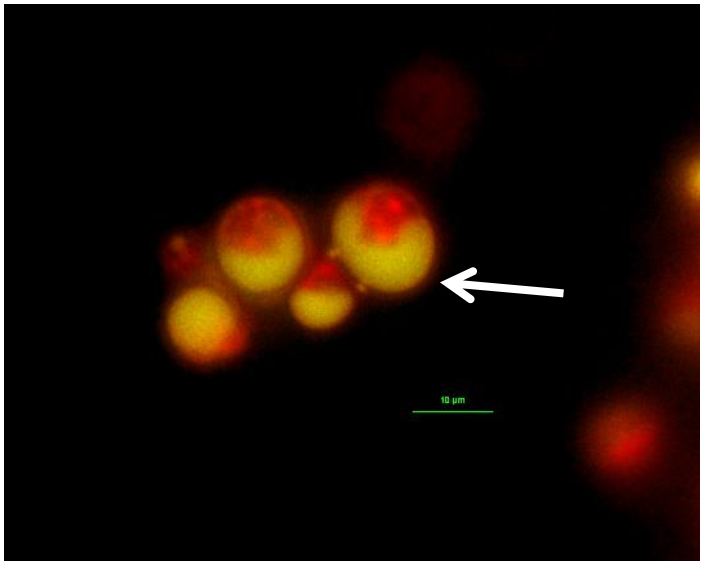


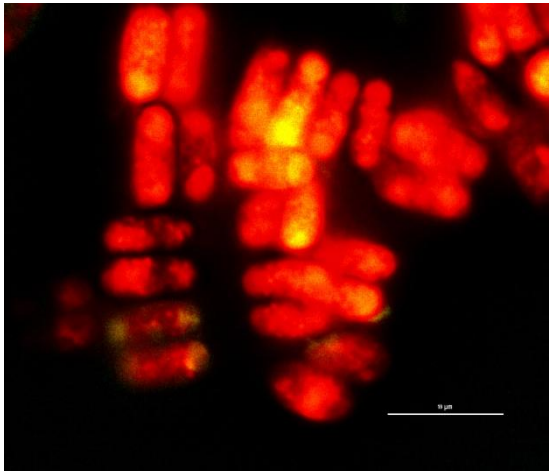
***Nannochloropsis* sp.**
(ca. 31% oil content)

擬球藻

小球藻

***Chlorella vulgaris* ESP-1**
(ca. 50% oil content)





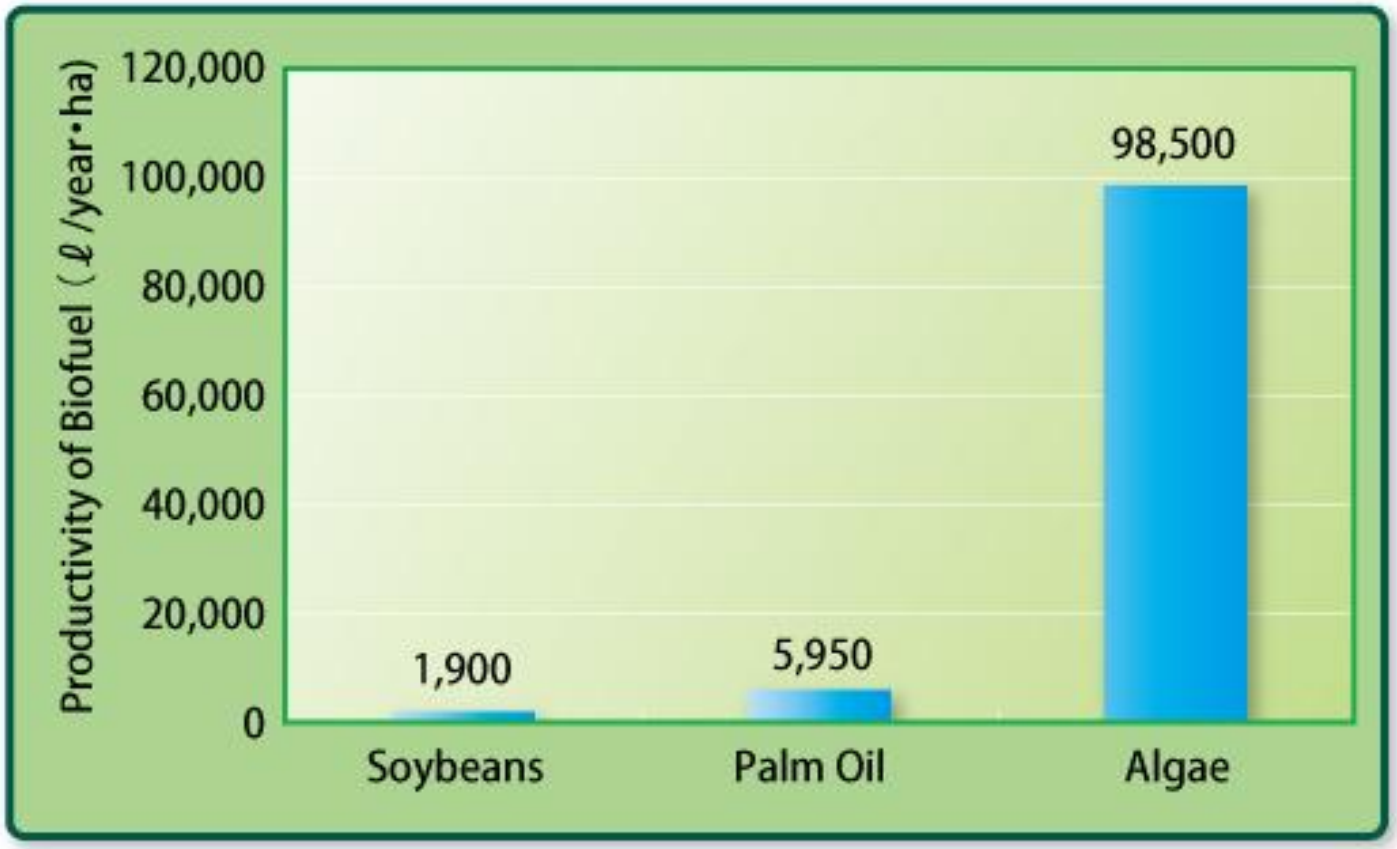
斜角柵藻

***Scenedesmus obliquus* CNW-N**
(ca. 25% oil content)

Productivity of Biofuels from Different feedstock

不同料原之 生質燃料產能

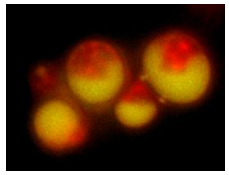
Algae are considered **“ Third generation biofuel ”** with extremely high productivity than other feedstock

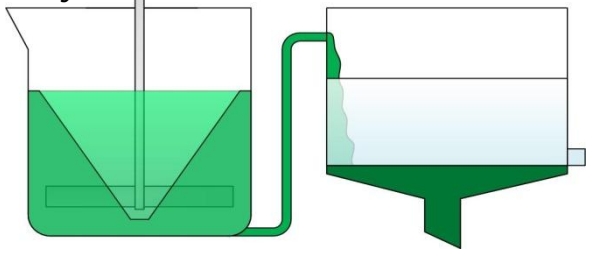


Source: “Prospect of Biomass Energy of Sea Algae”, Prof. Shin Watanabe, Tsukuba University

One-step biodiesel production from wet microalgae biomass 微藻生質柴油製造流程

Microalgae conc. = 1-5 g/L dry wt.
lipid content: 30-50% dry wt.

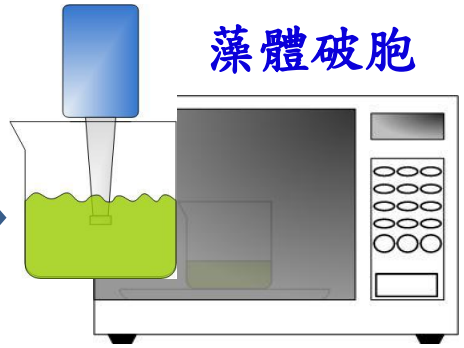




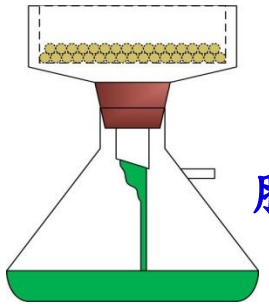
Harvesting
(H_2O content: 90%)

藻體收集

藻體破胞

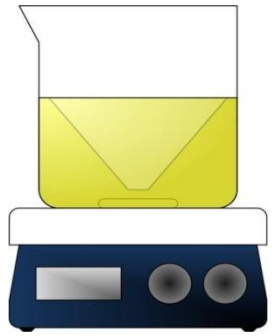


Cell wall disruption
(H_2O content: 90%)

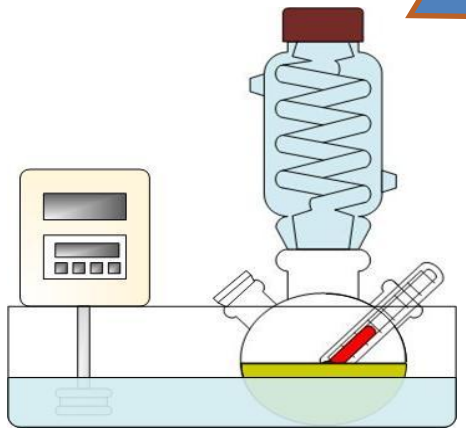


脫水

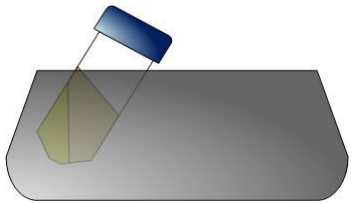
Rapid dewatering
(H_2O content: < 30%)



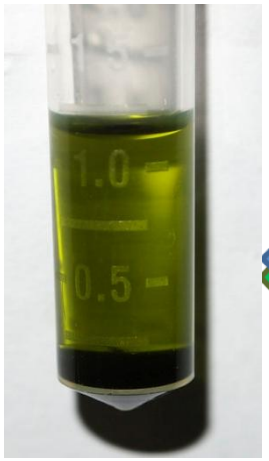
Oil extraction
油脂萃取



Direct transesterification
轉酯化



Product separation
(Phase separation)
分離純化



微藻生質柴油

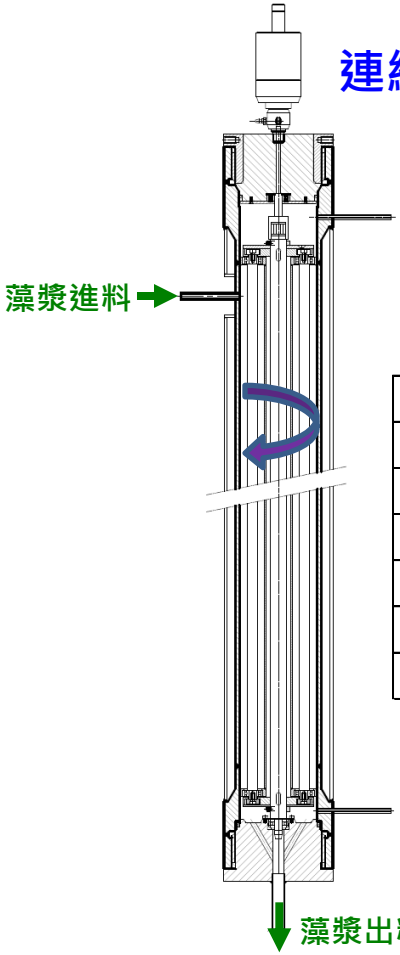
模廠級高壓水破壁系統

600MPa微藻高壓水破壁設備

主要規格：

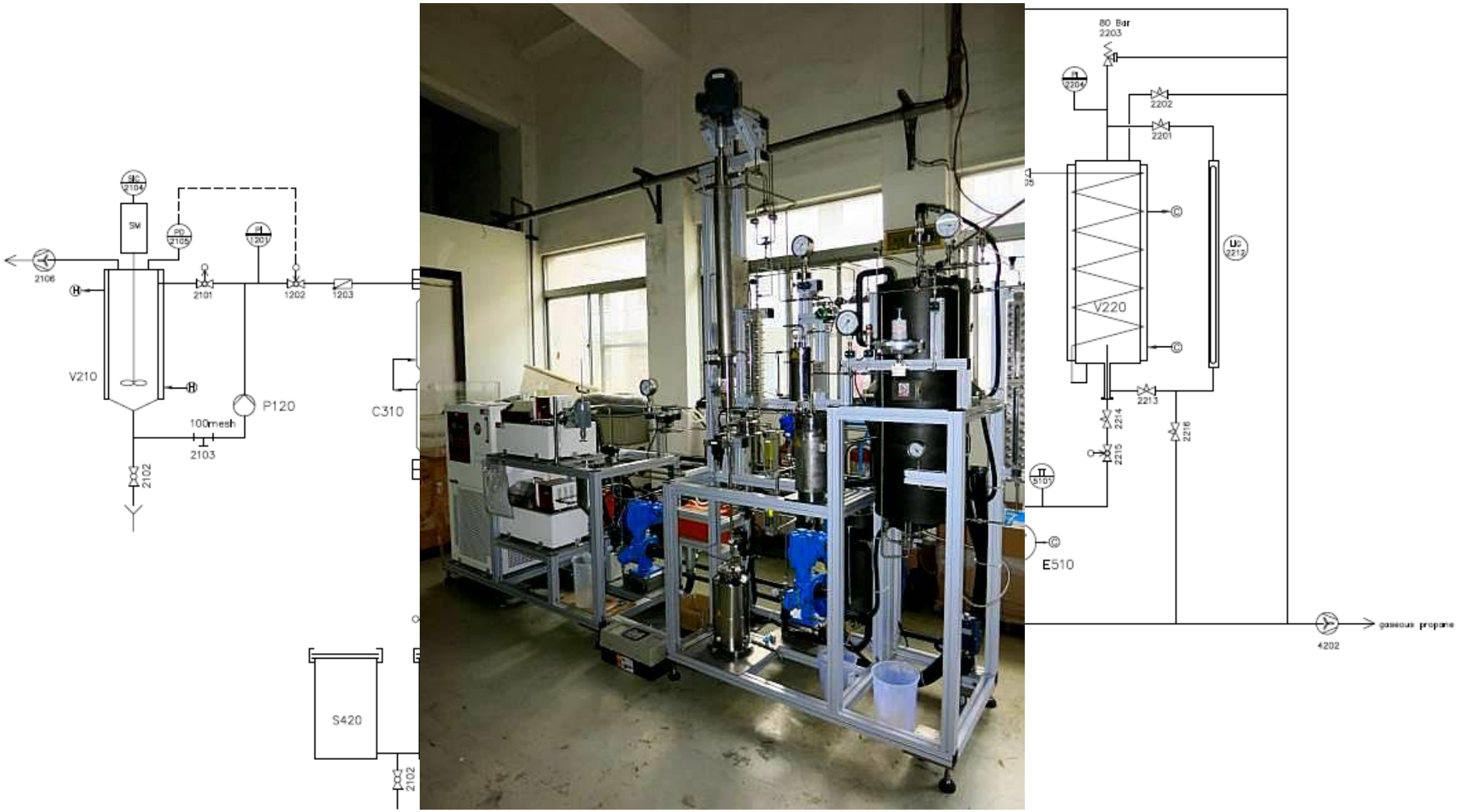
- 設計壓力600MPa
- 設計溫度0~80℃
- 高壓泵流量3L/min(max)
- 處理槽容積11L

連續式藻油萃取pilot plant

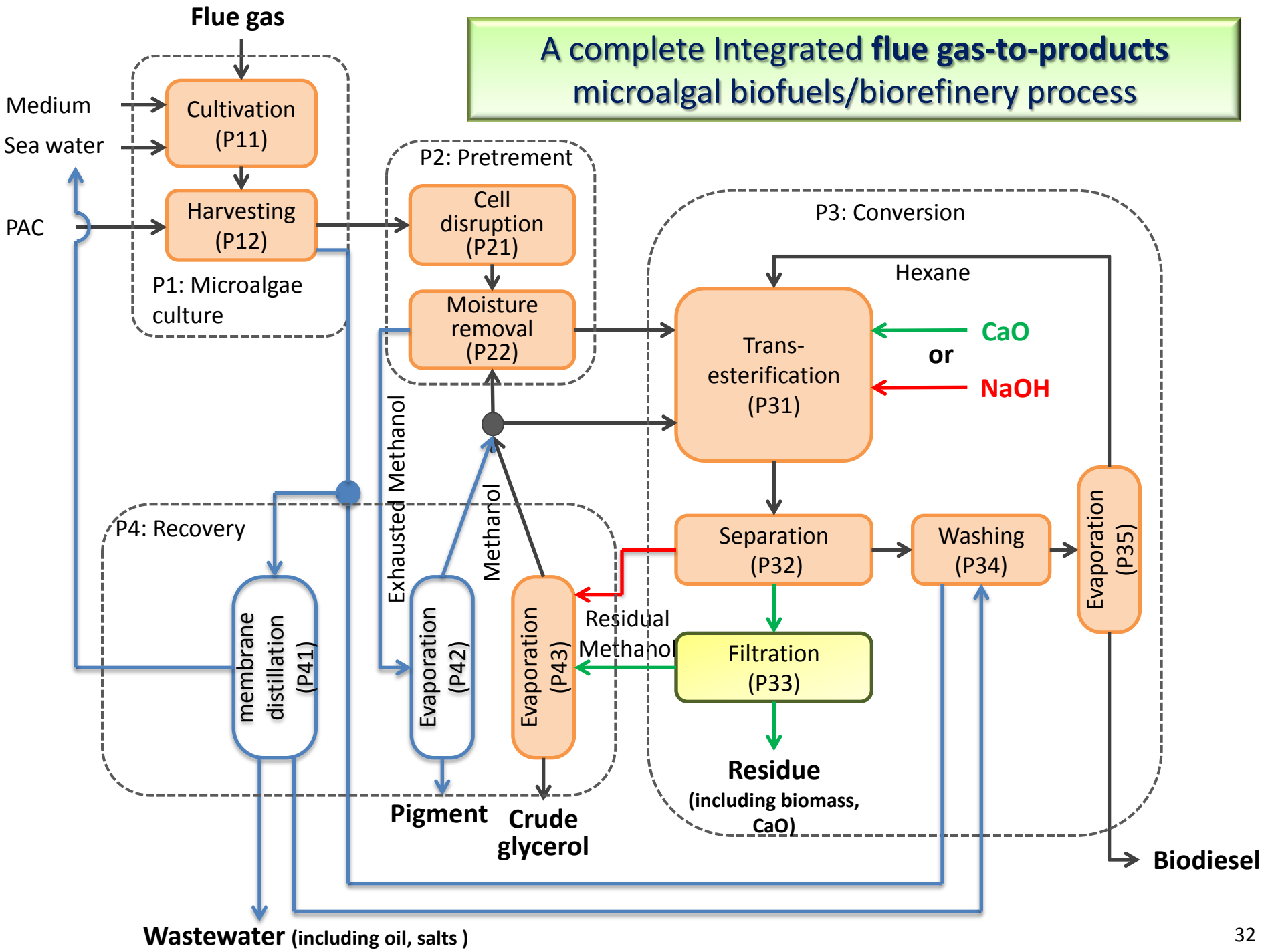


			設計參數
D	mm	槽內徑	350
L	mm	滾子有效長度	2000
s	rpm	滾子轉速	30
t	mm	藻液膜厚	1
Q	LPH	藻液進料流量	20
tr	min	滯留時間	6.6

● 模廠級連續式微生物油脂萃取系統設計圖 (lipid propane extraction)



A complete Integrated **flue gas-to-products** microalgal biofuels/biorefinery process



Japan Science and Technology Agency (JST CREST Project)

Isolation, characterization and optimal cultivation of carbohydrate-rich microalgae
海洋性藻類からのバイオエタノール生産技術の開発

與日本神戶大學合作開發高碳水化合物含量之微藻

Prof. Jo-Shu Chang 張嘉修 (NCKU)
Prof. Akihiko Kondo (Kobe University, Japan)
Prof. Tomohisa Hasunuma (Kobe University, Japan)

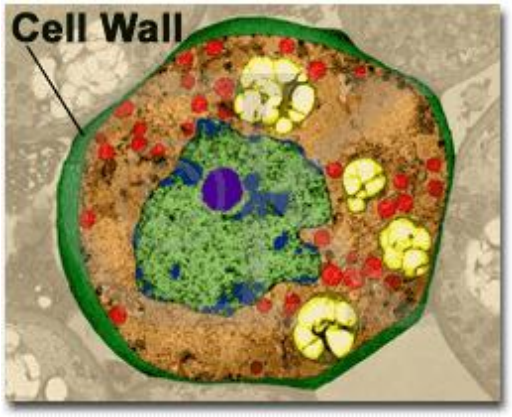


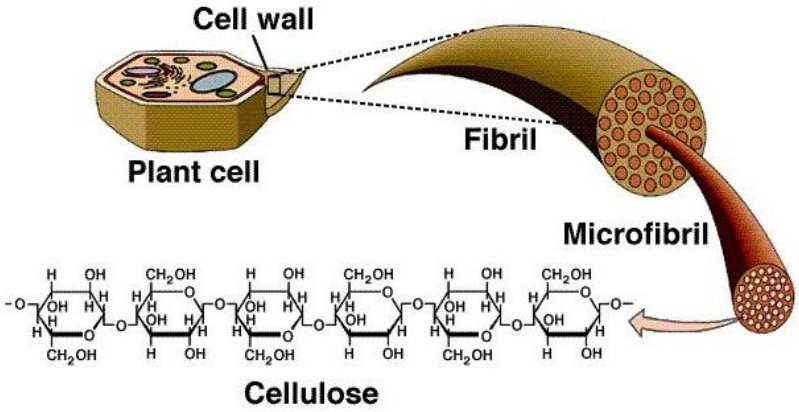
Project period: 2011-2015

Microalgal carbohydrates

- **Cytoplasm**: starch
- **Inner cell wall**: cellulose
- **Outer cell wall**: pectin, alginate, agarose, etc. (valuable sugars)

• Microalgal cell wall





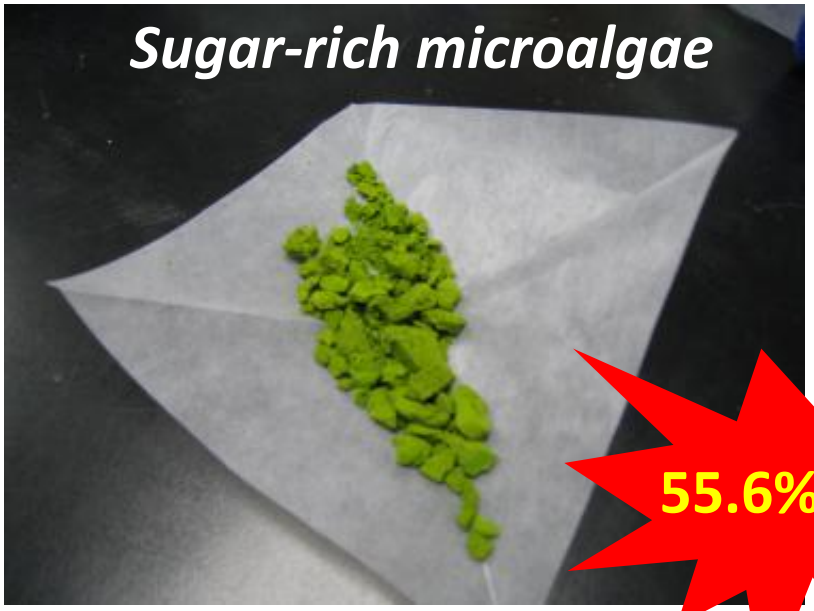
✓ **Cellulose is the major component of microalgal cell wall**

✓ **Functions: protection, maintenance**

The major components of cell wall in different algae

taxonomy	Outer cell wall	Inner cell wall
Red algae	alginate	cellulose
Brown algae	alginate	cellulose
Green algae	pectin	cellulose
Blue algae	pectic acid, mucopolysacharides	cellulose

高碳水化合物含量之微藻



55.6% sugar

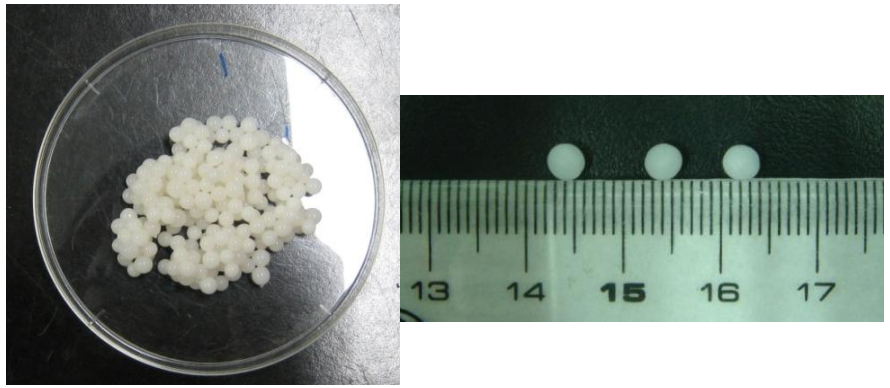
Sugar composition

Glucose	46.8 %
Xylose	5.3 %
Arabinose	3.5%
Others	44.4%

Fermentation products:

- ✓ **Biofuels**
  - Bioethanol, biobutanol, bioH_2
- ✓ **Chemicals**
  - Succinic acid, lactic acids, diols

PVA immoilized cells for succinic acid production



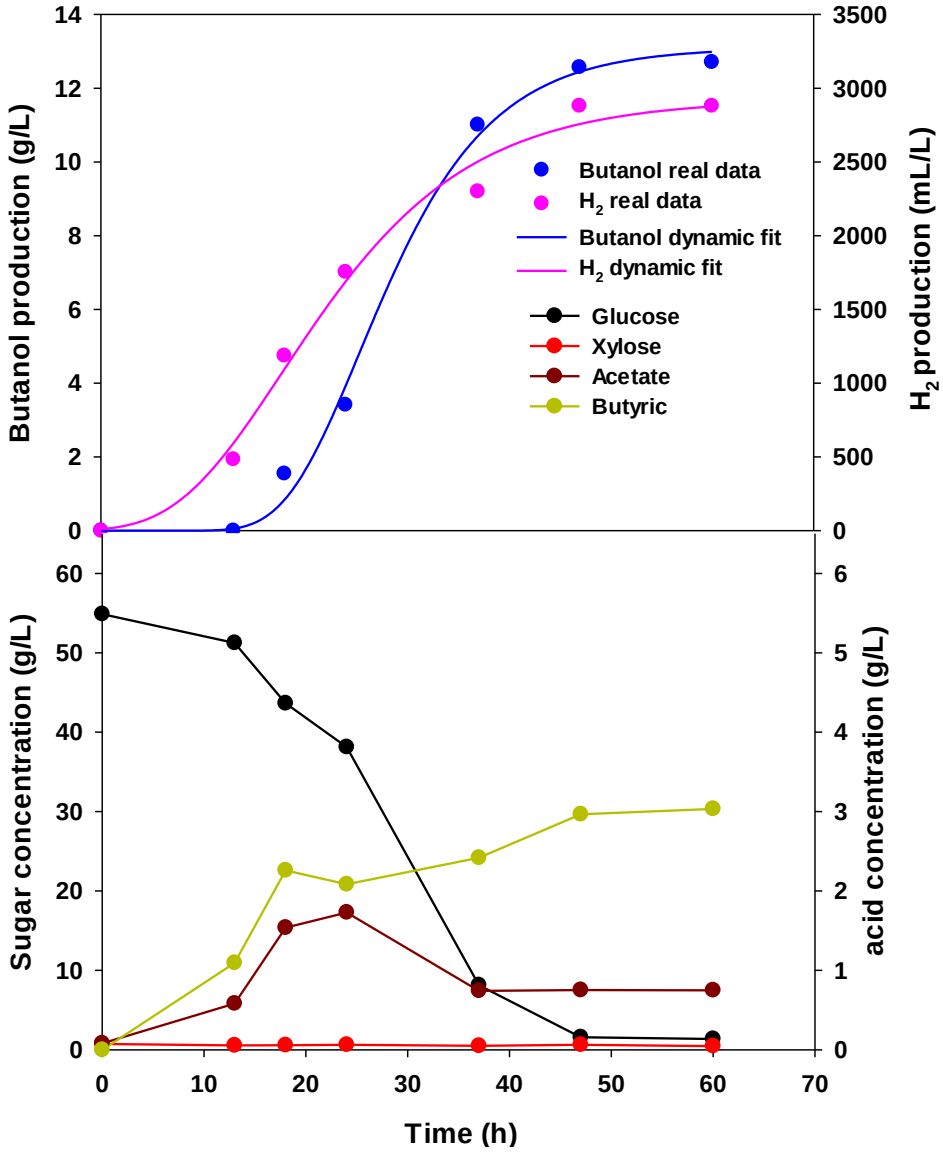
Continuous Lactic acid fermentation using glucose or microalgal hydrolysate

PVA immobilized cells of *Lactobacillus plantarum* 23
Continuous culture (dilution rate = 0.25 h^{-1})

Carbon source	Lactate Conc. (g/L)	Lactate Yield (g /g)	C-source consumption (%)	Lactate productivity (g/l/h)
Glucose (40 g/l)	31.75±1.53	0.93±0.02	96.62±3.05	7.94±0.38
Microalgae hydrolysate (40 g/l reducing sugar)*	39.71±1.09	0.99±0.03	95.37±1.46	9.93±0.27

* Sugar composition of microalgal hydrolysate (40 g/L reducing sugar)
Glucose: 36.04 g/l
Xylose: 3.06 g/l
Arabinose:1.17 g/l

Butanol production from hydrolysate of *Chlorella vulgaris*



- **Carbon source in medium:**
  - Glucose=54.88 g/L
  - Xylose=0.73 g/L
  - Total sugar=55.61 g/L
- **Solvent prouction:**
  - Butanol: 13.10 g/L
  - Yield: 0.58 mol/mol sugar
  - Productivity: 0.66 g/L/h
  - Lag phase: 18.1 h
  - Acetone:Butanol:Ethanol = 2:6:1
- **H_2 prouction:**
  - H_2: 2924.9 mL/L
  - Yield: 0.39 mol/mol sugar
  - Productivity: 104.2 g/L/h
  - Lag phase: 7.5 h
- **Sugar utilization:**
  - Glucose: 97.52%
  - Xylose: 37.51%

Ethanol production via SHF using acidic hydrolysate of wet *S. obliquus* CNW-N biomass

- Biomass loading: 40g L^{-1}
- Reaction temperature: 121 ℃
- Reaction time: 20min
- Acid concentration: 2%
- **With/without centrifugation**

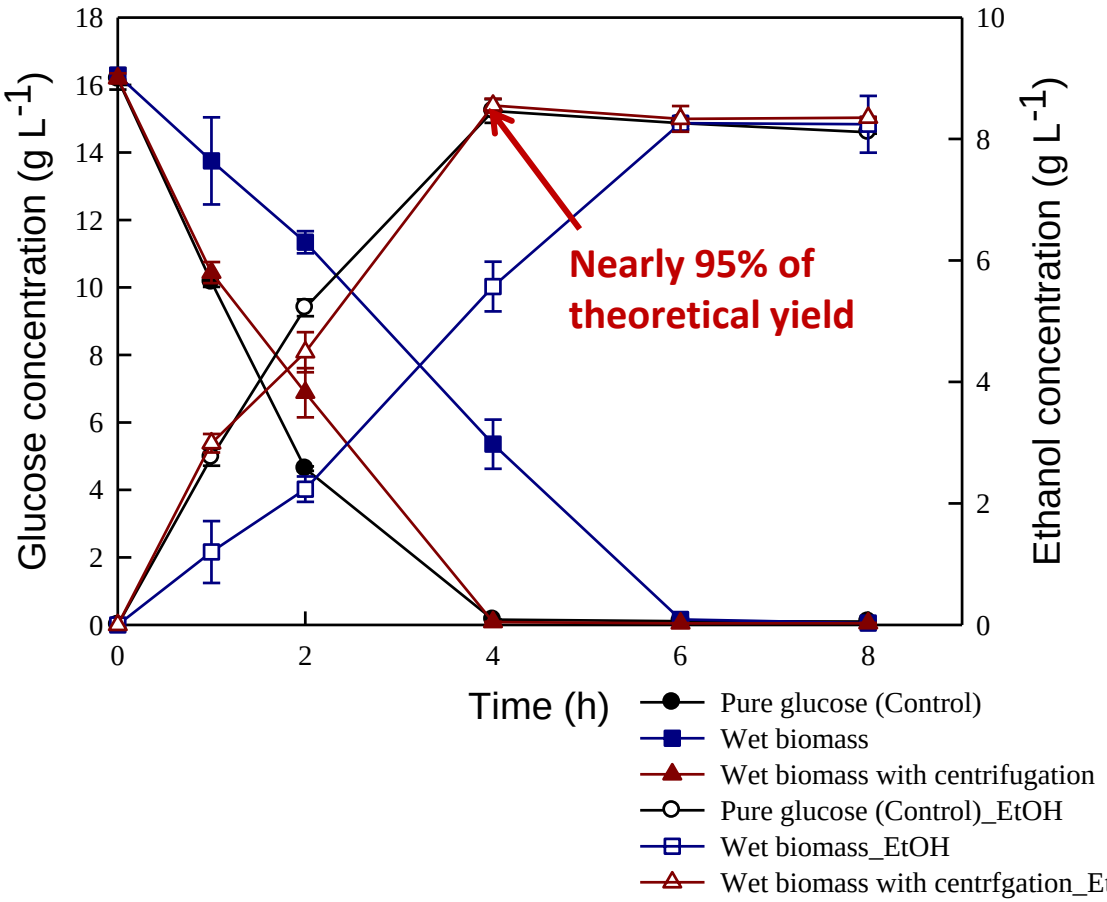
Algal hydrolysate

Initial glucose conc.: 16-16.5g L^{-1}

Ethanol fermentation

Final ethanol conc.: 8.2-8.5g L^{-1}

$$C_6H_{12}O_6 + \text{yeast} \rightarrow 2C_2H_5OH + 2CO_2$$



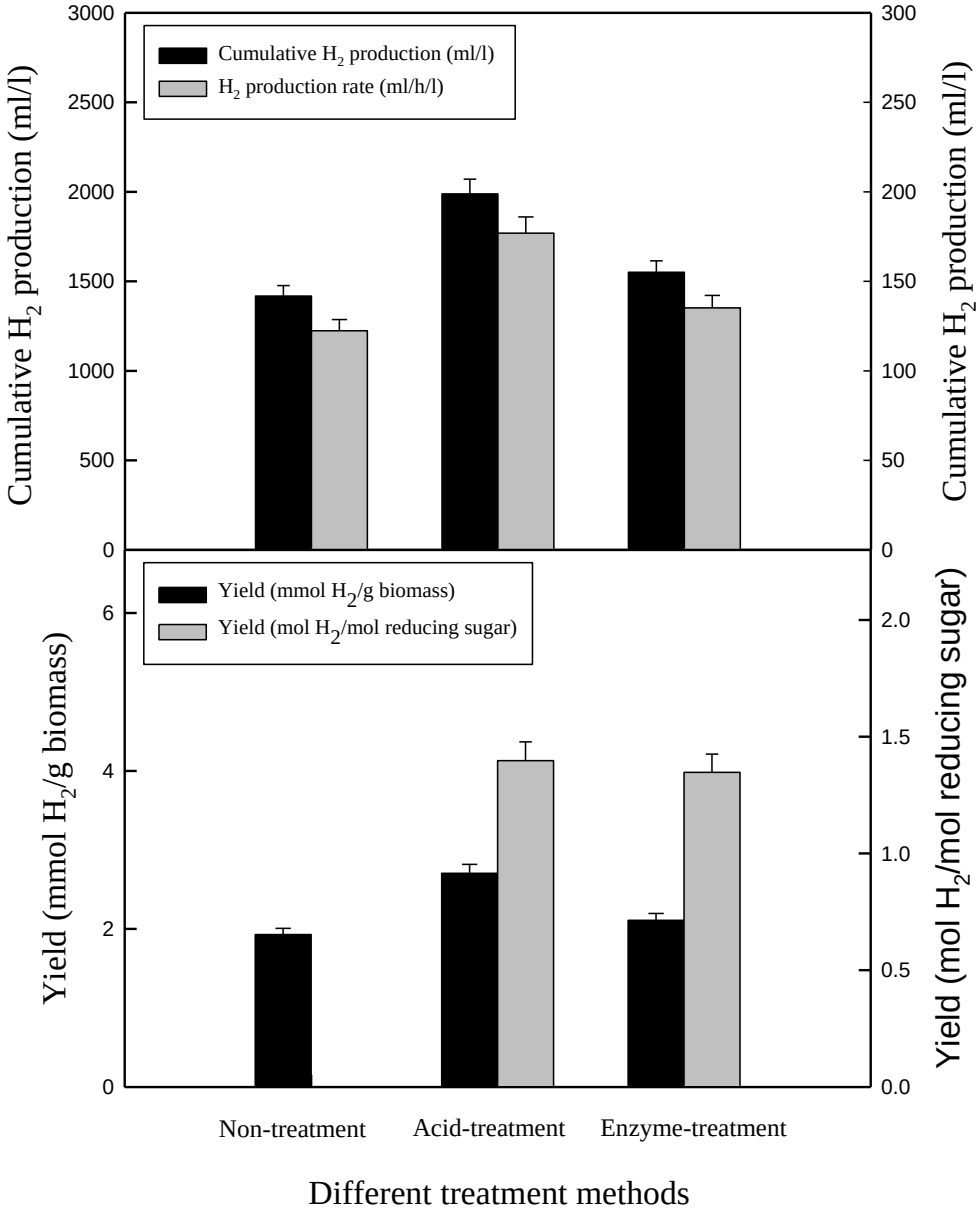
S.-H. Ho et al. / Bioresource Technology (under revision)

BioH2 production

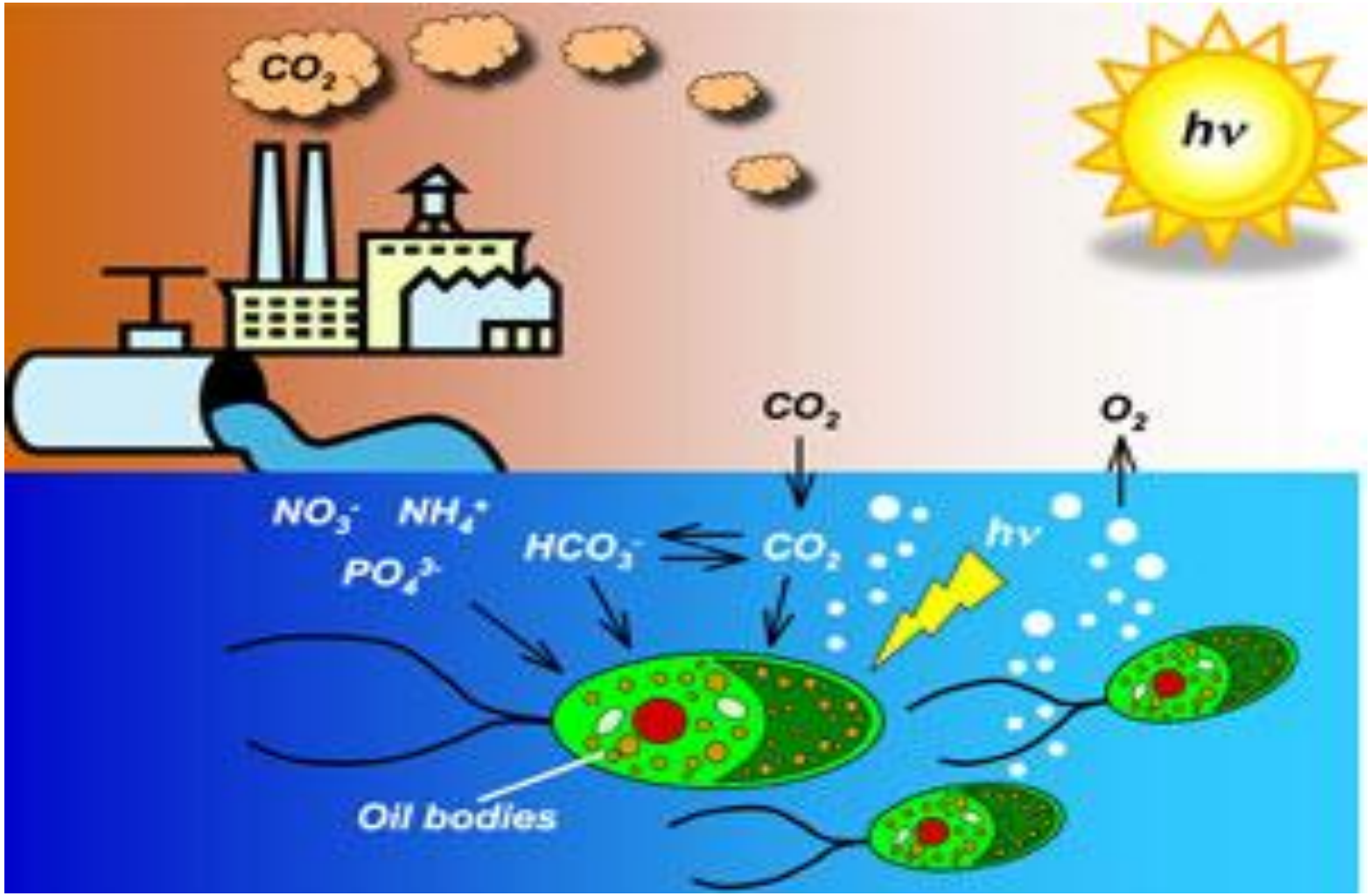
using carbohydrate-rich microalgal biomass after different hydrolysis treatment

Microalgae feedstock

Chlorella vulgaris FSP-E with 46% carbohydrate content (per dry weight)



微藻環境淨化系統



Components of the different wastewater effluents

Quality (mg/L)	Piggery wastewater	Aquaculture wastewater	Municipal wastewater	Industrial wastewater
				
Total nitrogen (TN)	550 ± 73	60 ± 3.6	54 ± 2	34 ± 2
Ammonia – N (NH_4^+ – N)	491 ± 57	5.6 ± 1	36 ± 12	38.2 ± 11
Nitrate – N (NO_3^- – N)	1.7 ± 0.7	12 ± 1	2 ± 1	3.1 ± 0.2
Total phosphorus (TP)	20 ± 6	6.8 ± 0.3	12 ± 0.2	6.6 ± 0.5
COD	427 ± 63	112 ± 21	95 ± 21	83 ± 7
Suspended solids (SS)	83 ± 22	32 ± 3	22 ± 3	24 ± 3
pH	8.5 ± 0.5	8.5 ± 0.5	8.4 ± 0.3	7.9 ± 0.5

The pretreatment of swine wastewater

Piggery waste

Summer：40 ~ 50 L water/pig
Winter：20~30 L water/pig

Solid- liquid separation

0.5 ~ 1 day
(Total Solid < 20%)

Anaerobic fermentation

7 ~ 10 days

Activated sludge treatment

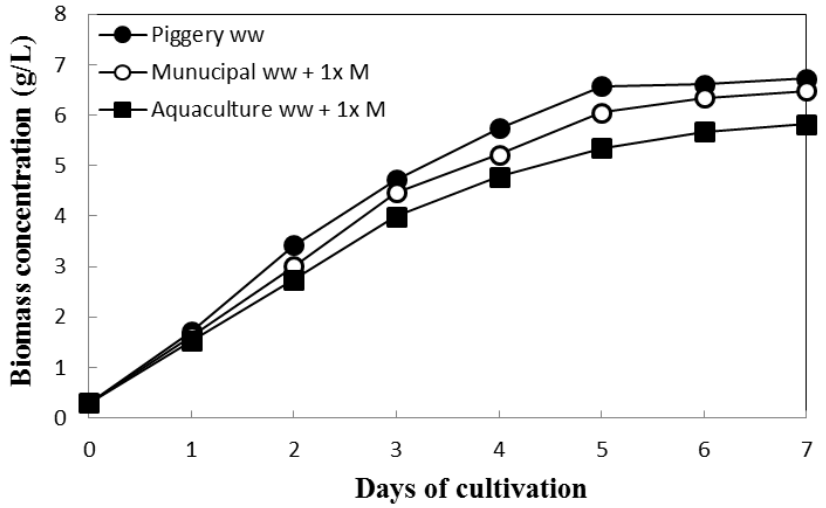
1 ~ 3 days

Final sedimentation

0.5 day

使用不同來源之廢水(排放水養殖微藻

Chlorella sp. GD養殖適用的廢水範圍廣



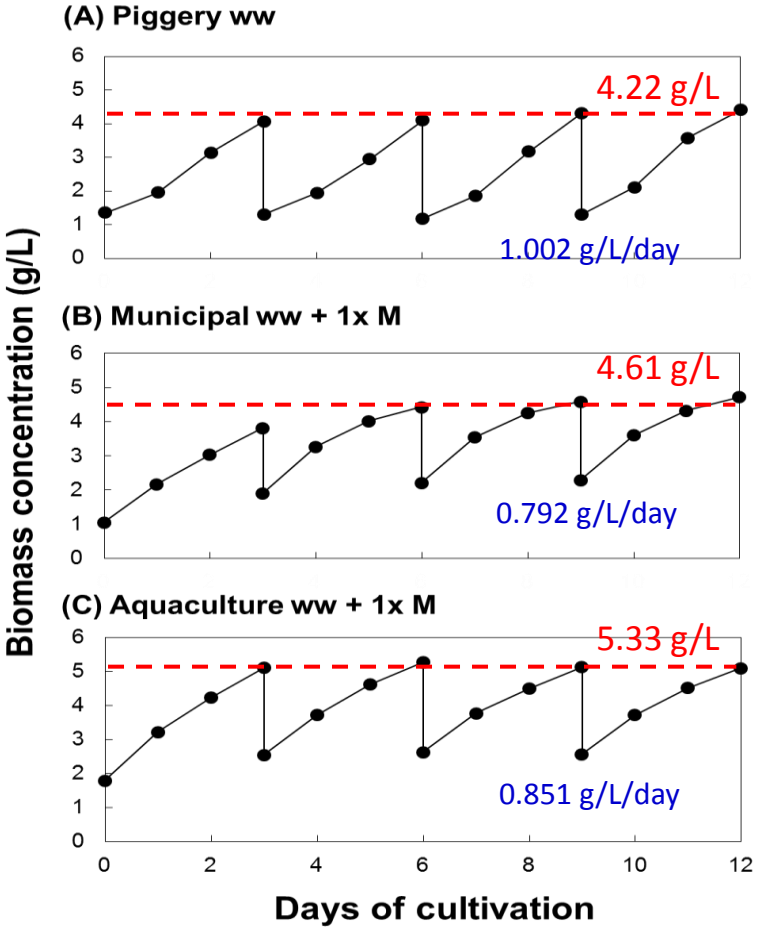
	生活廢水	魚塭廢水	豬場廢水
TN (mg/L)	50~60	40~60	500~600
TP (mg/L)	5~15	0~10	10~30
TN移除率(%)	~ 80	~ 85	~ 50

(TP移除率皆約為100%)

- 可直接以生活廢水和魚塭廢水為微藻培養所需的水源，以添加1x營養源於廢水中，分別具有最大的微藻生物質產率0.811和0.715 g/L/day。
- 可直接與持續使用豬場廢水進行微藻養殖，微藻生物質產率約1 g/L/day。

使用廢水建立*Chlorella* sp. GD之穩定養殖程序

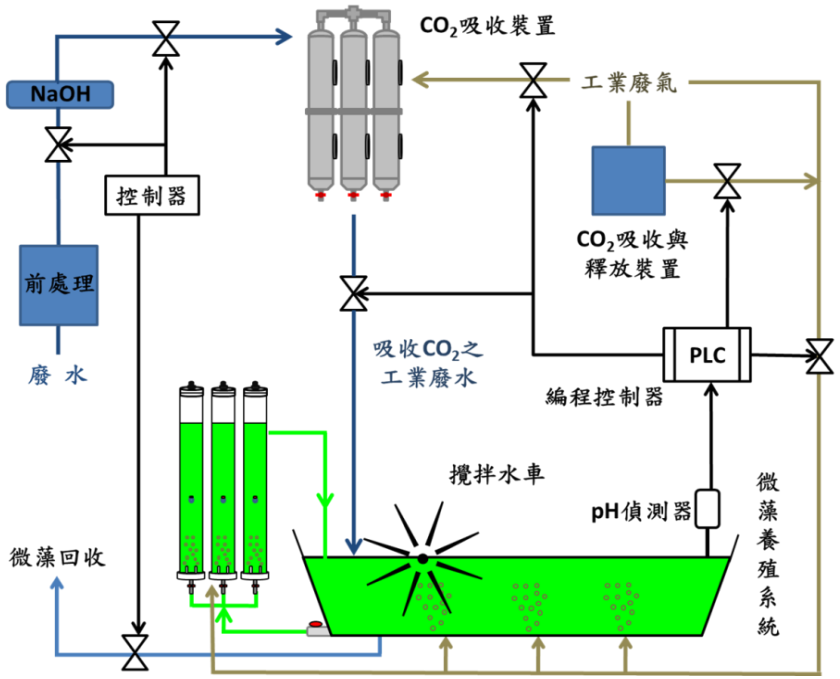
每3天置換一半培養基之半連續培養



- 可使用豬場、生活及魚塭廢水進行長期的穩定微藻養殖。

以廢水固碳再利用於微藻養殖之模組化技術開發

A. 設計示意圖



B. 10 公噸pilot實體裝置圖

此模組主要包括2噸規模之微藻養殖系統 – 跑道式微藻養殖槽(Raceway)和光生物反應器(Photobioreactor, PBR)，以及可將廢氣中的CO_2捕捉於鹼性廢水中的CO_2吸收裝置

Cultivation of *Chlorella* sp. GD using piggery wastewater for biomass and lipid production

Wastewater

Bar screens

Raw influent

Effluent

Aerobic treatment

Anaerobic fermentation

Settling tank

Flue gas

CO_2 / NO_X / SO_X

Water, Nitrogen, Phosphorus

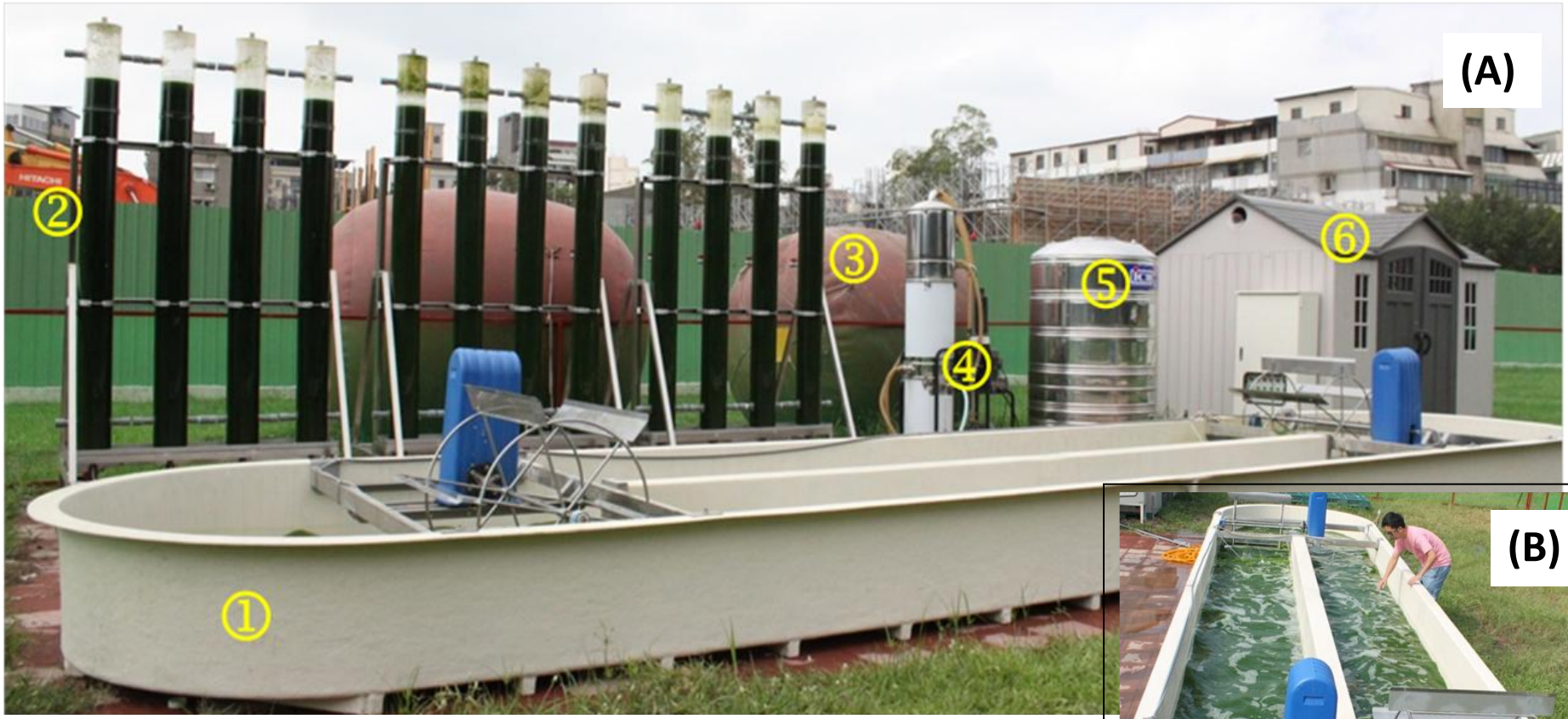
Solar

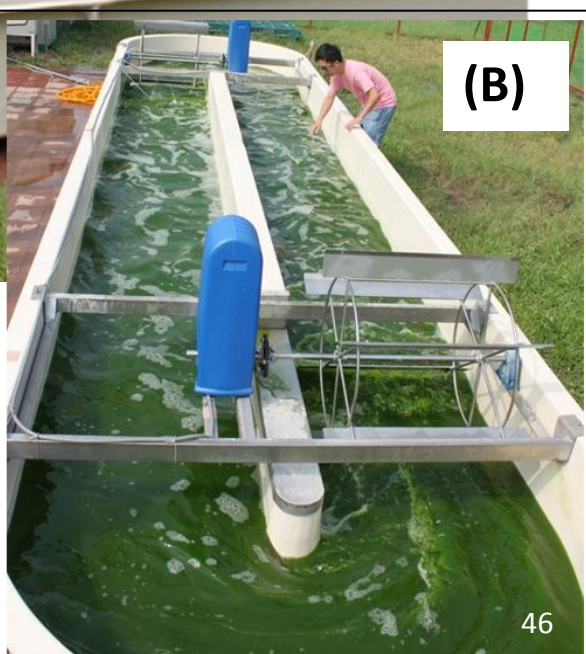
Microalgae culture system

Microalgal biomass/lipid

- Animal feeds
- Biofuels
- Cosmetics
- Health foods
- High-value molecules
- Pharmaceutical products

建立10噸規模WCCU微藻循環養殖模組



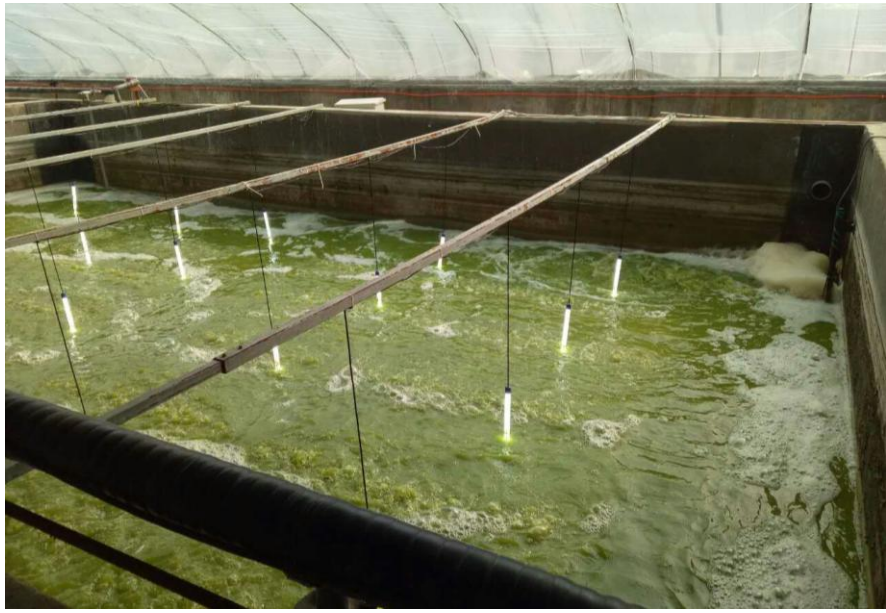


10噸規模WCCU微藻循環養殖模組(**A**)，此系統包括① 10噸養殖規模的跑道式微藻養殖槽(Raceway，10 m × 2 m × 0.7 m; 同於**B**)、② 12支光生物反應器(PBR，ϕ 16 cm × 250 cm high)、③ 集氣袋、④ CO_2吸收裝置、⑤ 儲水塔及⑥ 機電與氣體空壓設備屋。

中國天津某養豬場中國800公噸微藻廢水養殖場

高COD 降解效率 (6500 mg/L→ 330 mg/L)

N/P 去除率 > 90%



異營/混營微藻畜牧廢水處理輔導廠商成功案例

中央畜牧場
全台豬場廢水
沼氣發電最成功案例

沼氣發電

越南合作案

降解 COD
6500 mg/L→330 mg/L

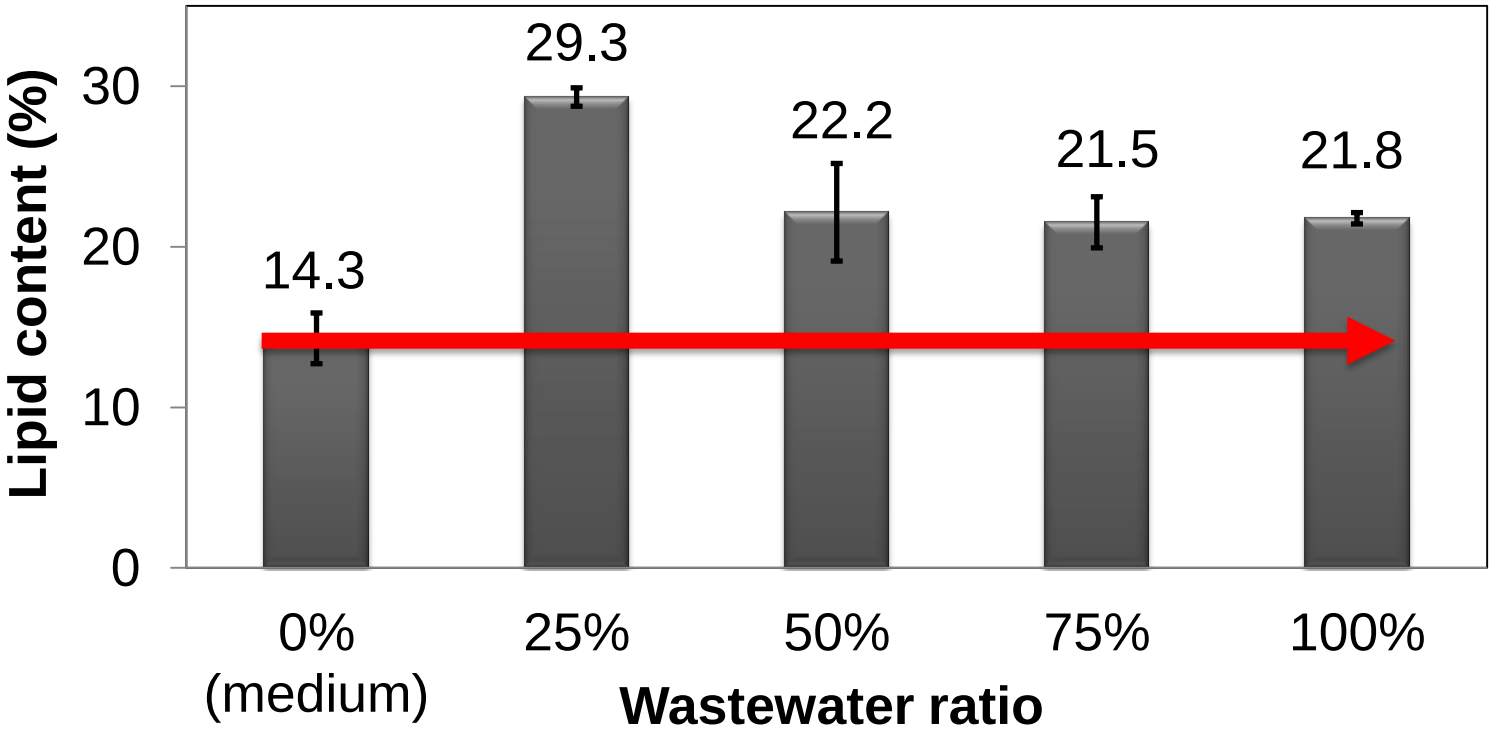
降解COD
7000 mg/L→310 mg/L

台糖豬廠廢水

大成集團豬廢水合作案

降解 COD
5800 mg/L→210 mg/L

Lipid content of *Chlorella* sp. with different ratios of wastewater

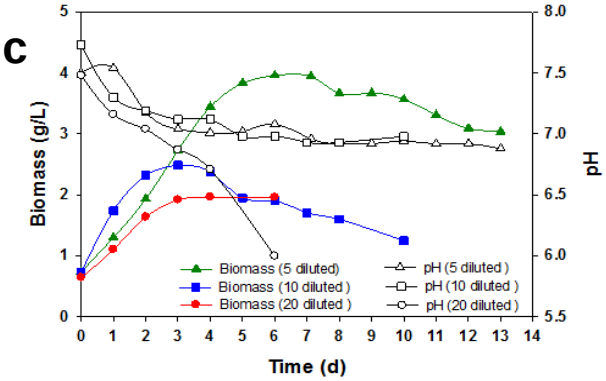


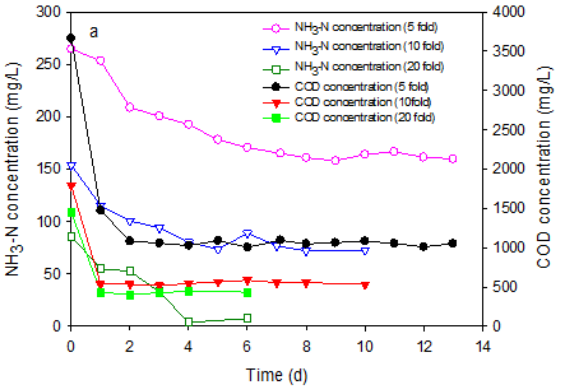
- The different ratios of wastewater were diluted by culture medium.
- The lipid contents of *Chlorella* sp. with wastewater were >5% (w/w) higher than those with medium.

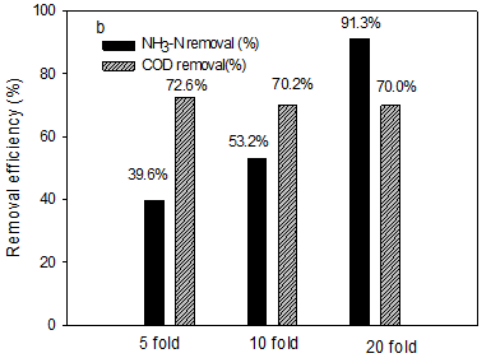
以豬廠廢水養殖高碳水化合物含量微藻 (*Chlorella vulgaris* JSC-6)

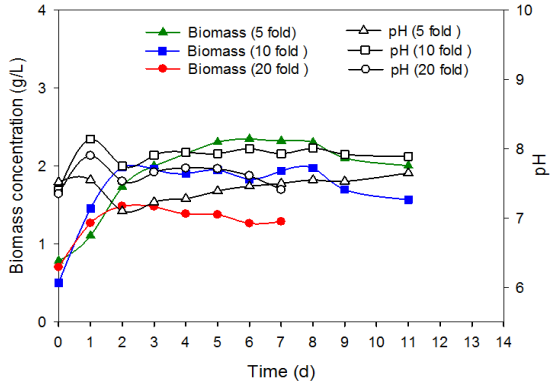
Mixotrophic growth

混營培養



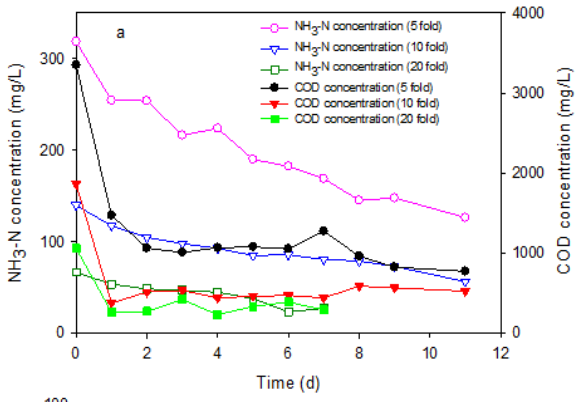


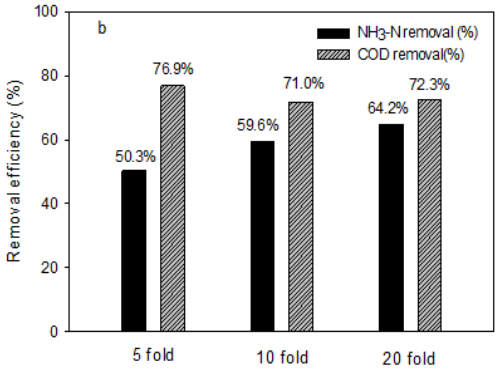




Heterotrophic growth

異營培養





Yue Wang et al, 2015, Bioresource Technology,

C. vulgaris JSC-6 cultivated with swine wastewater for carbohydrate production

Yue Wang et al, 2015, Bioresource Technology, 198, 619-625

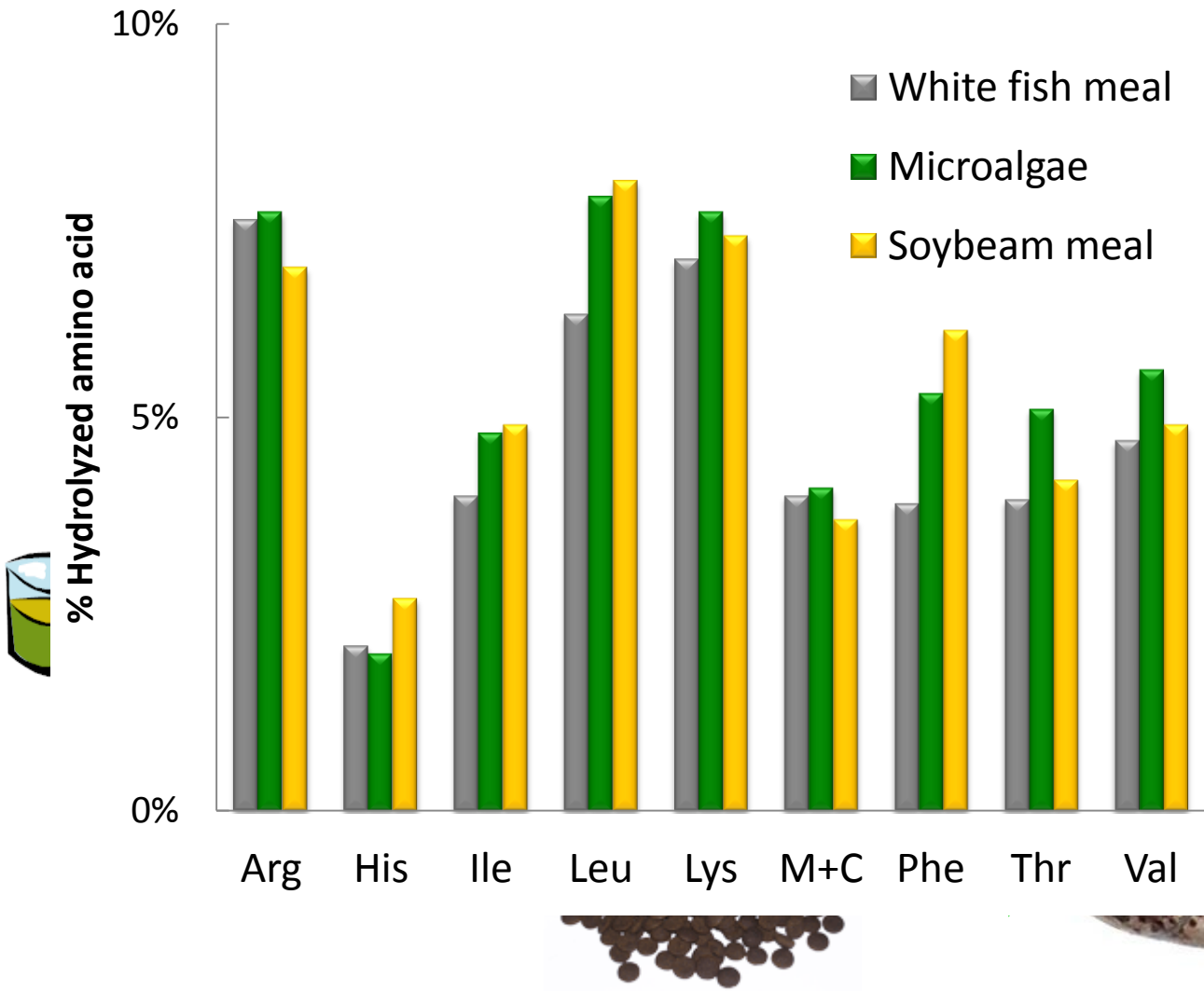
	Mixotrophic			Heterotrophic		
	5-fold	10-fold	20-fold	5-fold	10-fold	20-fold
Biomass concentration (g/L)	3.96	2.49	1.96	2.35	1.98	1.49
Specific growth rate (d^{-1})	1.73	1.27	1.03	1.21	1.02	0.75
Maximum cell productivity (g/L/d)	1.30	1.74	1.11	1.11	1.46	1.26

	Mixotrophic			Heterotrophic		
	5-fold	10-fold	20-fold	5-fold	10-fold	20-fold
Total carbohydrate content (%)	58.3	46.0	46.6	54.0	44.3	44.8
Glucose content (%)	54.9	43.0	46.6	49.6	41.1	44.8
Xylose content (%)	2.3	2.0	0	2.4	2.1	0
Arabinose content (%)	1.6	1.0	0	2.1	1.1	0
Glucose productivity (g/L/day)	0.17	0.11	0.15	0.11	0.74	0.13
Xylose productivity (g/L/day)	0.007	0.005	0	0.005	0.004	0
Arabinose productivity (g/L/day)	0.005	0.002	0	0.00	0.002	0

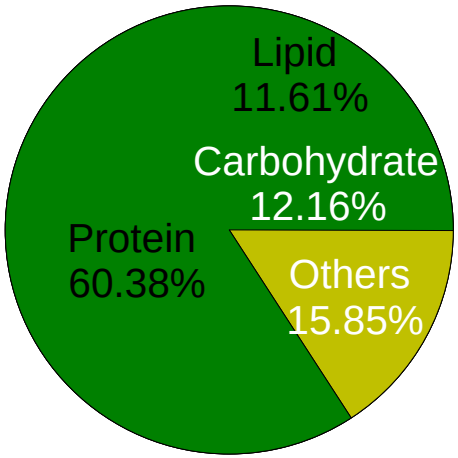
高價值微藻產品之開發

以微藻製備石班魚苗餌料

Development of a specific microalgae strains as



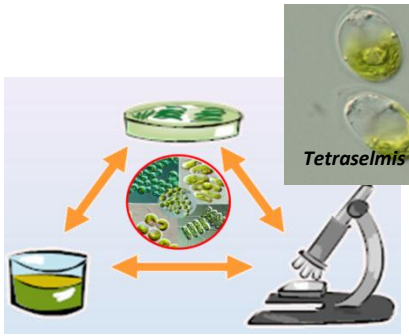
豐年蝦



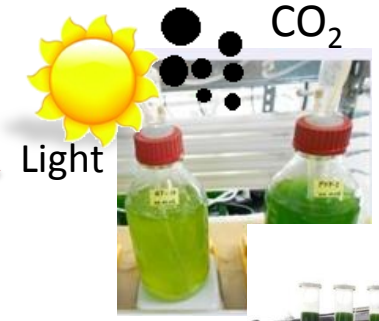
Feed 魚飼料壓製

Grouper 石班魚

以抗弧菌之微藻開發蝦飼料



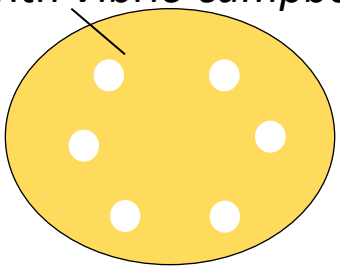
Strain isolate



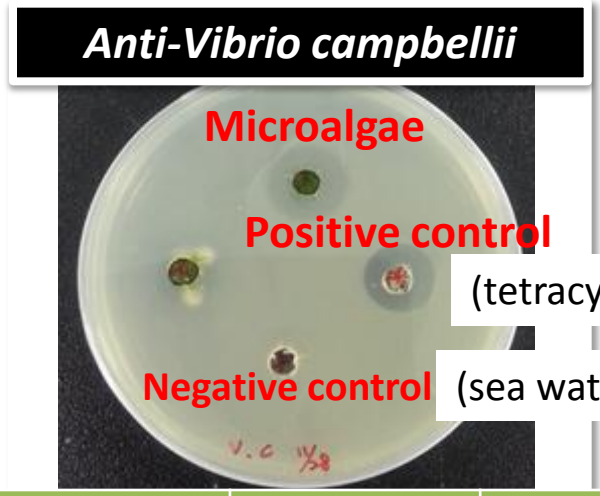
Cultivation

(弧菌)

Agar plate with *Vibrio campbellii*



Anti-*Vibrio* analysis



Development of nourishing agent or feed

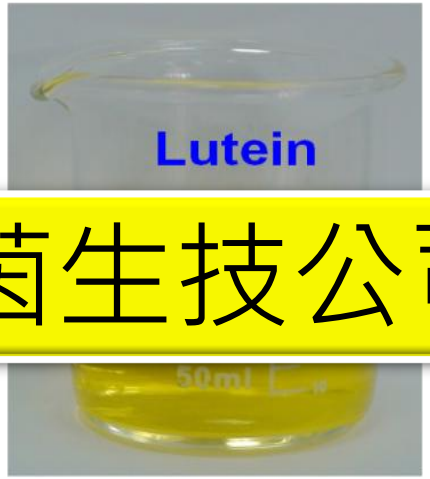
Inhibition zone	Positive control	Negative control	microalgae
Anti-*Vibrio compbellii*	1.5 cm	-	1.6 cm

以微藻生產葉黃素

Lutein production

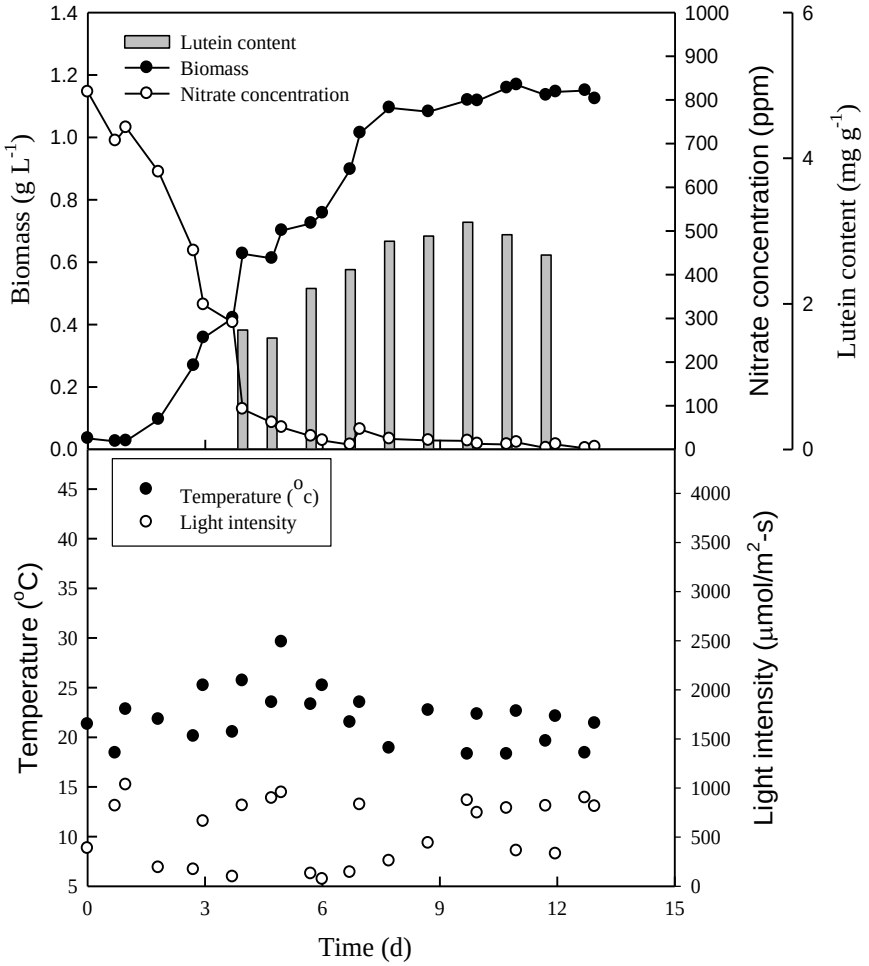
Lutein content > 7.0 mg/g
(over 20 fold of marigold flower)

Microalga: *Scenedesmus obliquus* CNW-N
Cultivation condition: 5% CO_2, 0.125vvm



此技術已技轉給綠茵生技公司

Commercial scale lutein production (300 ton capacity)

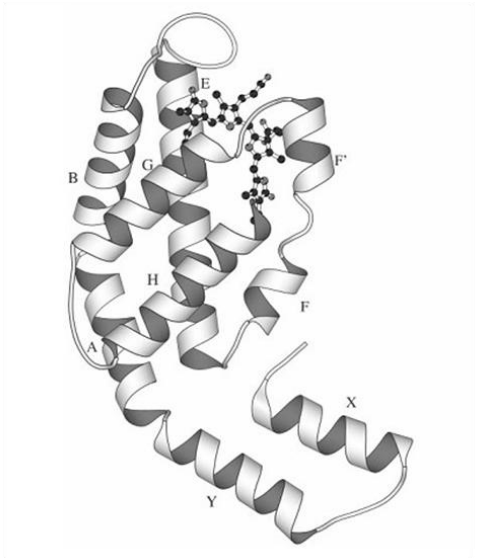


Strain: *Chlorella sorokiniana*

藻藍素(phycocyanin)之生產

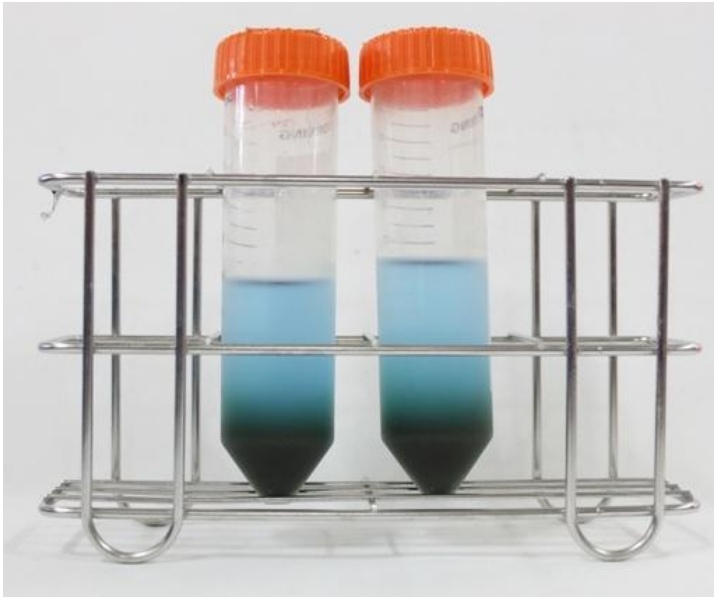
Spirulina sp.

Spirulina sp.



Structure of phycocyanin

phycocyanin



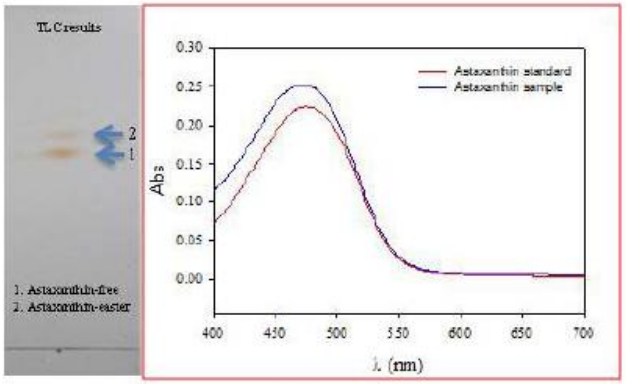
以微藻生產蝦紅素(astaxanthin)

Agar

100 ml

5 L
fermentor

此技術已技轉給群融生技公司

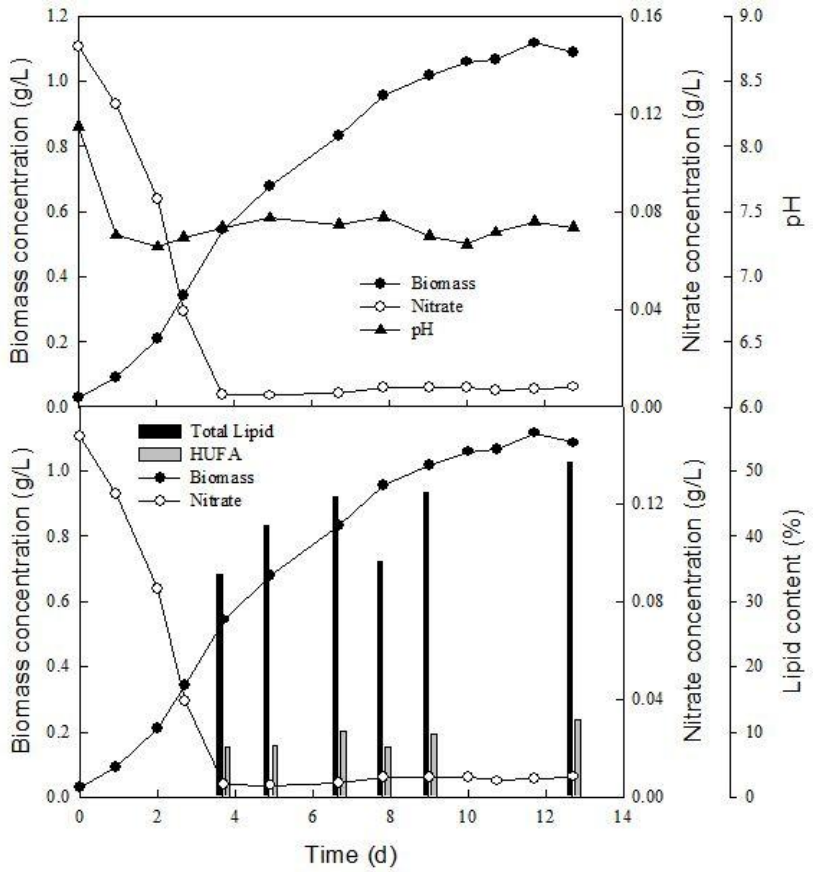


Astaxanthin analysis

100 L
fermentor

以微藻生產多元未飽和脂肪酸

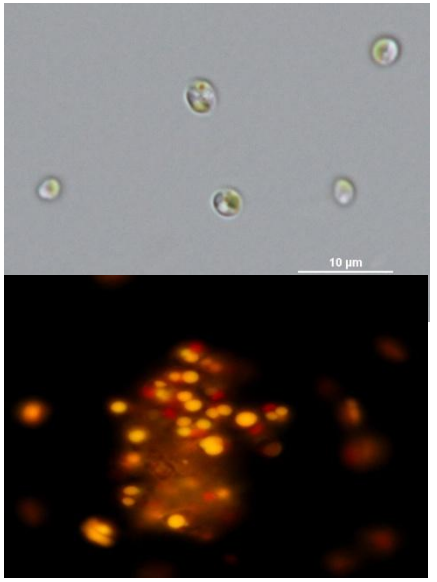
(EPA)



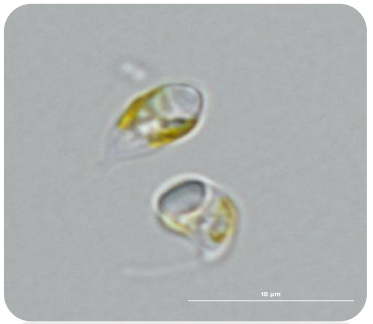
Biomass production (g L^{-1})	Biomass productivity (g L^{-1} d^{-1})	HUFA productivity (mg L^{-1} d^{-1})
1.086	0.146	1.257

*:maximum value in the culture

Nannochloropsis oceanica



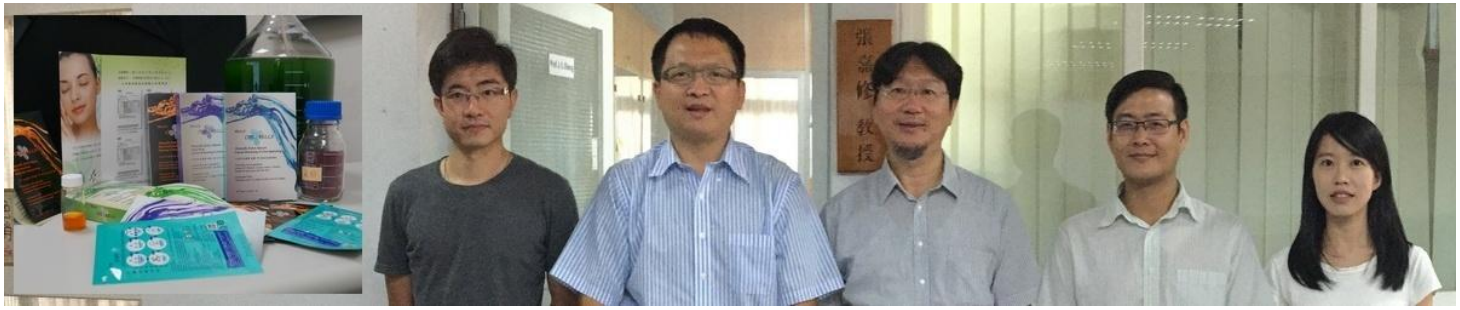
Pavlova salina



藻類生技產品的商業化

Green Feel GF Commercialization team

Has started a company in March 2016

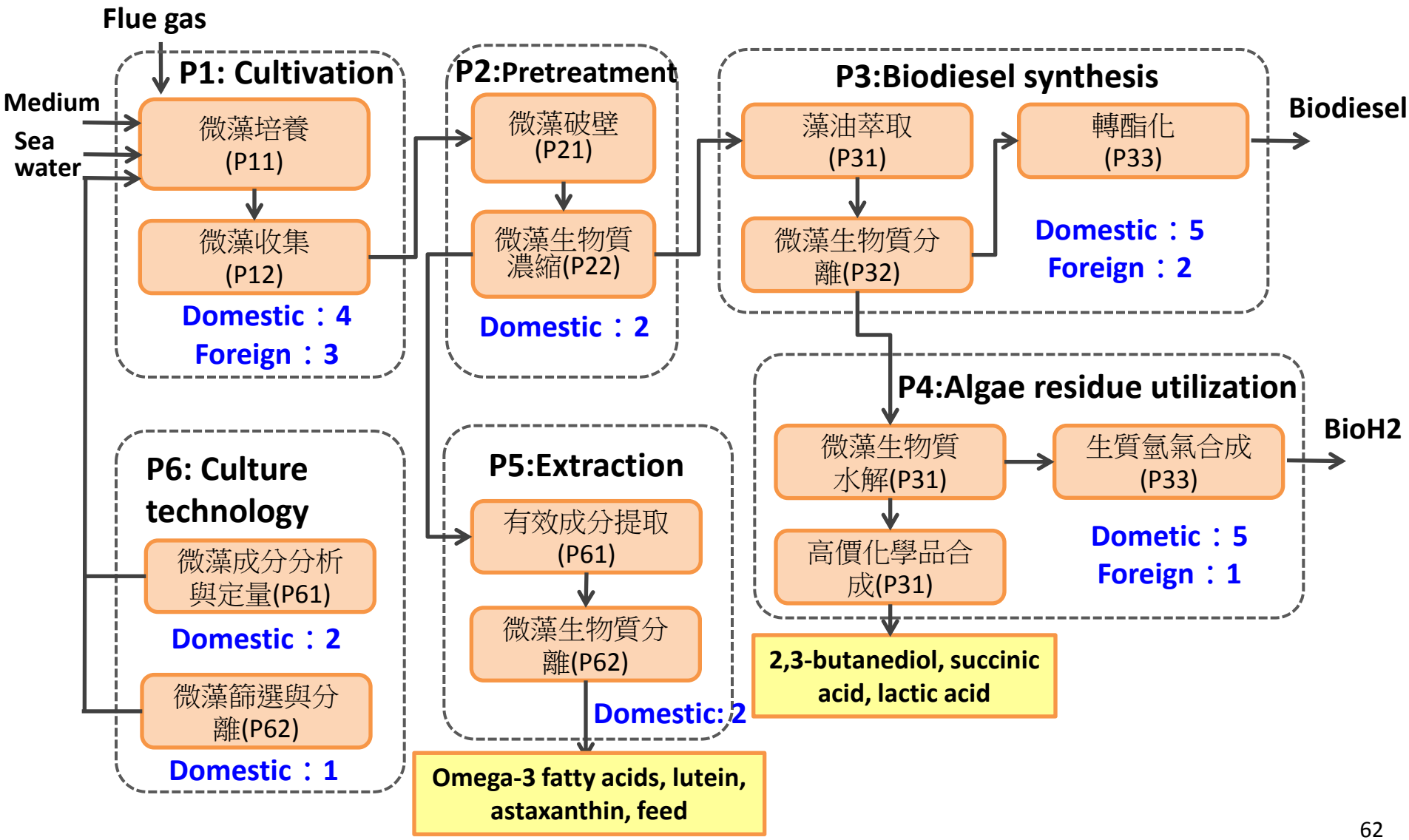


- 本團隊至Silicon Valley參加天使基金 (Angel fund) 創投媒合營
- 已成立新創公司『群融生技股份有限公司』

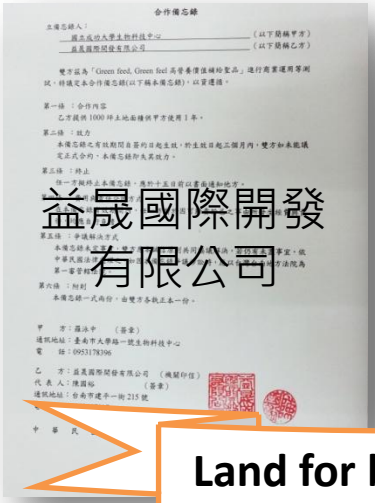
現有產品展示

"104年度科技部創新創業激勵計畫(FITI) 榮獲"創業潛力獎" (獎金55萬元)

智慧財產權布局 (目前已有約 40件專利)

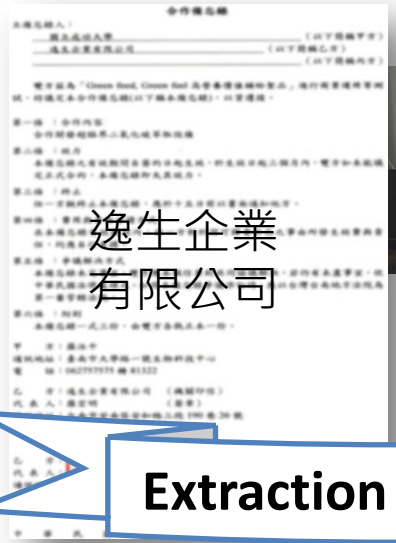


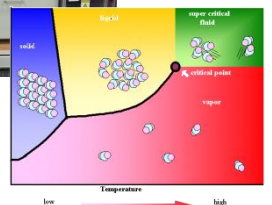
合作廠商



益晟國際開發
有限公司

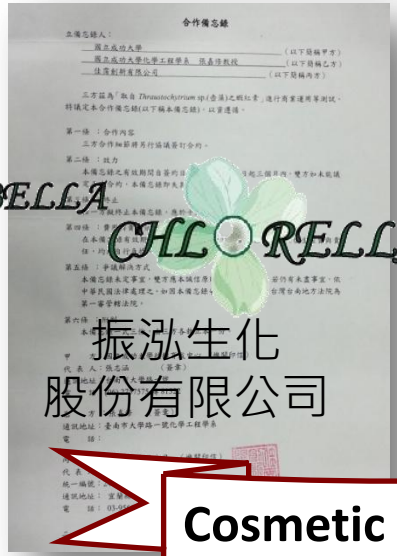
Land for building factory





逸生企業
有限公司

Extraction technology

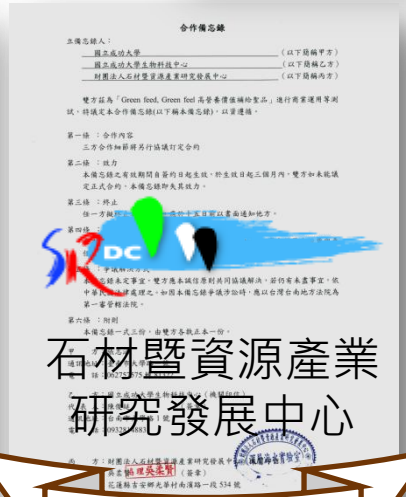


BELLA CHLORELLA

振泓生化
股份有限公司

蕾迪詩生物科技
股份有限公司

Cosmetic materials



石材暨資源產業
研究發展中心

Marketing channel

dic **Japan** (微藻色素)

GREENYN **綠茵生技**(微藻色素)

GROBEST
全興飼料股份有限公司

Feed supplements & health food

Current commercial products (1)

vation using microalgae as feed (2)

(movie)

Current commercial products (3)

Microalgae-based dessert



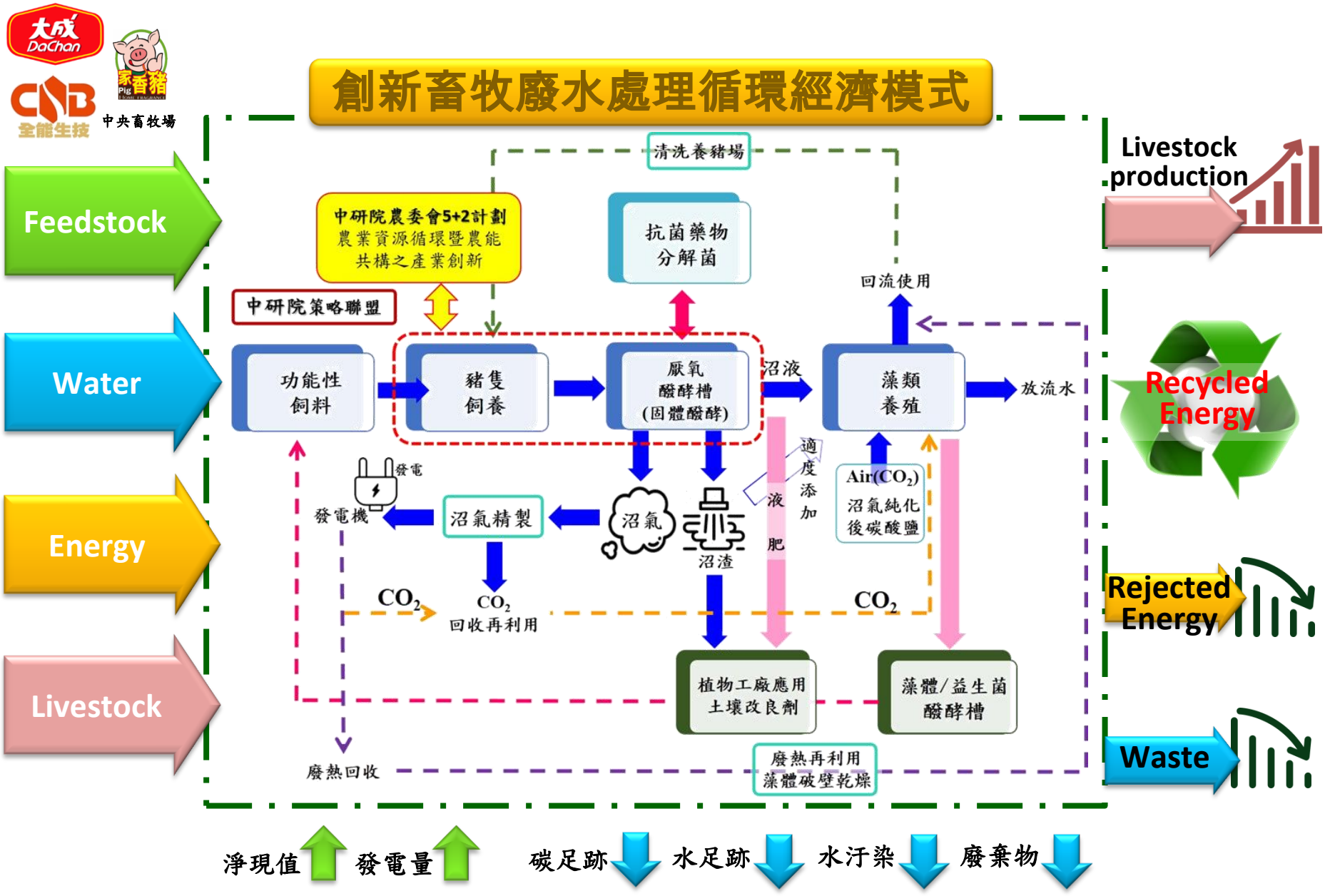






未來展望

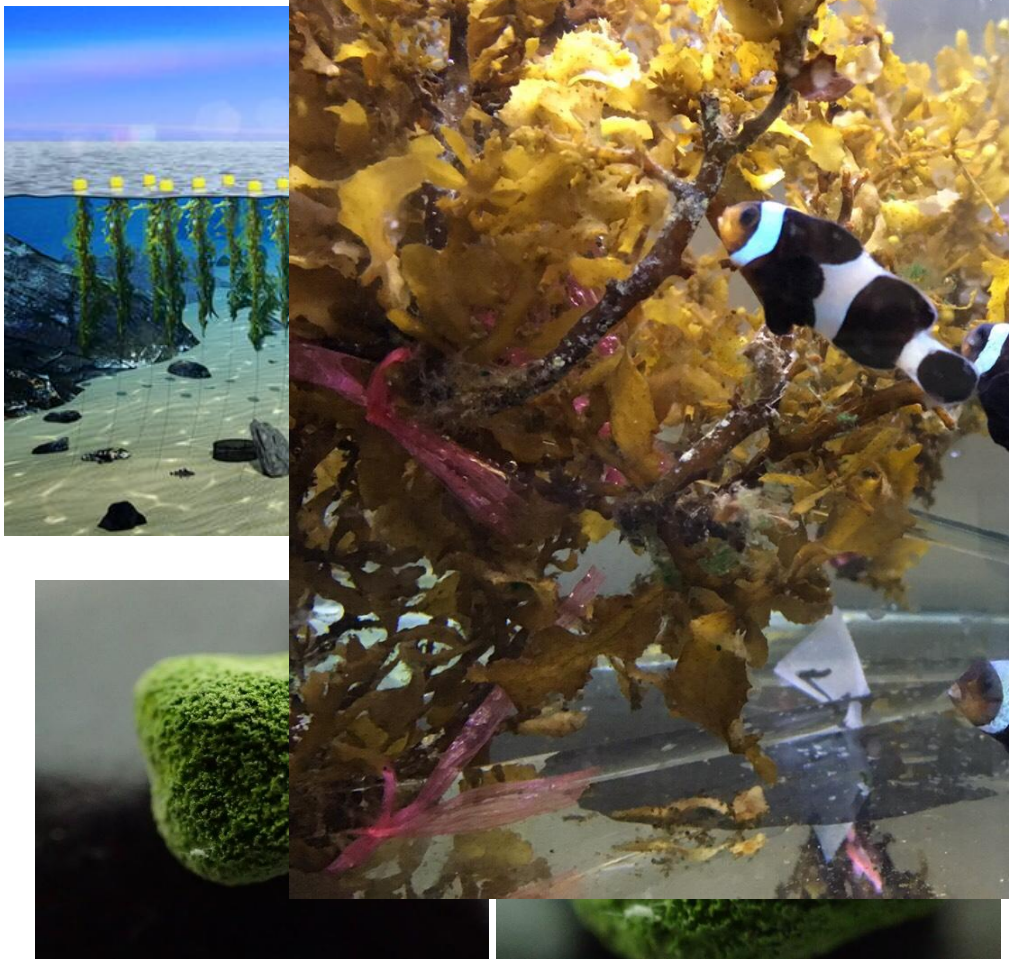
創新畜牧廢水處理循環經濟模式



畜牧廢水處理及藻類蝦紅素生產循環經濟模式

未來的糧食與資源要靠海洋

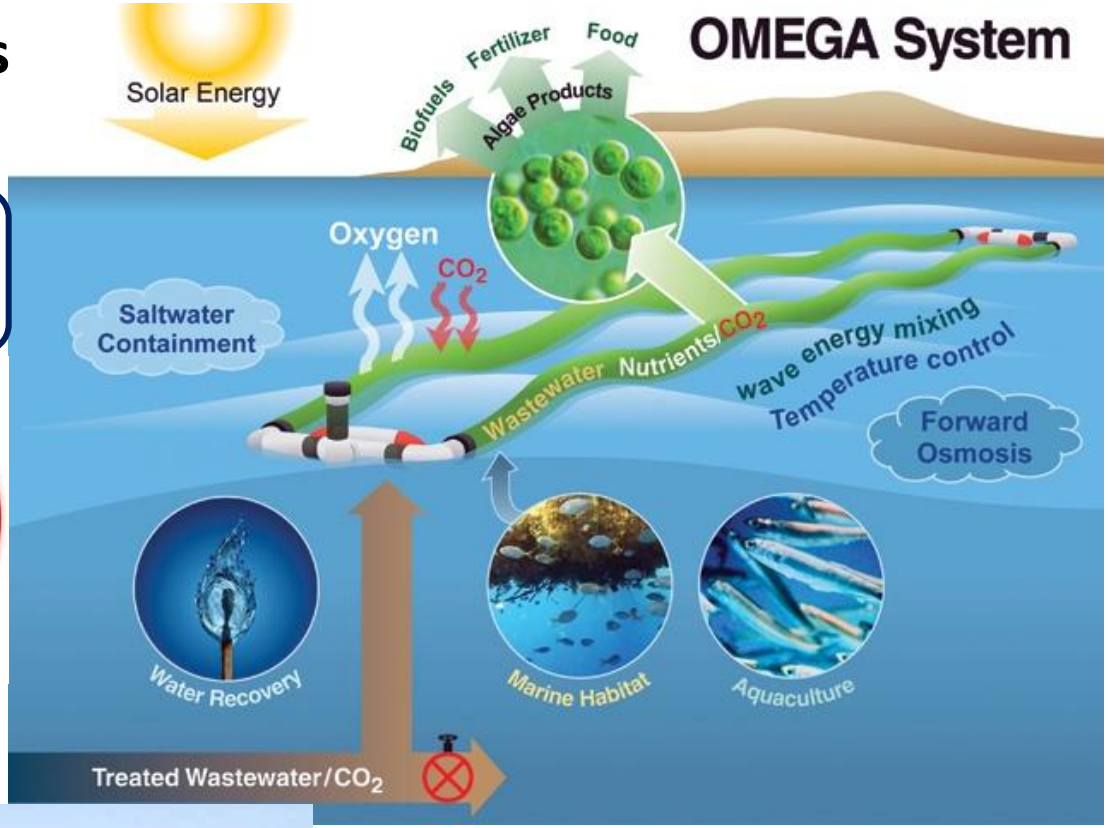
海洋牧場

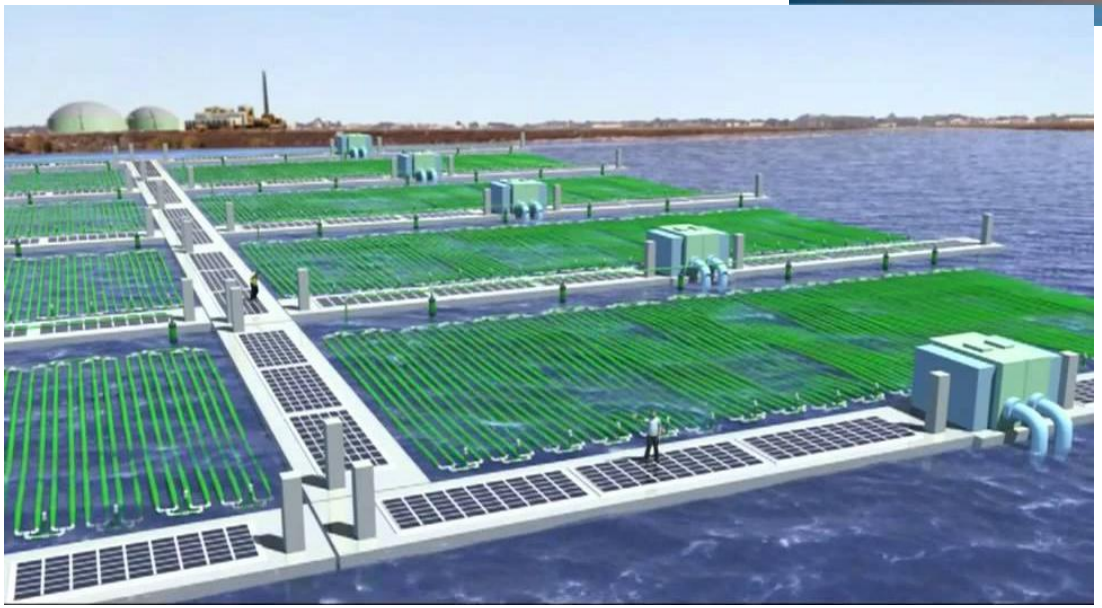


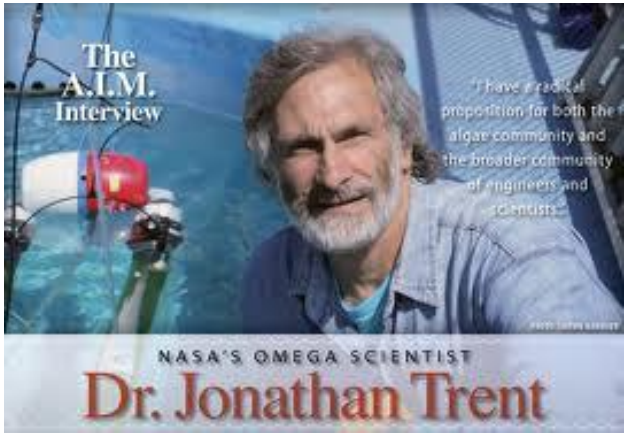
以中鋼公司轉爐石製造的人工藻礁

EU Food-Energy-Water Nexus project (pre-proposal approved)

OMEGA project in Taiwan







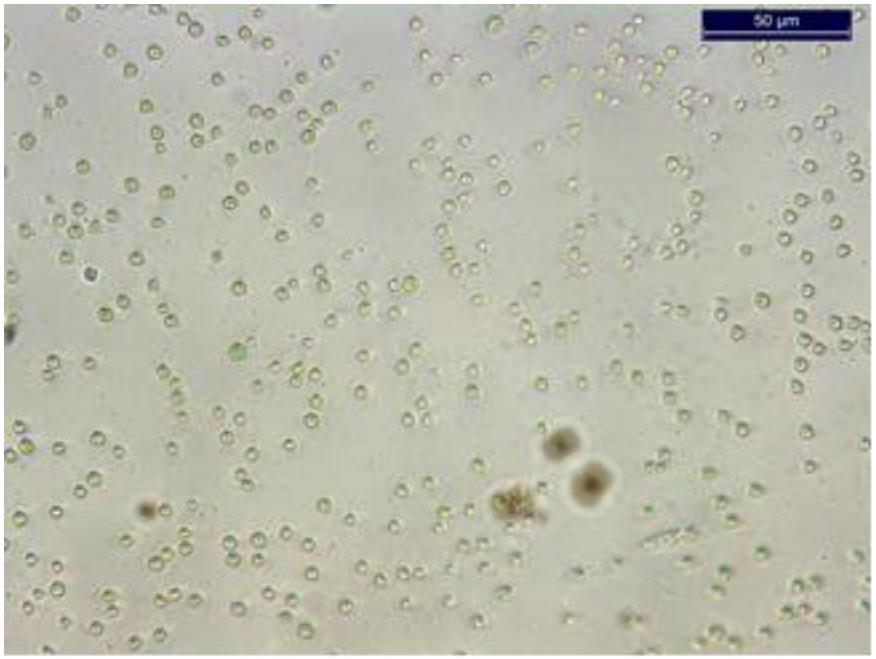
把Taipei 101變成微藻光生物反應器

Thank you for your attention

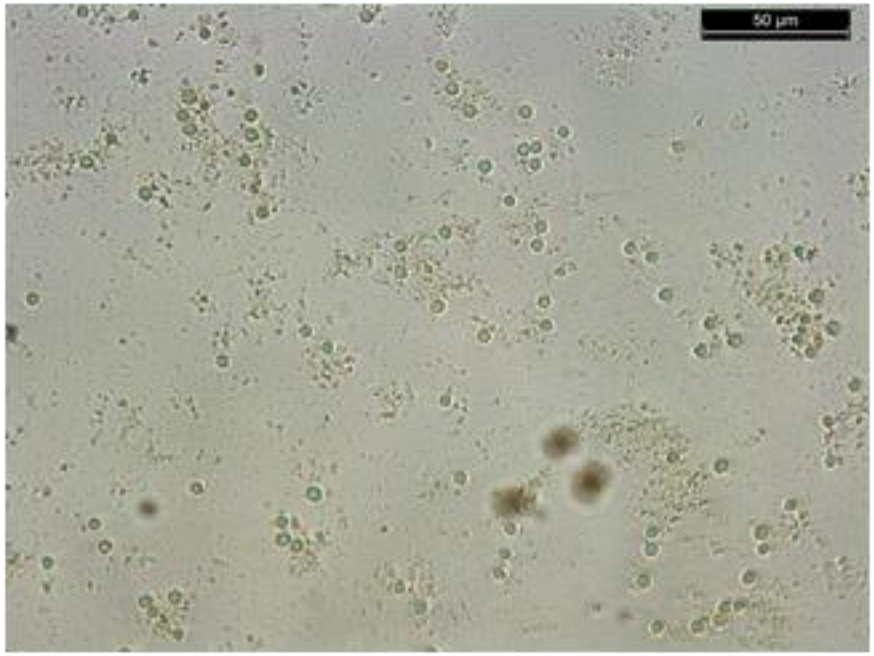
相關影片展示

- 中鋼公司/成大模廠
- NEP-II CO2再利用計畫
- 公視新聞

Chlorella sp. ESP-31處理前後之顯微鏡照片 (400x倍率)



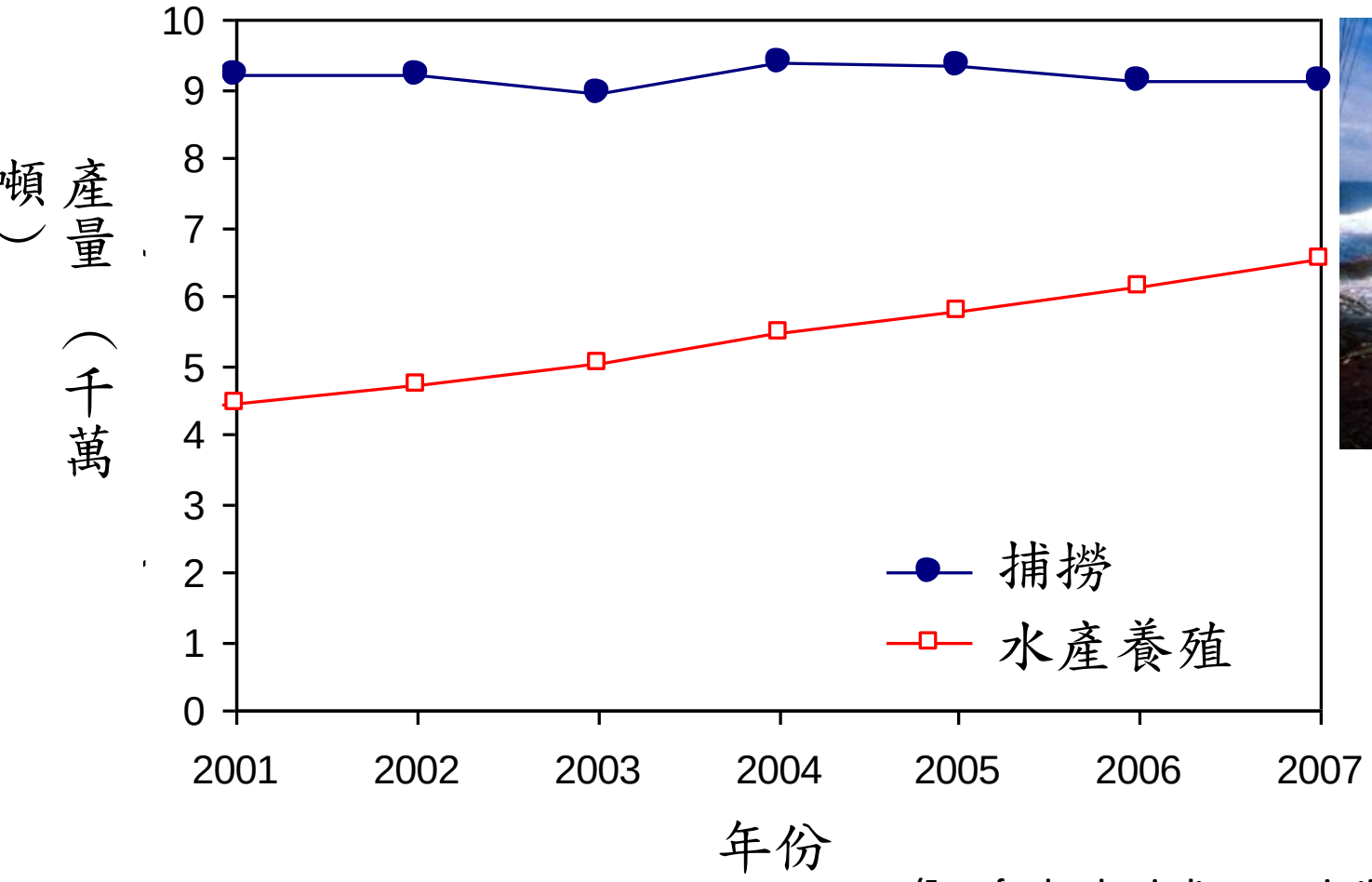
破壁前



破壁後

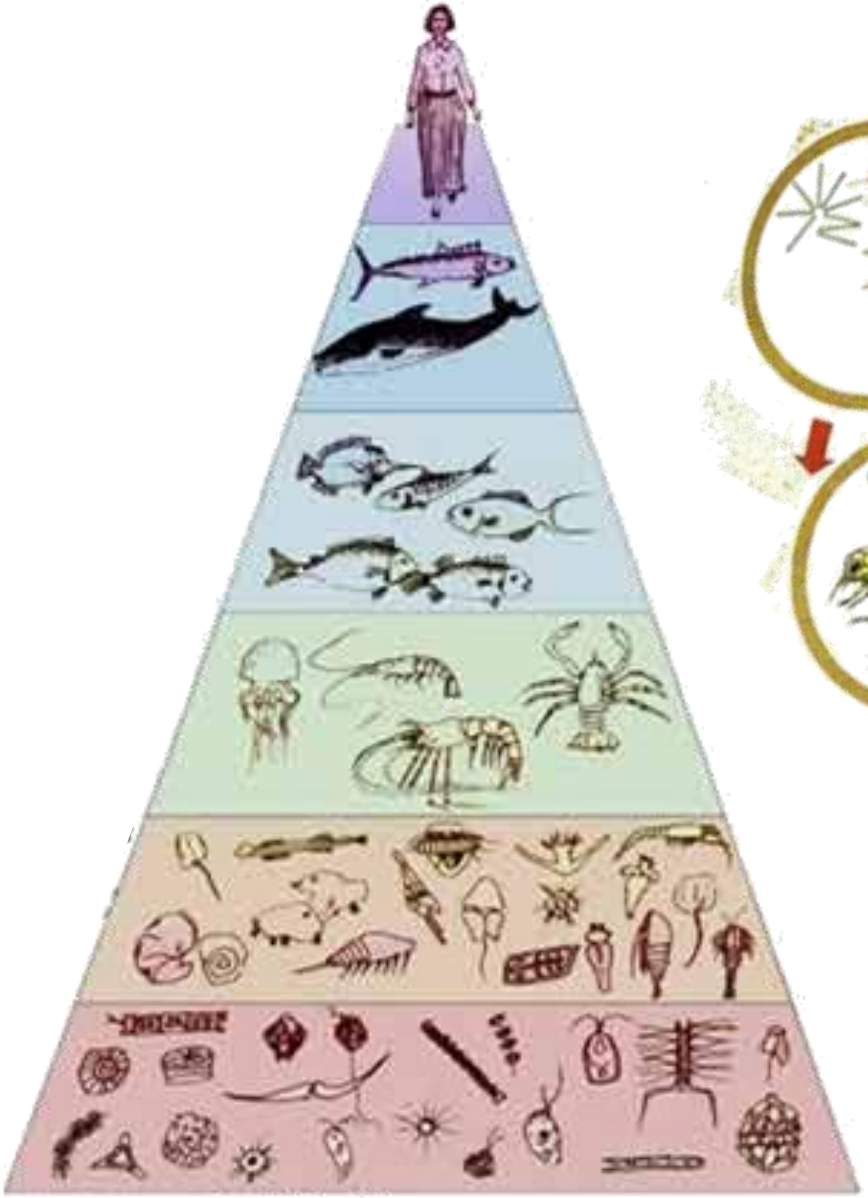
水產養殖會逐漸取代捕撈
➔魚粉漲價與缺貨

微藻可作為魚粉替代品 (動物性蛋白來源)



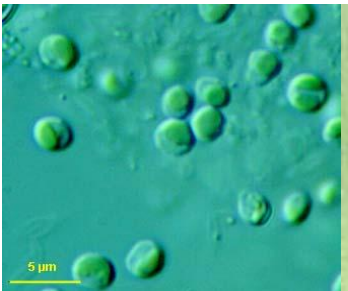
(From food and agriculture organization; FAO)

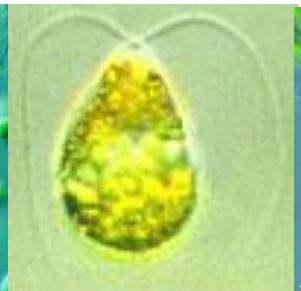
是微藻支撐住海洋食物鏈的金字塔



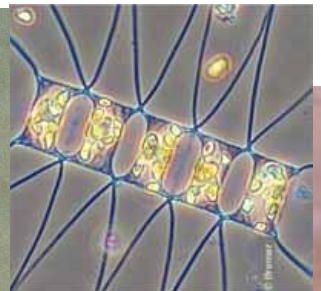
一些常用於水產養殖的微藻

微藻	應用
Nannochloropsis oculata 擬球藻	雙枚貝
Isochrysis galbana 等鞭金藻	雙枚貝
Tetraselmis chui 周氏扁藻	雙枚貝
Skeletonema costatum 骨藻	蝦
Chaetoceros muelleri 牟氏角毛藻	蝦



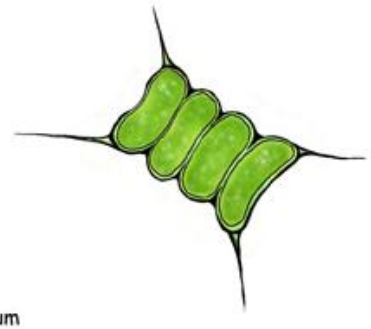


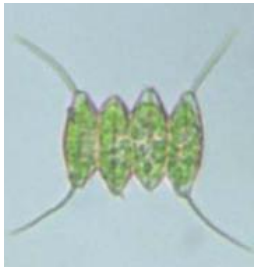


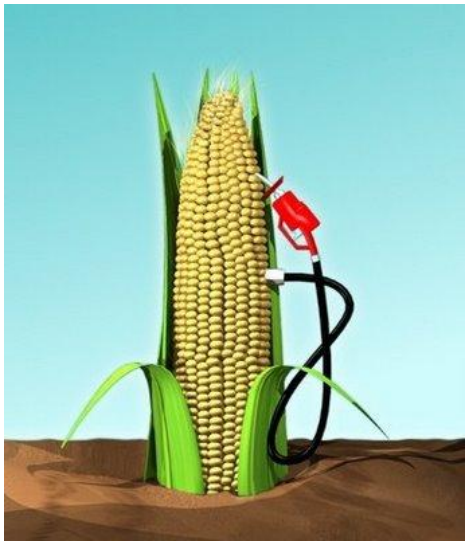


柵藻 (Scenedesmus)

綠藻類，含有較多的葉黃素等類胡蘿蔔素，能夠吸收大量二氧化碳並轉化為醣類，有機會取代傳統使用糧食作物生產生質酒精的方式







行政院國家科學委員會
National Science Council

微藻美容產品跨領域技術研發平台之研究

Development and commercialization of microalgae cosmetic and personal care products

國科會大產學計畫計畫 (with Ladies Biotech Co.)

Budget size：NT $ 20M

Jo-Shu Chang[1], Duu-Jong Lee[2], Chia-Che Chang[3], Chun-Yen Chen[4], Hui-Min Wang[5], Jian-Liang Pan[6]

1. Department of Chemical Engineering, NCKU
2. Department of Chemical Engineering, NTU
3. Graduate Institute of Biomedical Science, NCHU
4. Center for Bioscience and Biotechnology , NCKU
5. Department of Fragrance and Cosmetic Science, KMU
6. Department of Chemical and Biochemical Engineering, KYU





Cosmetic product from microalgae

綠藻美容系列產品


綠藻精華液


綠藻日霜


綠藻晚霜


綠藻面膜

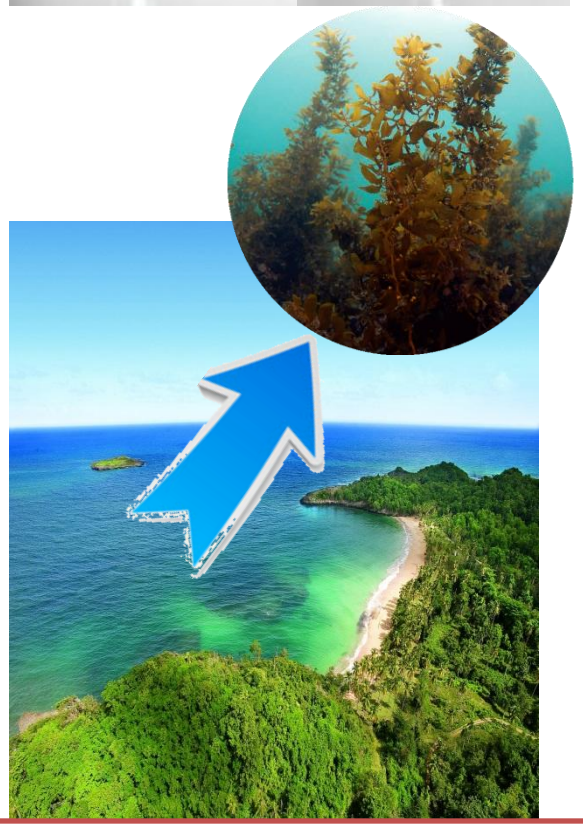

綠藻水磁場

以深層海水(Deep-sea water)養殖微藻

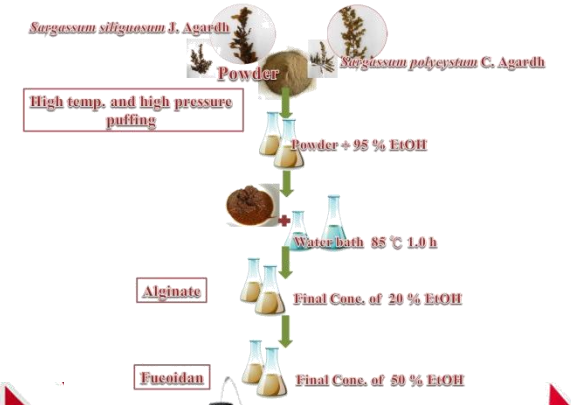
以馬尾藻開發褐藻糖漿

Sargassum sp.

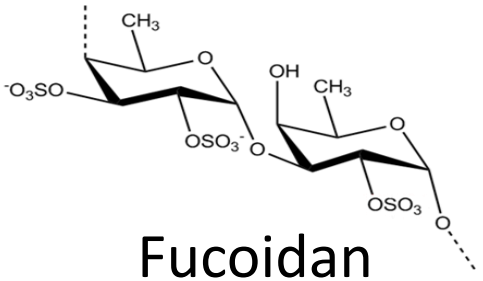
sp.



Extraction & Analysis



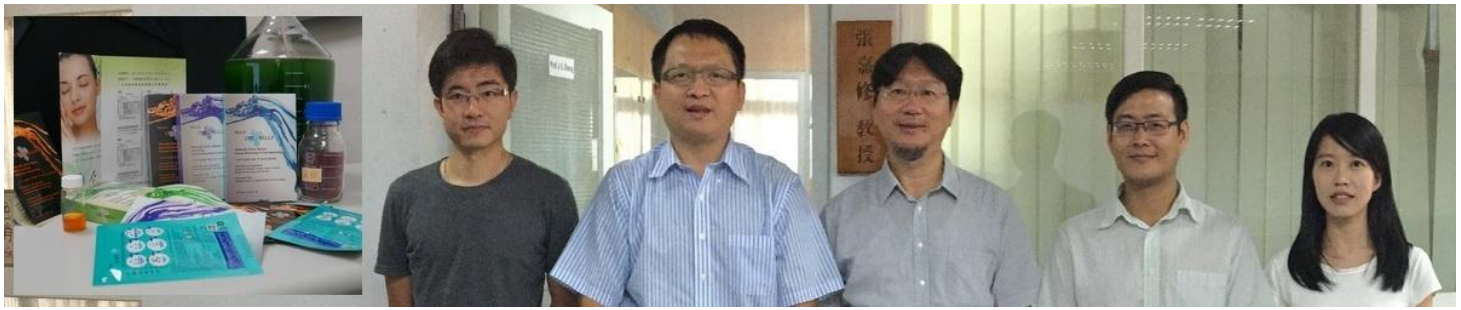
Application



Fucoidan

Health Supplements

Green Feel 創業團隊 於2016年4月籌創一家新公司 (群融生技)



• 本團隊至美國矽谷參加天使基金創投accelerator吸收海外資金

"104年度科技部創新創業激勵計畫(FITI)榮獲"創業潛力獎" (獎金55萬元)

Current target (1): 以微藻進行蝦類養殖

1. 淨
2. 穩
3. 提
4. 增
5. 提
6. 降
7. 降

Agar pl

白蝦

泰國蝦

草蝦

明蝦

Ant

Play

Current target (2): 藻類糕點相關產品









Current target (3): 藻類化妝保養品

Current target (4): 藻類色素與飼料

Business Plan based on microalgae-derived products

Green Feel

2016-2030 CO_2 capture/carbon credit & wastewater treatment

2016

飼料營養添加劑

- ω-3多元不飽和脂肪酸
  - 取代重金屬魚油
- 必需胺基酸
  - 降低添加劑成本
- 天然蝦紅素
  - 取代人工蝦紅素
- 海洋弧菌抗性
  - 取代抗生素
- 天然抗氧化物質
  - 取代防腐劑

2016

香粧品

- 抗UV功效
  - 可做為防曬、抗UV產品
- 天然抗氧化物質
  - 可做為抗老化產品
- 藻類多糖
  - 可做為保濕產品

2018

保健食品

- 天然蝦紅素
  - 可降低心血管疾病、減緩視力退化、預防老年痴呆症、帕金森氏症、預防癌症
- 藻藍素
  - 具高營養、可抗氧化、降低膽固醇、抗發炎
- 葉黃素
  - 可預防眼部退化型黃斑部病變
- 藻類多醣體、褐藻糖膠
  - 可提升免疫力、降低膽固醇、血糖及血脂
- DHA藻油
  - 無重金屬汙染、可降低心血管疾病、促進嬰幼兒腦部發育、預防憂鬱症
- 必需胺基酸
  - 可提升免疫力、調節生理機能、促進新陳代謝、加速體內修復

2019

生質能源

- 藻油
  - 可作為生質柴油之來源
- 藻體殘渣
  - 可進一步發酵以生產氫氣、乙醇、丁醇等

2021

糖尿病、癌症用藥

- 糖尿病用藥
  - 可降低胰臟β細胞損傷，恢復胰島素合成
- 癌症用藥
  - 可抑制癌細胞增生、抑制血管不正常新生

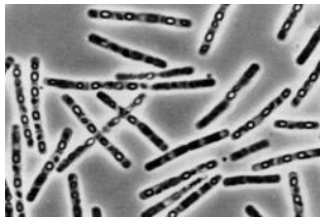
Future resources for food and feed will be from algae

Steel slag as support for microalgal growth

生物法破壁技術

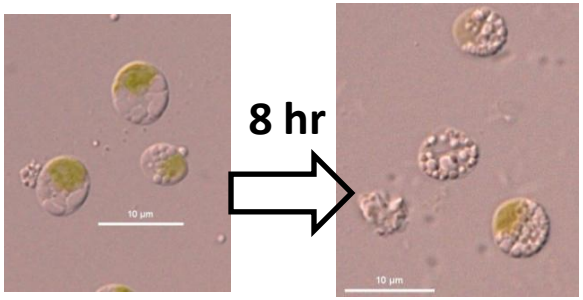
(Collaboration with ITRI)

***Bacillus sp.* KA-G1**



Biodiesel and lutein

Evaporation



Cell disruption performance