

Options for CO₂ Bio-utilization

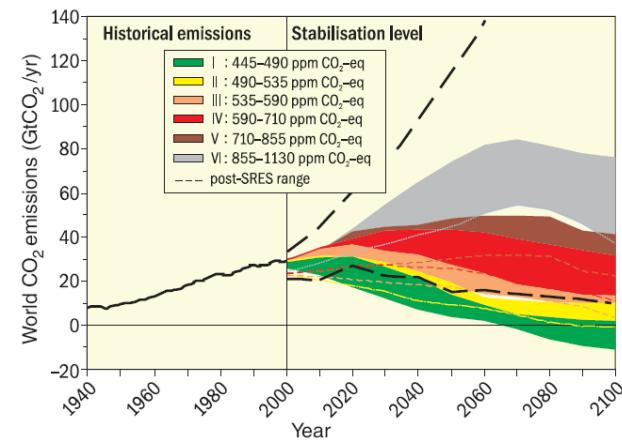
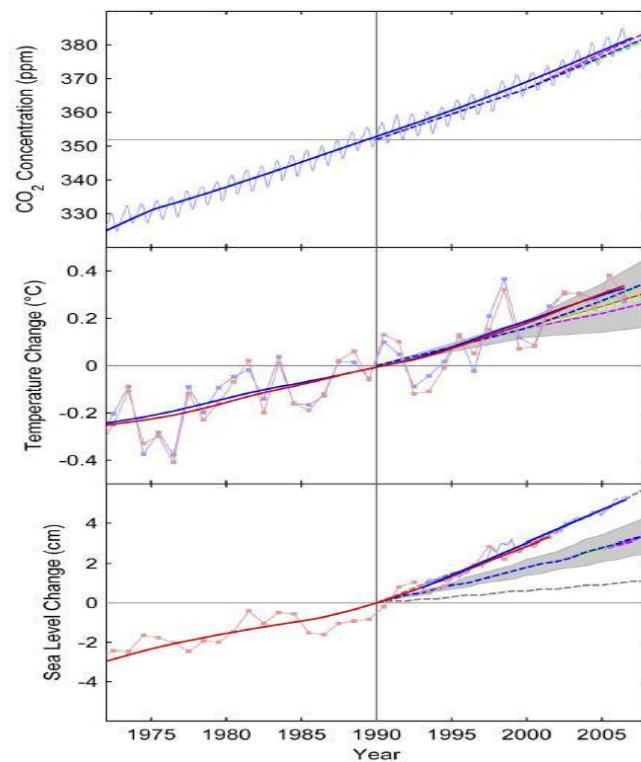
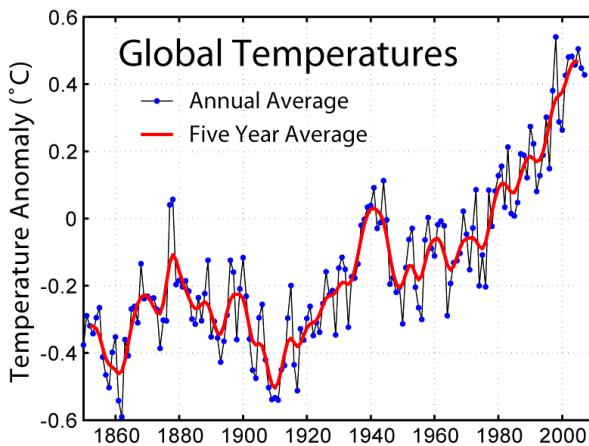
➤ Background



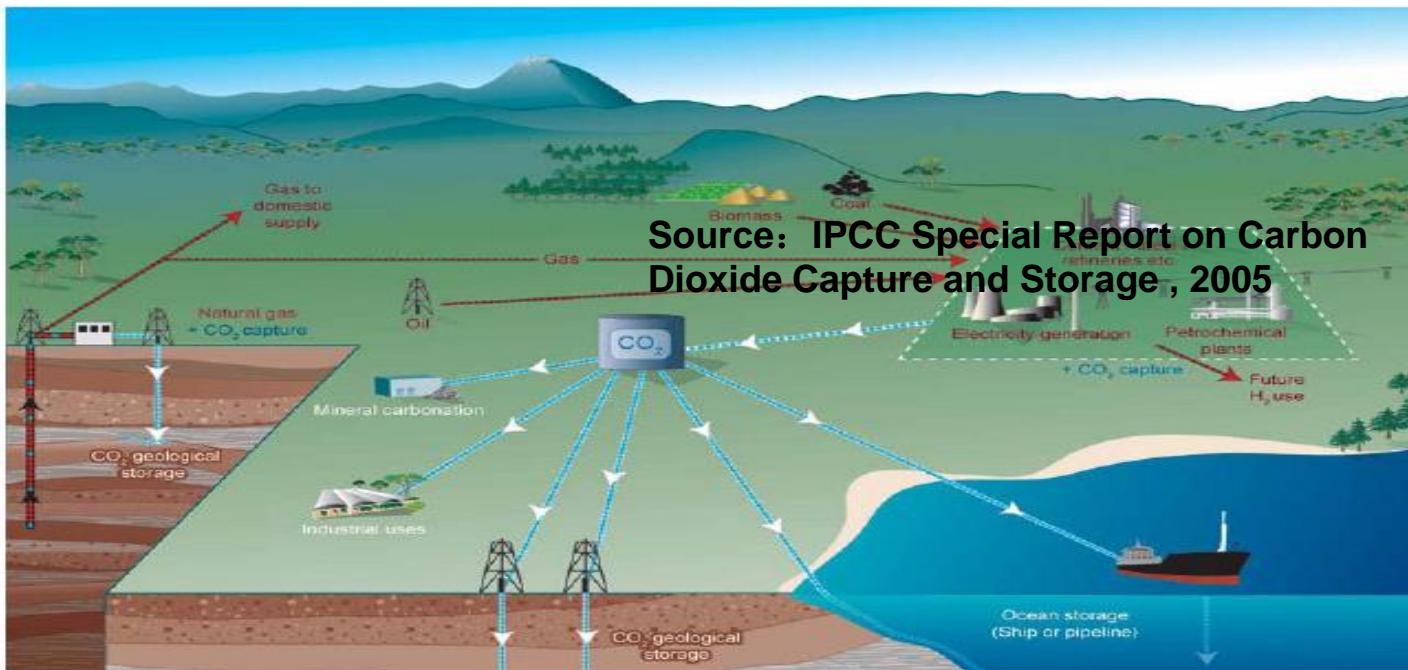
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CO₂ and Climate Change

CO₂ concentration has rapidly increased and led to the climate change.



CO₂ capture, utilization and storage (CCUS) might solve CO₂ problem



**Three key technologies: CO₂ Capture
CO₂ Utilization
CO₂ Storage**



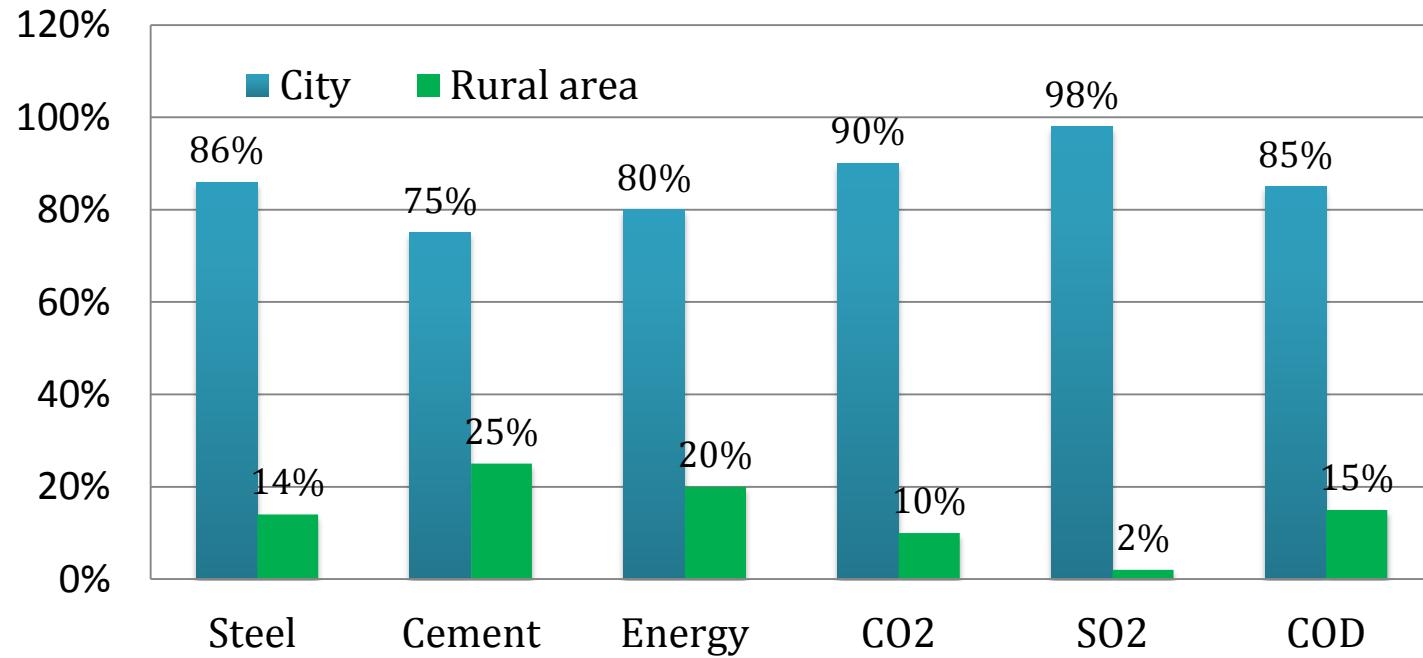
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Technology Assessment of CO₂ utilization-2013

学科分类	二氧化碳利用技术全称	中文简称	英文简称
地质利用 <i>Geological Utilization</i>	二氧化碳强化石油开采 二氧化碳驱替煤层气 二氧化碳强化天然气开采 二氧化碳强化页岩气开采 二氧化碳增强地热系统 二氧化碳铀矿浸出增采 二氧化碳强化深部咸水 二氧化碳与甲烷重整制备合成气 二氧化碳经一氧化碳制备液体燃料 二氧化碳直接加氢合成甲醇 二氧化碳合成碳酸二甲酯 二氧化碳合成甲酸技术 二氧化碳合成可降解聚合物材料 二氧化碳间接非光气合成异氰酸酯 二氧化碳间接制备聚碳酸酯/聚酯 二氧化碳间接制备乙烯基聚酯 二氧化碳间接制备聚丁二酸乙二酷		
化工利用 <i>Chemical Utilization</i>	钢渣直接矿化利用二氧化碳 钢渣间接矿化利用二氧化碳 磷石膏矿化利用二氧化碳 钾长石加工联合二氧化碳矿化 微藻固定二氧化碳转化为生物燃料		
生物利用 <i>Biological Utilization</i>	微藻固定二氧化碳转化为生物肥料技术 微藻固定二氧化碳转化为食品和饲料添加剂技术 二氧化碳气肥利用技术	微藻制备生物肥料 微藻制备食品和饲料添加剂 气肥	CO ₂ -AF CO ₂ -AS CO ₂ -GF



Urbanization-induced Environment Pollution



CO₂ Bio-utilization

**CO₂ Biological Utilization:
A Two-fold means for Carbon reduction
and Environment management**



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CO₂ Bio-utilization: Features

CO₂ Bio-utilization

Carbon Reduction, Energy Solution, Environment Protection

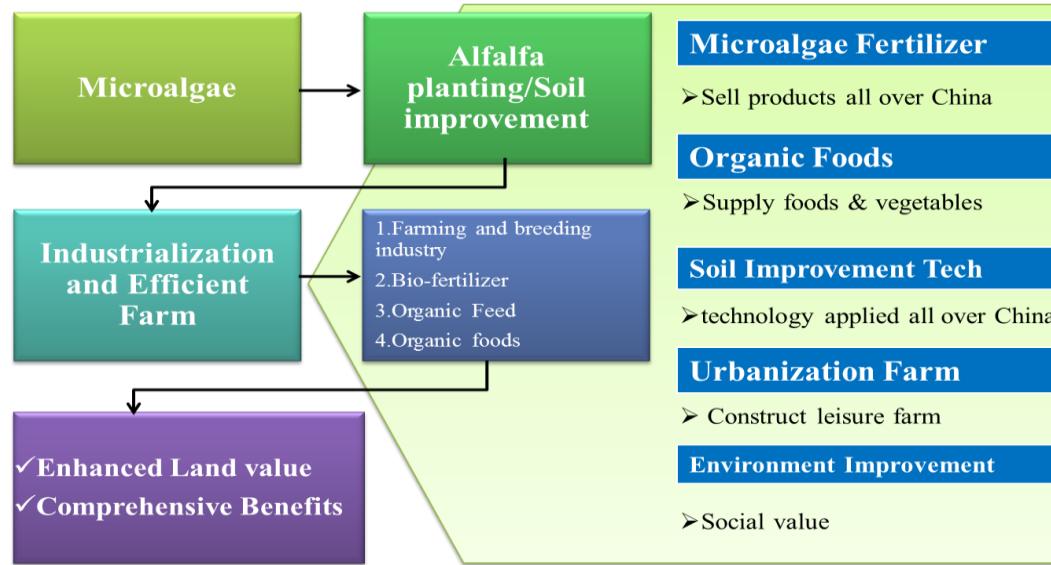
- **Capacity:** 90 million t/a of CO₂ can be used assume bio-fertilizer is applied on 50% of the farmland in China
- **Economic Benefits:** Value-added products can be obtained
- **Environmental Benefits:** Can be used for waste water treatment, soil refinery, etc.
- **Energy Security:** Potential option for oil production



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CO₂ Bio-utilization at SARI

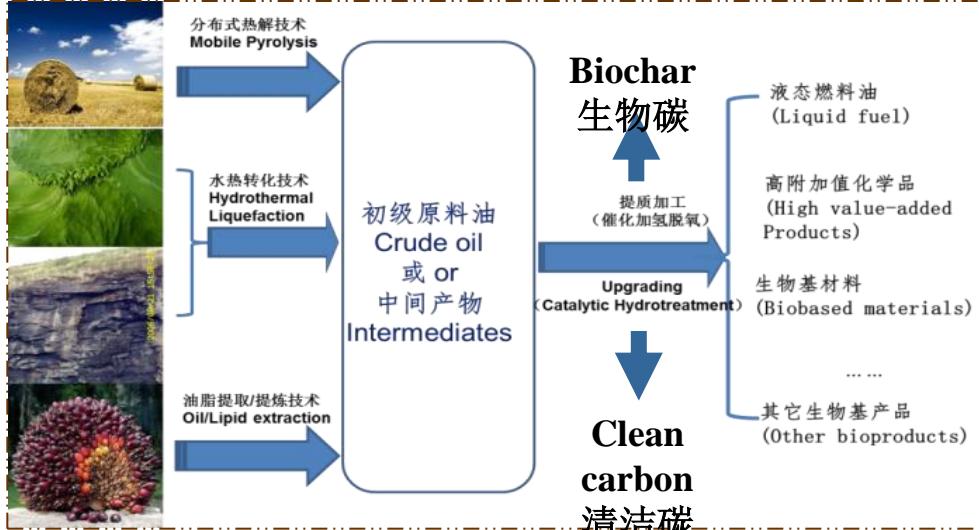
1. CO₂ fixation by microalgae



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CO₂ Bio-utilization at SARI

2. Biomass Conversion



- ◆ MW-assisted pyrolysis
- ◆ Non-hydrogen conversion
- ◆ Upgrading



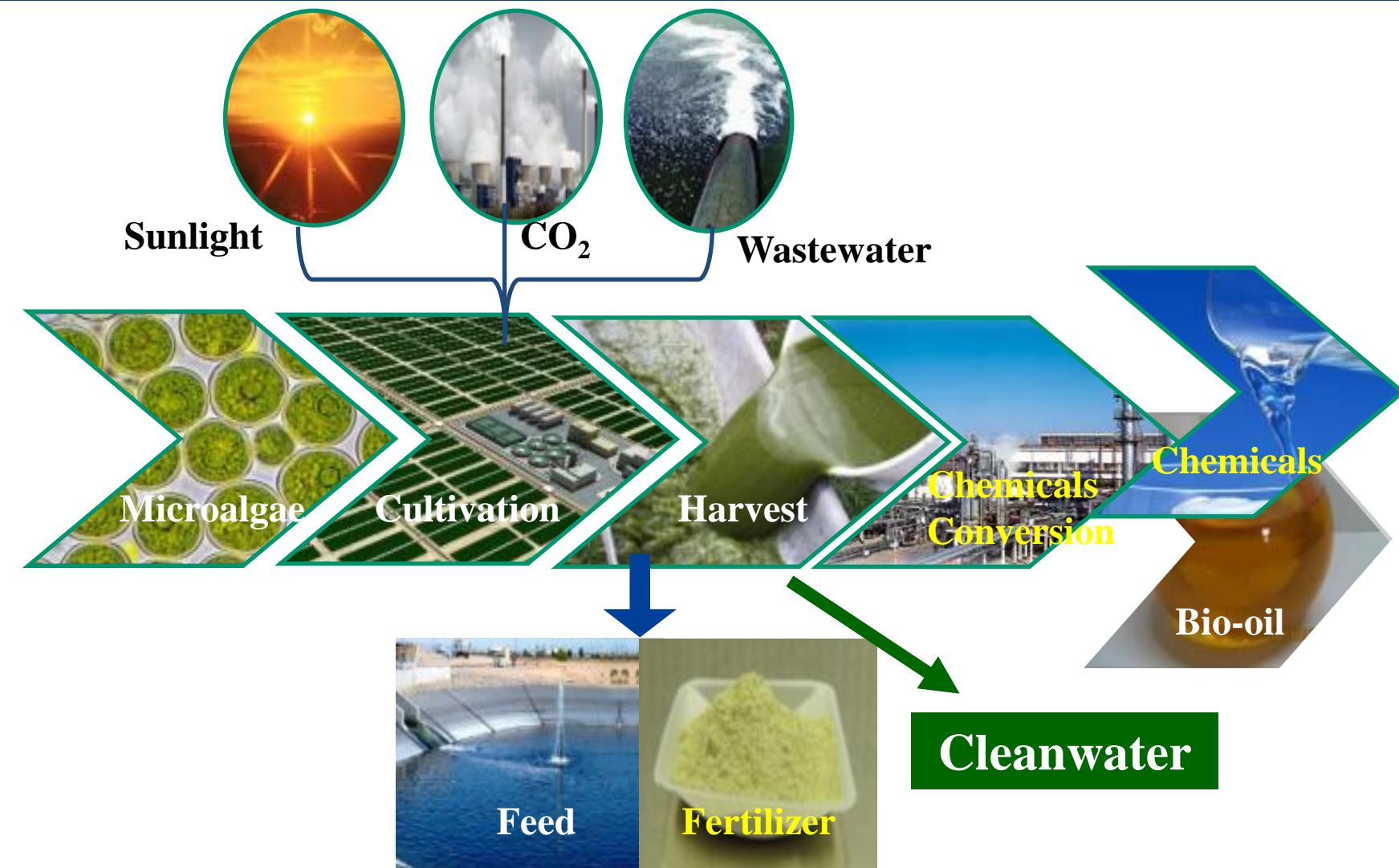


Activity of CO₂ Biological Utilization

CO₂ Solution: Algea & Biomass Conversion



Focus - *Microalgae & related Biochemical Engineering*



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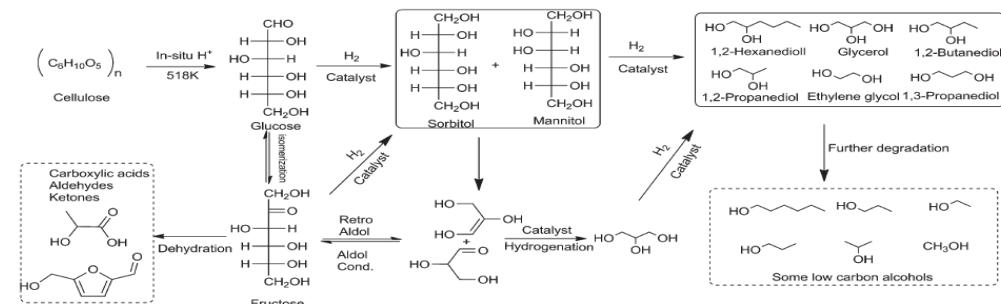
解决方案和核心竞争力

微藻-改良土壤



生物微藻肥改良土壤
生物炭肥提高含炭量

微藻-化学品



将 CO_2 微藻生物捕集与生物基化学品制备的高度耦合，对微藻进行高密度高品质光自养培养，固定大量工业废气中 CO_2 ，采收后的藻体经预处理后制备高品质生物基二元醇。

Microalgae for Biofertilizer



Microalgal Biofertilizer



Chemical Fertilizer

✓ 1 ton of microalgae absorbs 2 tons of CO₂

✓ Improve soil quality via organic planting

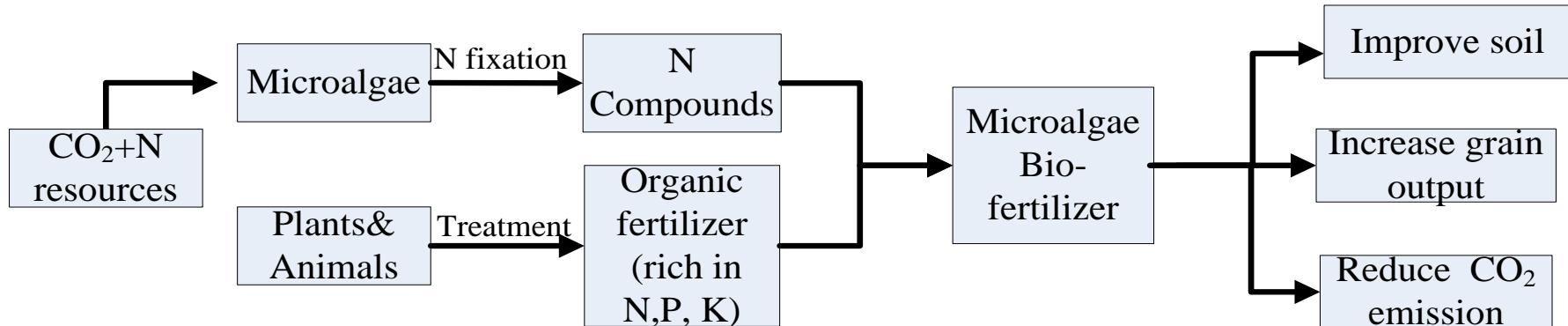
✓ 1 ton of chemical fertilizer release 2.72 tons of CO₂

✓ Degrade soil quality via soil erosion



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Sustainable Agriculture based on Microalgae



Replace Chemical Fertilizer

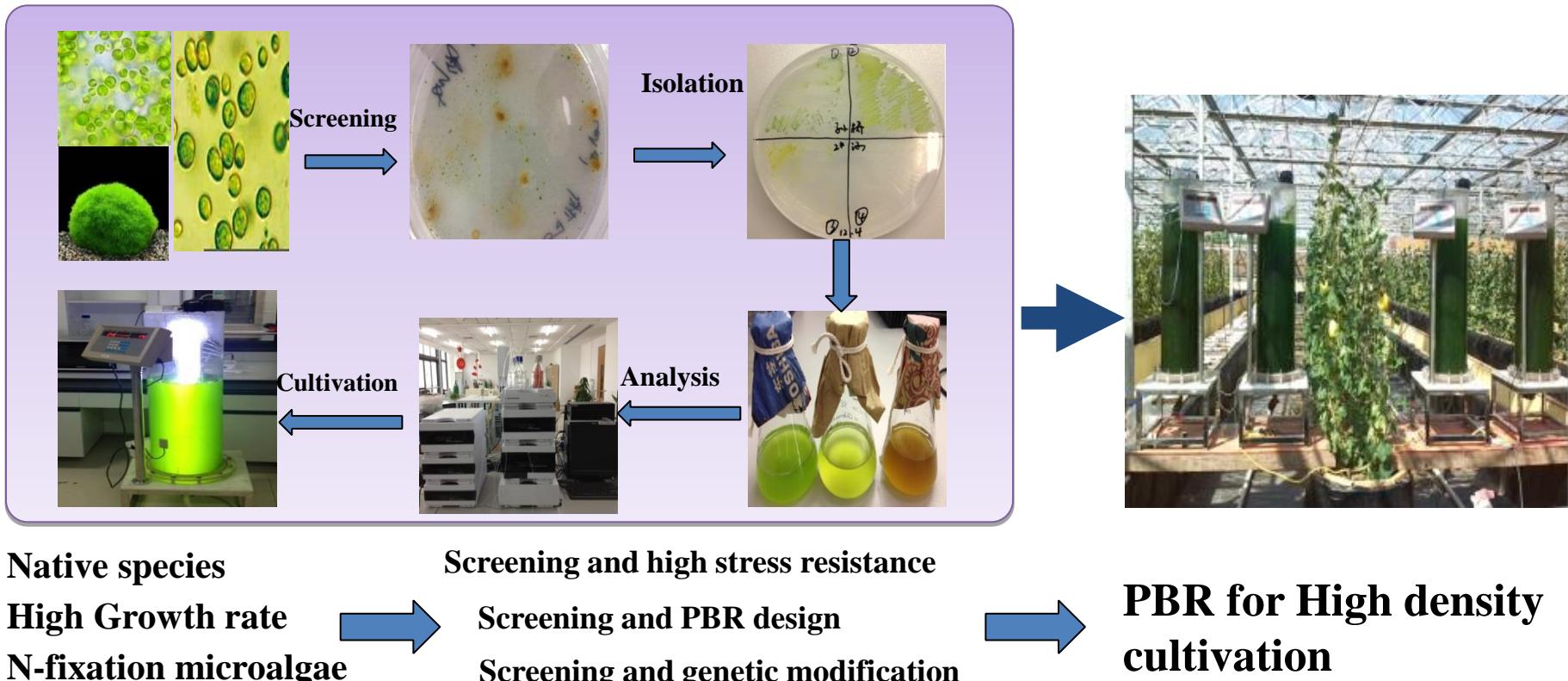


Merits of Microalgae Fertilizer

- ✓ Improve fertility of soil
- ✓ Improve organic matter content of soil constantly
- ✓ Increase product quality
- ✓ Protect environment

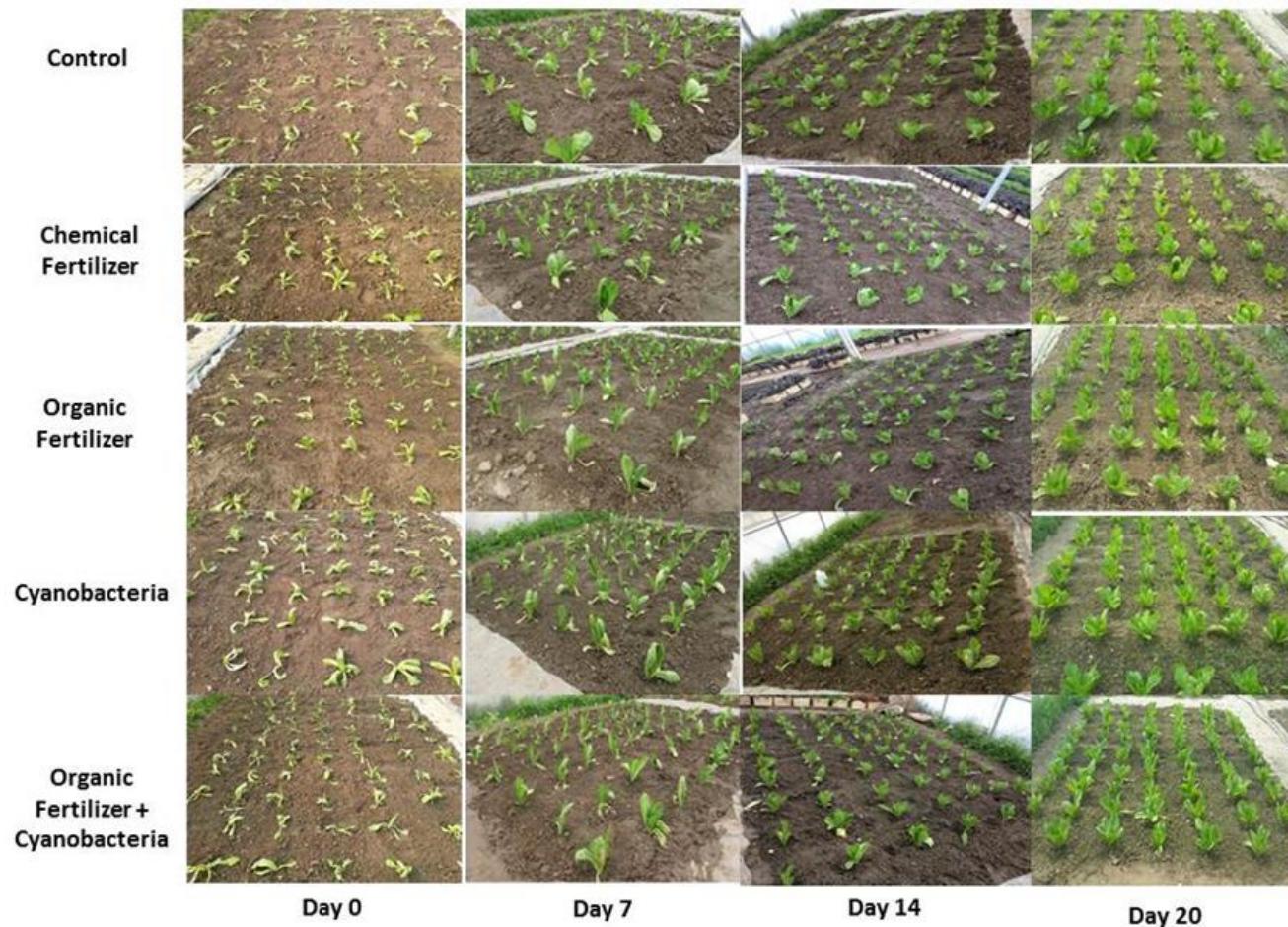


Microalgae for Green Agriculture--Algae Species



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Field Test—Lettuce Green Romaine



Lettuce Green Romaine was cultivated with different fertilizers, algae with organic fertilizer showed the best result with 17% increase in average individual weight.

Microalgae for Chemicals

- Hydrothermal Liquefaction of Microalgae to Glycol
- Hydrothermal Liquefaction of Microalgae for Bio-oil
- Hydrothermal Liquefaction of Microalgae for Hydro-char

Green Chemistry

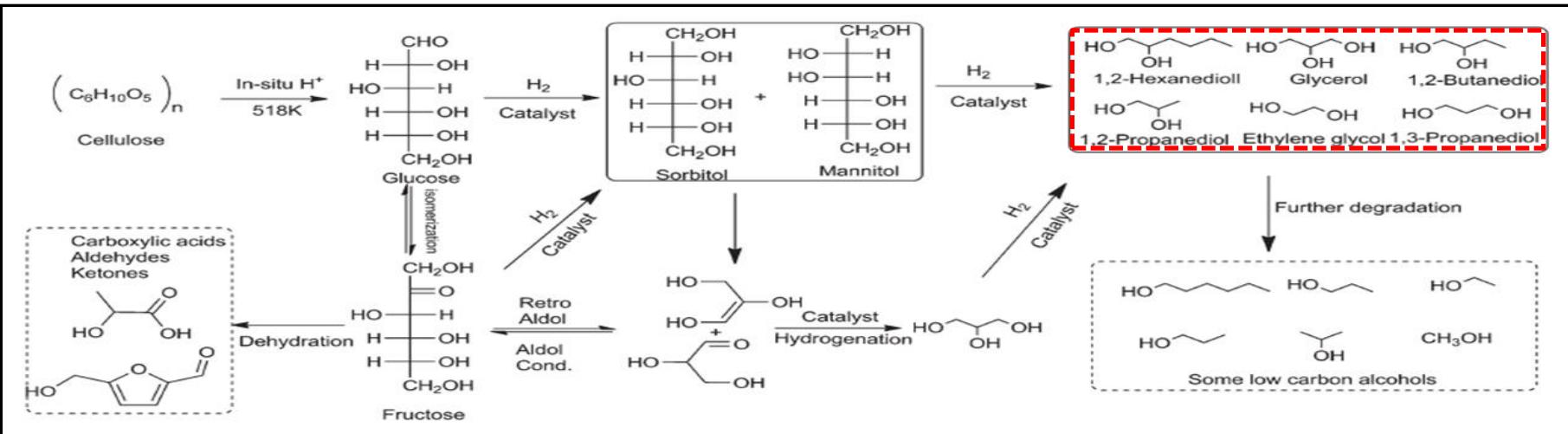
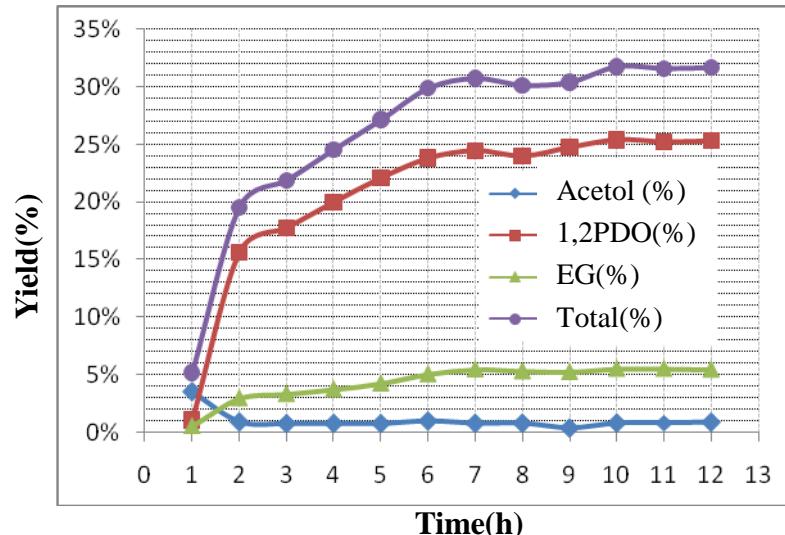


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Hydrothermal Liquefaction of Microalgae to Glycol



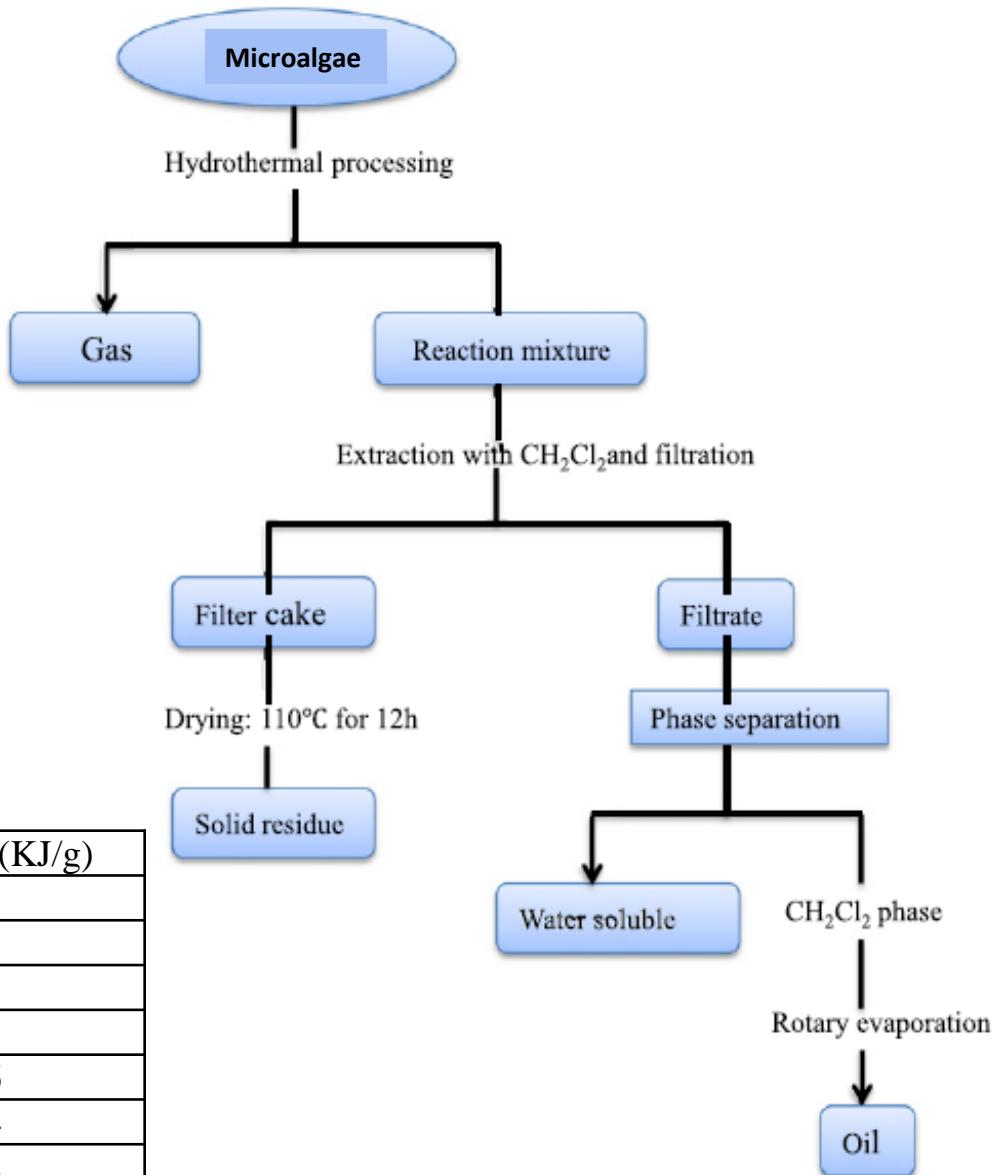
H_2 & Catalyst
→



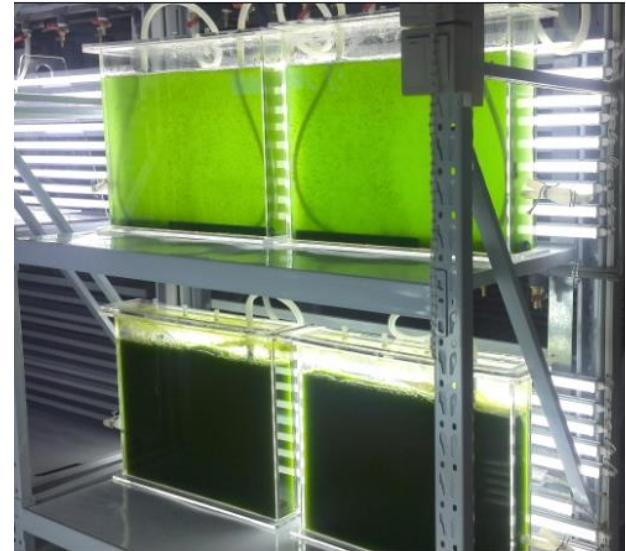
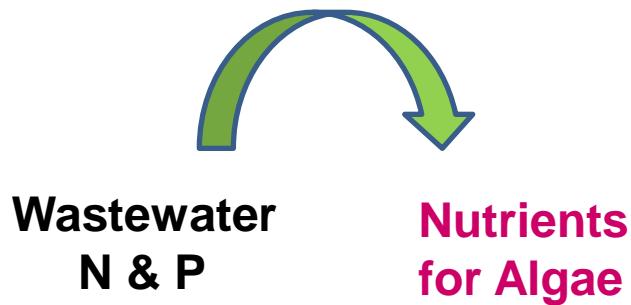
Hydrothermal Liquefaction of Microalgae for Bio-oil



No.	Conversion Rate/%	Yield/%	HHV(KJ/g)
Raw	-	-	16.11
1	85.36	40.45	24.21
2	77.50	26.36	24.45
3	76.31	23.00	35.81
4	77.45	30.74	27.66
5	82.58	30.62	32.34
6	88.88	25.65	36.78



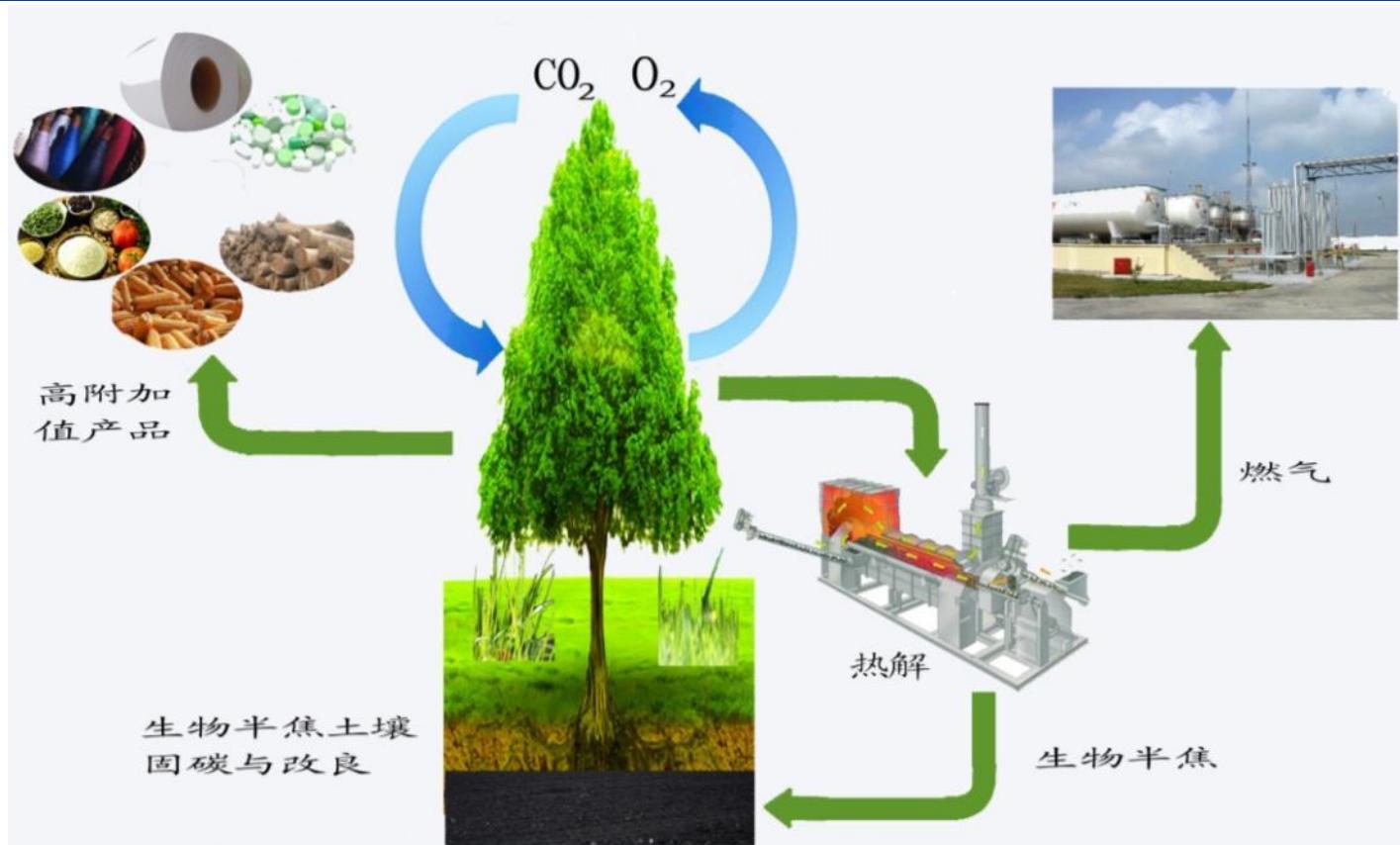
Microalgae for Wastewater Treatment



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Distributed Biomass to Oil & Power System---Biomass & Agriculture Wastes



- **Resource utilization of straw** – converted to bio-oil, bio-gas and bio-carbon and used to supply oil, chemicals and power
- **Bio-carbon used to improve soil** - supplement carbon for soil and improve soil fertilization
- **Low-carbon energy supply and improving rural labor to find work locally**



Hydrothermal Liquefaction of Microalgae for Hydro-char

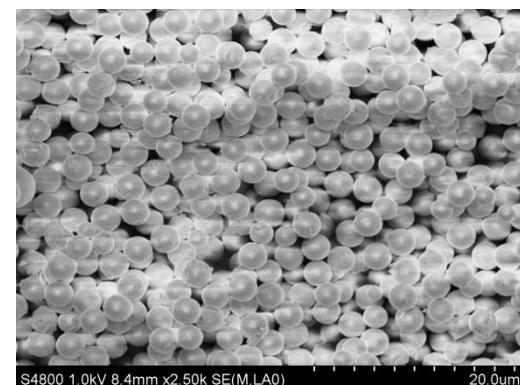
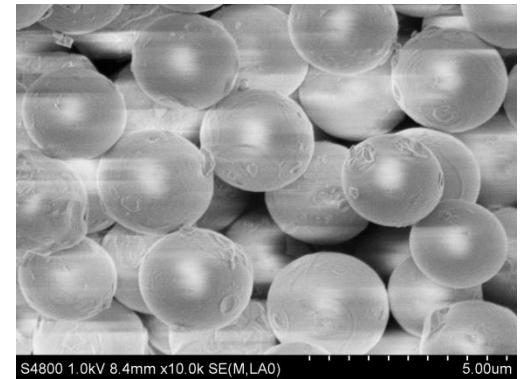
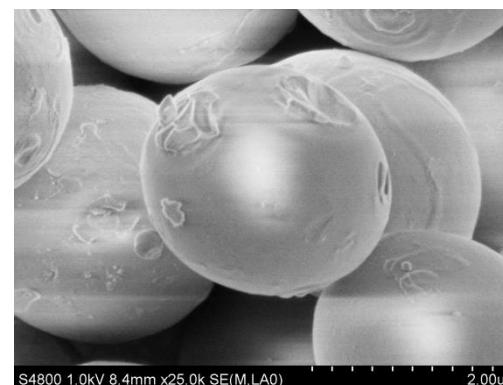
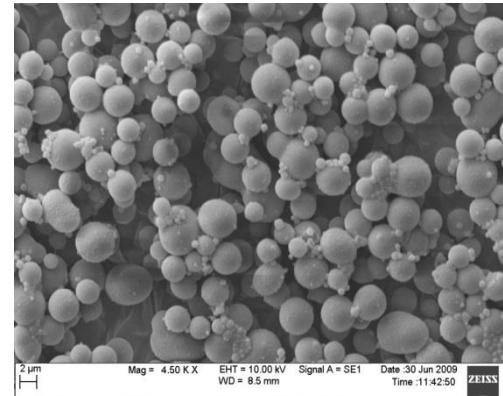
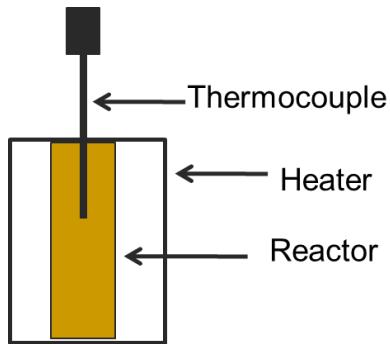


Hydrothermal

Biocrude

Carbonization

Carbon Materials

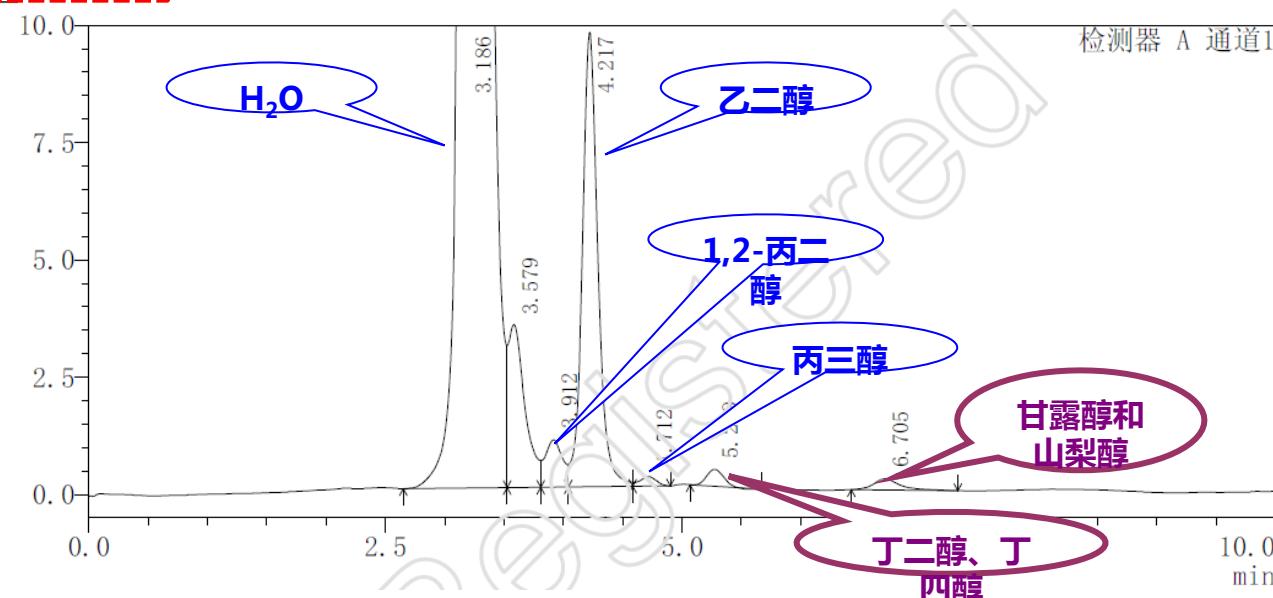




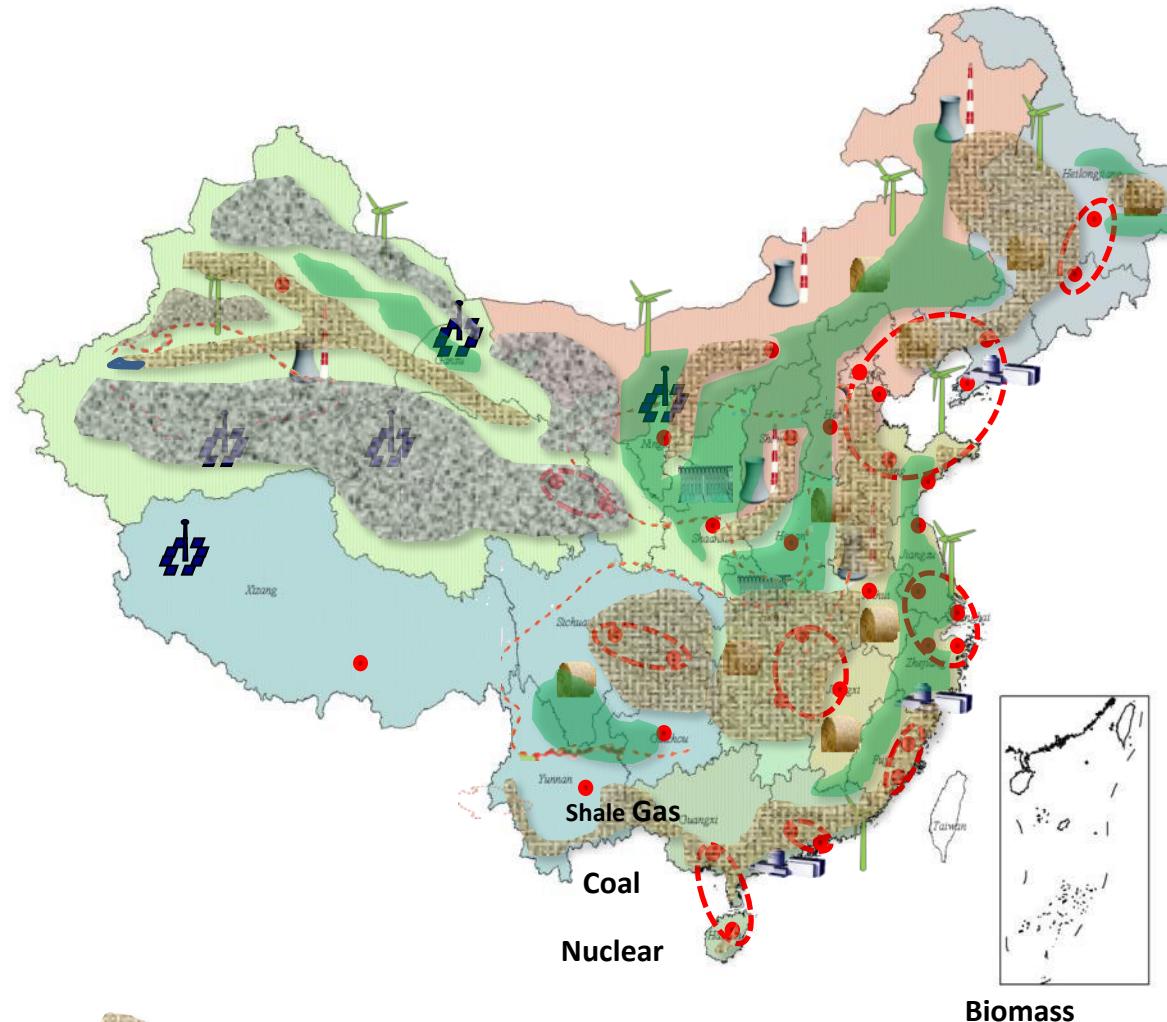
纤维素水热加氢较好的得到了二醇类化学品

催化剂 编号	纤维素转化率 (%)	产品收率 (%)			
		乙二醇	丙二醇	丙三醇	C ₆ 醇
1	98	58.90	6.77	0.57	2.46
2	98	53.07	6.98	0.71	1.42
3	100	58.14	6.43	1.24	3.06
4	96	54.64	11.01	1.37	0.60

纤维素加氢反应
典型产物分析



CONCLUSION: “eco-CCR”-Scenario Analysis in China



Distributed oil & power system based on biomass



Fuel &chemicals production system based on microalgae



Three-dimensional Agriculture based on Microalgae and Soil Improvement System

◆ Distributed oil & power system based on biomass

Regions that is rich in biomass and straw; eastern regions with high energy demand

◆ Three-dimensional Agriculture based on Microalgae and Soil Improvement System

northeast/northern regions; saline-alkali field in east coast regions; sandy field in northwest regions

◆ Fuel &chemicals production system based on microalgae

West regions that is rich in coal; east regions with high energy demand

Acknowledgements

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技术合作者/Technical Partners



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CHINA SHENHUA



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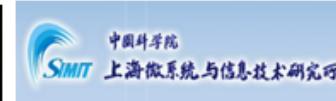


ThermoFisher
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HUAYI
华谊集团

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- Chinese Academy of Sciences
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Thanks



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