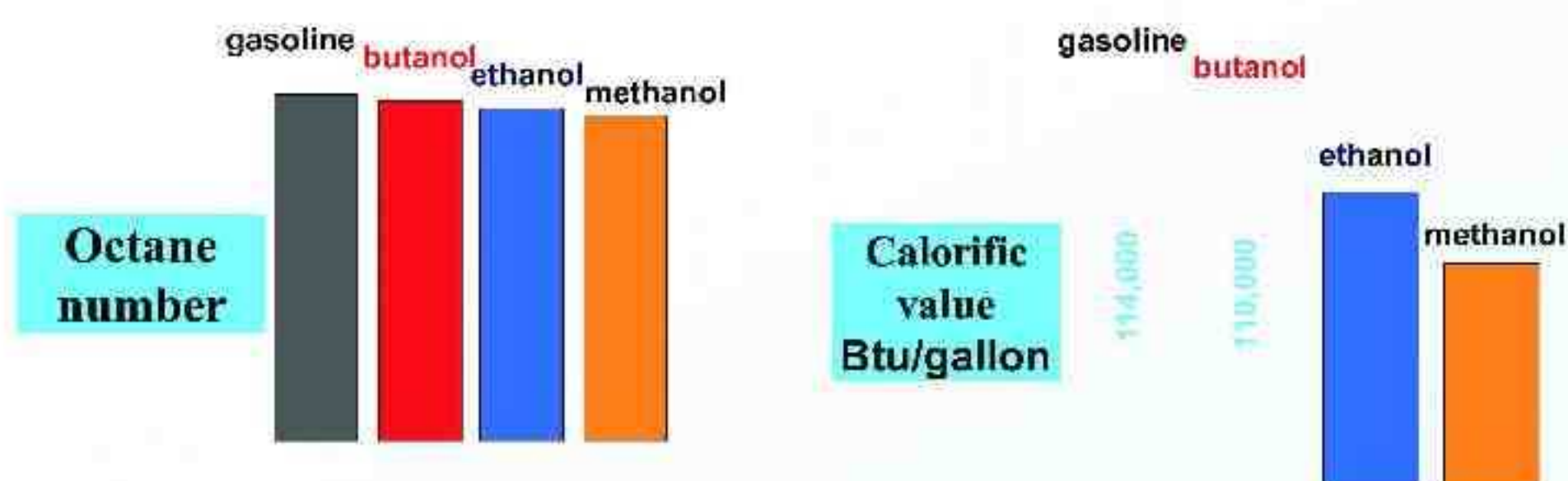




Introduction

Due to extensive oil consumption and its increasing price trend, the use of biofuels as a partial replacement for fossil fuels has gained great attention worldwide. Butanol is a four-carbon primary alcohol used as a chemical feedstock and as a renewable fuel. Butanol is preferable to ethanol, because it is less hygroscopic, less corrosive, less volatile, and has a higher energy density. The biological production of acetone/butanol/ethanol (ABE) has prompted a great deal of interest in the light of diminishing oil resources worldwide and unpredictable fluctuations in petroleum.



First generation of biofuels

Feedstocks: food-based crops



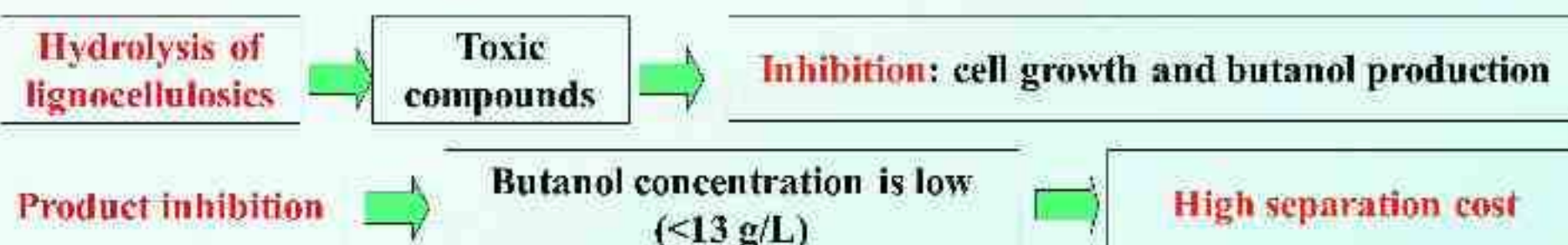
Food crisis

Second generation of biofuels

Feedstocks: lignocellulosic materials

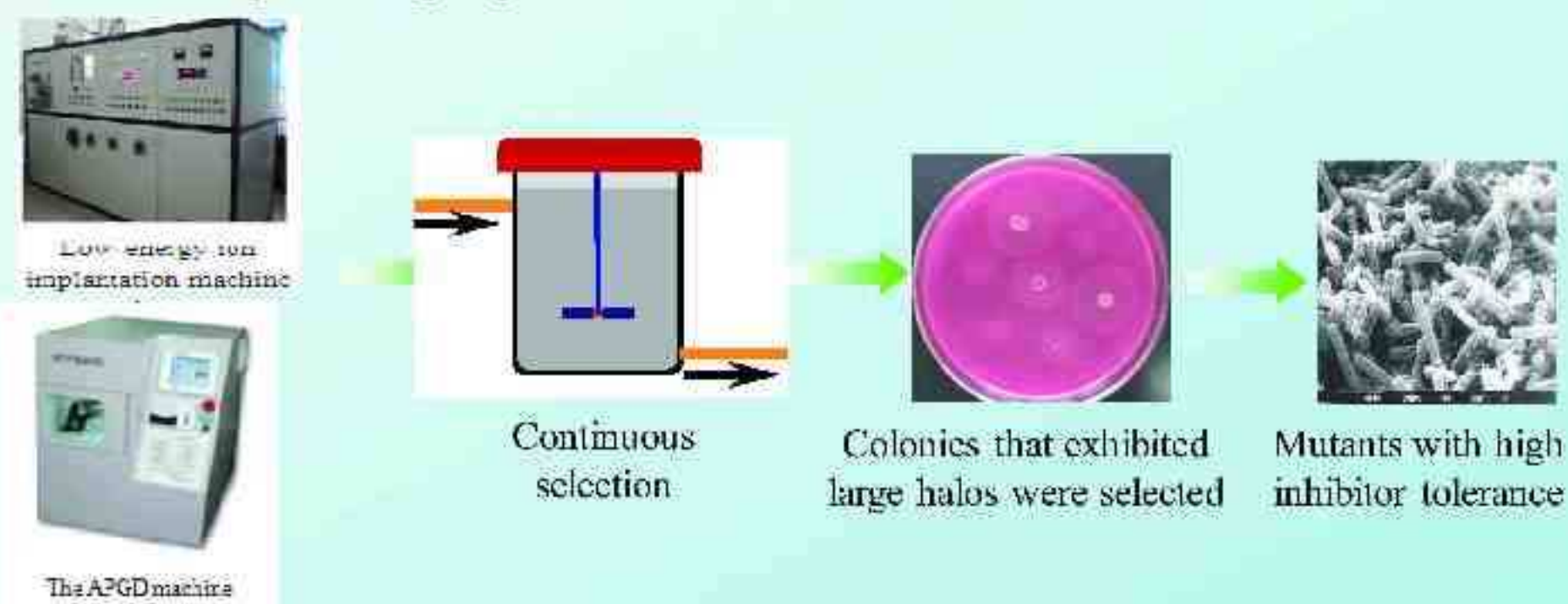


Bottlenecks



Research

Breeding of highly tolerant mutation



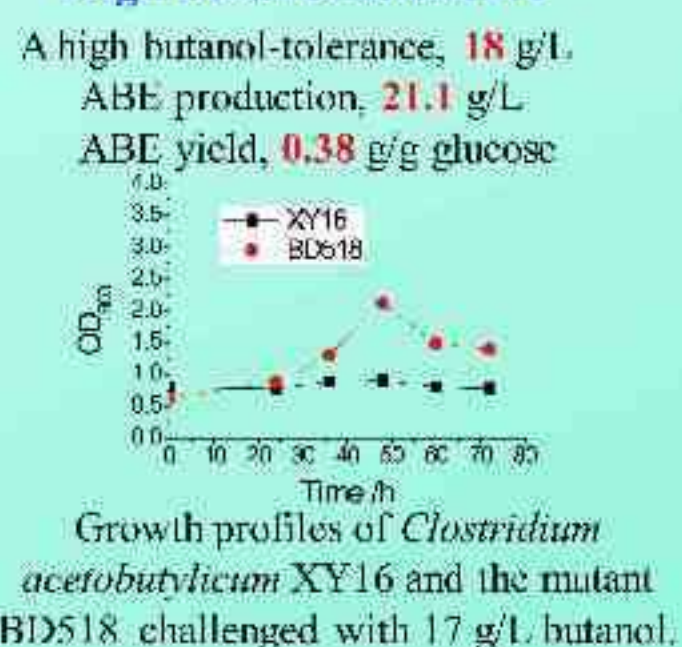
Clostridium beijerinckii IB4
(CCTCC NO:M2010310)

Highly inhibitor tolerance

Substrate	Inhibitor removal	Culture	ABE (g/L)	Yield (g/g)	Productivity (g/L·h)
Corn fiber	XAD-4 resin	<i>C. beijerinckii</i> BA101	9.3	0.39	0.1
Corn fiber	None	<i>C. beijerinckii</i> BA101	1.7	×	×
Corn fiber	Active carbon	<i>C. beijerinckii</i> IB4	10.1	0.36	0.14
Corn fiber	None	<i>C. beijerinckii</i> IB4	9.5	0.34	0.13

Clostridium acetobutylicum BD518
(CCTCC NO:M2010308)

High butanol-tolerance



Enhancement of ABE fermentation using different strategies



ABE fermentation integrated with pervaporation



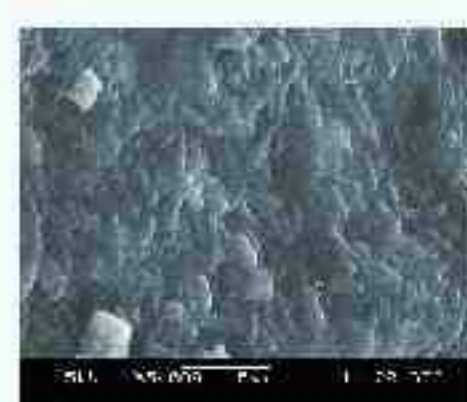
Separation factor of butanol: 5-27
Solvent in permeate: 100 g/L
Direct integrated with fermentation process more than 200h at 37°C
High flux: 600 g/(m²·h)

PDMS-Ceramic composite membrane

produced by the State Key Laboratory of Materials-oriented Chemical Engineering, NJUT



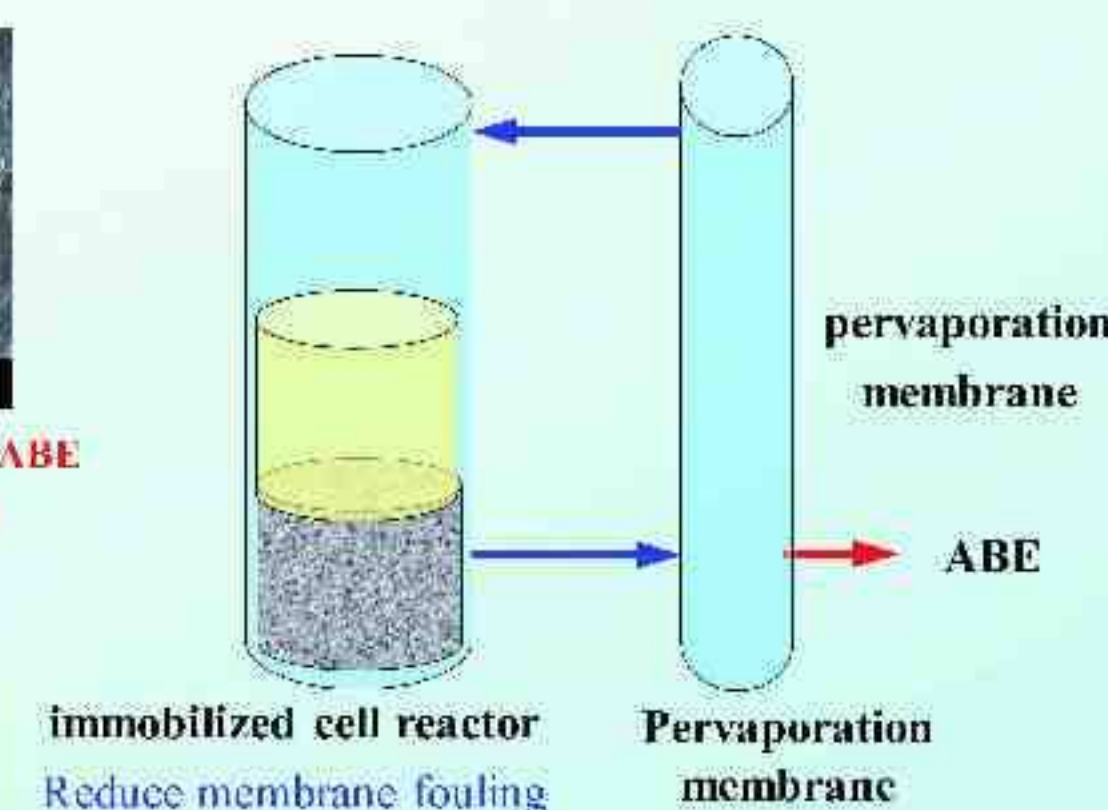
ABE fermentation by immobilized cells of *Clostridia* integrated with pervaporation



Fouled membrane surface of ABE fermentation by free cell



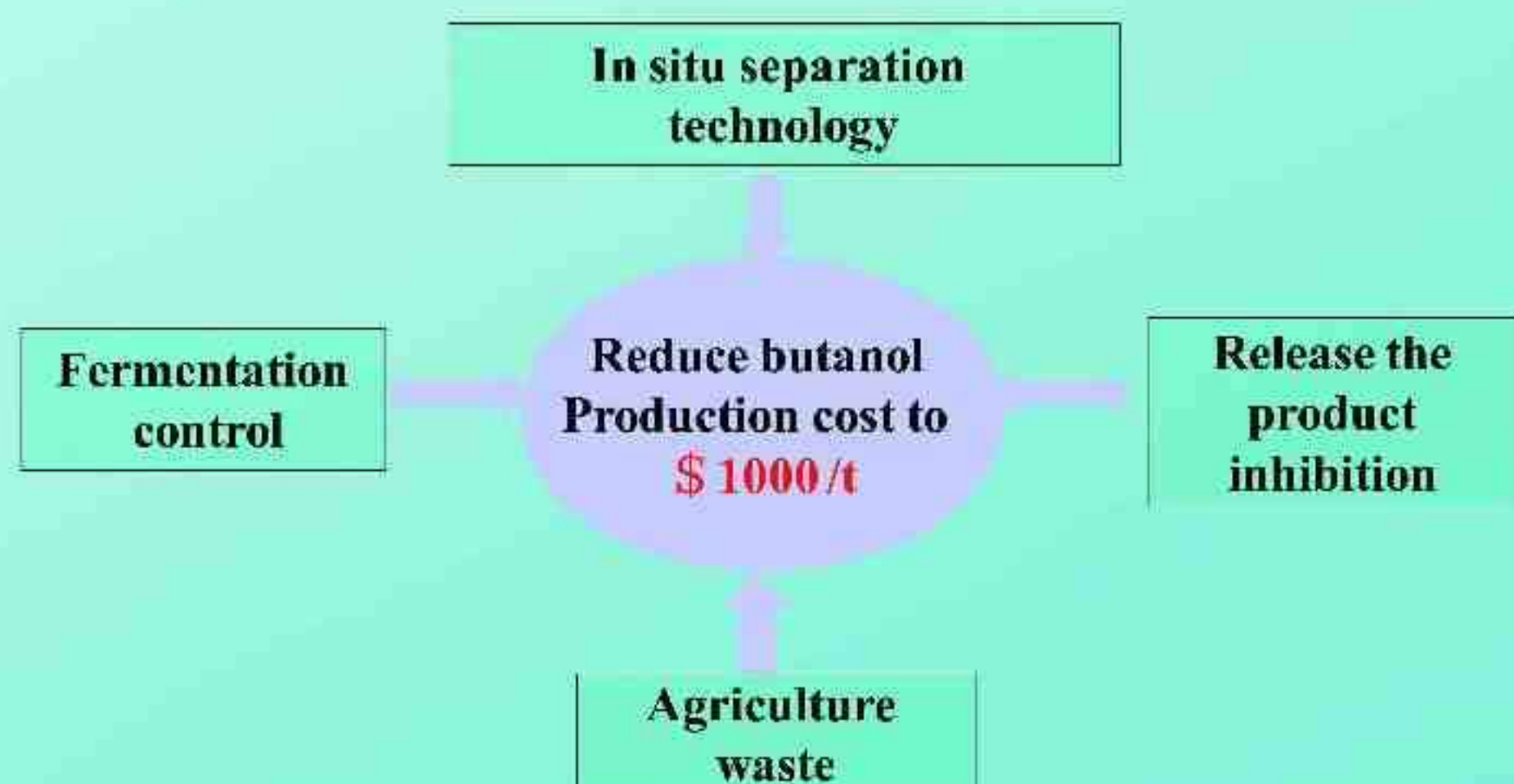
Fouled membrane surface of ABE fermentation by immobilized cell



Fermentation process	ABE productivity (g/L/h)	ABE yield (g/g)	Glucose utilization (g/L/h)	Butanol in reactor (g/L)	ABE remove (%)
Batch fermentation	0.257	0.349	0.8	18.51	/
Fed-batch fermentation integrated with pervaporation with pH control	0.394	0.298	1.35	3.32	90.0%
Fed-batch fermentation integrated with pervaporation with pH control by immobilized cells	0.595	0.311	1.91	3.70	92.6%

ABE productivity and glucose utilization rate were improved by 131%, 139% respectively. Butanol concentration in the reactor was below 4g/L.

Prospect



Analysis of butanol production from agricultural wastes in Jiangsu Province



40 million tons of straw per year in JiangSu province

- Produce 2.6 million tons of butanol
- Save 2.2 million tons of gasoline
- Reduce 45.5 million tons of CO₂