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Hydrothermal Modification of Lignocellulosic Waste as Microbial Immobilization Carriers for Ethanol Fermentation

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Research Interest

- **Resource technologies for biomass waste**
- **Pollution control technologies for solid waste**
- **Life cycle assessment (LCA) of solid waste system**

Contributed over 50 articles in the field of solid waste, to journals including EST, BT, CEJ, WM, WMR, et al.

Outlines

- Lignocellulosic waste resources
- Microbial immobilization with natural carriers
- Hydrothermal modification of lignocellulosic carriers
- Physicochemical properties of modified carriers
- Immobilization performance of modified carriers

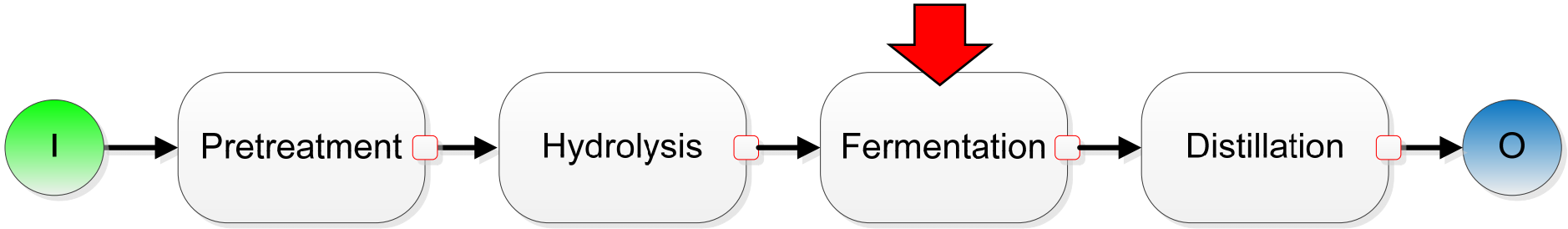
Lignocellulosic waste

- A promising source for bioenergy
  - Large amount of agricultural waste
  - Less than 50% has been reused or resourced

Crop stalks generated per year in China					
category	Agricultural output (Mt)	Straw factor	Straw generation (Mt)	Standard coal factor	Standard coal equivalent (Mt)
Rice straw	204.2	1	204.2	0.429	87.6
Wheat straw	121.0	1.17	141.6	0.500	70.8
Corn stalks	205.6	1.04	213.8	0.529	113.1
In total	530.9		559.7		271.5

Lignocellulosic waste

- Ethanol production from lignocellulosic waste
  - Feasibility and valuable product
  - Bottlenecks in lignocellulosic ethanol production



- Chemical:
  - Acid, Alkaline, Solvent
- Physicochemical:
  - Steam explosion, Hydrothermal, Ammonia related
- Biological:
  - Fungi, Enzymatic

- Microbe is hardly maintained as free state
- activity is easily inhibited by the toxic substances

(Sittijunda, 2013)

Ideas for microbial immobilization

- Microbial immobilization is an important solution
  - Biomass retainment
  - Protection from inhibitors
- Natural lignocellulosic carriers
  - Low cost, high strength, good surface property and no inhibition
  - Different kinds of lignocellulosic carriers show different physicochemical properties
  - Application of natural carriers such as rapeseed straw on ethanol fermentation has been reported

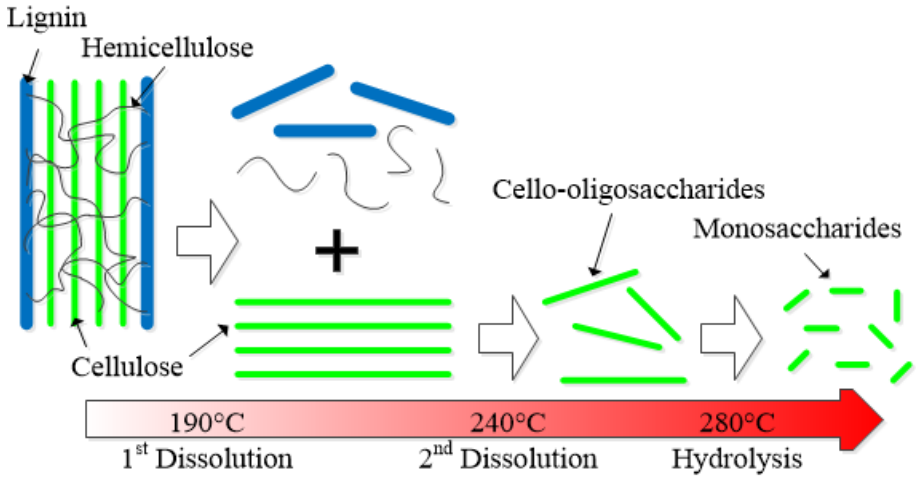
(Fang, 2011; Sittijunda, 2013)

Ideas for microbial immobilization

Modification of lignocellulosic carriers

- Improving immobilization performance by modifying structure, porosity and surface roughness
- Different approaches for modification

- Chemical:
  - Acid, Alkaline, Solvent
- Physicochemical:
  - Steam explosion, Hydrothermal, Ammonia related
- Biological:
  - Fungi, Enzymatic



(Park, 2015; Yan, 2012; Zhao, 2015)

Hydrothermal modification

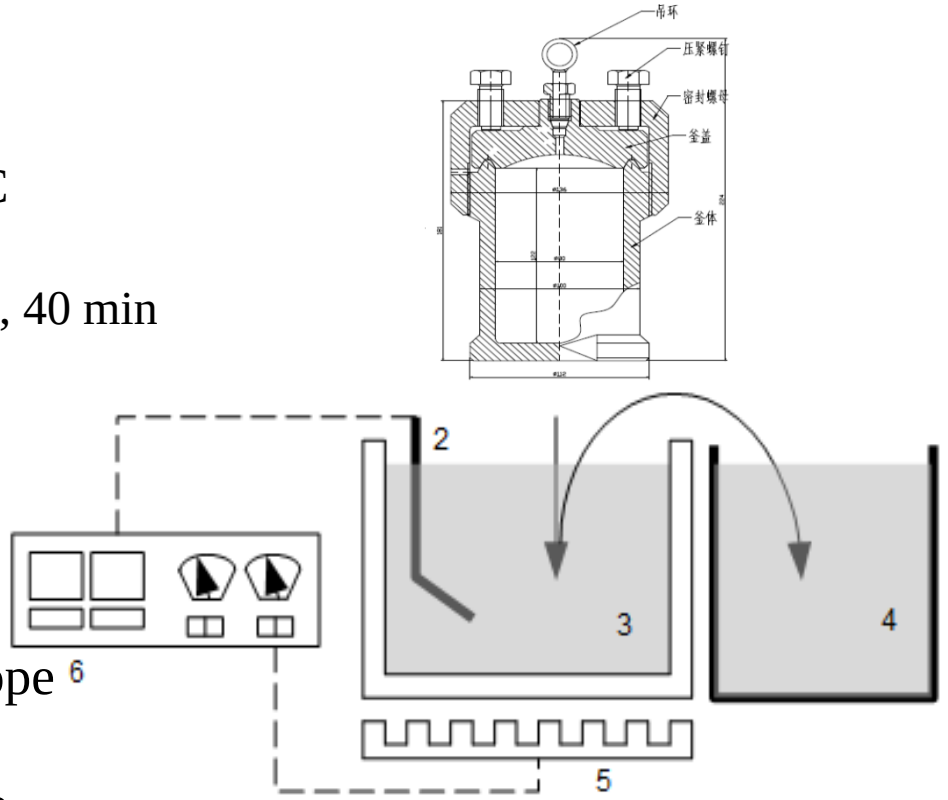
Experimental design

- **Corn stover**

- Temperature:
  - 190 ºC, 200 ºC, 210 ºC, 220 ºC
- Reaction time:
  - 5 min, 10 min, 20 min, 30 min, 40 min
- Size (diameter):
  - 0.5 cm, 1.0 cm, 2.0 cm

  - Specific surface area
  - Porosity property
  - Scanning electron microscope
  - Immobilization test

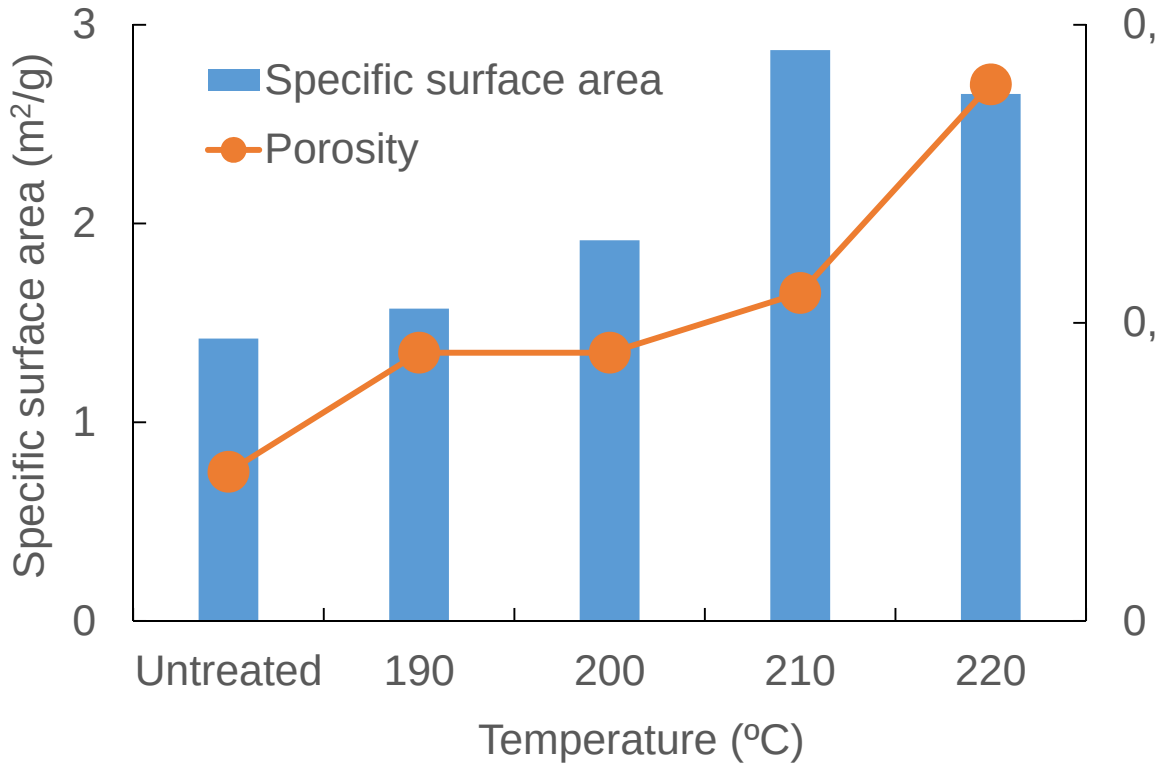
  with yeast and mixed culture

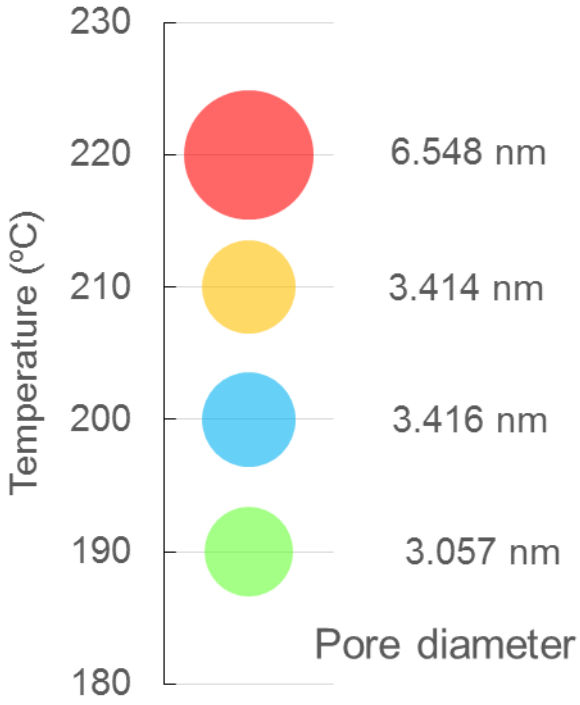


1. Reactor; 2. Thermocouple; 3. Salt bath; 4. Water cooler;
5. Electric heating elements; 6. Temperature controller.

Physicochemical property

Temperature effects on physicochemical properties

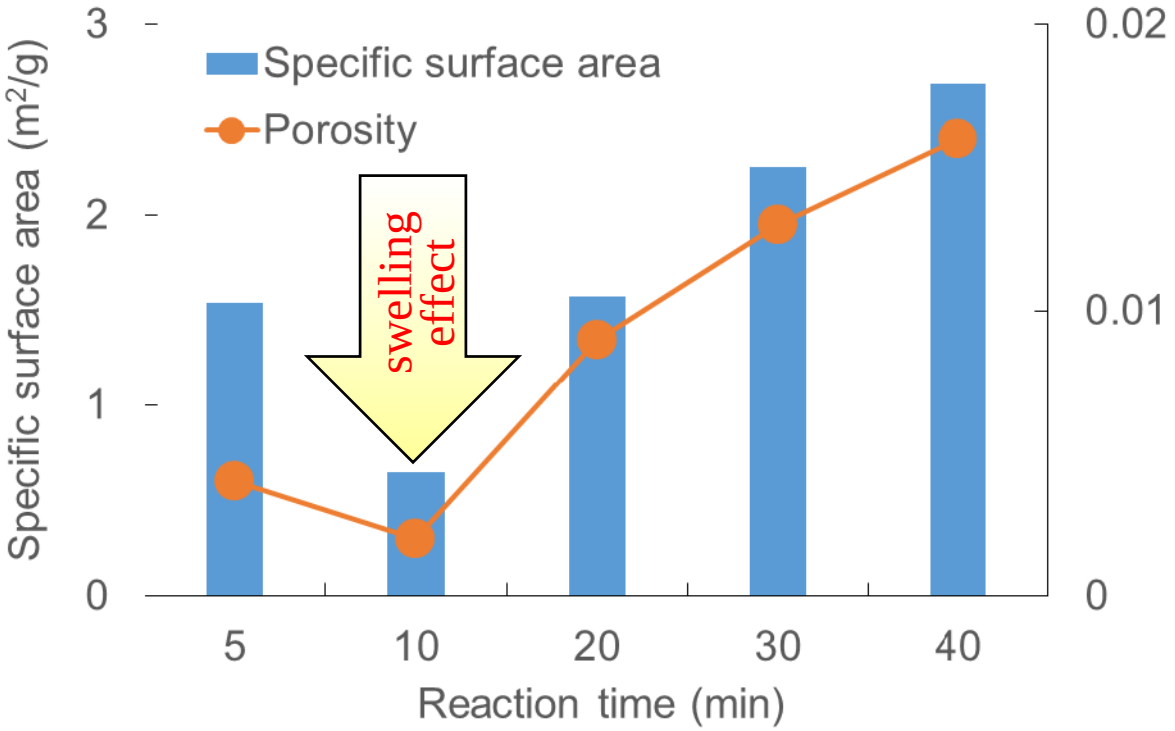


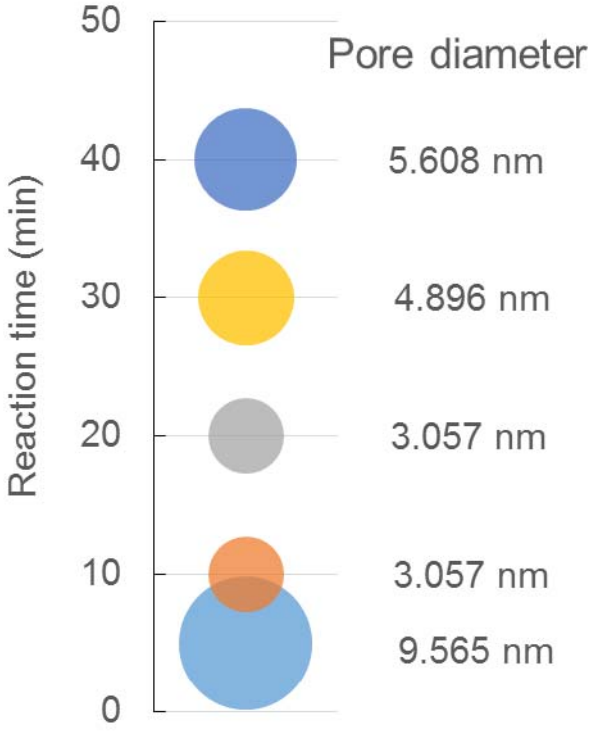


Reaction time: 20 min; Carrier size: 2.0 cm

Physicochemical property

Reaction time effects on physicochemical properties





Temperature: 190 ºC; Carrier size: 2.0 cm

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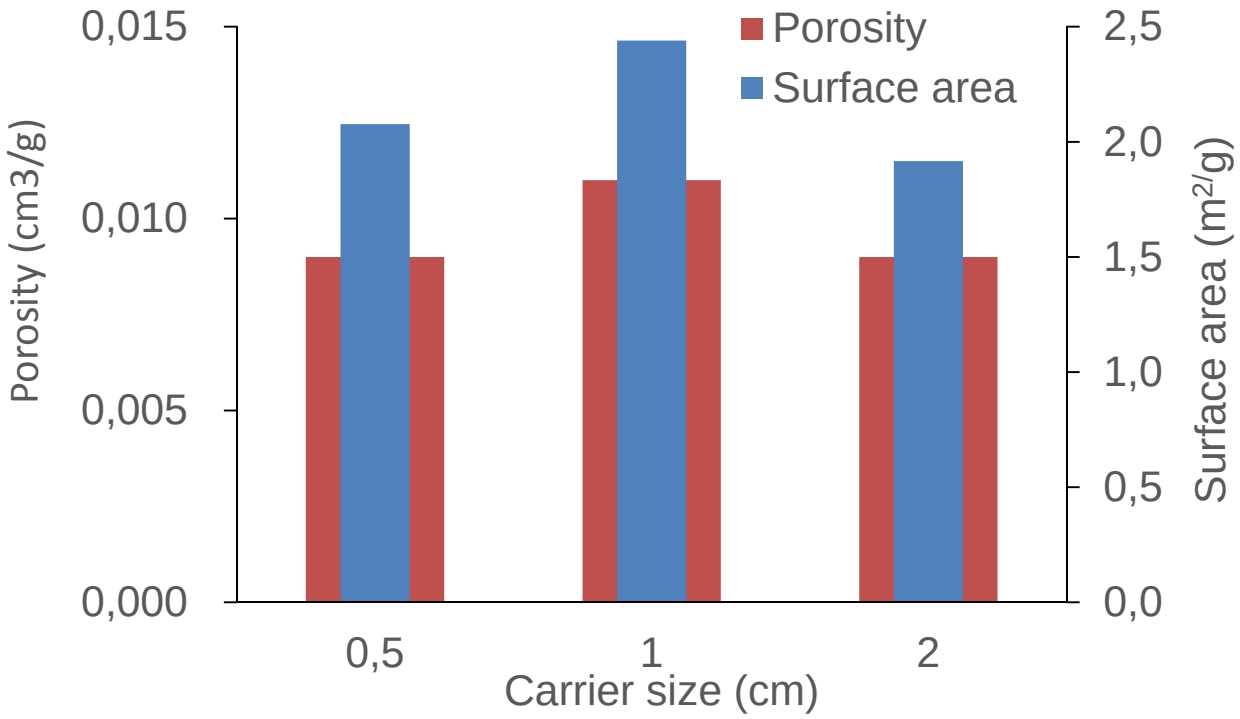
Physicochemical property

Physicochemical properties with different sizes



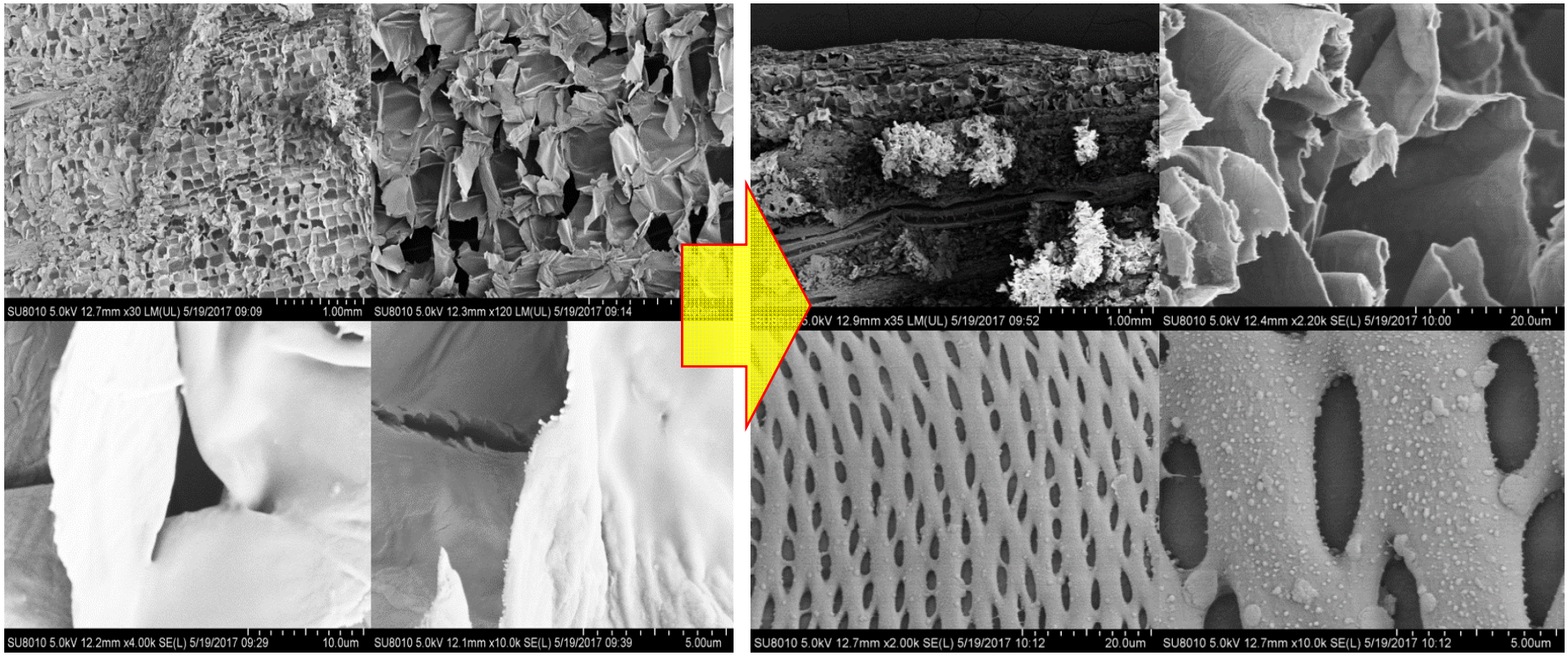
The surface area and porosity of the carriers can be increased to twice and triple respectively after hydrothermal modification

SEM observation

Pictures of untreated and modified carriers

Untreated carriers

Modified carriers

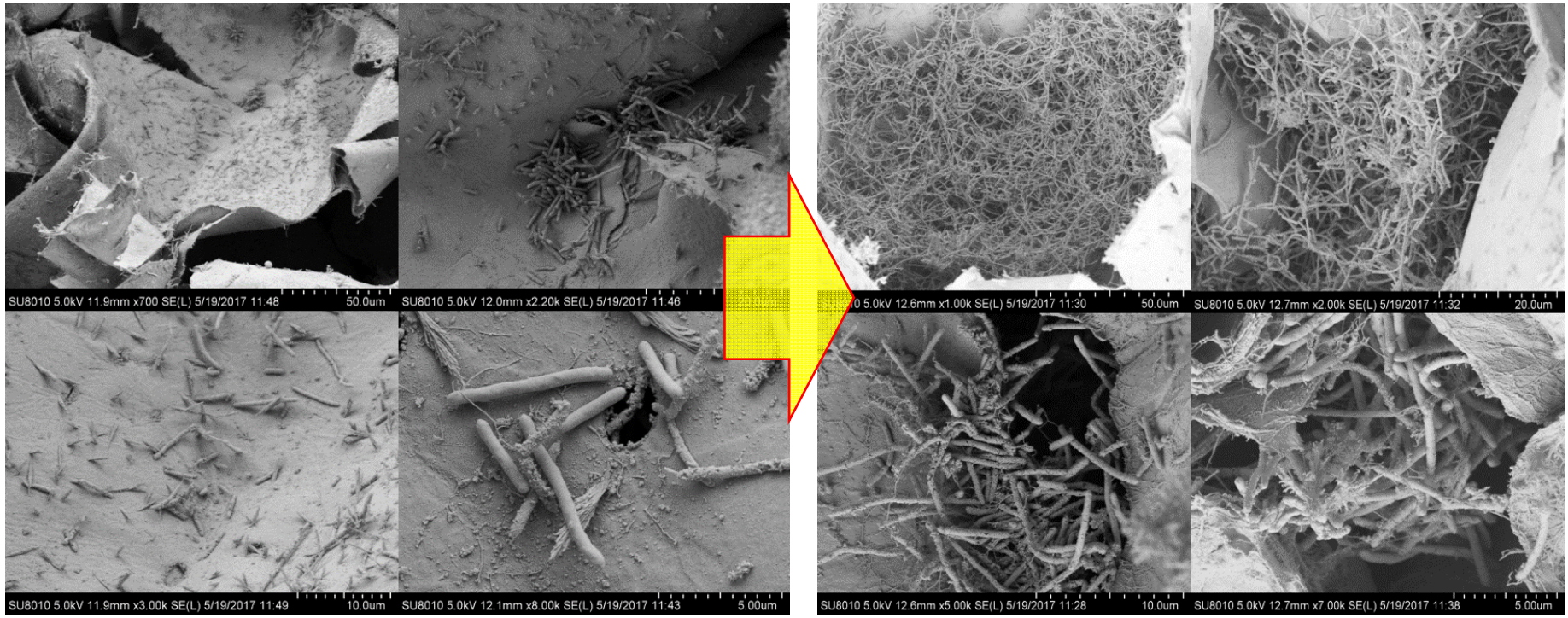


SEM observation

Pictures of untreated and modified carriers

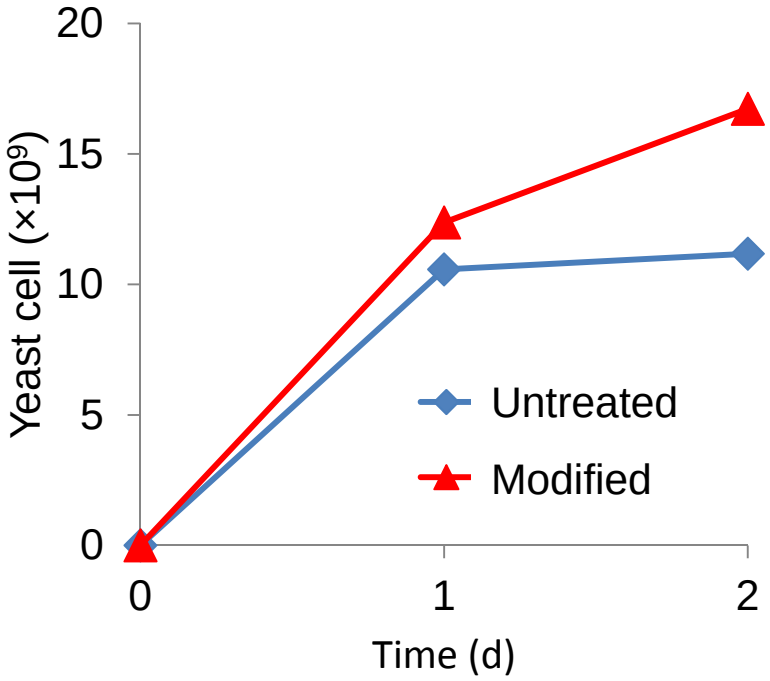
Bacteria immobilized on untreated carriers

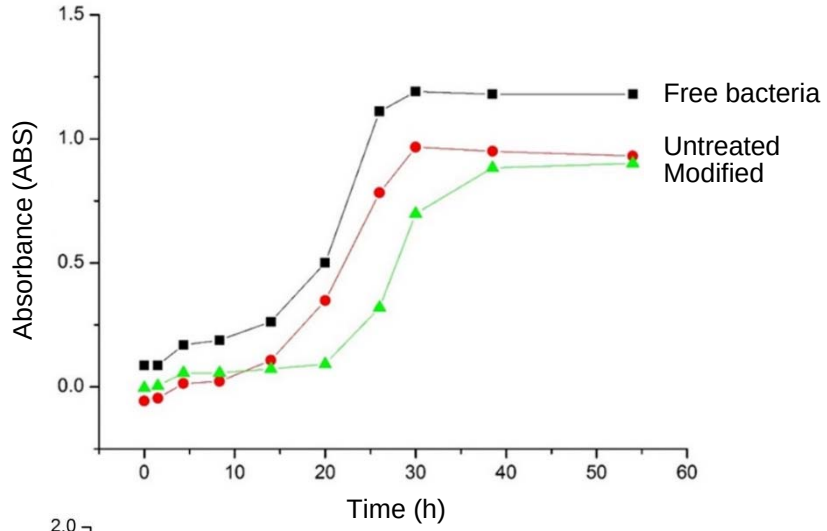
Bacteria immobilized on modified carriers

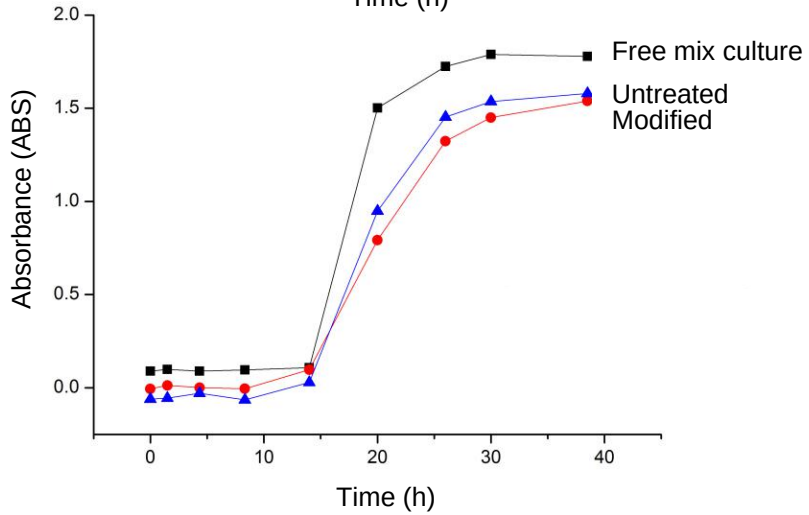


Immobilization performance

Immobilization of yeast and bacteria

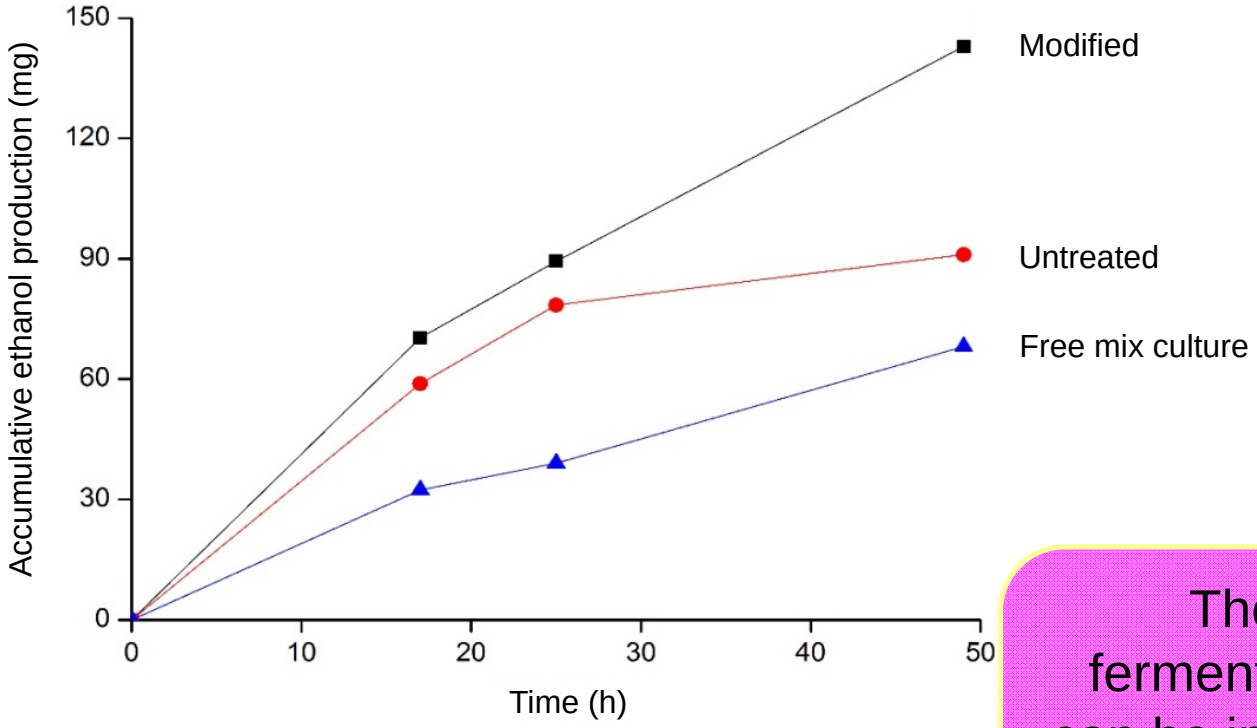






Immobilization performance

Fermentation performance with mix culture



The biomass and fermentation performance can be improved significantly by applying the hydrothermal modified carriers

Thanks for your attention!

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