High-performance Enzymatic Membrane Bioreactor based on Radial Gradient Pores PSf Membrane via Facile Enzyme Immobilization

Xue-Yan Zhu (21429008), Xiao-Jun Huang*

MOE Key Laboratory of Macromolecular Synthesis and Functionalization,

Department of Polymer Science and Engineering, Zhejiang University, Hangzhou 310027, China

Introduction

Enzymatic membrane bioreactors (EMBR), endowed with synergistic catalysis-separation performances, offer enormous potential for practical applications in recent decades. Conventionally, membrane properties and operating parameters play significantly important roles in catalysis-separation processes of these complicated and large-scaled systems.

Therefore, to achieve higher catalytic and filtration efficiencies, hollow fiber polysulfone microfiltration membranes with perfect radial gradient distributed pores were selected as substrates, and subsequently the enzyme-immobilization process was achieved in a facile way by pressure-driven filtration and crosslinking, to finally construct an enhanced EMBR system. Lipase from *Candida rugosa* was introduced as functional enzyme cross-linked by glutaraldehyde (GA), with the catalytic hydrolysis of glycerol triacetate as the model reaction. From the study, the whole EMBR system showed an excellent performance around 0.178 mmol min^{-1} g^{-1} under optimum operating conditions, indicating that not only the stability, but also the membrane activity of the EMBR obviously improved after microfiltration and crosslinking.

Back Ground

The Advantage of the EMBR

Enzyme Immobilization

- Bring enzyme stability
- Enable enzyme reuse
- Reduce process complexity
- Allow continuous operation
- Control catalytic process

Polymer Membrane

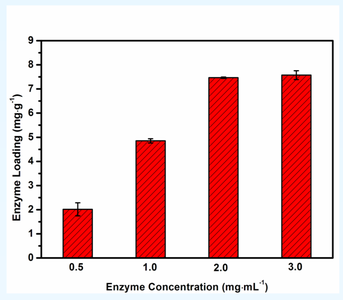
- Separation
- Different kinds
- Various morphologles

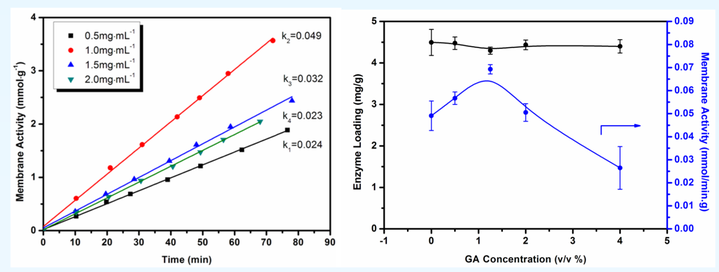
Enzymatic Membrane Reactors (EMBRs)

- Scale up easy
- Increase productivity
- Decline by-product formation
- Lower energy

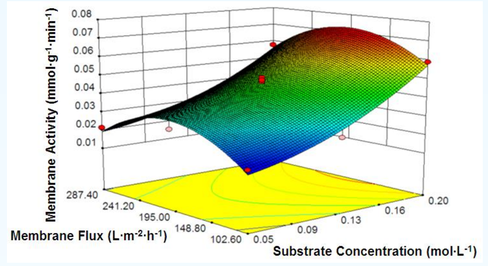
Performance Optimization

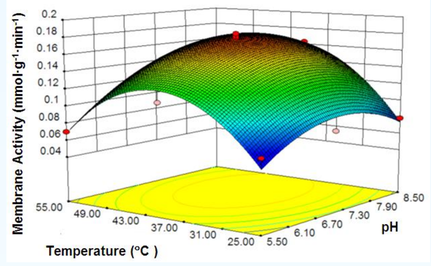
Immobilization Process Optimization





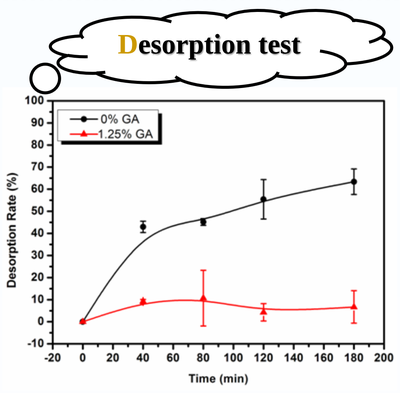
Catalytic Process Optimization

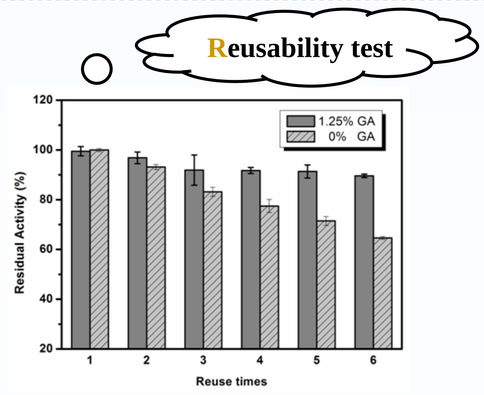




Catalytic efficiency

- ✓High enzyme loading
- ✓Durable enzyme aggregation
- ✓High mass transfer efficiency
- ✓Suitable temperature and pH

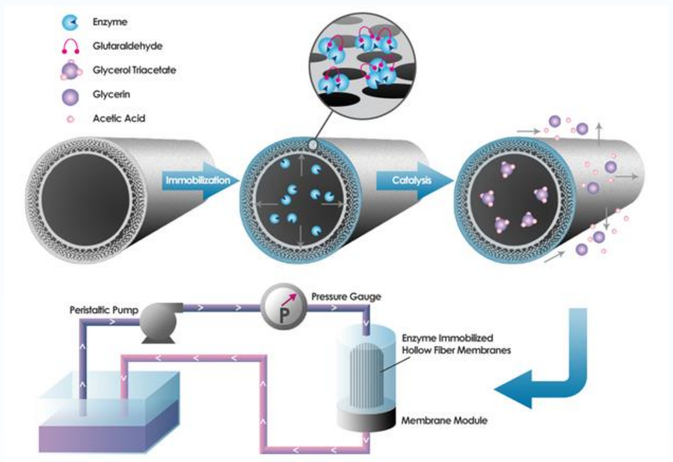




Enhancing stability of EMBR

Graphical Abstract

The Preparation Process of the EMBR



□ Filtration & Crosslinking

1 Pressure-driven filtration:
- Lipase buffer solutions;
- Dead-end filtration equipment

2 Crosslinking:
- Glutaraldehyde (GA) buffer solution;

Support material: PSF membrane with perfect radial gradient pores

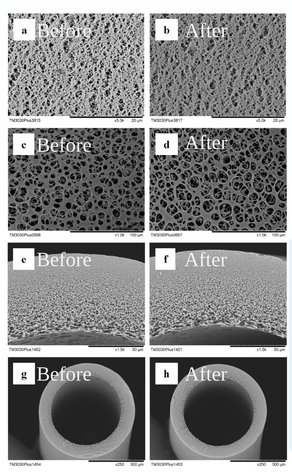
- ✓Low mass transfer resistance
- ✓High mechanical property

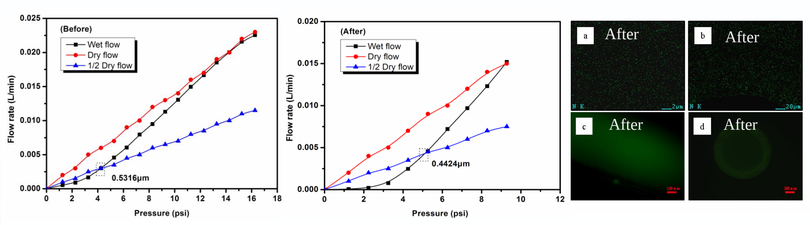
Immobilization technology :adsorption & crosslinking

- ✓ Simple preparation process
- ✓ Stable catalytic activity

Characterization

The Surface Morphology and Composition of Enzymatic Membrane





- ✓Morphology (SEM): perfect radial gradient pores;
- ✓Pore size (LLP): decreased from 0.5316 μm to 0.4424 μm;
- ✓Distribution (EDX): distributed evenly and continuously;

Results

- A lipase-immobilized membrane bioreactor with enhanced performance was prepared by immobilizing lipase in/on the PSF hollow fiber microfiltration membrane with radial gradient distributed pores through filtration and crosslinking.
- The whole EMBR system showed an excellent performance around 0.178 mmol min^{-1} g^{-1} under optimum operating conditions, indicating that not only the stability, but also the membrane activity of the EMBR obviously improved after microfiltration and crosslinking.
- This simple and low-cost approach to fabricate high-performance EMBR offers great potential as applications for various lipase-catalyzing reactions in industrial productions.

Acknowledgments:

National Natural Science Foundation of China（Grant no. 51473143）
National Natural Science Foundation of China（Grant no. 21274126）

Reference:

[1] P. Jochems, Y. Satyawali, L. Dielsab and W. Dejonghea, *Green Chem*, 2011, **13**, 1609.

[2] J. K. Poppe, R. Fernandez-Lafuente, R. C. Rodrigues and M. A. Z. Ayub, *Biotechnol Adv*, 2015, **33**, 511.

[3] X Y Zhu, C Chen, P C Chen, Q L Gao, F Fang, J Li, X J Huang, *RSC Adv*, 2016, **6**, 30804.