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

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

The Preparation Process of the EMBR:
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

Immobilization technology: Adsorption & crosslinking

Characterization
The Surface Morphology and Composition of Enzymatic Membranes

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

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;

Immobilization Process Optimization
- High enzyme loading
- Catalytic efficiency
- High mass transfer efficiency
- Durable enzyme aggregation
- Suitable temperature and pH

Enzymatic Membrane Reactors (EMBRs)

Scale up easy
Increase productivity
Less energy

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.

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