# Modularization of Ceramic Hollow Fiber Membrane Technology for Air Separation

DE-FE0031473

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# Projection Objective and Tasks

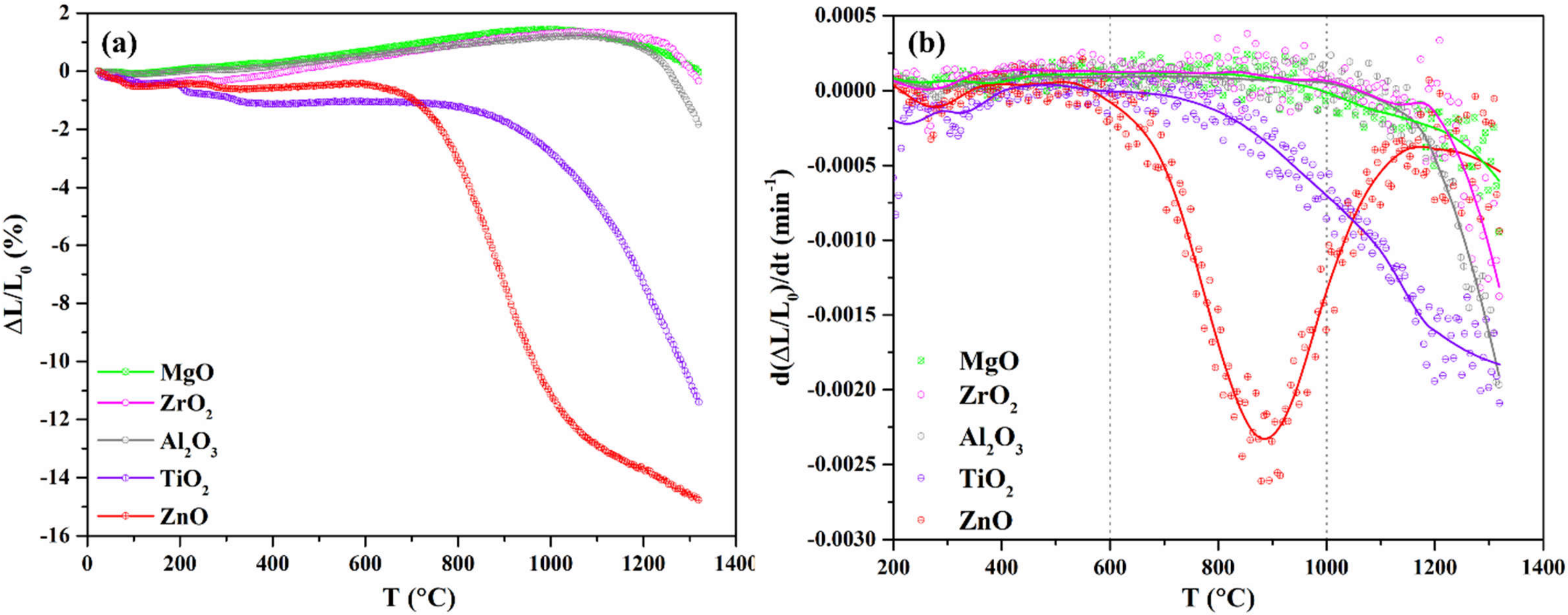
## Objective:

Develop membrane stack and module for air separation and oxygen production using ceramic hollow fiber membrane technology

## Strategic alignment of project to Fossil Energy objectives

- **Cost of Energy and Carbon Dioxide (CO2) Capture**
  - Using pure oxygen instead of air for combustion of power plant produces CO2, no need to separate nitrogen from down stream;
  - Can reduce the cost and simplify the system for CO2 capture.
- **Power Plant Efficiency Improvements**
  - Pure oxygen instead of air increases efficiency of power plant;
  - Cost-effective, reliable technologies to improve the efficiency of coal-fired power plants.

# Fabrication of Membranes



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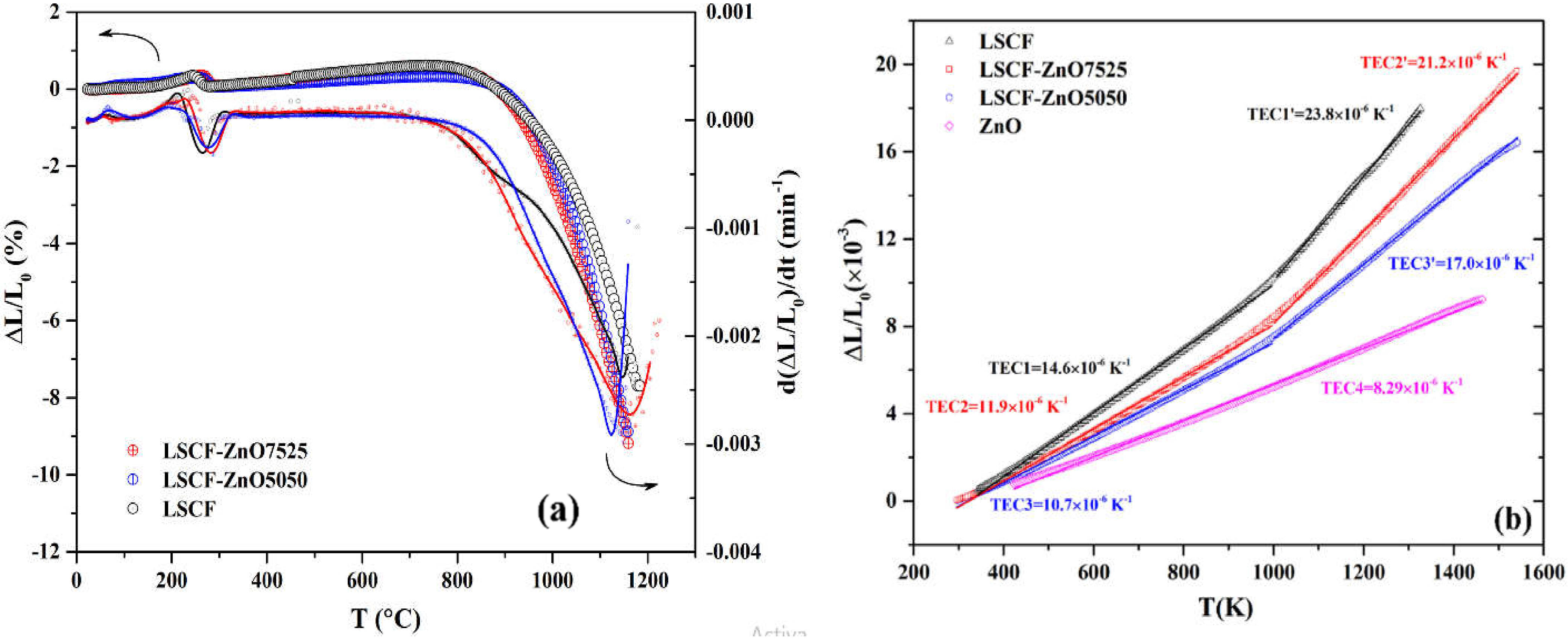

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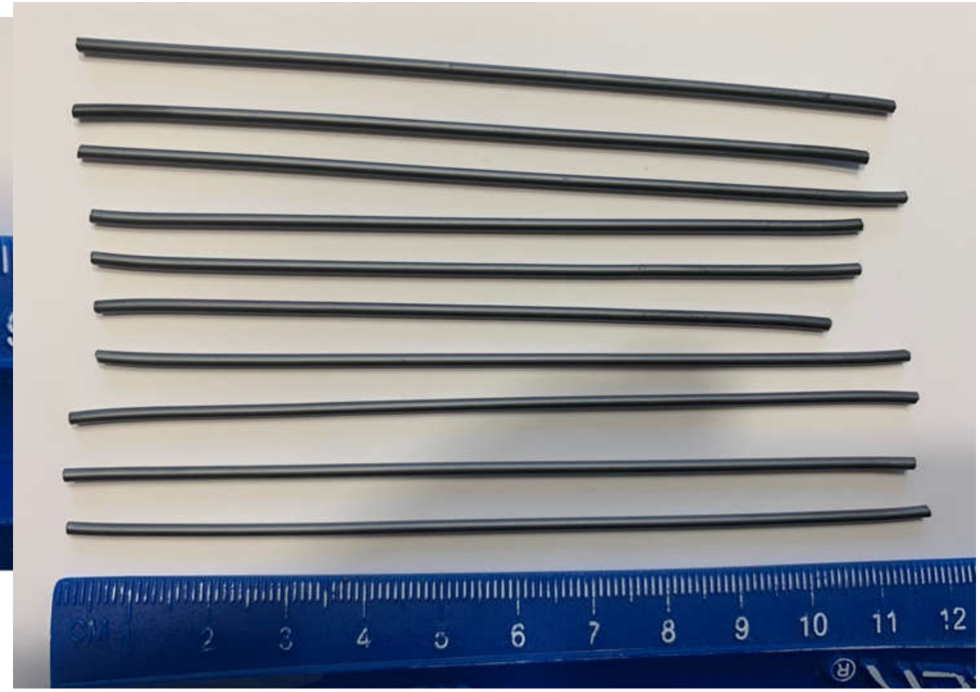
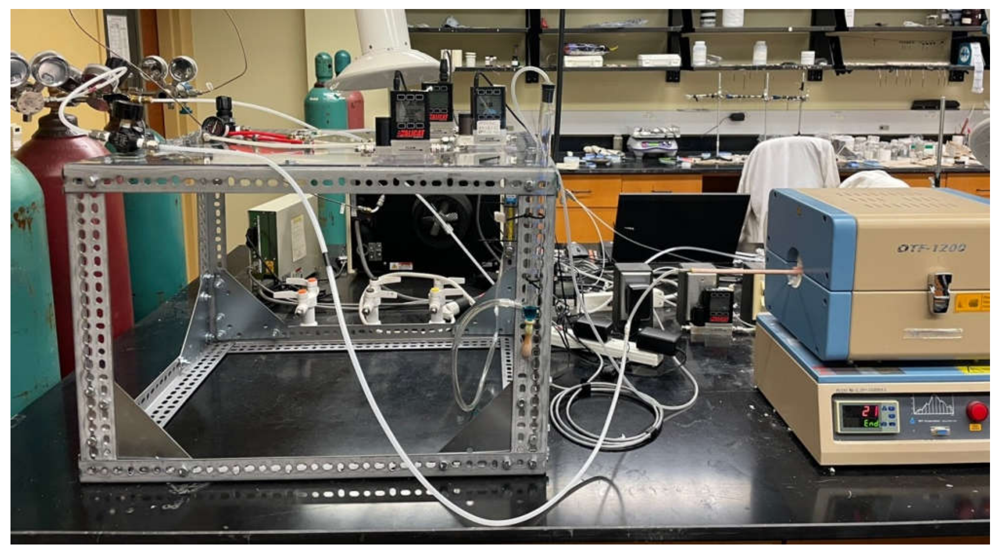
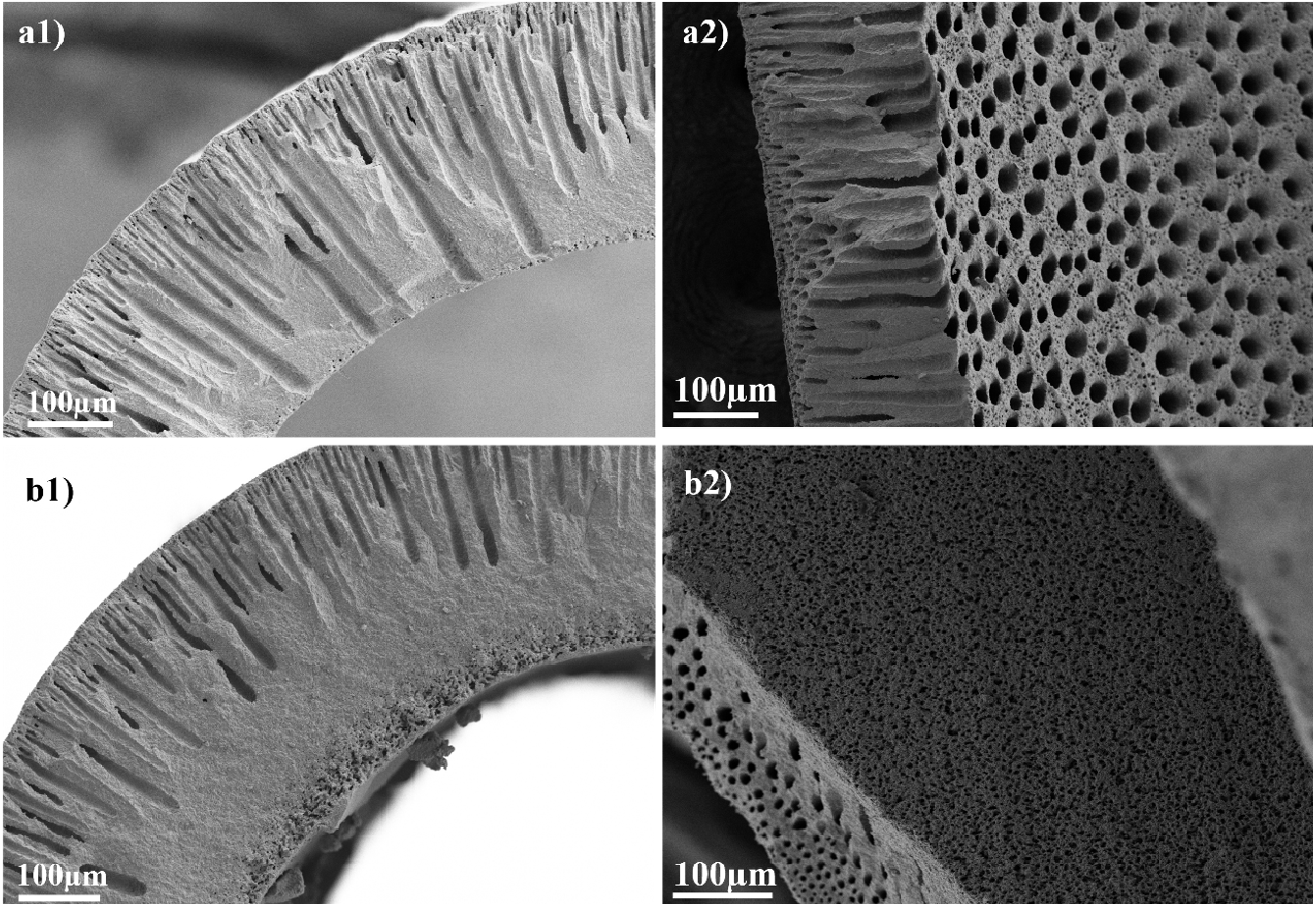
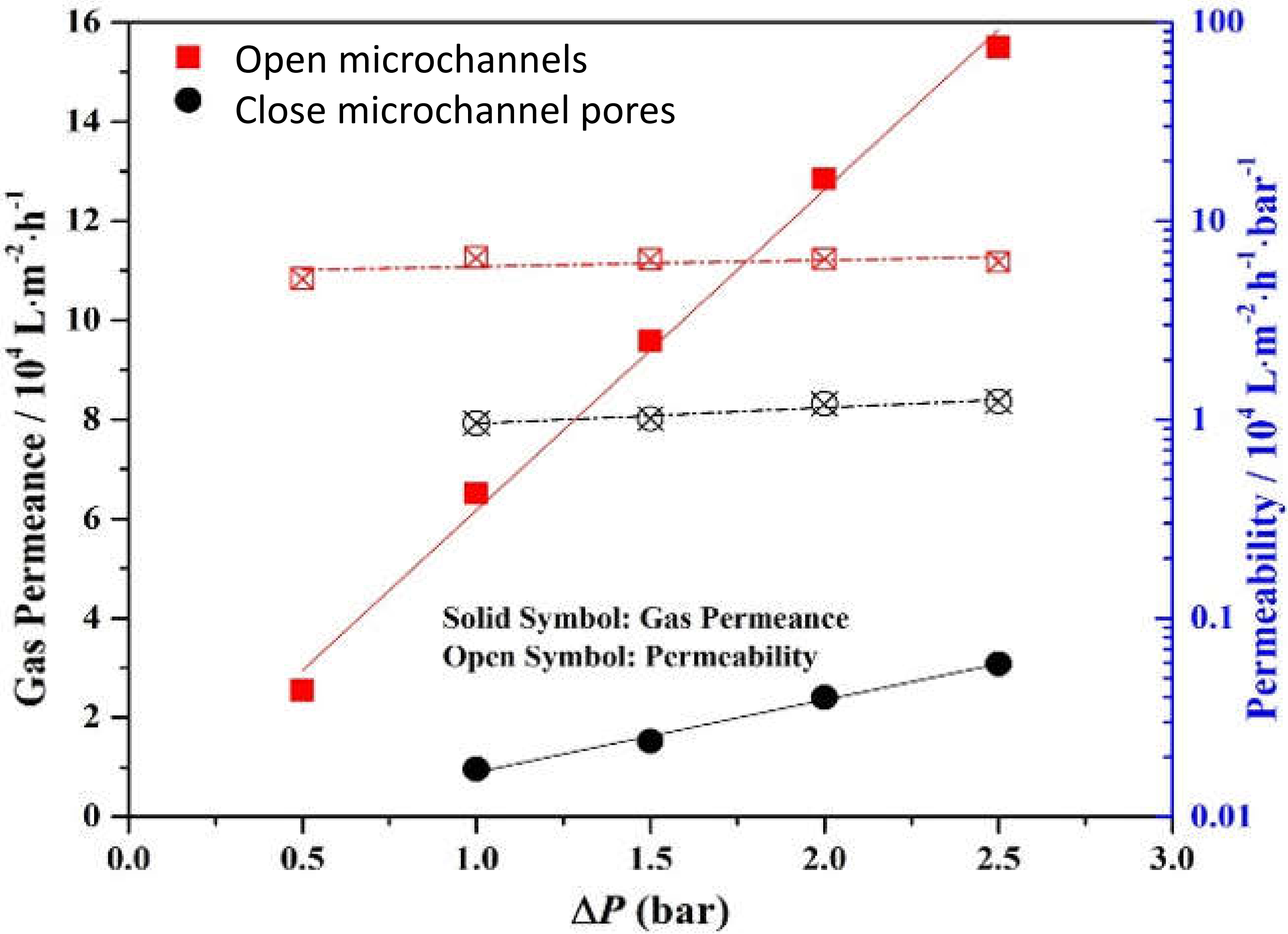




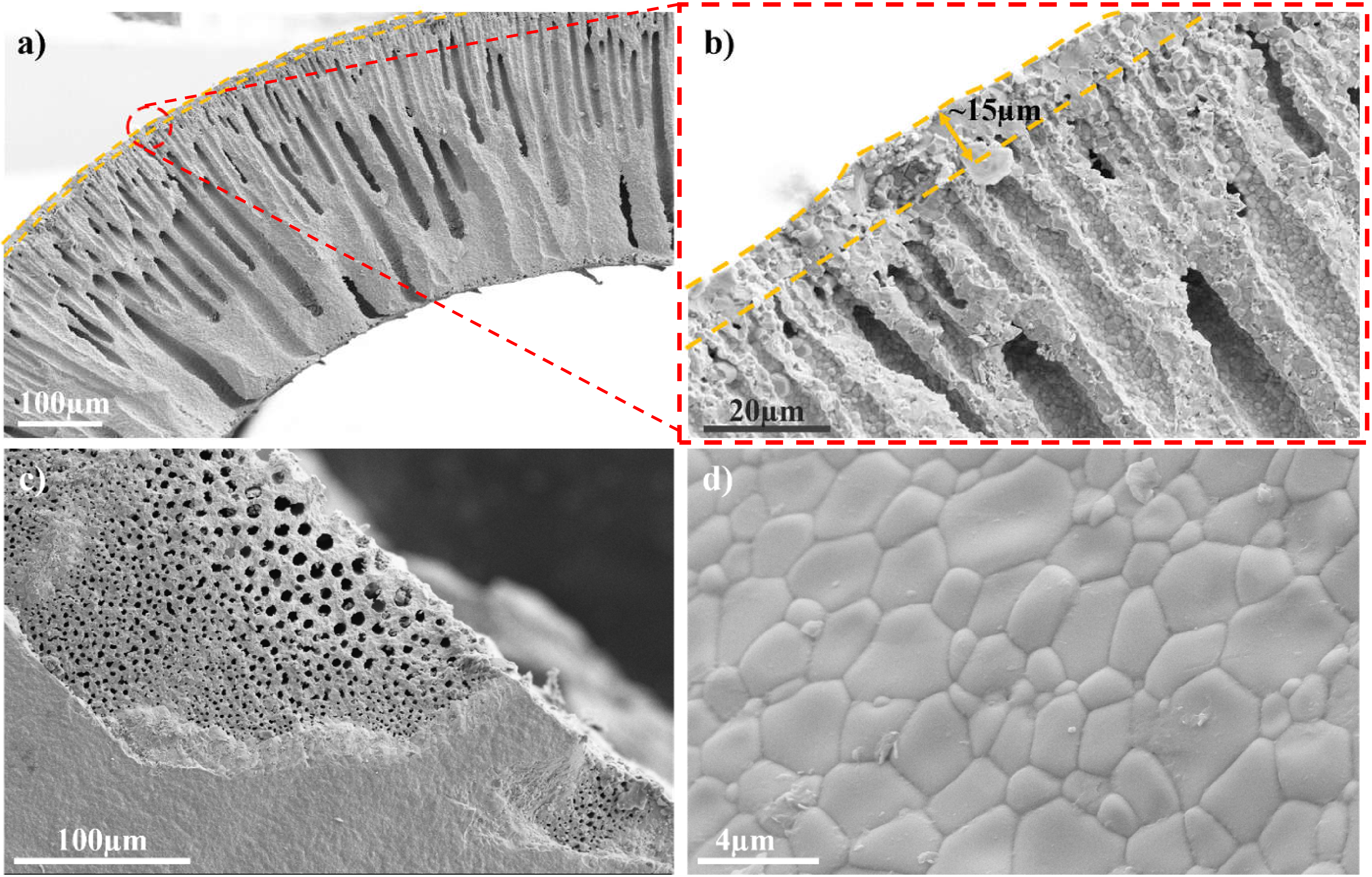
# Characterization of Membranes



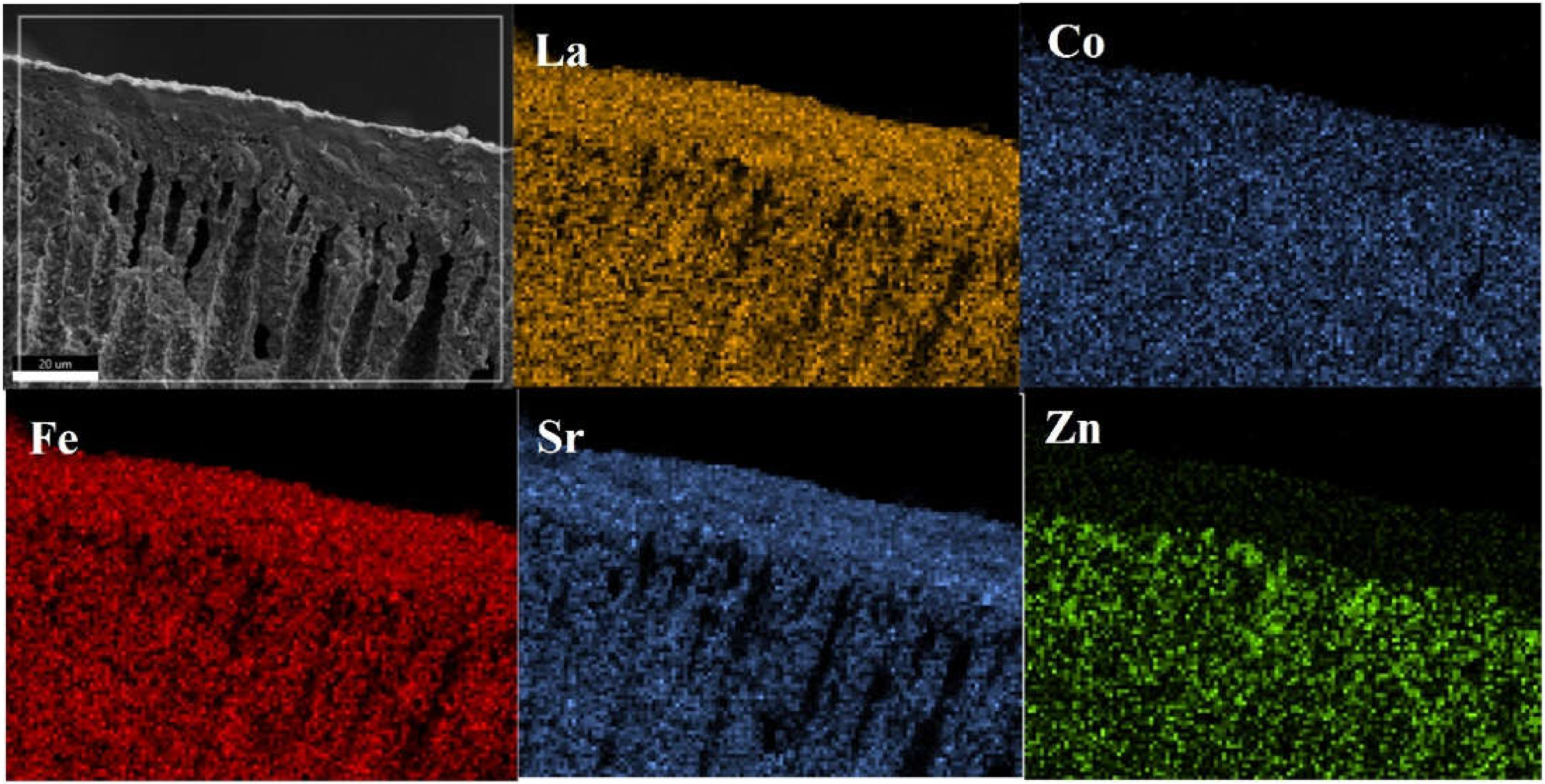
# Gas Diffusion Performance of Substrate



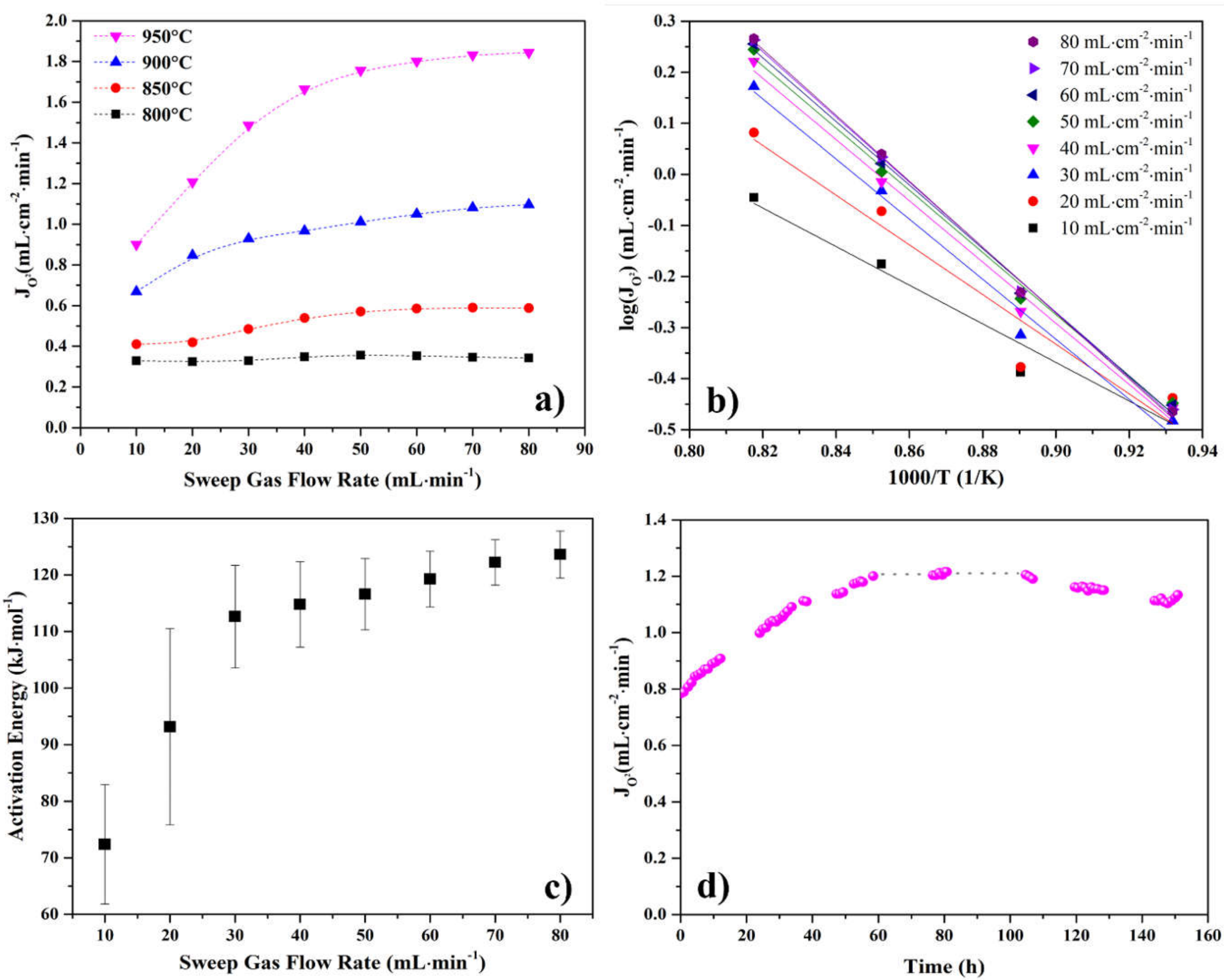
# Microstructure of Membrane Device



# EDS Analysis of Membrane



# Oxygen Permeation Performance



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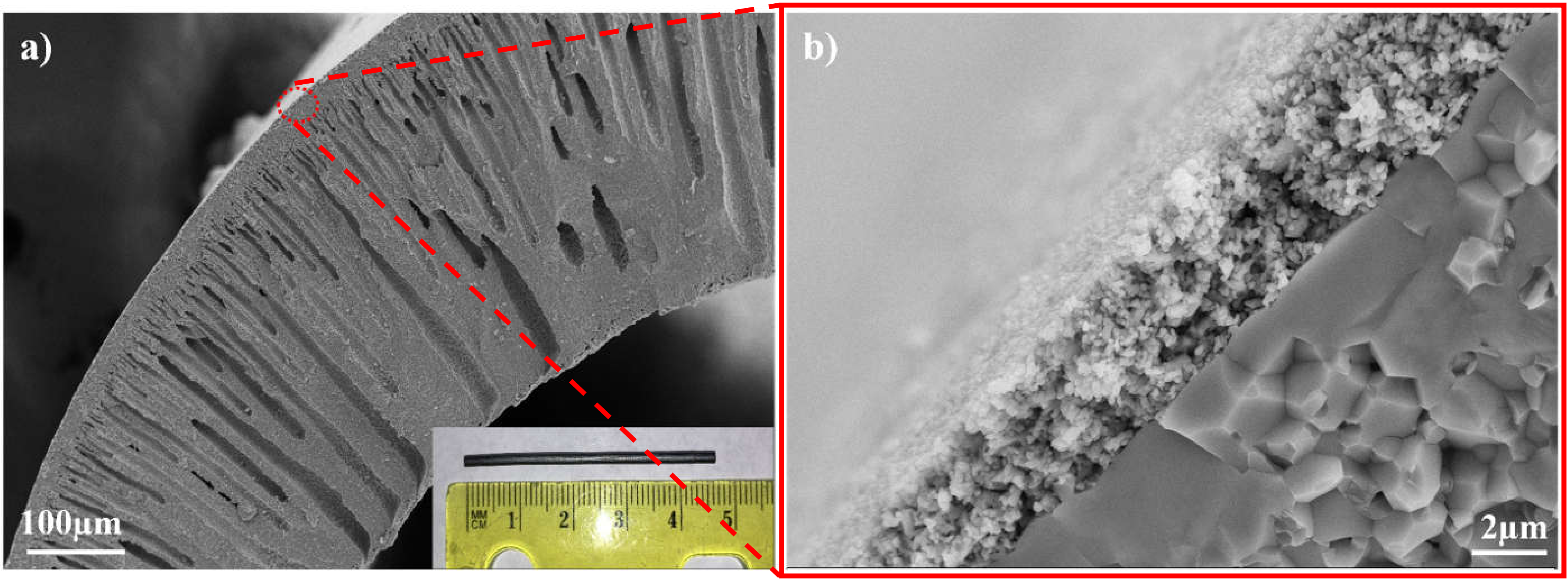

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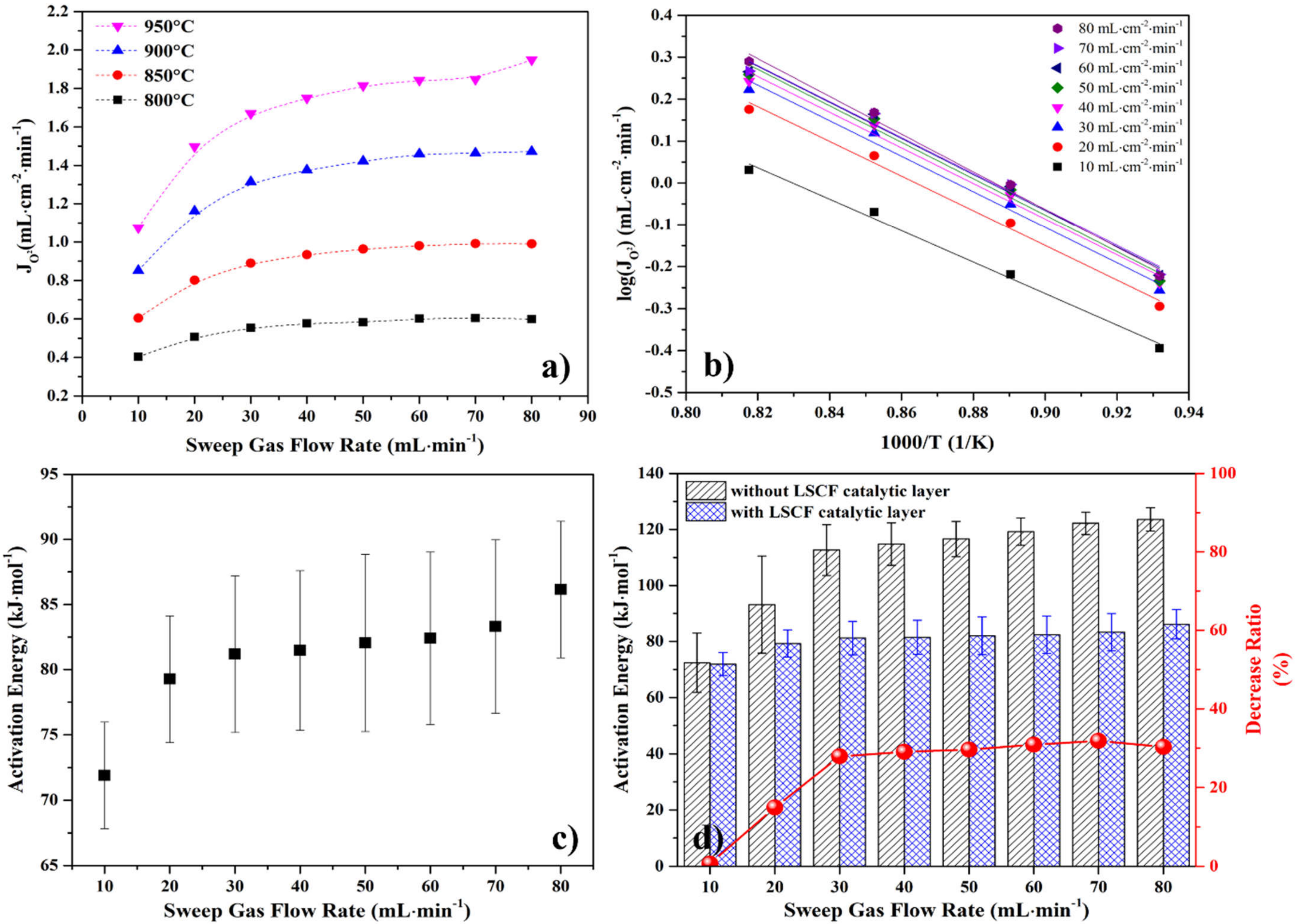
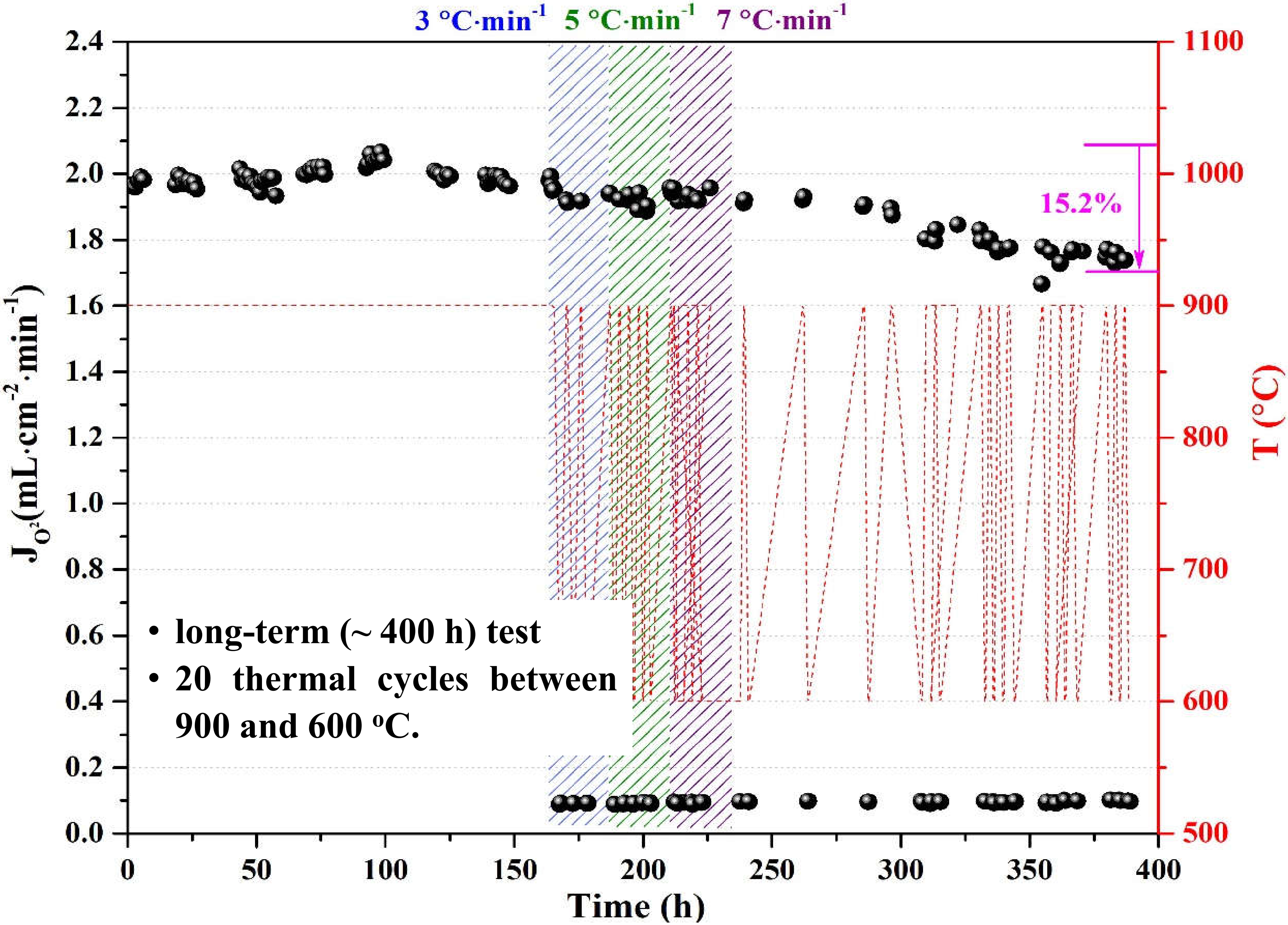
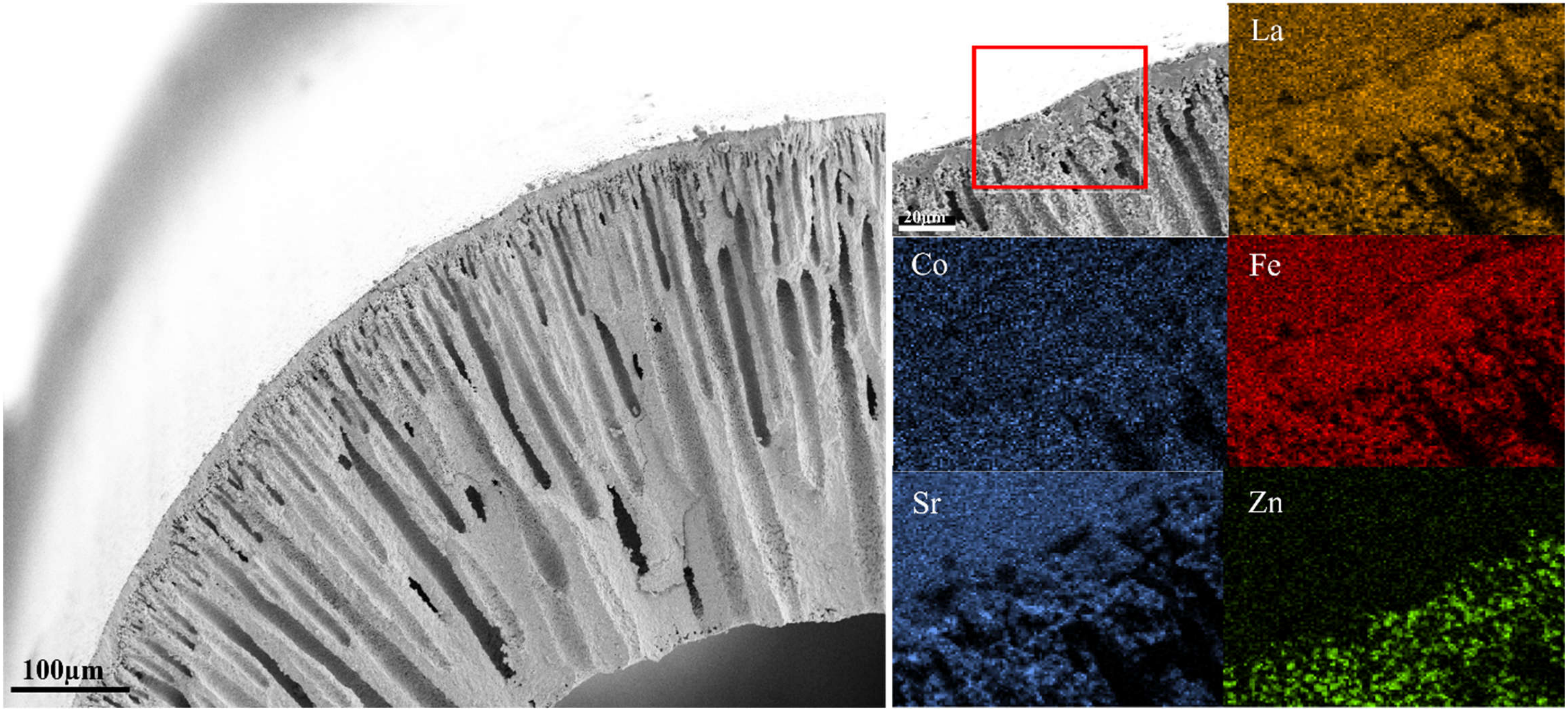


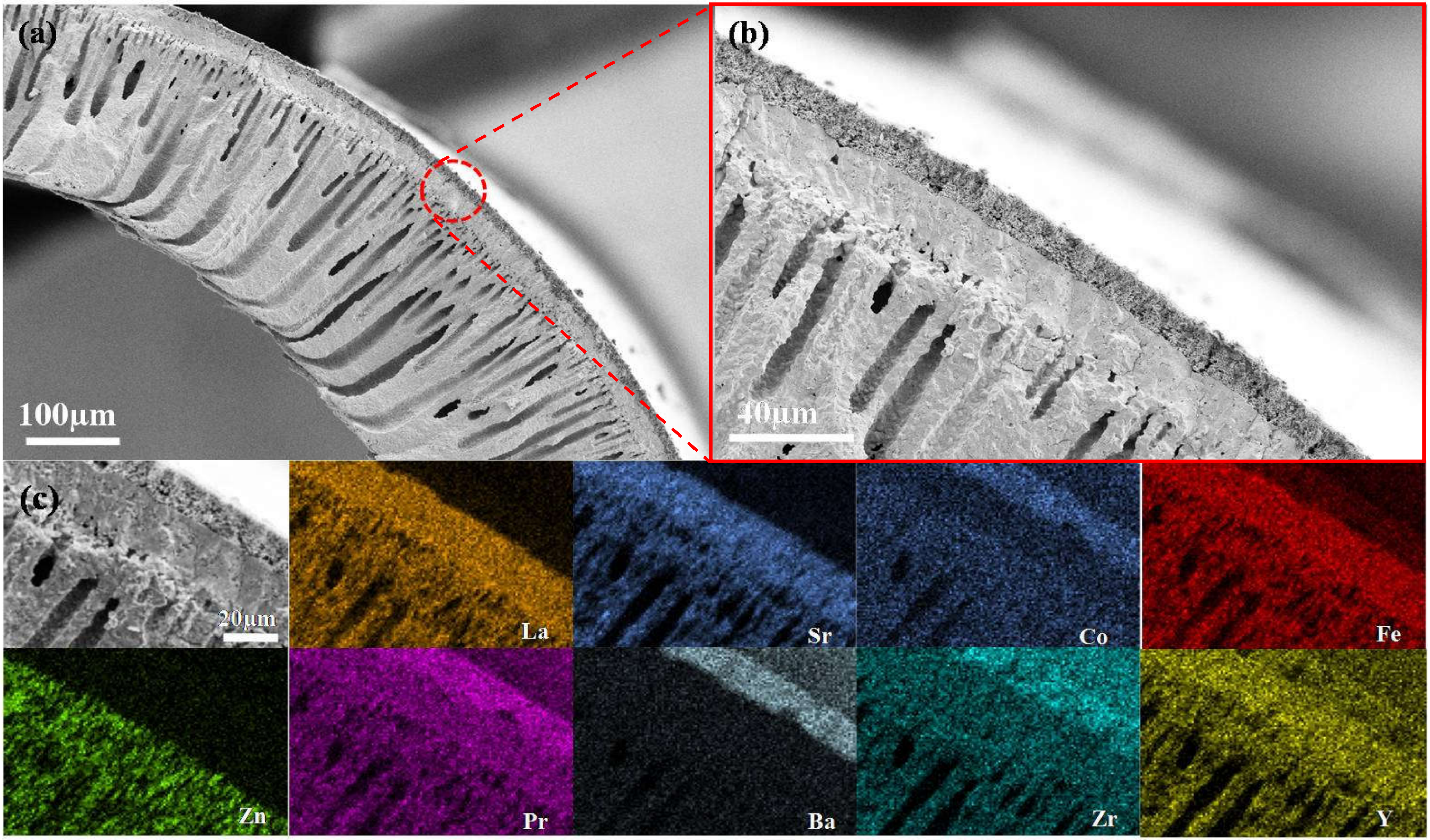
# Long-Term Stability of Membrane



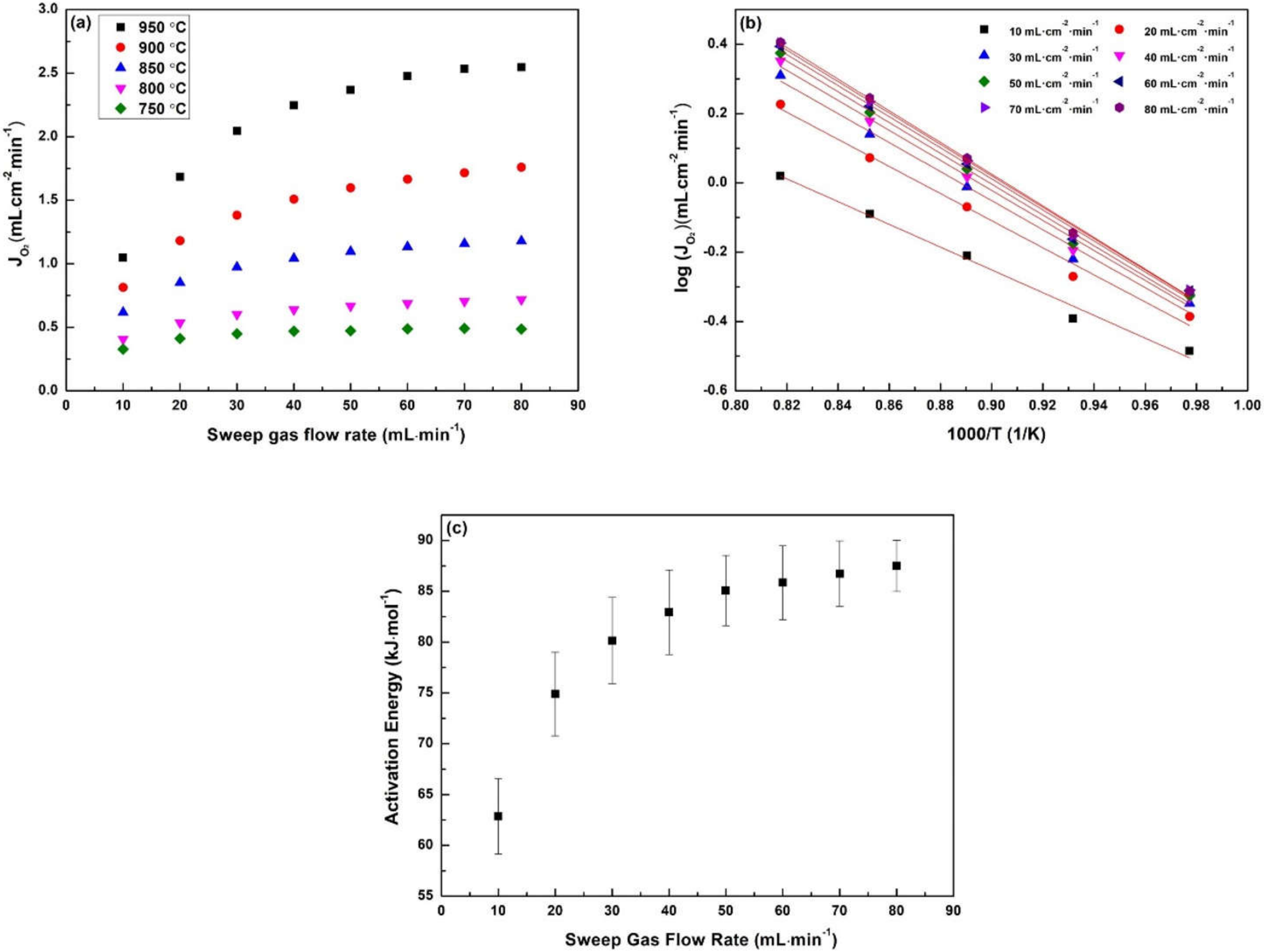
# Characterization of membrane after stability test



# Membrane with Different Surface Catalyst



# Oxygen Permeation Performance

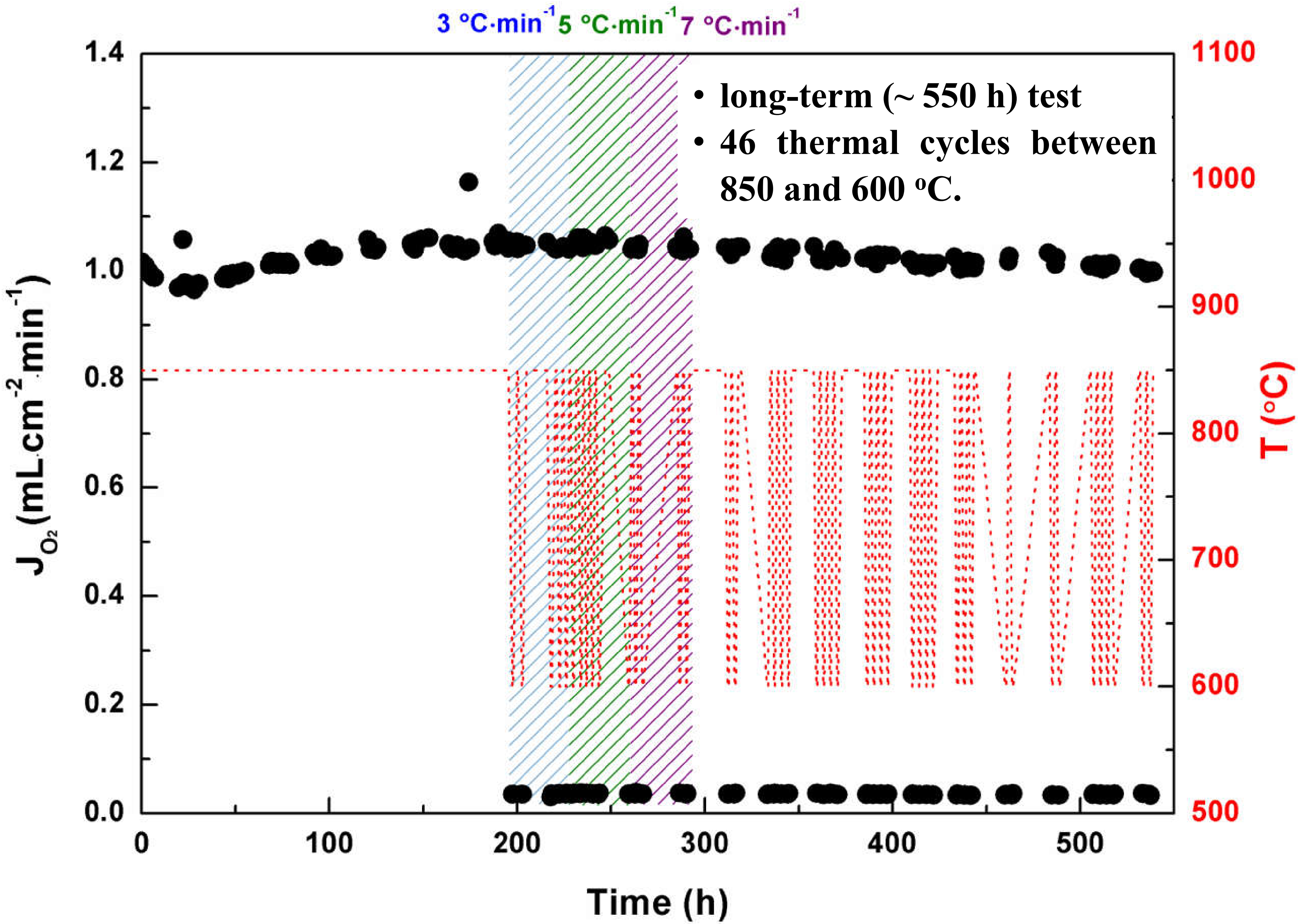


# Performance Comparison

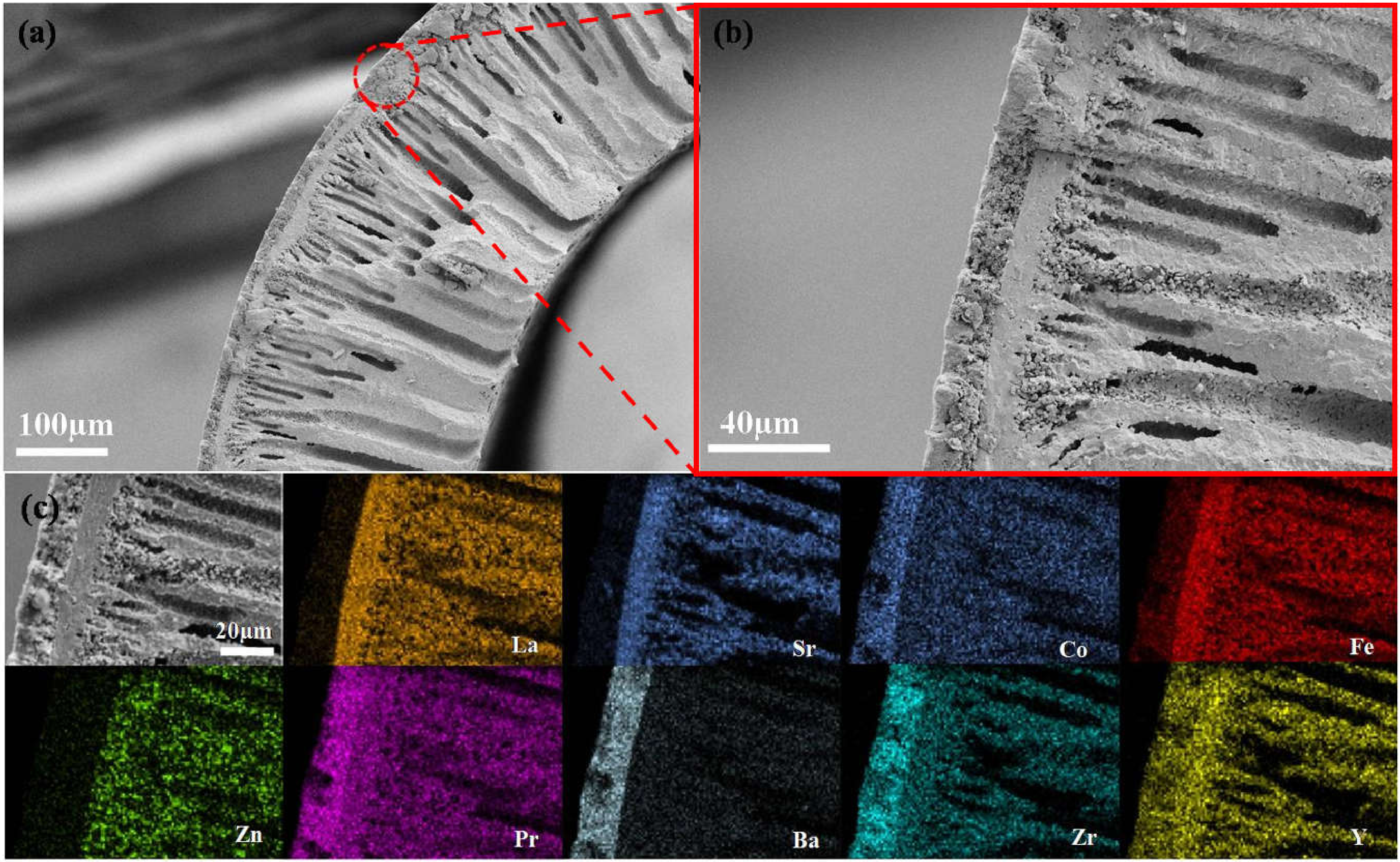
| Reference | Surface catalysts | Dense layer thickness (μm) | Sweep gas | $J_{O2}$ (mL/cm²/min) |
|---|---|---|---|---|
| This work | $PrBaCo(Fe_{0.6}Zr_{0.2}Y_{0.2})O_{5+\delta}$ | 20 | Ar | 1.76 |
| [1] | HCl | 40 | He | 0.6 |
| [2] | LSCF | 40 | He | 1.5 |
| [3] | None | 88 | He | 1.4 |
| [4] | Pt | 100 | Ar | 1.1 |
| [5] | None | 300 | He | 0.3 |
| [6] | $Ba_{0.5}Sr_{0.5}Co_{0.9}Nb_{0.1}O_{3-\delta}$ | 530 | He | 0.7 |
| [7] | LSCF | 710 | He | 1.0 |
| [8] | $(La_{0.5}Sr_{0.5})_2CoO_{4+\delta}$ | 750 | He | 0.9 |

- **Thin film separation layers do improve oxygen permeation flux**

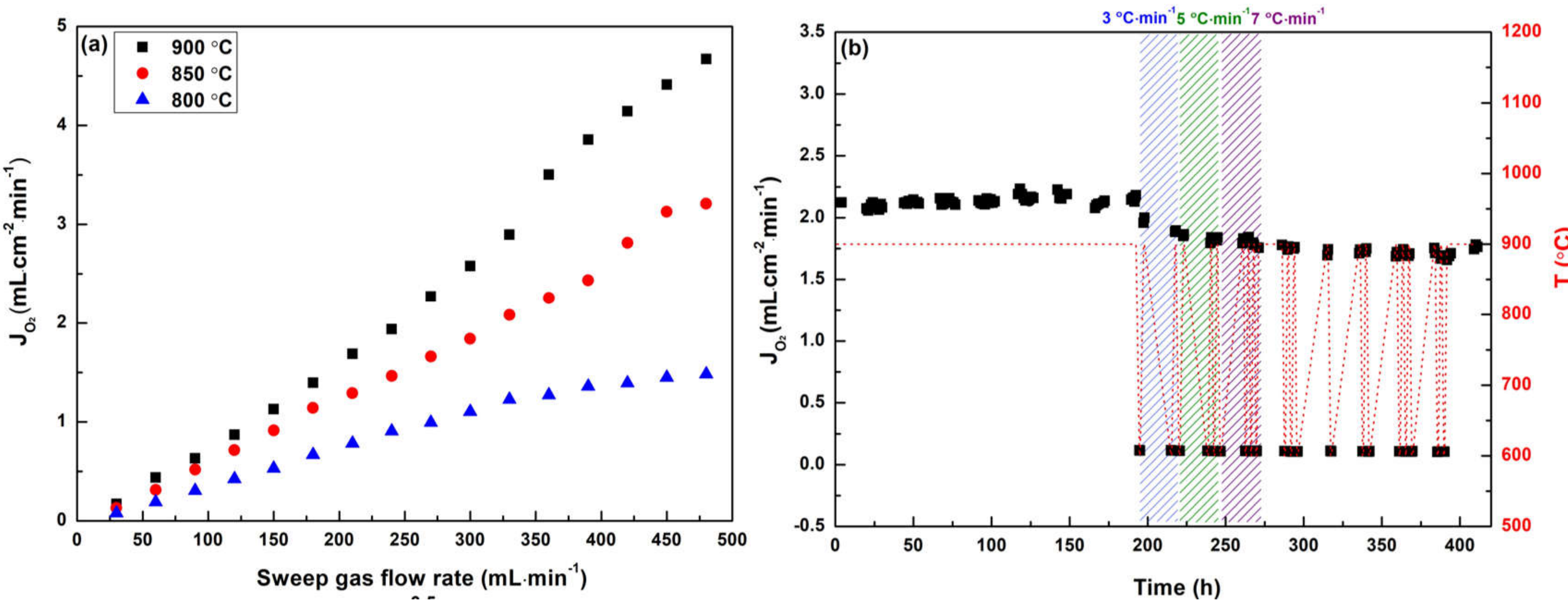
# Accelerated Long-term Stability



# Characterization after Long-term Stability Test

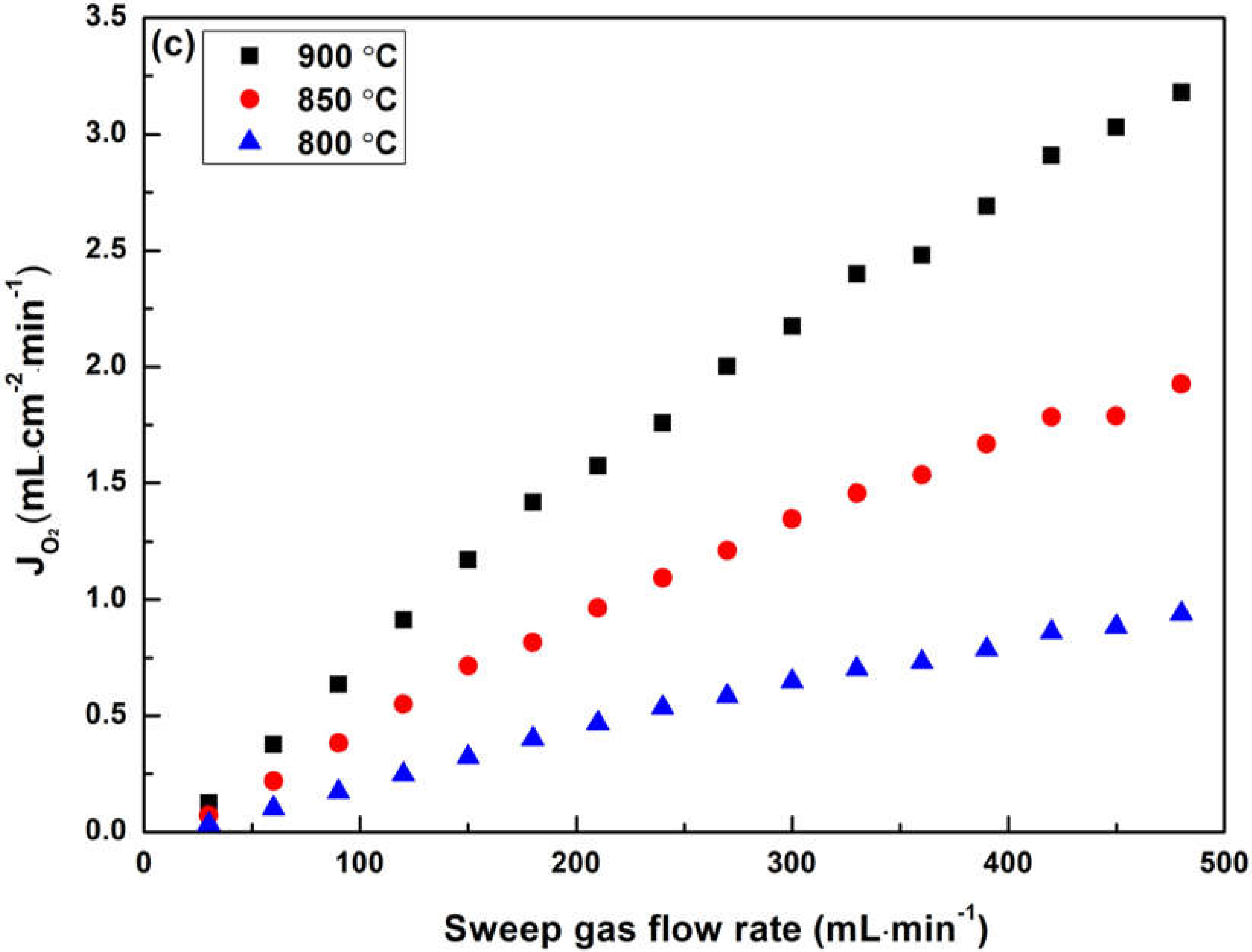


# Membrane Stack Test



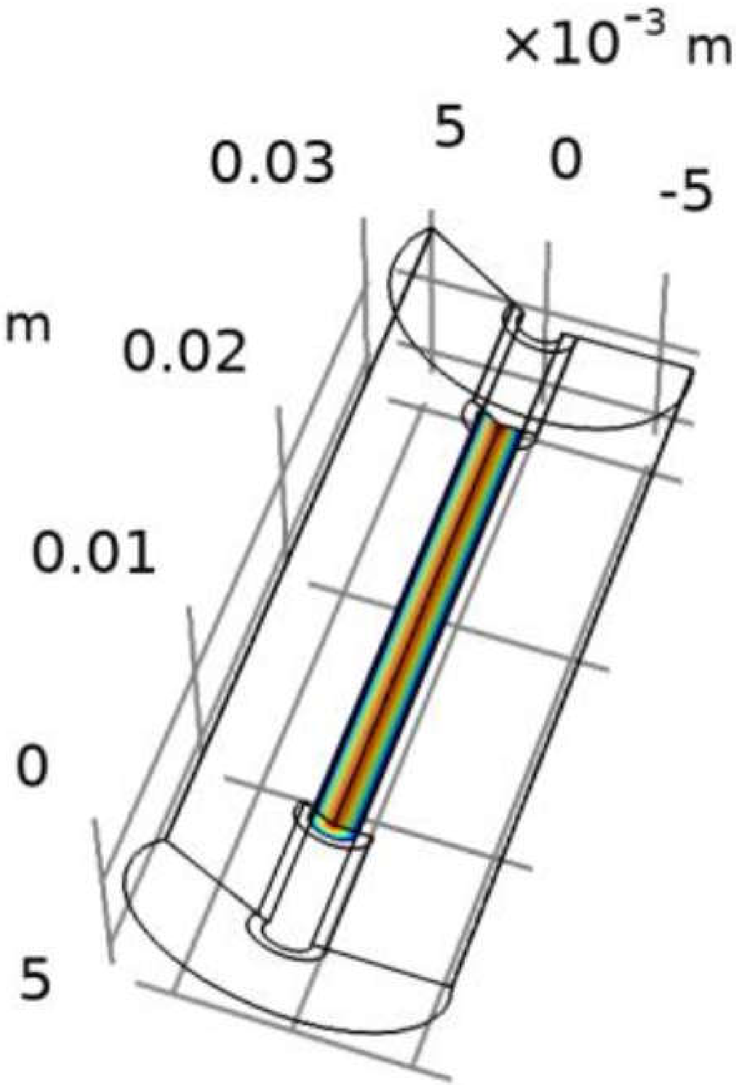

- Proof of concept;

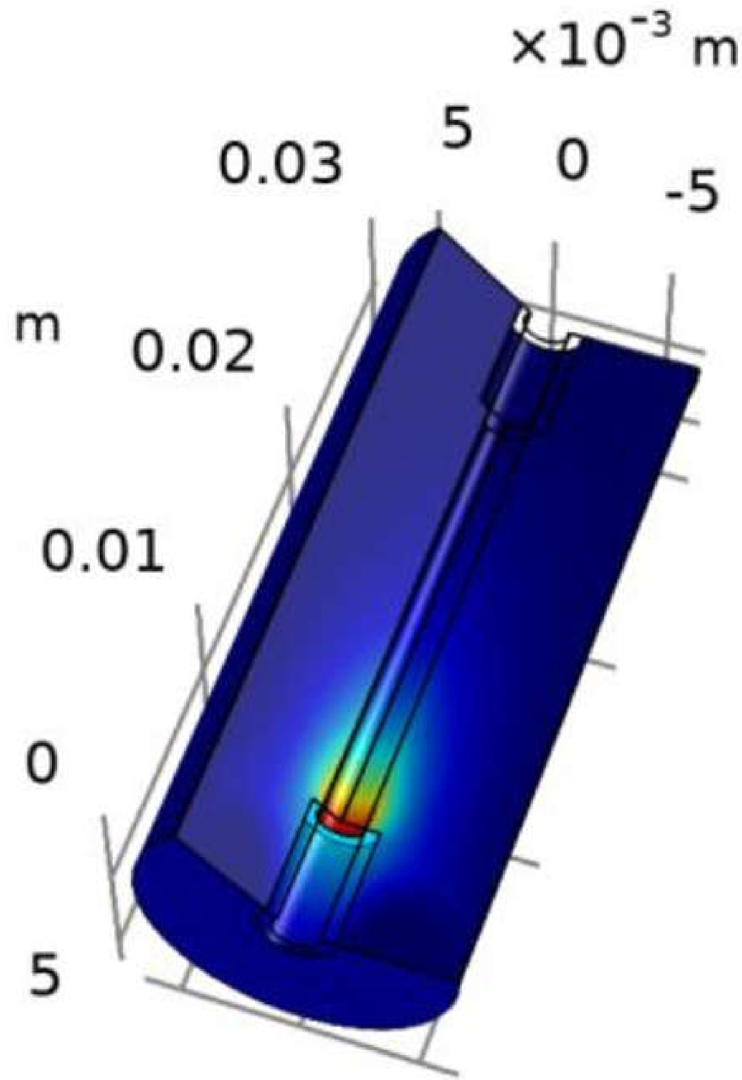
# Membrane Stack Test




- Performance after long-term stability test;
- New membrane stack is being fabricated;
- Further stack test will be conducted;
- Accelerated long term stability test is still running.

# Multiphysics Modeling of Membrane



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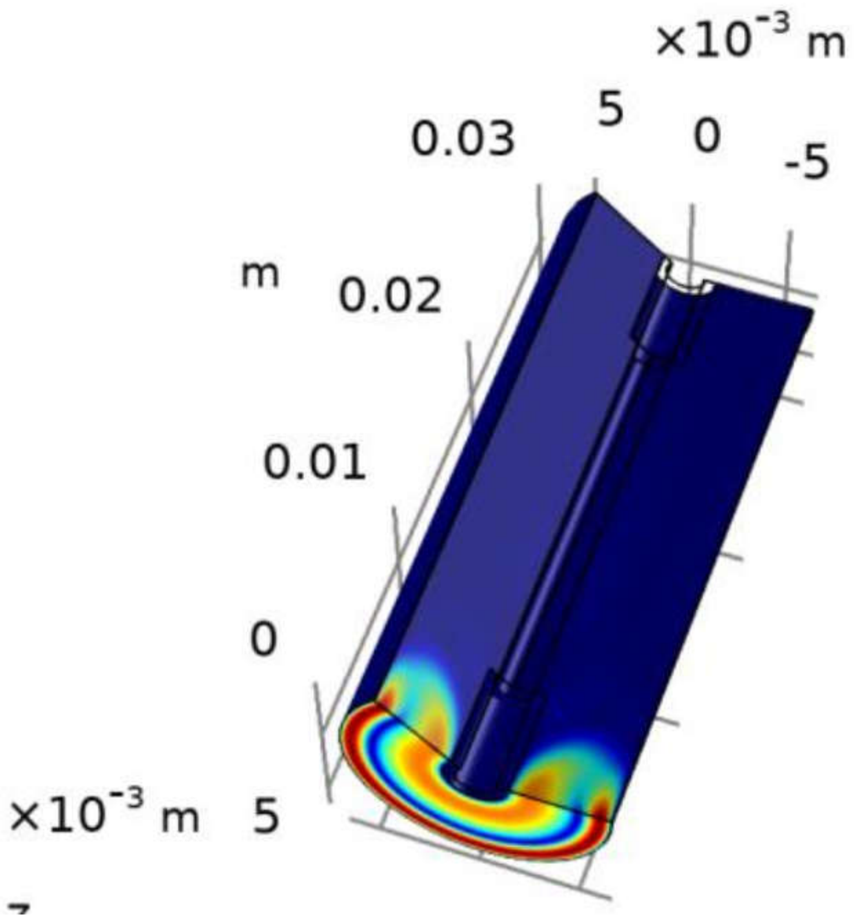


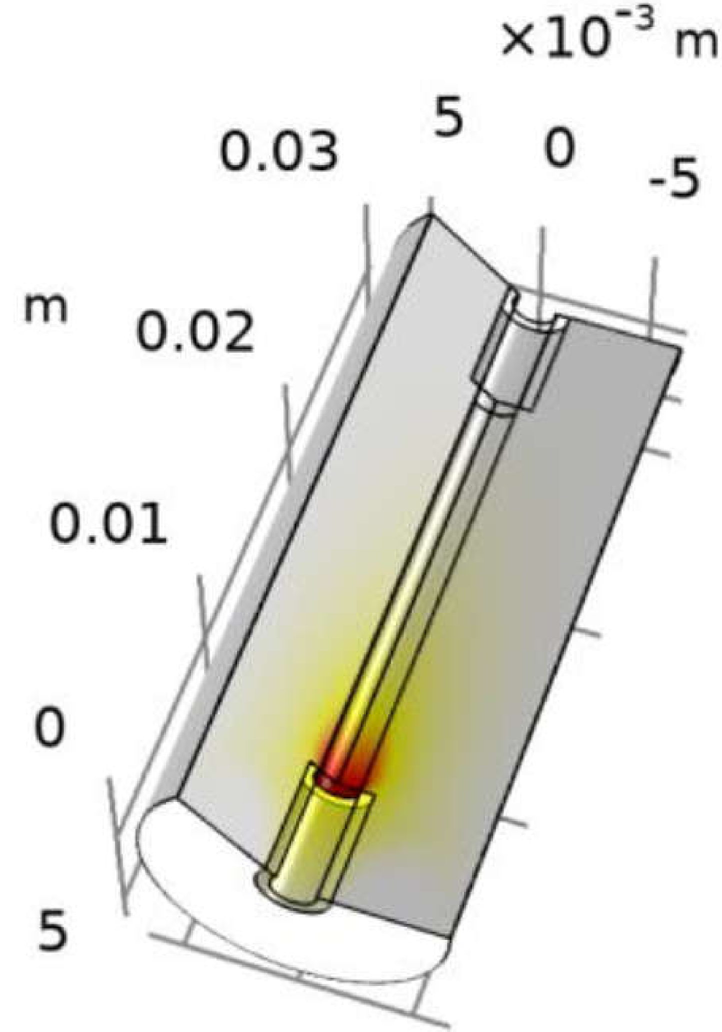

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