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Supplementary Information

Biocatalytic PEI-PSS membranes through aqueous phase separation: influence of casting solution pH and operational temperature

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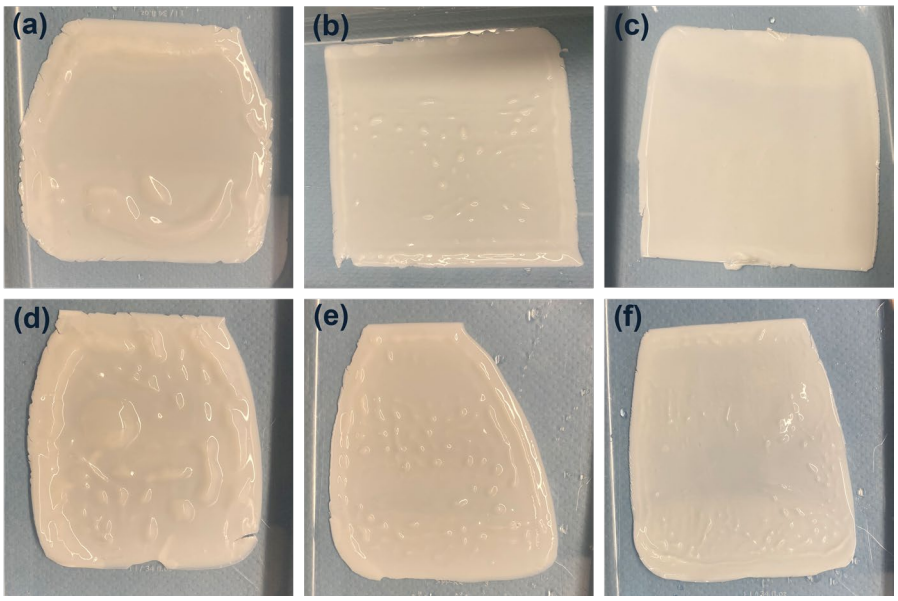

Fig. S1 Photographs of the prepared membranes without lysozyme (a) M-p$H_{11.4}$, (b) M-p$H_{10.9}$, (c) M-p$H_{10.5}$, and with lysozyme (d) M-L-p$H_{11.4}$, (e) M-L-p$H_{10.9}$, (f) M-L-p$H_{10.5}$.

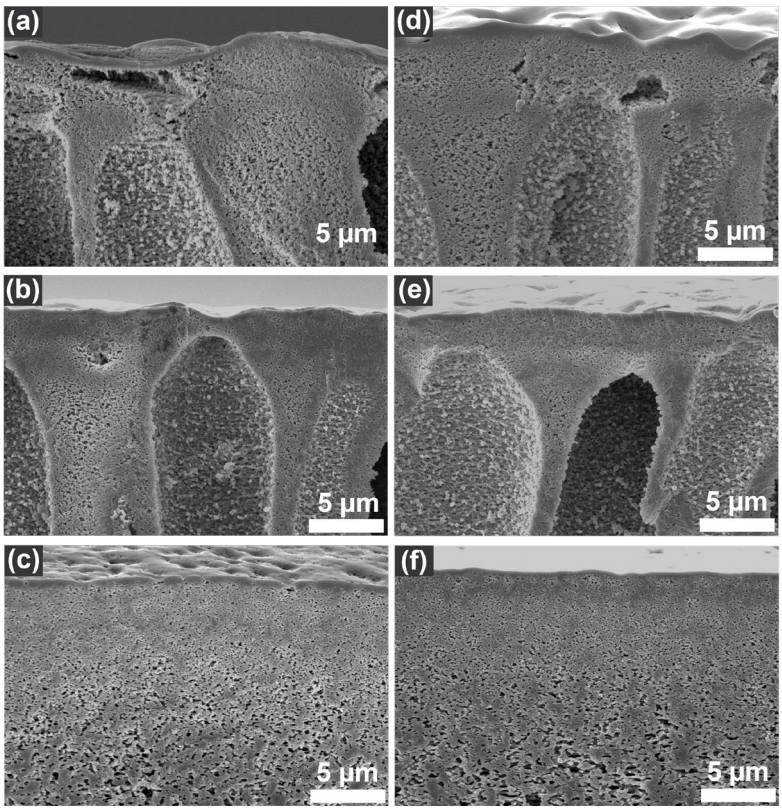

Fig. S2 Cross-section SEM images of the PEI-PSS membranes without lysozyme (a) M-$pH_{11.4}$, (b) M-$pH_{10.9}$, (c) M-$pH_{10.5}$, and with lysozyme (d) M-L-$pH_{11.4}$, (e) M-L-$pH_{10.9}$, (f) M-L-$pH_{10.5}$.

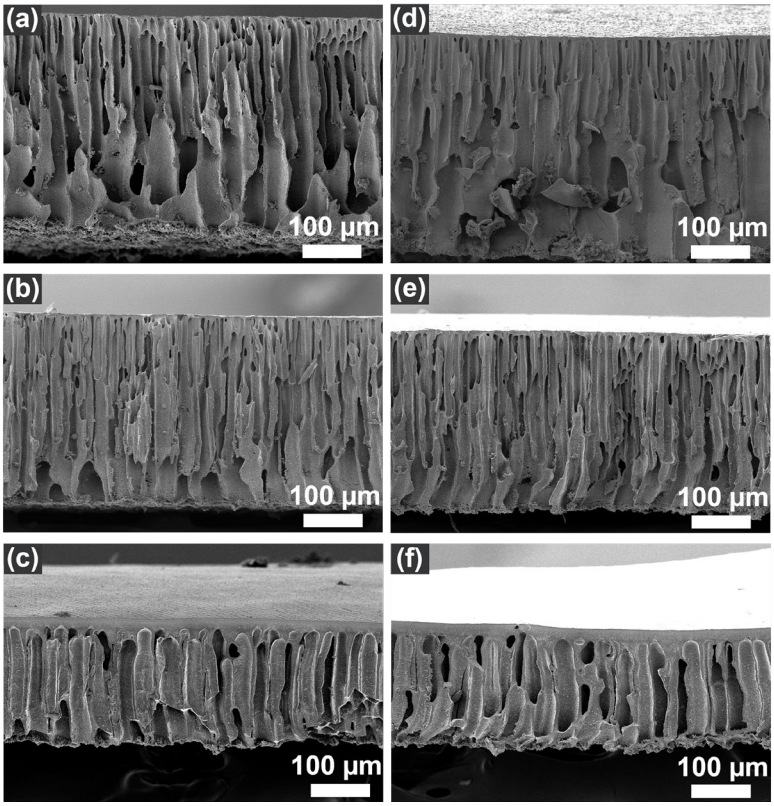

Fig. S3 The full cross-section SEM images of the PEI-PSS membranes without lysozyme (a) M-$pH_{11.4}$, (b) M-$pH_{10.9}$, (c) M-$pH_{10.5}$, and with lysozyme (d) M-L-$pH_{11.4}$, (e) M-L-$pH_{10.9}$, (f) M-L-$pH_{10.5}$.

Porosity calculation

The porosity (ε) of the membrane is calculated using the Equation S1:

$$\varepsilon(\%) = \frac{V_{pore}}{V_{total}} * 100 = \left(1 - \frac{V_{pure}}{V_{total}}\right) * 100 = \left(1 - \frac{m_{pure}/\rho_{pure}}{s*h}\right) * 100$$

Where m_{pure} and ρ_{pure} is the dry weight and density (1.1 g·cm^{-3}) of the pure dry membrane without pores. Here we assume that the density of the pure membrane is similar with the polyelectrolyte complexes.[1] s and h are the surface area and thickness (measured from SEM images in Fig.S3) of the dry membrane.

Table S1. Porosity of the membranes prepared with different pH casting solution.

Membranes	M-$pH_{11.4}$	M-$pH_{10.9}$	M-$pH_{10.5}$	M-L-$pH_{11.4}$	M-L-$pH_{10.9}$	M-L-$pH_{10.5}$
Porosity (%)	81.4	78.7	67.1	81.8	77.1	66.0

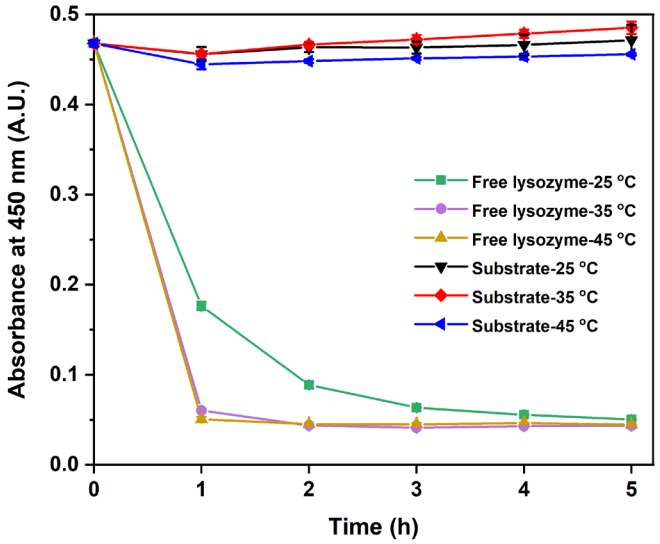

Fig. S4 Absorbance at 450 nm of 2.5 mL substrate suspension with 100 µL free lysozyme solution (5 $mg \cdot L^{-1}$) and 100 µL PBS buffer (blank sample) measured at different temperatures.

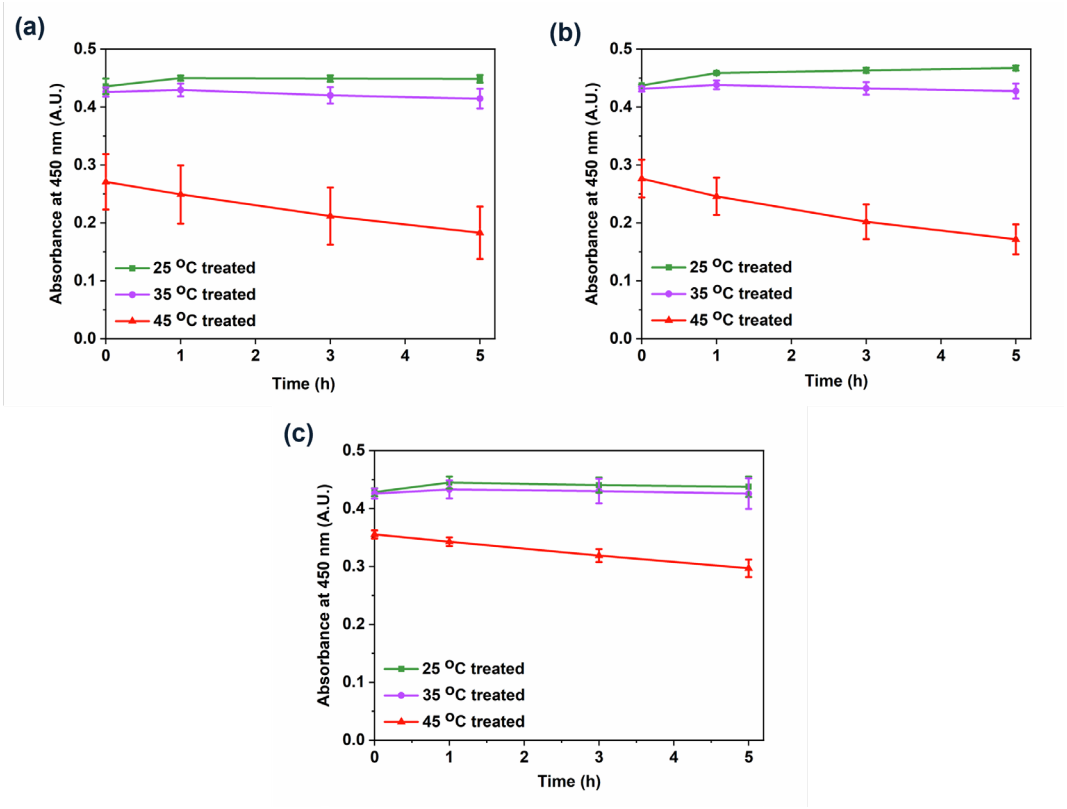

Fig. S5 Absorbance at 450 nm of the substrate suspension after the biocatalytic membranes (a) M-L-pH$_{11.4}$, (b) M-L-pH$_{10.9}$, and (c) M-L-pH$_{10.5}$ were treated in the suspension for 1 hour at different temperatures. All values are shown as averages of three samples, and the error bar represents the standard deviation.

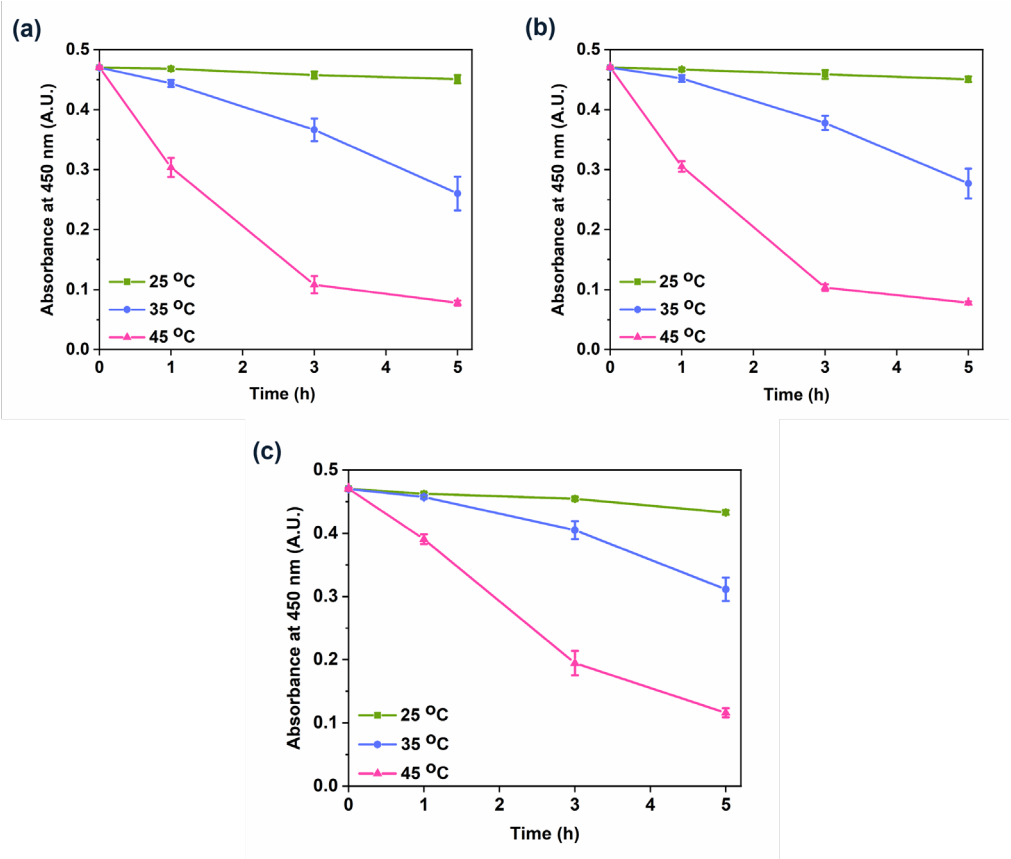

Fig. S6 Enzymatic activity of the biocatalytic membranes (a) M-L-pH$_{11.4}$, (b) M-L-pH$_{10.9}$, and (c) M-L-pH$_{10.5}$ after being treated in substrate for 1 hour at different temperatures, and then put in new 0.15 mg·mL^{-1} substrate suspension.

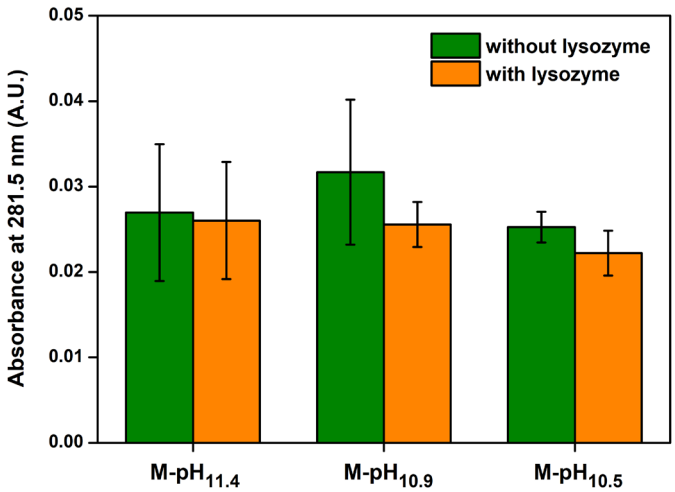

Fig. S7 Absorbance at 281.5 nm of the supernatant water of the PEI-PSS membranes without and with lysozyme stored in water for 7 days.

Table S2. Overview comparation between the biocatalytic PEI-PSS and PAH-PSS membranes.

Membranes	PAH-PSS	M-L-pH$_{11.4}$	M-L-pH$_{10.9}$	M-L-pH$_{10.5}$
Casting solution pH	pH~13	pH~11.4	pH~10.9	pH~10.5
Coagulation bath pH	pH~1	pH~4	pH~4	pH~4
Water permeability ($L \cdot m^{-2} \cdot h^{-1} \cdot bar^{-1}$)	12±2	3.6±0.2	50±16	452±83
Lysozyme loading ($\mu g \cdot cm^{-2}$)	4.49±0.41	~7.5	~7.5	~7.5
Highest activity ($U \cdot cm^{-2}$)	2.47±0.49	4.29±0.15	3.80±0.17	2.35±0.30
7 days activity ($U \cdot cm^{-2}$)	1.23±0.47	3.25±0.12	4.31±0.03	2.64±0.09
7 days stability	50.2%	75.8%	100%	100%
60 days activity ($U \cdot cm^{-2}$)	\	1.85±0.07	2.67±0.07	1.57±0.04
60 days stability	\	43%	62%	59%

Reference

1. R. Köhler, I. Dönch, P. Ott, A. Laschewsky, A. Fery and R. Krastev, *Langmuir*, 2009, **25**, 11576-11585.