Supporting Information

Formation of High-Capacity Protein-Adsorbing Membranes Through Simple Adsorption of Poly(acrylic acid)-Containing Films at low pH

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Table S-1. Water permeabilities of nylon membranes before and after modification with PSS/PAH/PAA films.

Multilayer in membrane pore	pH of PAH and PAA deposition solution	Water permeability of unmodified nylon membranes (mL/cm^2 min atm)	Water permeability of modified nylon membrane (mL/cm^2 min atm)	Reduction of Water permeability (%)
PSS/PAH/PAA	2	114±10	57±4	50±10
	3	107±17	34±11	68±22
	4	116±6	75±11	35±11
	5	120±18	79±32	34±31

Each experiment was repeated with two different membranes, and the ± values represent the standard deviation of multiple measurements on these membranes.

Table S-2. Water permeabilities of nylon membranes before and after modification with PSS/PAH/PAA-NTA-Cu^{2+} films.

Multilayer in membrane pore	pH of PAH and PAA deposition solution	Water permeability of unmodified nylon membranes (mL/cm^2 min atm)	Water permeability of modified nylon membrane (mL/cm^2 min atm)	Reduction of Water permeability (%)
PSS/PAH/PAA	2	105±3	77±6	27±6
	3	123±3	98±5	20±5
	4	123±2	56±1	55±2
	5	131±5	39±5	70±6

Each experiment was repeated with two different membranes, and the ± values represent the standard deviation of multiple measurements on these membranes.

Table S-3. Water permeabilities of nylon membranes before and after modification with PAA monolayers.

Monolayer in membrane pore	pH of PAA deposition solution	Water permeability of unmodified nylon membranes (mL/cm^2 min atm)	Water permeability of modified nylon membrane (mL/cm^2 min atm)	Reduction of Water permeability (%)
PAA	2	116±10	42±8	64±12
	3	143±11	46±15	68±14
	4	122±5	111±4	9±5
	5	136±23	128±22	6±23

Each experiment was repeated with two different membranes, and the ± values represent the standard deviation of multiple measurements on these membranes.

Table S-4. Water permeabilities of nylon membranes before and after modification with PAA-NTA-Cu^{2+} films.

Monolayer in membrane pore	pH of PAH and PAA deposition solution	Water permeability of unmodified nylon membranes (mL/cm^2 min atm)*	Water permeability of modified nylon membrane (mL/cm^2 min atm)	Reduction of Water permeability (%)
PAA	2	86±1	75±2	13±3
	3	89±1	68±2	24±3
	4	90±2	80±2	11±3
	5	80±2	74±1	7.5±3

Each experiment was repeated with two different membranes, and the ± values represent the standard deviation of multiple measurements on these membranes.
*Membrane coupons were cut from a large sheet, and this particular batch of coupons showed a ~30% lower permeability (before modification) than others.

Table S-5. Water permeabilities of nylon membranes before and after modification with PAA/PAH/PAA or PAA/PEI/PAA.

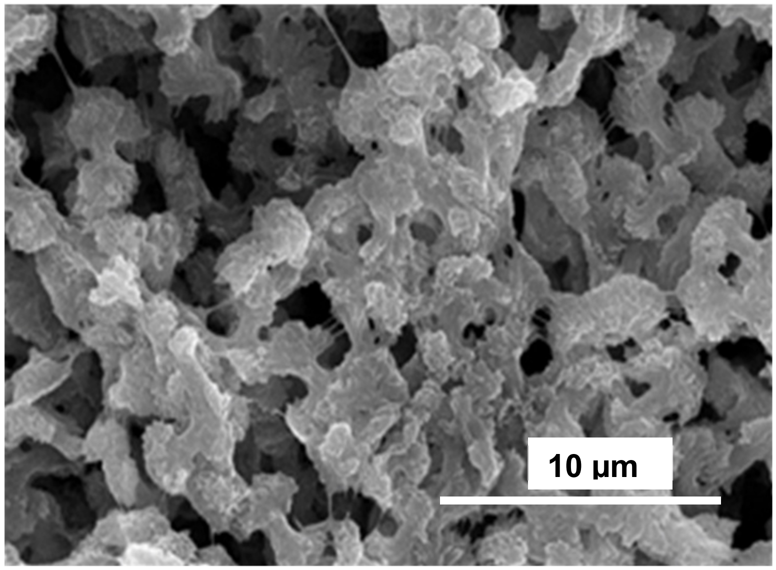
Multilayer in membrane pore	pH of PAH and PAA deposition solution	Water permeability of unmodified nylon membranes (mL/cm^2 min atm)	Water permeability of modified nylon membrane (mL/cm^2 min atm)	Reduction of Water permeability (%)
PAA/PAH/PAA	3	114±7	25±5	78±9
PAA/PEI/PAA	3	123±7	69±3	44±7

Each experiment was repeated with two different membranes, and the ± values represent the standard deviation of multiple measurements on these membranes.

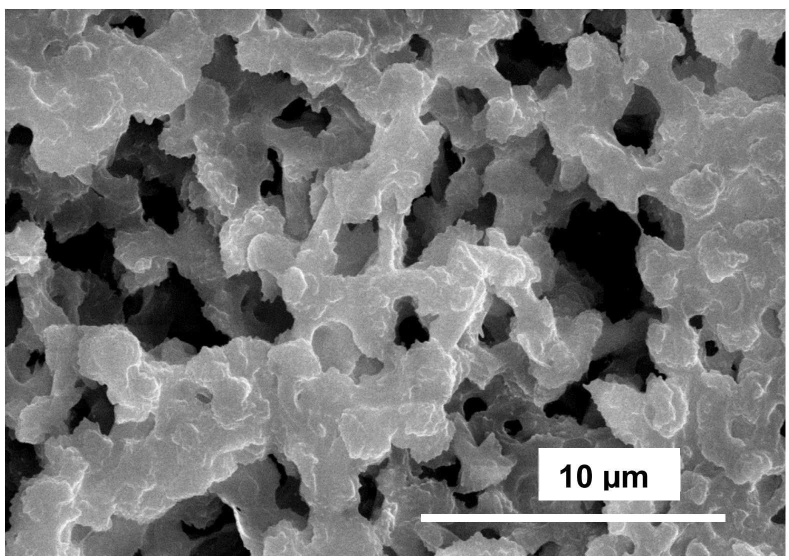
Table S-6. Water permeabilities of bare membranes and membranes modified with PAA/PAH/PAA-NTA-Cu^{2+} or PAA/PEI/PAA-NTA-Cu^{2+}.

Multilayer in membrane pore	pH of PAH and PAA deposition solution	Water permeability of unmodified nylon membranes (mL/cm^2 min atm)	Water permeability of modified nylon membrane (mL/cm^2 min atm)	Reduction of Water permeability (%)
PAA/PAH/PAA	3	118±4	59±2	50±4
PAA/PEI/PAA	3	123±1	77±2	38±2

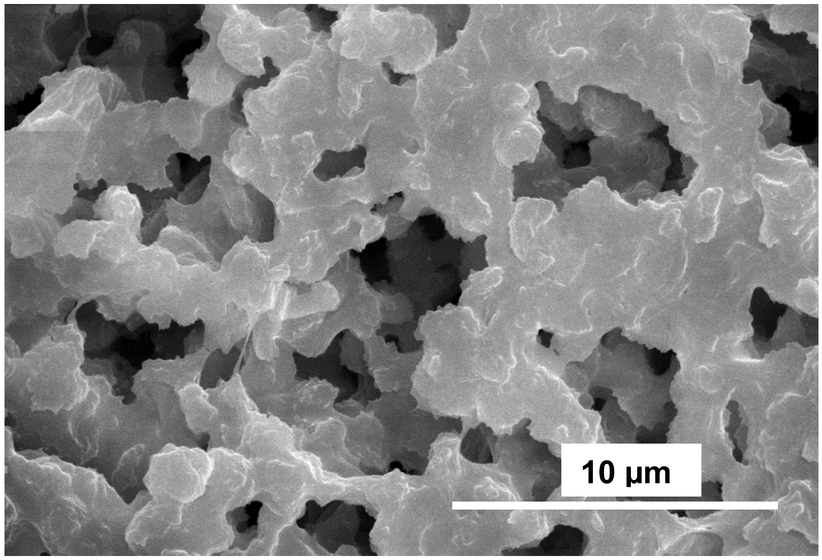
Each experiment was repeated with two different membranes, and the ± values represent the standard deviation of multiple measurements on these membranes.



(a)



(b)



(c)

Figure S-1. SEM images of a bare nylon membrane with nominal 1.2 µm pores (a), and similar membranes modified with PSS/PAH/PAA deposited at pH 2 (b) and pH 5 (c).

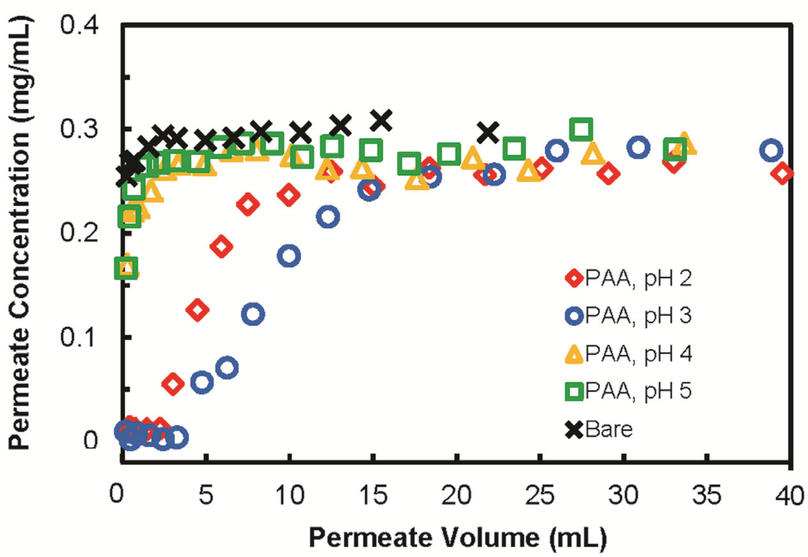


Figure S-2. Breakthrough curves for the passage of 0.3 mg/mL lysozyme through nylon membranes modified with single layers of PAA adsorbed at various pH values. The protein-solution flow rate was 1 mL/min, which corresponds to a linear velocity of 19 cm/h above the membrane.

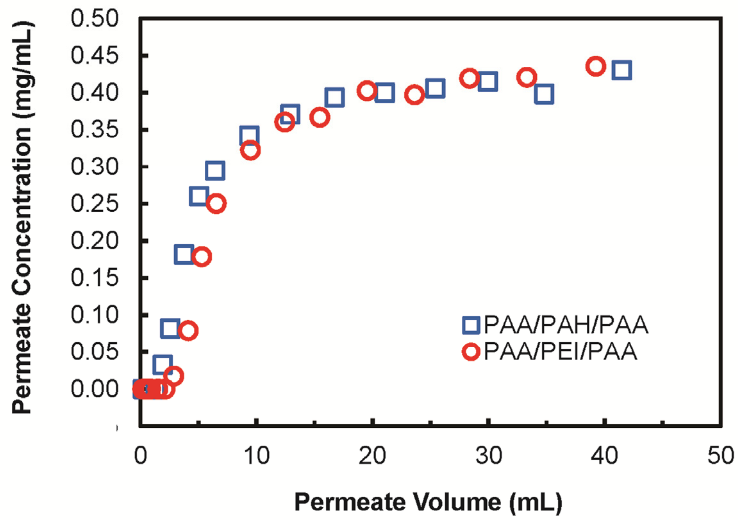


Figure S-3. Breakthrough curves for the passage of 0.45 mg/mL lysozyme through nylon membranes modified with PAA/PAH/PAA or PAA/PEI/PAA multilayers. The pH of PAA, PAH and PEI deposition solutions was 3, and the protein solution flow rate was 1 mL/min.

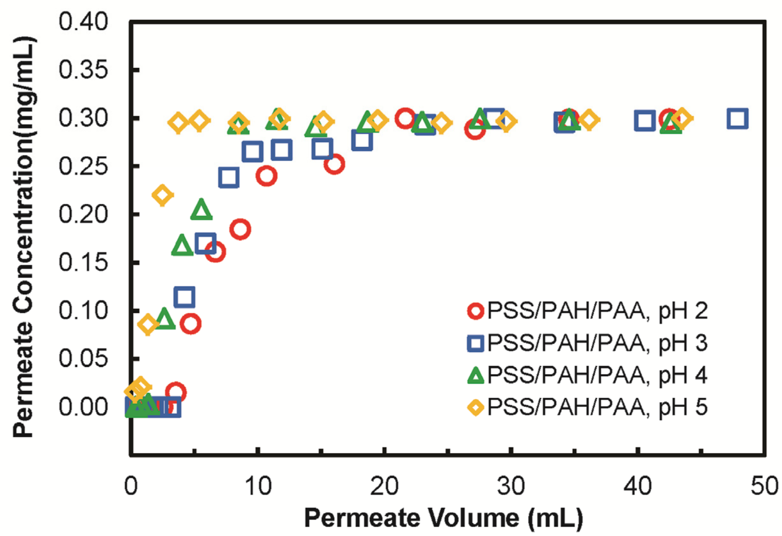


Figure S-4. Breakthrough curves for the passage of 0.3 mg/mL Con A (pH 6, 20 mM phosphate buffer) through nylon membranes modified with PSS/PAH/PAA-NTA-Cu^{2+} films adsorbed at different pH values. The protein solution flow rate was 1 mL/min.

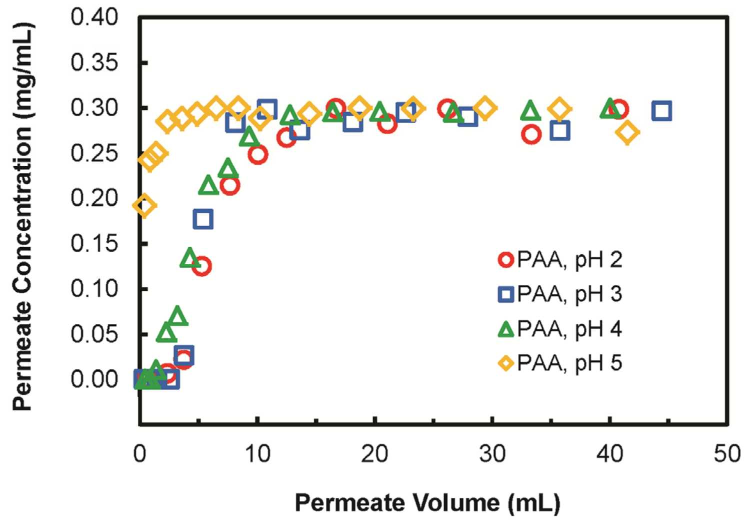


Figure S-5. Breakthrough curves for the passage of 0.3 mg/mL Con A through nylon membranes modified with PAA-NTA-Cu^{2+} film (pH of PAA deposition solutions were varied). The protein solution flow rate was 1 mL/min.

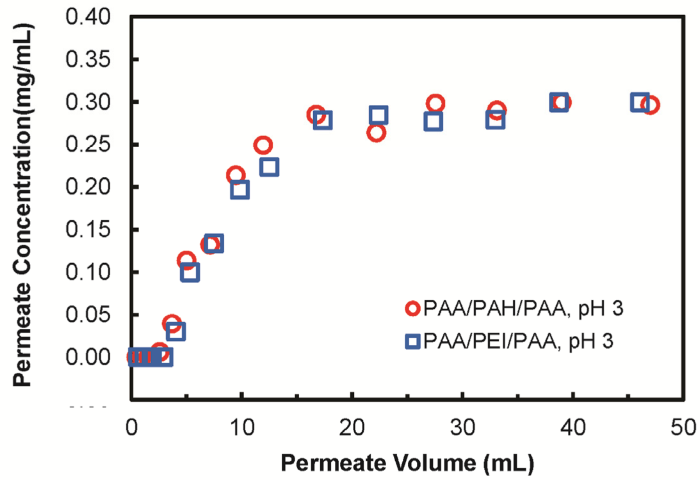


Figure S-6. Breakthrough curves for the passage of 0.3 mg/mL Con A through nylon membranes modified with PAA/PAH/PAA-NTA-Cu^{2+} and PAA/PEI/PAA-NTA-Cu^{2+} films. The protein solution flow rate was 1 mL/min.

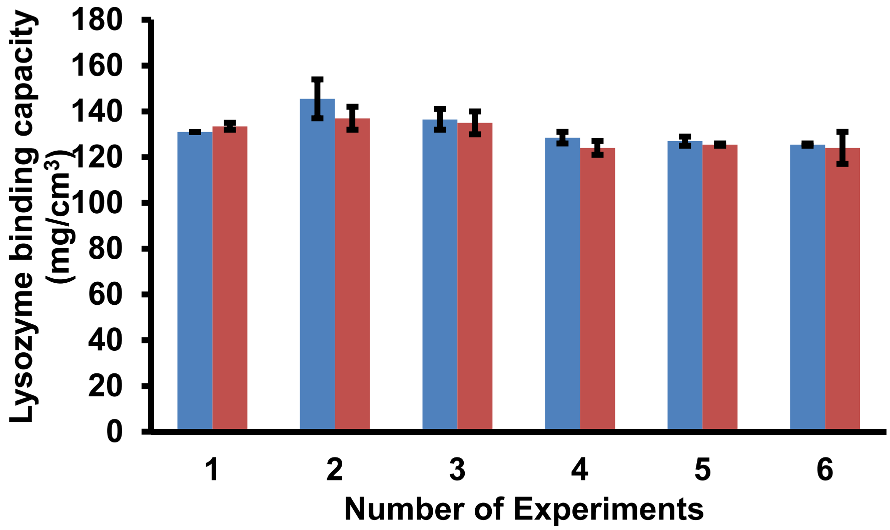


Figure S-7. Repetitive lysozyme binding capacities for nylon membranes modified with PAA/PEI/PAA films deposited at pH 3. (The blue and maroon bars show the different replicates on the two different membranes)

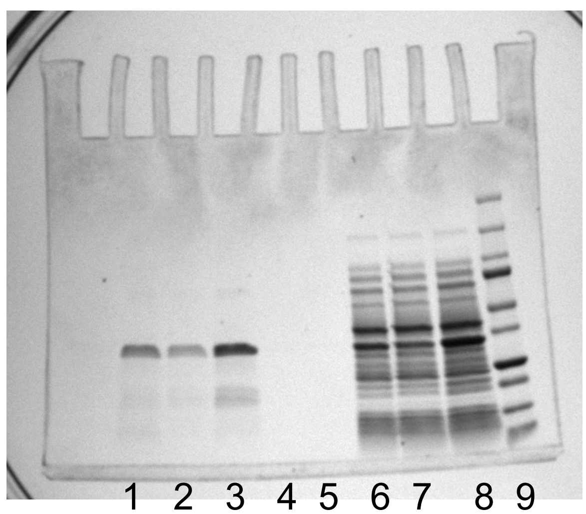


Figure S-8. The original gel image from which Figure 5(b) was taken (purification of CSN 8 from a cell extract). The lanes are: 1- first eluent from the membrane; 2- second eluent from a spin-trap column; 3- first eluent from a spin-trap column; 4- membrane wash; 5- spin-trap wash; 6- protein solution that passed through the membrane; 7- protein solution treated with the spin-trap column; 8- cell lysate; 9- protein ladder. Figure 5 in the text shows only lanes 9, 8, 6, and 1.