Supporting Information

Hydrogel-coated polyamide nanofiltration membranes for seawater ion separation

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S1. X-ray Photoelectron Spectroscopy (XPS) analysis of membrane surface composition

XPS was used to examine the surface chemical composition of the fabricated membranes. As shown in Figure S1, characteristic peaks corresponding to C1s (~285 eV), O1s (~531 eV), and N1s (~399 eV) were observed for the polyamide TFC membrane formed via interfacial polymerization between MPD and TMC on the PES ultrafiltration substrate. Minor peaks corresponding to S2p (~168 eV) and S2s (~229 eV) were also detected, which originate from the sulfone groups of the underlying PES substrate and are consistent with previous reports.

The reduced intensity of sulfur signals (S2p and S2s) indicates effective coverage of the PES substrate by the polyamide selective layer. The presence of the N1s peak at approximately 399 eV confirms the incorporation of amide groups formed during the interfacial polymerization reaction between MPD and TMC. Additionally, the absence of a Cl 2p peak indicates the consumption of the TMC monomer during polyamide formation.

Following the hydrogel coating of the TFC membrane with PVA, the XPS spectra showed an increase in oxygen content, attributed to the hydroxyl functional groups present in the PVA hydrogel. Changes in elemental composition are further reflected in the atomic concentration values summarized in Table S1. These results support the presence of the hydrogel layer on the membrane surface after modification.

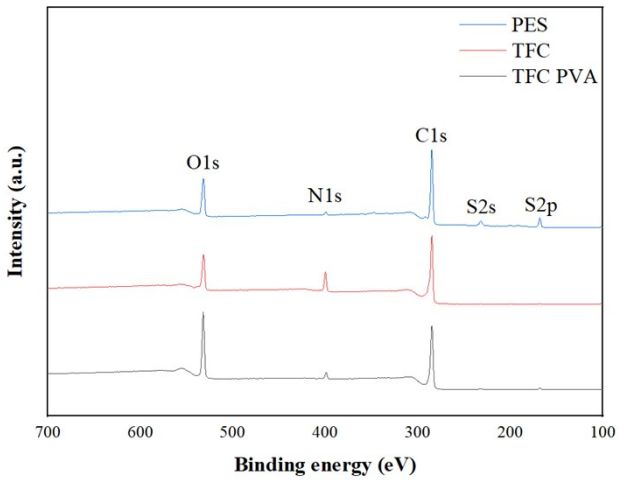

Figure S1: XPS spectra of the PES UF membrane, and fabricated (TFC and TFC PVA) NF membranes.

Table S1: Surface elemental composition and O/N ratios of the PES UF membrane, fabricated (TFC and TFC PVA) composite membrane from XPS analysis.

Membrane	Atomic percent (%)					
	C	O	N	Cl	S	O/N
PES	79.2	15.1	1.5	0.1	3.8	10.1
TFC	77.1	13.2	9.6	0.0	0.1	1.3
TFC PVA	74.6	21.1	3.0	0.0	1.3	7.0

S2. Benchmarking of NF membrane performance

Table S2: Benchmarking of this work against reported nanofiltration membranes.

Membrane	Type	Feed	Pressure (bar)	Flux (L m^{-2} h^{-1})	Rejection (%)	Ref
NF270	Commercial NF	Seawater (~35 g/L)	4	25.5	Na^+: 8.3 Mg^{2+}: 38.1	This study
TS80	Commercial NF	Seawater (~35 g/L)	4	8.3	Na^+: 10.8 Mg^{2+}: 49.6	This study
TFC	Polyamide TFC NF	Seawater (~35 g/L)	4	10.9	Na^+: 27.3 Mg^{2+}: 43.6	This study
TFC–PVA	Hydrogel-coated TFC NF	Seawater (~35 g/L)	4	2.2	Na^+: 46.1 Mg^{2+}: 73.2	This study
1.0:1.0 PSS-PDADMAC	APS-based PEC NF	Single salt solution (5mM)	4	4.0	Na_2SO_4: ~20 $MgCl_2$: ~65	[1]
PSS–PDADMAC	PEC tubular NF	Single salt solution (5mM)	3	0.3	$MgCl_2$: 92.0 $MgSO_4$: 70.0 NaCl: 54.0 Na_2SO_4: 27.0	[2]
PQA	Positively charged NF	Single salt solution (1000 ppm)	10	29	$MgCl_2$: 97.0 NaCl: 69.1 $MgSO_4$: 29.6 Na_2SO_4: 20.2	[3]
XL-PEE	Cross-linked epoxide-based TFC NF	Single salt solution (5mM)	10	20	$MgCl_2$: 89.0 NaCl: 81.0 $CaCl_2$: 87.0	[4]

Membrane	Type	Feed	Pressure (bar)	Flux (L m^{-2} h^{-1})	Rejection (%)	Ref
TBDA-SO_3 (0.1%)	Positively charged TFC NF (PIP/TBDA-TMC)	Single salt solution (2 g/L)	10	78	$MgCl_2$: ~97 NaCl: ~50 $CaCl_2$: ~98 Na_2SO_4: ~99	[5]
SF-TFC	Positively charged TFC NF (DAGH-TMC)	Single salt solution (0.01 M)	7	31	$MgCl_2$: 95.8 LiCl: 30.6	[6]

S3. References

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