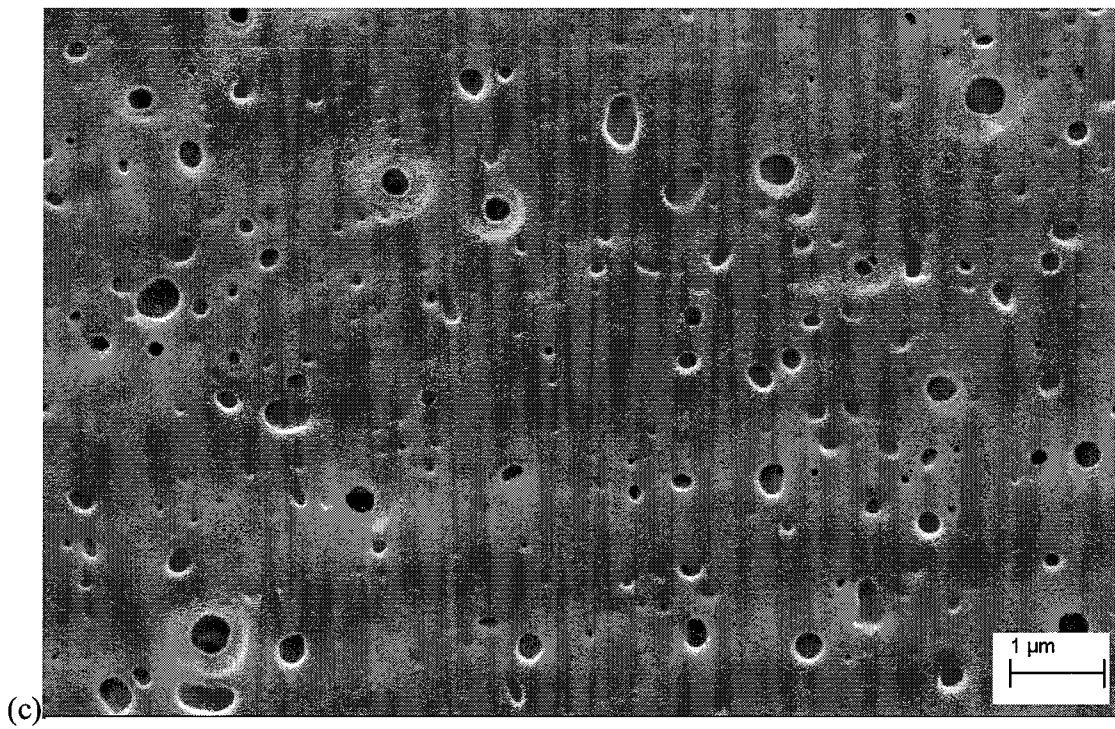
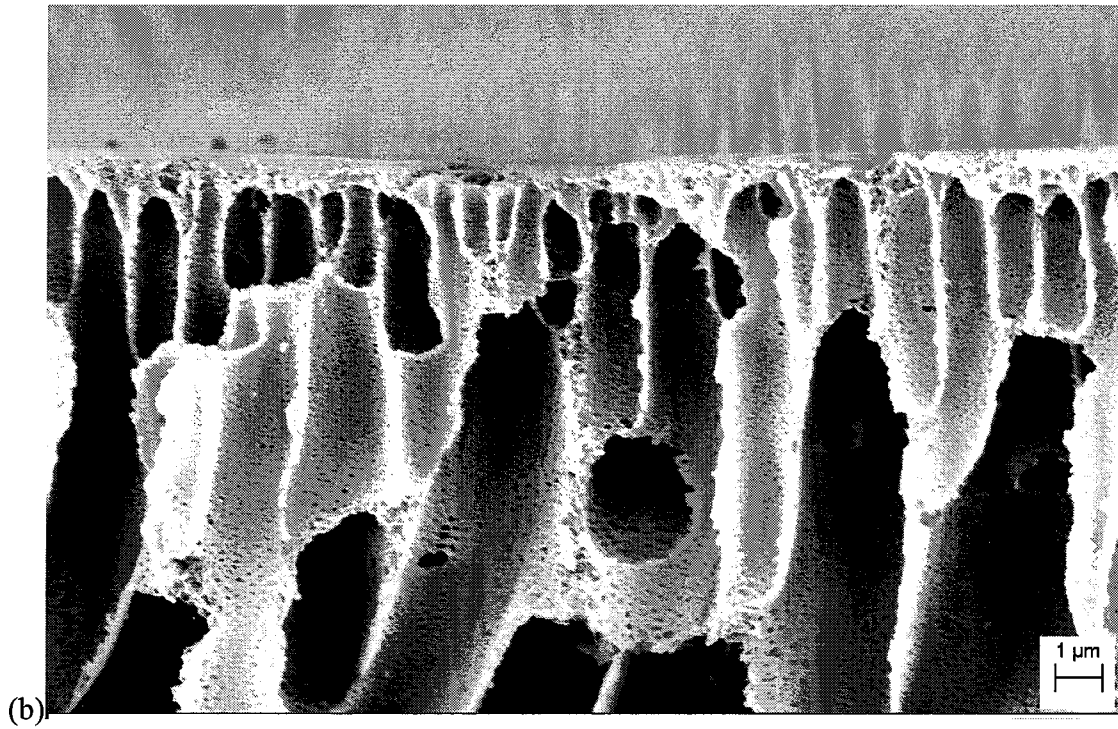


FIG. 1**Table 1** Synthesis conditions for TFC FO membranes

Membrane ID	Substrate via phase inversion					Rejection layer via interfacial polymerization ^a			
	PSf (wt.%)	NMP (wt.%)	PVP (wt.%)	LiCl (wt.%)	Thickness of casting solution (μm)	MPD (wt.%)	SDS (wt.%)	Water (wt.%)	TMC in n-hexane (wt/v.%)
TFC-1	17.5	82.0	0.5	-	175	1.0	-	99.0	0.05
TFC-2	15.5	81.0	0.5	3.0	150	1.5	0.1	98.4	0.1

FIG. 2

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FIG. 2 (CONT.)



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FIG. 2 (CONT.)

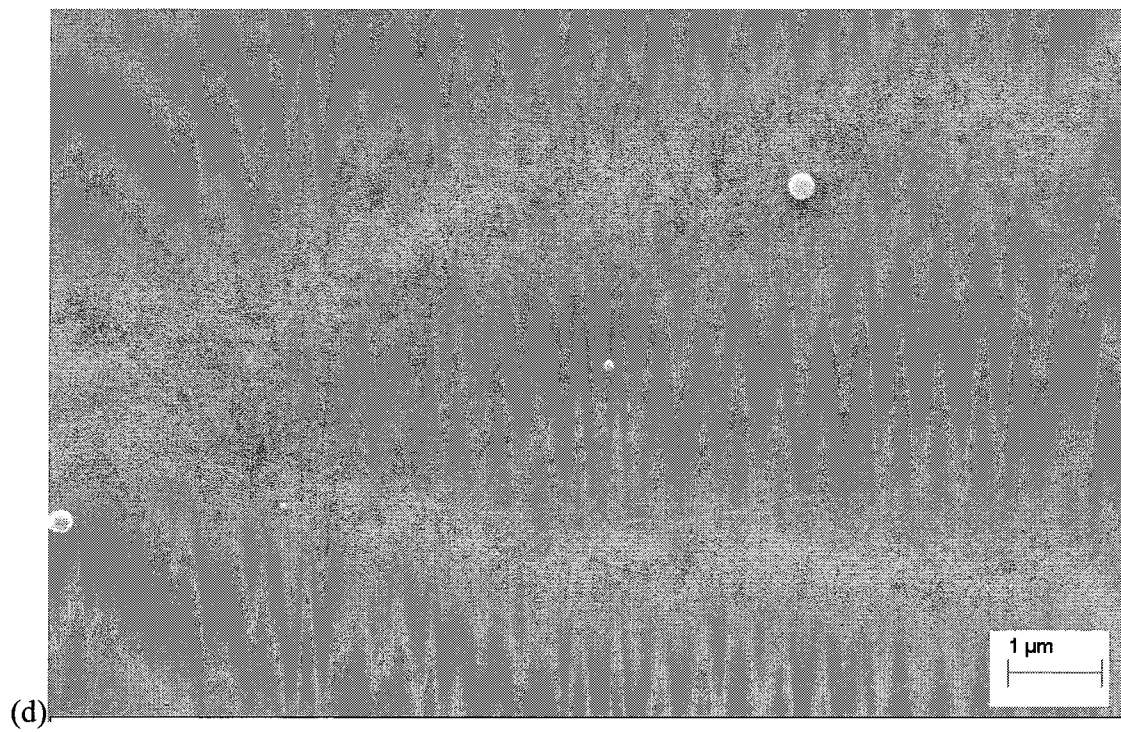
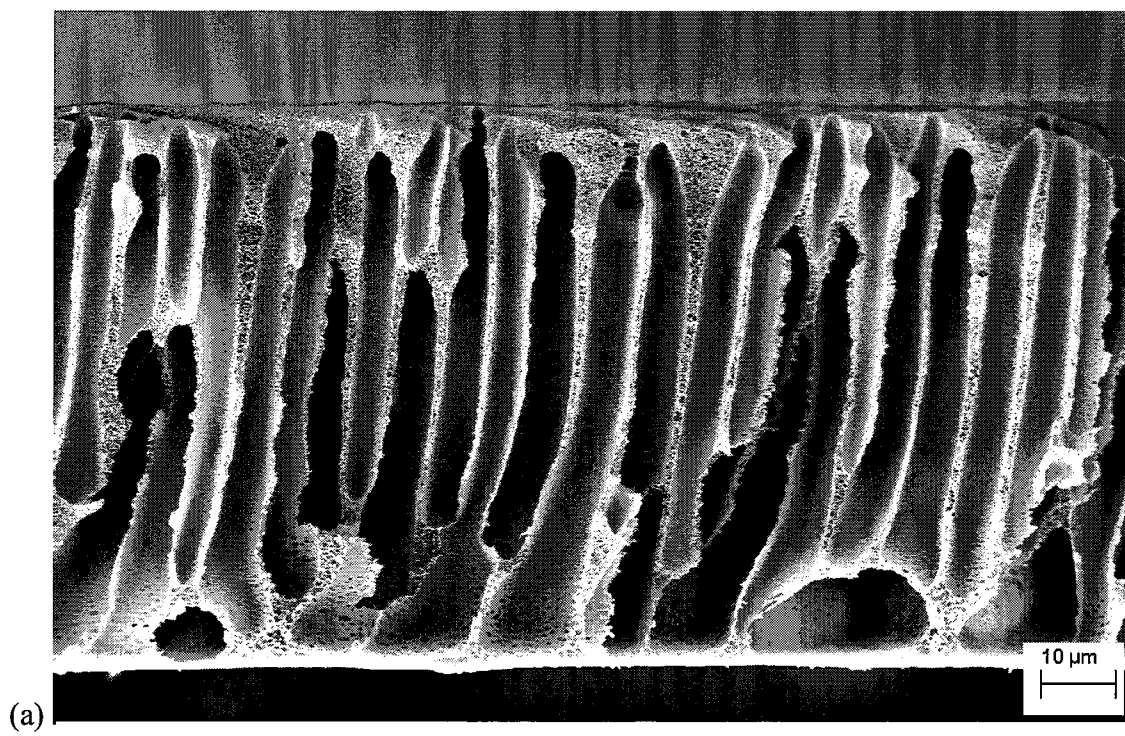
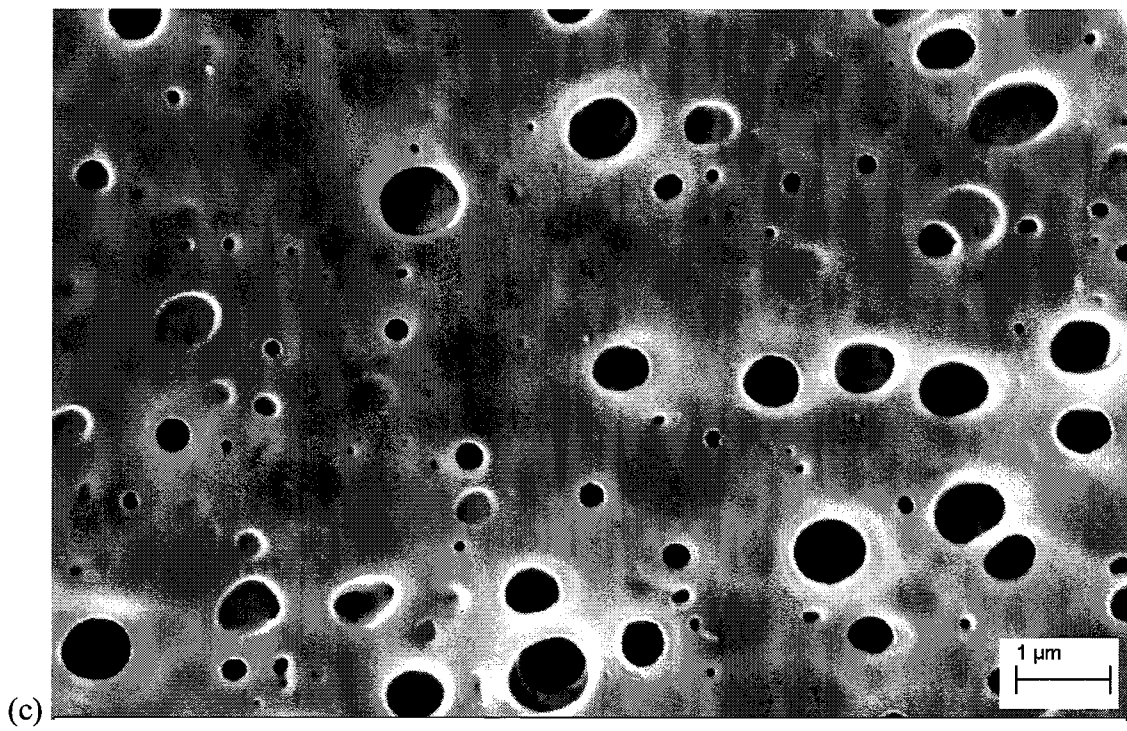
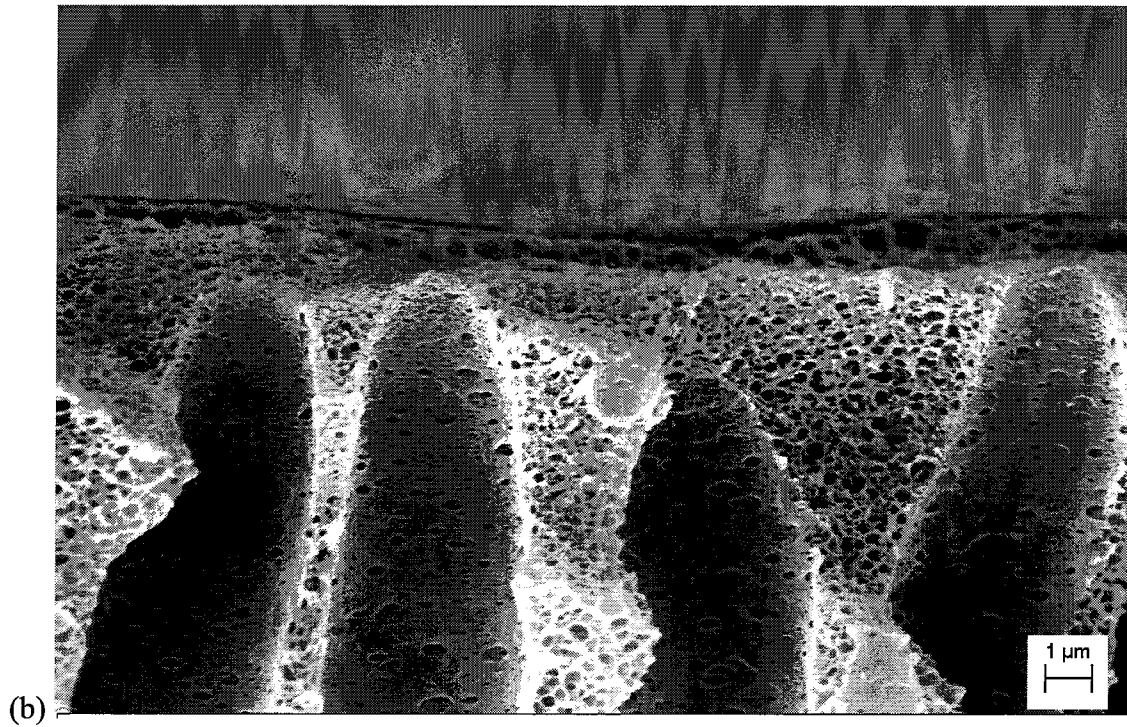


FIG. 3



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FIG. 3 (CONT.)



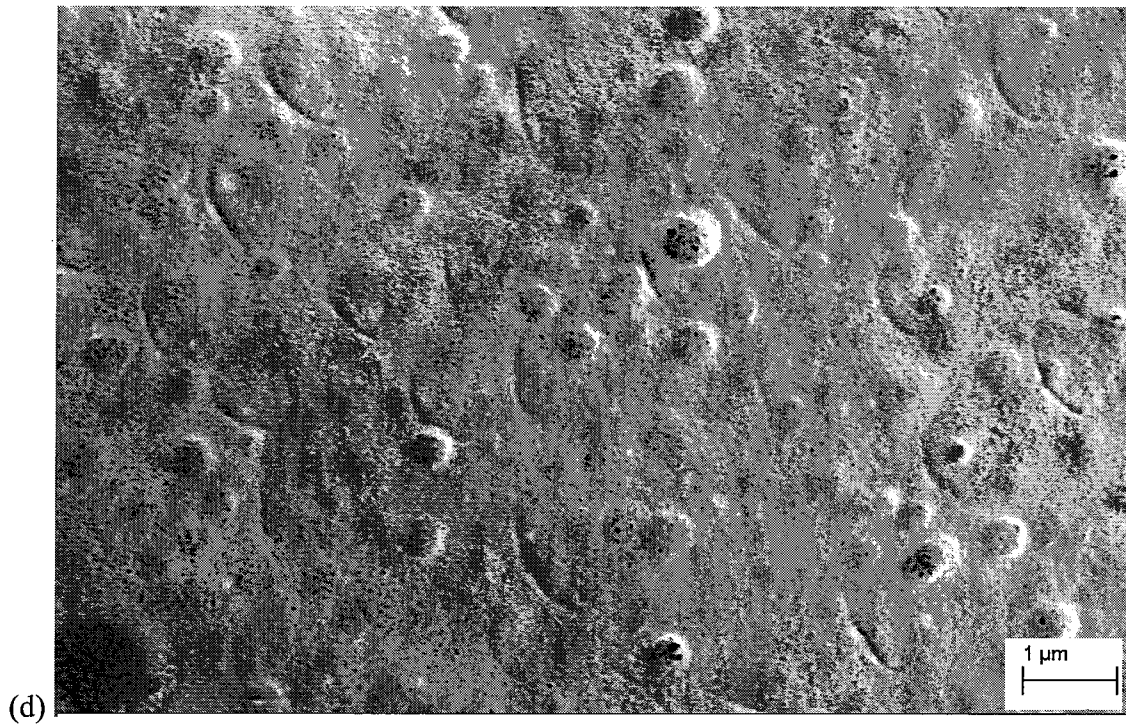


FIG. 4

Table 2 Characteristics of FO membrane substrates ^a

Sample	Thickness ^c (μm)	Porosity ^d (%)	s value ^e (mm)	Pure water flux ^f ($\text{L}/\text{m}^2\cdot\text{h}$)	Contact angle ($^\circ$)
S-1 (TFC-1)	76.1 ± 3.0	77 ± 3	0.71 ± 0.14	107 ± 10	56 ± 1
S-2 (TFC-2)	72.8 ± 0.7	82 ± 2	0.67 ± 0.17	190 ± 15	53 ± 3
CTA-HW ^b	90.0 ± 6.0 (60 ^b)	64 ± 1	0.72 ± 0.15	-	74 ± 2 ^g
CTA-W ^b	44.7 ± 14.1 (20 ^b)	46 ± 1	1.00 ± 0.54	-	69 ± 2 ^g
CTA-NW	144 ± 24	50 ± 2	1.38 ± 0.26	-	74 ± 3 ^h
BW30	152 ± 4	35 ± 1	37.5 ± 19.6	-	92 ± 2 ⁱ
BW30-o	58.1 ± 5.1	49 ± 1	14.0 ± 1.6	-	92 ± 2 ⁱ

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FIG. 5

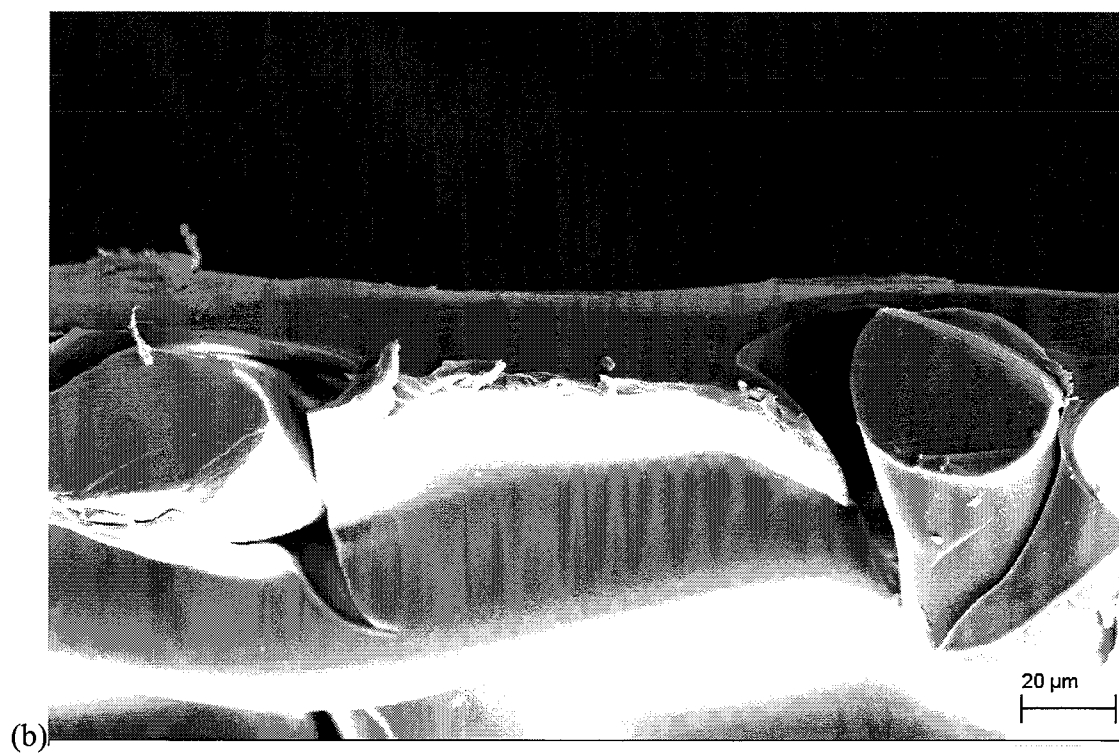
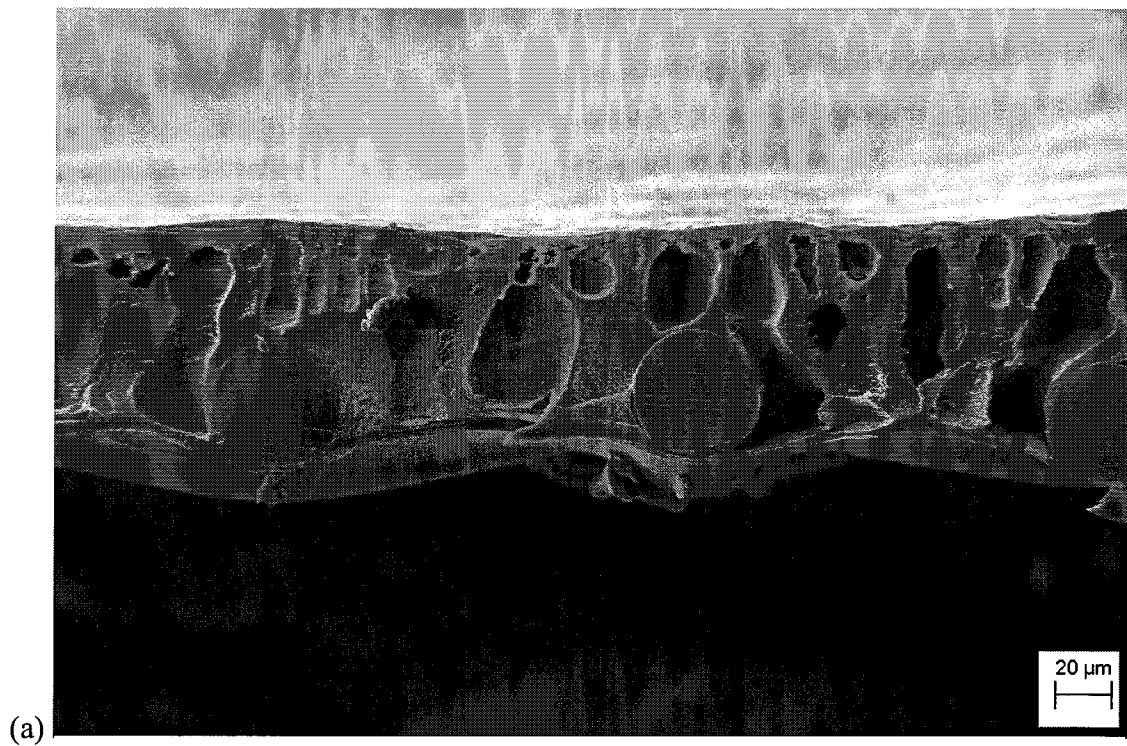


FIG. 5 (CONT.)

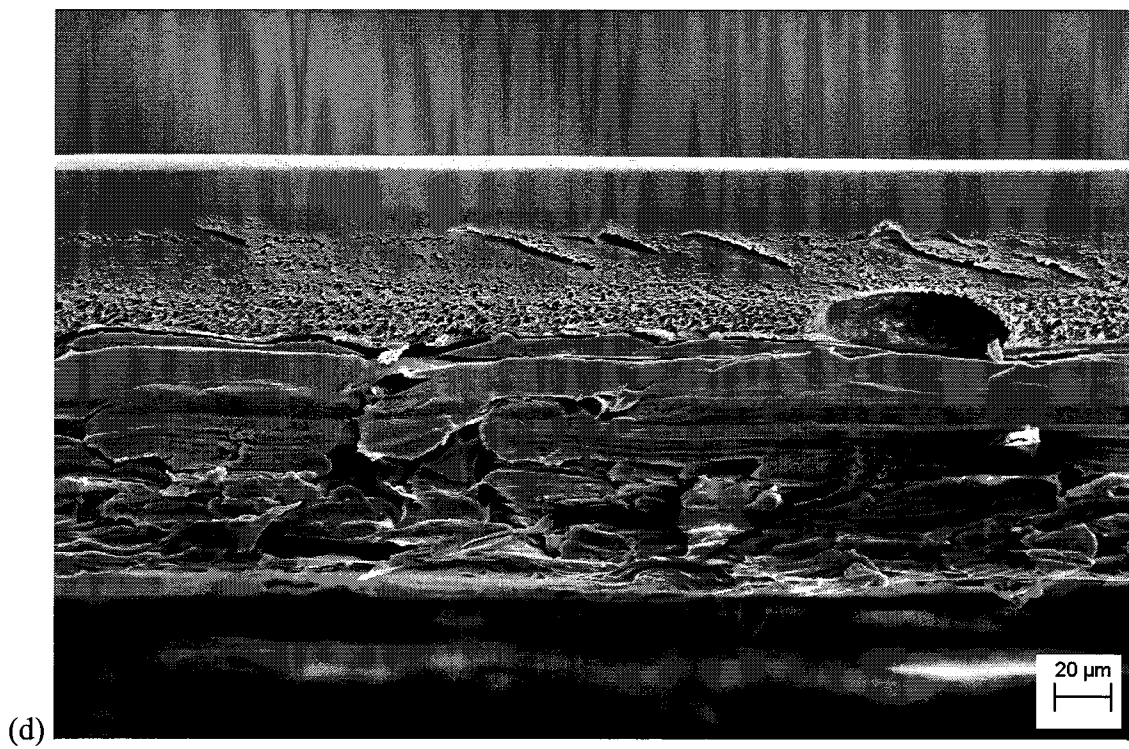
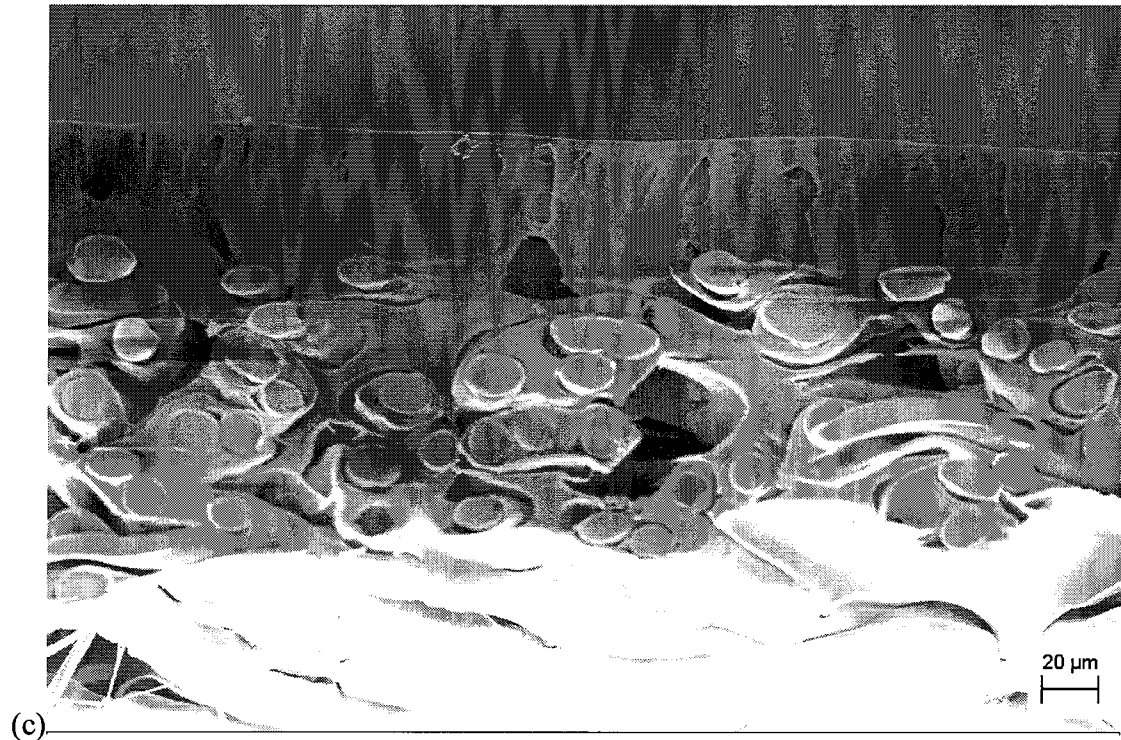


FIG. 5 (CONT.)

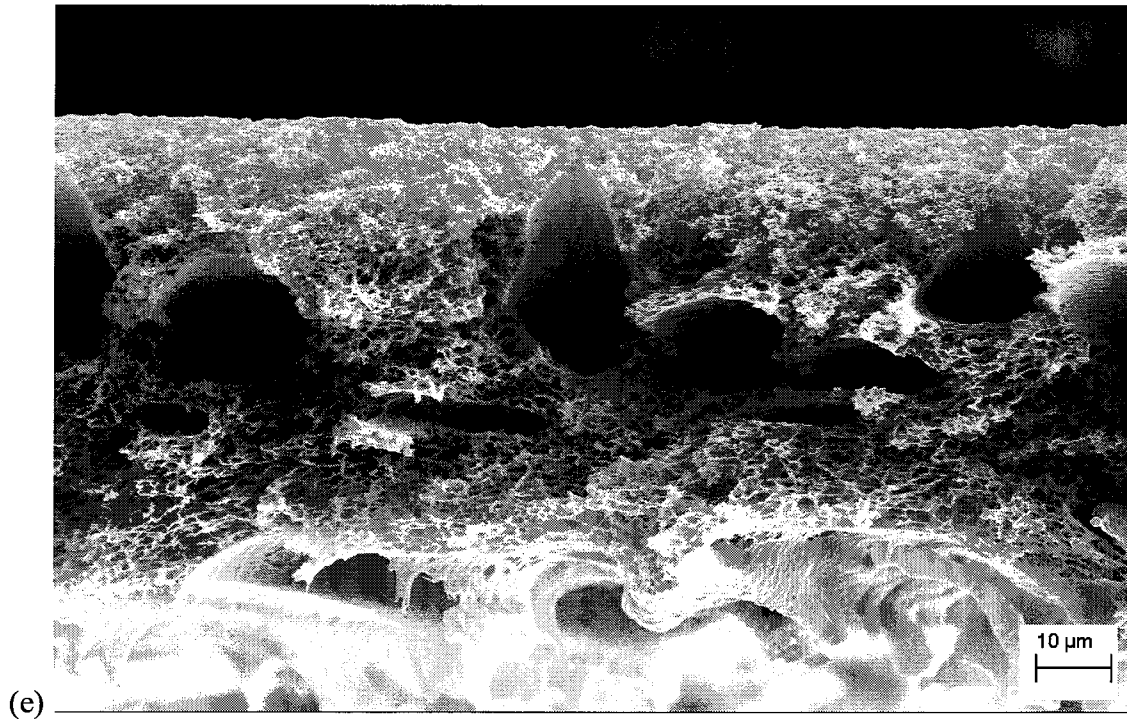


FIG. 6

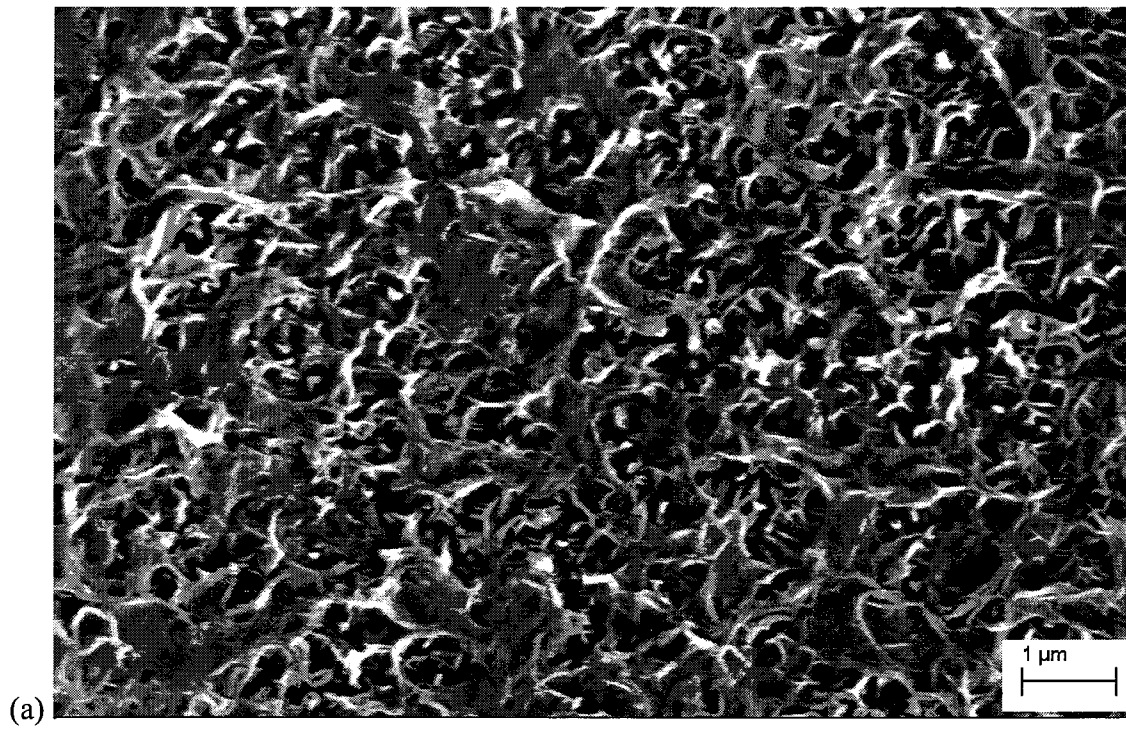


FIG. 6 (CONT.)

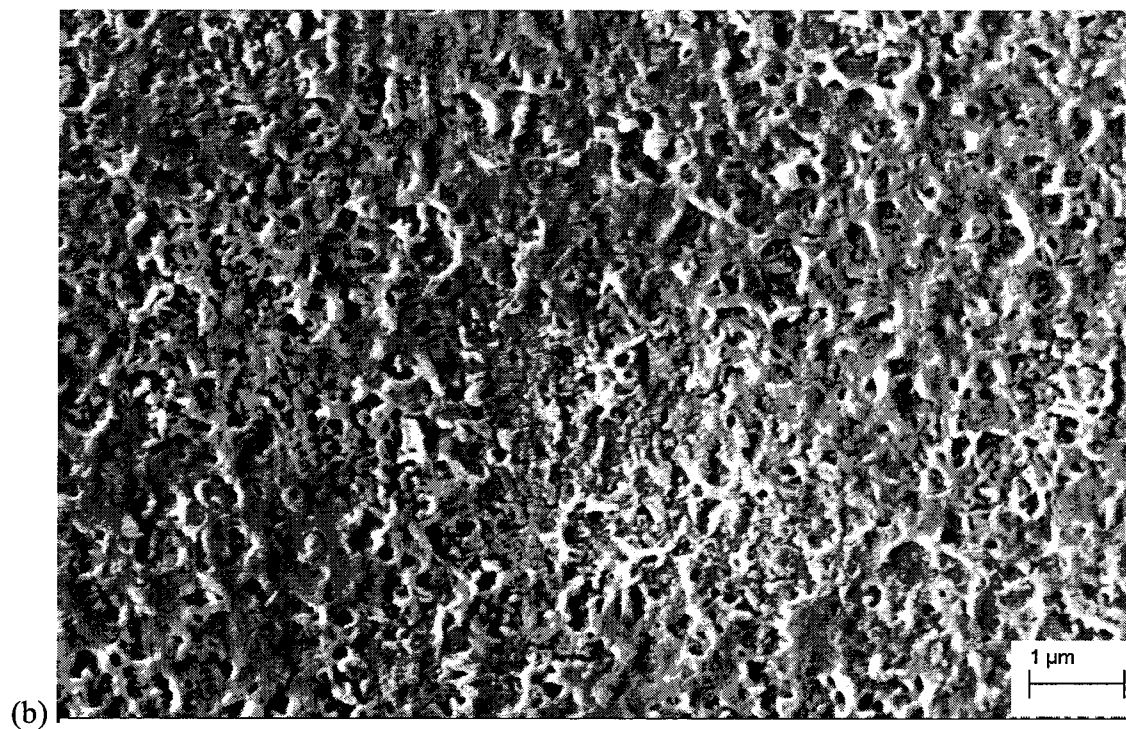
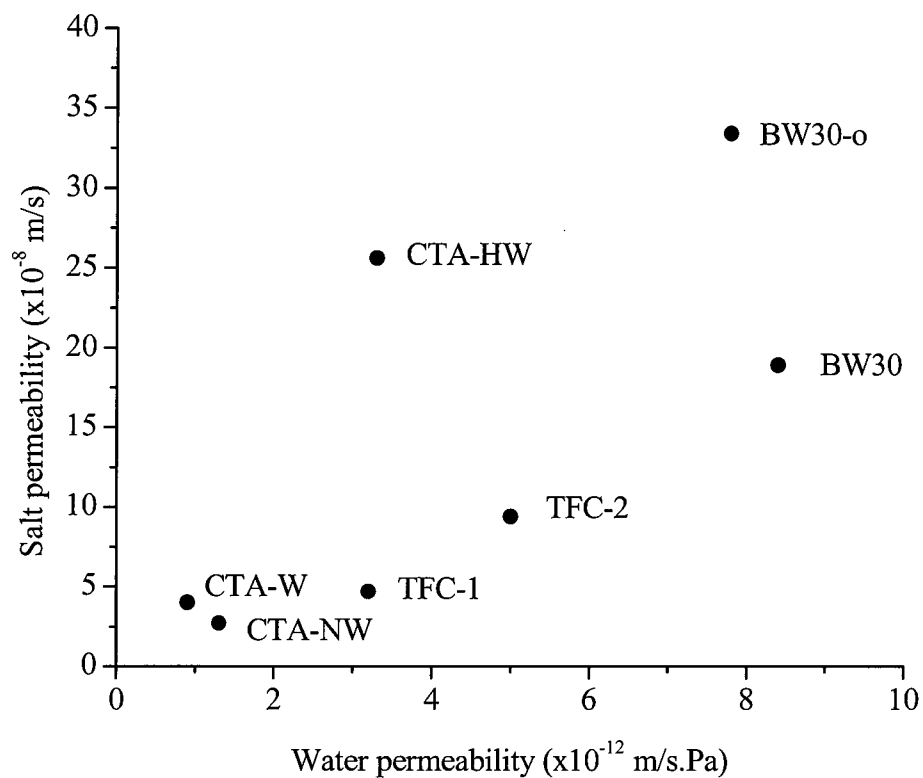


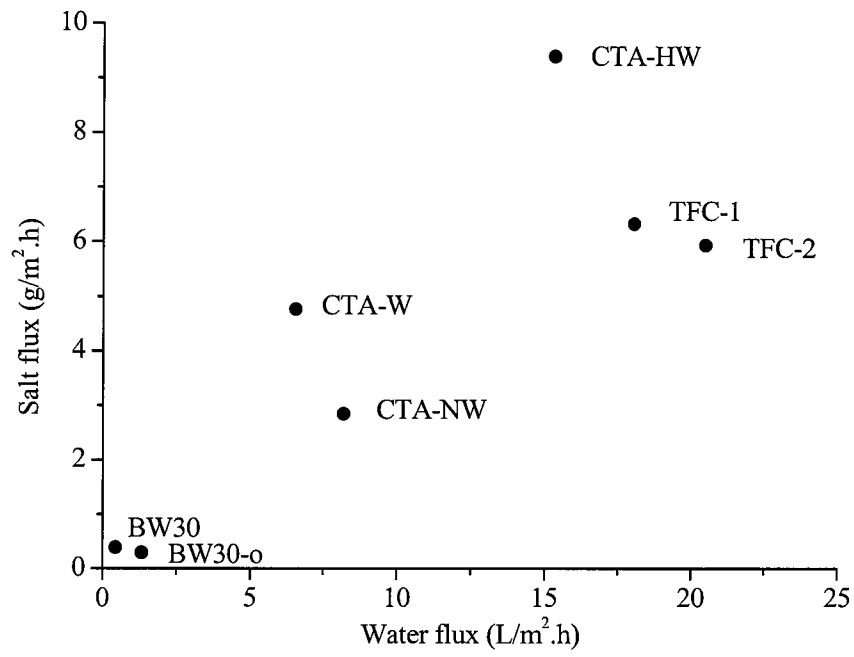
FIG. 7

Table 3 Properties of synthesized TFC FO membranes and commercial membranes ^a

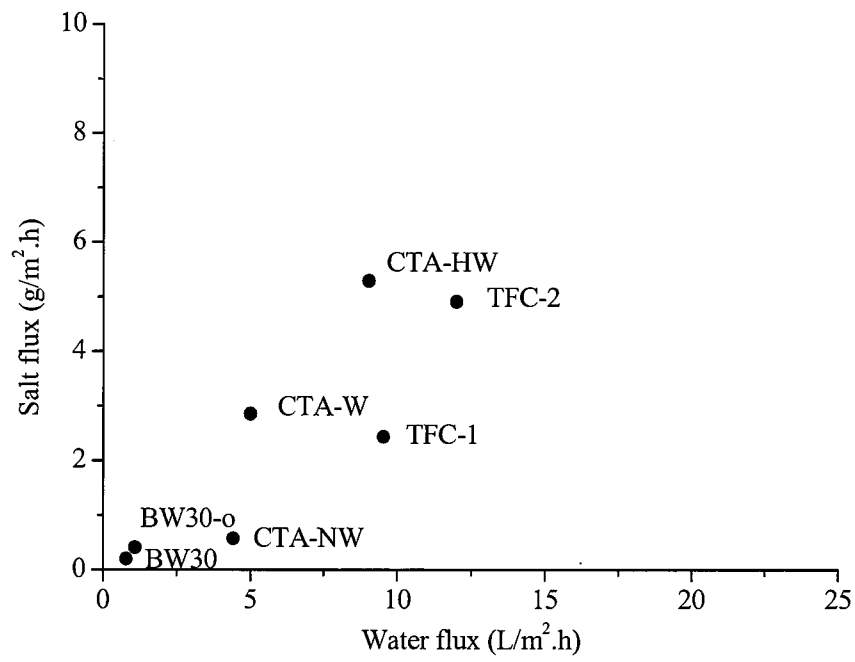
Sample	Contact angle (°)	Surface morphology	Water permeability ^b		NaCl rejection ^c (%)	Salt permeability B^d (10^{-8} m/s)	B/A^d (kPa)
			(L/m ² .h.bar)	(10^{-12} m/s.Pa)			
TFC-1	43 ± 4	Ridge-valley	1.15 ± 0.16	3.2 ± 0.5	94.5	4.7 ± 1.4	16 ± 6
TFC-2	45 ± 4	Ridge-valley	1.78 ± 0.23	5.0 ± 0.7	93.4	9.4 ± 1.9	20 ± 6
CTA-HW	63 ± 3	Smooth	1.19 ± 0.19	3.3 ± 0.5	78.5	25.6 ± 1.4	84 ± 8
CTA-W	73 ± 2	Smooth	0.33 ± 0.04	0.9 ± 0.1	81.9	4.0 ± 0.9	47 ± 12
CTA-NW	64 ± 2	Smooth	0.46 ± 0.07	1.3 ± 0.2	92.4	2.7 ± 0.2	22 ± 3
BW30	42 ± 2	Ridge-valley	3.04 ± 0.44	8.4 ± 1.2	92.2	18.9 ± 1.4	24 ± 3
BW30-o	42 ± 2	Ridge-valley	2.79 ± 0.40	7.8 ± 1.1	86.9	33.4 ± 4.3	47 ± 9

FIG. 8**FIG. 9****Table 4** FO water flux of synthesized TFC FO membranes and commercial membranes

Membrane orientation	AL-DS		AL-FS	
	0.5 M	2.0 M	0.5 M	2.0 M
TFC-1	18.1	44.8	9.53	18.1
TFC-1 (replicate)	16.5	37.8	9.01	16.7
TFC-2	20.5	54.3	12.0	22.2
TFC-2 (replicate)	19.5	53.1	14.9	27.9
CTA-HW	15.4	35.9	9.03	18.3
CTA-W	6.55	22.9	5.00	12.1
CTA-NW	8.19	21.8	4.42	8.54
BW30	0.44	1.59	0.78	0.48
BW30-o	1.33	2.18	1.09	1.90

FIG. 10

(a)



(b)

FIG. 11

Table 5 Comparison of FO performance with literature data

Structure	Material	FO performance		Testing conditions			References	
		Water flux (L/m ² .h)	Salt flux (g/m ² .h)	Membrane orientation	Feed solution	Draw solution		Temperature (°C)
TFC flat-sheet membrane	Polyamide-polysulfone	18.1	6.3	AL-DS	10 mM NaCl	0.5 M NaCl	23	Present work
		9.5	2.4	AL-FS	10 mM NaCl	0.5 M NaCl	23	Present work
TFC flat-sheet membrane	Polyamide-polysulfone	20.5	5.9	AL-DS	10 mM NaCl	0.5 M NaCl	23	Present work
		12	4.9	AL-FS	10 mM NaCl	0.5 M NaCl	23	Present work
Commercial asymmetric flat-sheet membrane (CTA-HW)	Cellulose triacetate	15.4	9.4	AL-DS	10 mM NaCl	0.5 M NaCl	23	Present work
		9	5.3	AL-FS	10 mM NaCl	0.5 M NaCl	23	Present work

FIG. 11 (CONT.)

Structure	Material	FO performance		Testing conditions			References
		Water flux (L/m ² .h)	Salt flux (g/m ² .h)	Membrane orientation	Feed solution	Draw solution Temperature (°C)	
Commercial asymmetric flat-sheet membrane (CTA-W)	Cellulose triacetate	6.6	4.8	AL-DS	10 mM NaCl	23	Present work
		5	2.9	AL-FS	10 mM NaCl	23	Present work
		8.2	2.8	AL-DS	10 mM NaCl	23	Present work
TFC flat- sheet membrane	Polyamide-polysulfone	4.4	0.6	AL-FS	10 mM NaCl	23	Present work
		18.16 0.96	±	AL-FS	DI water	25 ± 0.5	[29]
		20.5 ± 3.8	-	AL-FS	DI water	25 ± 0.5	[37]
TFC flat- sheet membrane	Polyamide-polysulfone	13.9 ± 1.0	-	AL-FS	DI water	25 ± 0.5	[37]

FIG. 11 (CONT.)

Structure	Material	FO performance		Testing conditions			References	
		Water flux (L/m ² .h)	Salt flux (g/m ² .h)	Membrane orientation	Feed solution	Draw solution		Temperature (°C)
TFC flat-sheet membrane	Polyamide-polysulfone	9.2 ± 0.2	-	AL-FS	DI water	1.0 M NaCl	25 ± 0.5	[37]
TFC flat-sheet membrane	Polyamide-polysulfone	6.2 ± 2.8	-	AL-FS	DI water	1.0 M NaCl	25 ± 0.5	[37]
TFC flat-sheet membrane	Polyamide-polysulfone	10.8 ± 2.4	-	AL-FS	DI water	1.0 M NaCl	25 ± 0.5	[37]
TFC flat-sheet membrane	Polyamide-polysulfone	12.5 ± 1.0	-	AL-FS	DI water	1.0 M NaCl	25 ± 0.5	[37]
TFC flat-sheet membrane	Polyamide-polysulfone	14.3 ± 2.5	-	AL-FS	DI water	1.0 M NaCl	25 ± 0.5	[37]
TFC flat-sheet membrane	Polyamide-polysulfone	25.0 ± 4.1	-	AL-FS	DI water	1.0 M NaCl	25 ± 0.5	[37]
TFC flat-sheet membrane	Polyamide-polysulfone	17.6 ± 0.4	-	AL-FS	DI water	1.0 M NaCl	25 ± 0.5	[37]
TFC flat-sheet membrane	Polyamide-polysulfone	5.6 ± 1.6	-	AL-FS	DI water	1.0 M NaCl	25 ± 0.5	[37]

FIG. 11 (CONT.)

Structure	Material	FO performance		Testing conditions			References	
		Water flux (L/m ² .h)	Salt flux (g/m ² .h)	Membrane orientation	Feed solution	Draw solution		Temperature (°C)
TFC flat-sheet membrane	Polyamide-polysulfone	0.5 ± 0.1	-	AL-FS	DI water	1.0 M NaCl	25 ± 0.5	[37]
TFC flat-sheet membrane	Polyamide-polysulfone	5.4 ± 0.6	-	AL-FS	DI water	1.0 M NaCl	25 ± 0.5	[37]
TFC flat-sheet membrane	Polyamide-polysulfone	5.6	-	AL-FS	DI water	1.0 M NaCl	25 ± 0.5	[37]
Double-skinned flat-sheet membrane	Cellulose acetate	48.2	6.5	MgCl ₂ -Bottom	DI water	5.0 M MgCl ₂	22 ± 0.5	[28]
		27.4	3.9	MgCl ₂ -Top	DI water	5.0 M MgCl ₂	22 ± 0.5	[28]
Double-skinned flat-sheet membrane	Cellulose acetate	17.3 ± 0.4	1.2 ± 0.2	AL-DS	DI water	2.0 M MgCl ₂	22 ± 0.5	[34]
		10.3 ± 0.3	0.8 ± 0.1	AL-FS	DI water	2.0 M MgCl ₂	22 ± 0.5	[34]

FIG. 11 (CONT.)

Structure	Material	FO performance		Testing conditions			References
		Water flux (L/m ² .h)	Salt flux (g/m ² .h)	Membrane orientation	Feed solution	Draw solution	Temperature (°C)
Double- skinned flat- sheet membrane	Cellulose acetate	14.7 ± 1.0	2.2 ± 0.4	AL-DS	DI water	2.0 M MgCl ₂	22 ± 0.5
		9.8 ± 0.7	1.2 ± 0.3	AL-FS	DI water	2.0 M MgCl ₂	22 ± 0.5
Double- skinned flat- sheet membrane	Cellulose acetate	9.5 ± 0.4	698.6 ± 14.8	AL-DS	DI water	2.0 M MgCl ₂	22 ± 0.5
		7.9 ± 0.5	824.8 ± 15.0	AL-FS	DI water	2.0 M MgCl ₂	22 ± 0.5
TFC hollow fiber	Polyamide-polyethersulfone	12.9	5	AL-DS	DI water	0.5M NaCl	23
TFC hollow fiber	Polyamide-polyethersulfone	5	2.12	AL-FS	DI water	0.5M NaCl	23
		32.2	3.5	AL-DS	DI water	0.5M NaCl	23
TFC hollow fiber	Polyamide-polyethersulfone	14	1.75	AL-FS	DI water	0.5M NaCl	23
		32.9	2.9	AL-DS	500 ppm (8.6 mM) NaCl	0.5M NaCl	20 ~ 25
Positively charged hollow fiber	Poly(amide-imide)- polyethylenimine	6.34	3	AL-DS	DI water	1.5 M MgCl ₂	23
		4.15	1.9	AL-FS	DI water	1.5 M MgCl ₂	23

FIG. 11 (CONT.)

Structure	Material	FO performance		Testing conditions			References
		Water flux (L/m ² ·h)	Salt flux (g/m ² ·h)	Membrane orientation	Feed solution	Draw solution Temperature (°C)	
Positively charged hollow fiber	Poly(amide-imide)- polyethylenimine	17.3	16.6	AL-DS	DI water	1.5 M MgCl ₂ 23	[38]
		11.7	3.9	AL-FS	DI water	1.5 M MgCl ₂ 23	[38]
Positively charged hollow fiber	Poly(amide-imide)- polyethylenimine	17.2	37.7	AL-DS	DI water	1.5 M MgCl ₂ 23	[38]
Asymmetric hollow fiber	Cellulose acetate	12.9	4.8	AL-FS	DI water	1.5 M MgCl ₂ 23	[38]
		7.3	-	AL-DS	DI water	2.0 M MgCl ₂ -	[27]
		5	-	AL-FS	DI water	2.0 M MgCl ₂ -	[27]
Asymmetric hollow fiber	Polybenzimidazole	3.84	-	AL-DS	DI water	2.0 M NaCl 22.5	[30]
		5.65	-	AL-DS	DI water	2.0 M MgSO ₄ 22.5	[30]
		7.74	-	AL-DS	DI water	2.0 M Na ₂ SO ₄ 22.5	[30]
		9.02	-	AL-DS	DI water	2.0 M MgCl ₂ 22.5	[30]
Asymmetric hollow fiber	Polybenzimidazole	36.5	-	AL-DS	DI water	5.0 M MgCl ₂ 23	[31]
Asymmetric hollow fiber	Polybenzimidazole	32.4	-	AL-DS	DI water	5.0 M MgCl ₂ 23	[31]

FIG. 11 (CONT.)

Structure	Material	FO performance			Testing conditions			References
		Water flux (L/m ² .h)	Salt flux (g/m ² .h)	Membrane orientation	Feed solution	Draw solution	Temperature (°C)	
Dual-layer hollow fiber	polybenzimidazole- polyethersulfone/polyvinylpyrrolid one	17.1	-	AL-DS	0.1 lysozyme aqueous solution	3.125 M MgCl ₂	-	[32]
		12.7	-	AL-FS	0.1 lysozyme aqueous solution	3.125 M MgCl ₂	-	[32]
Dual-layer hollow fiber	polybenzimidazole- polyethersulfone/ pyrrolidone	24.2	-	AL-FS	DI water	5.0 M MgCl ₂	23	[33]
		33.8	-	AL-DS	DI water	5.0 M MgCl ₂	23	[33]
		45.6	-	AL-DS	DI water	5.0 M MgCl ₂	38.5	[33]

FIG. 12

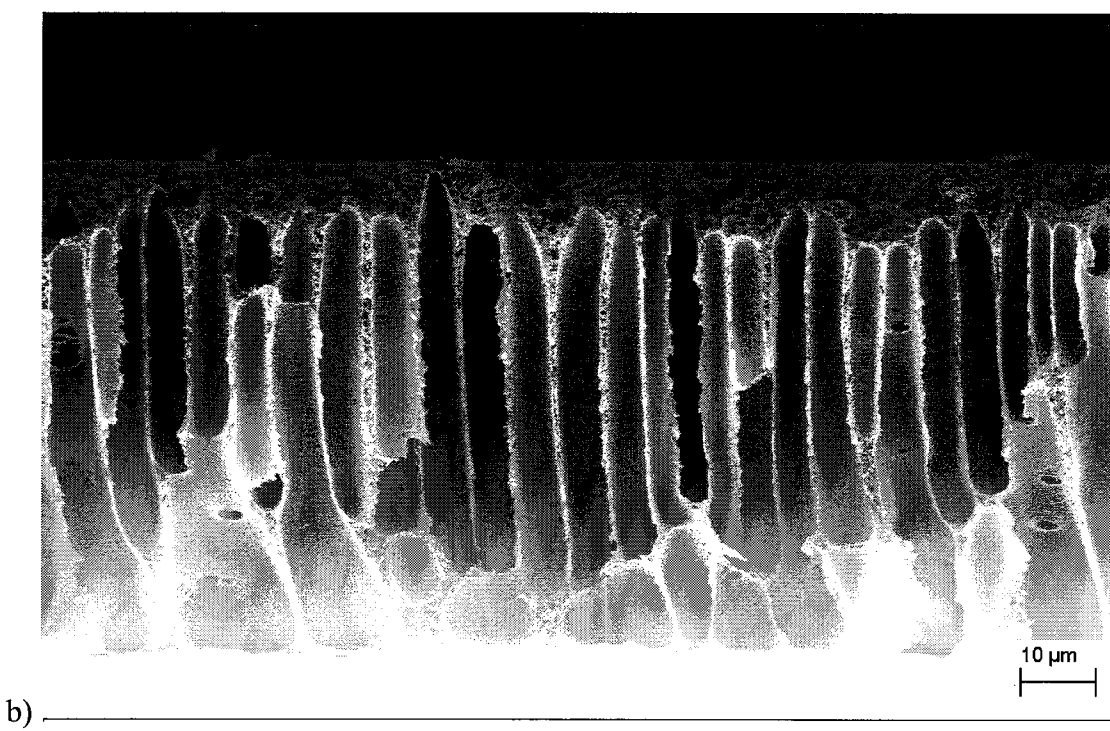
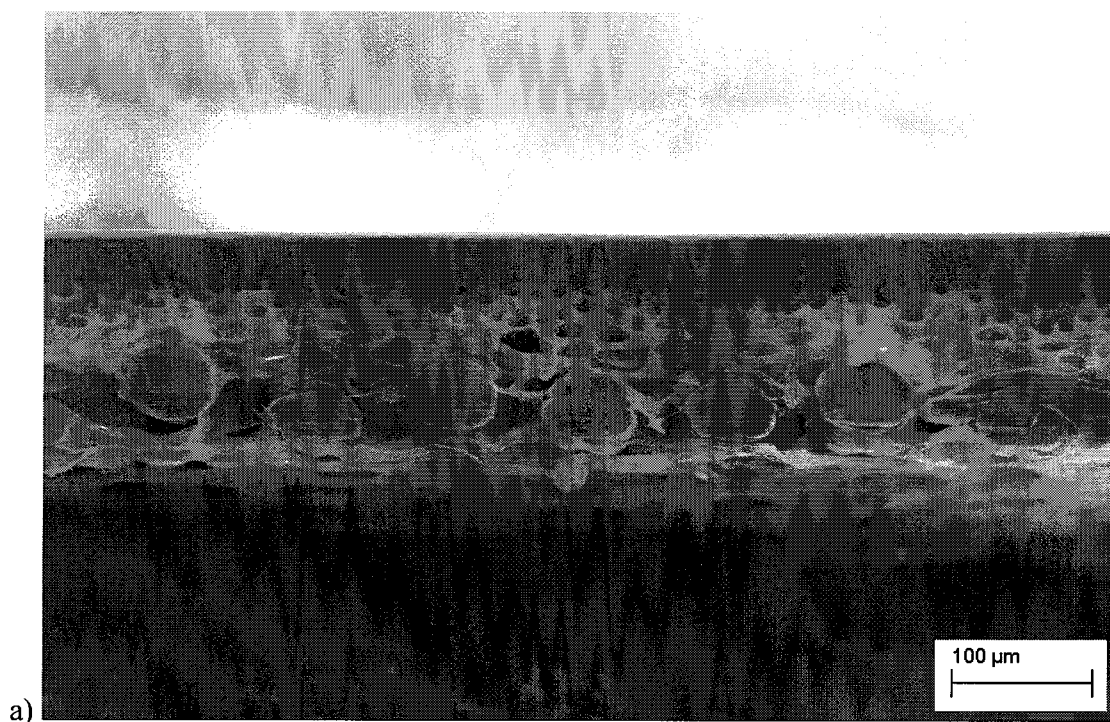


FIG. 13

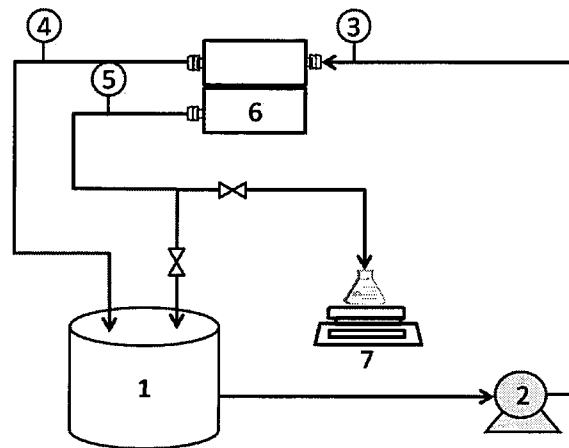


FIG. 14

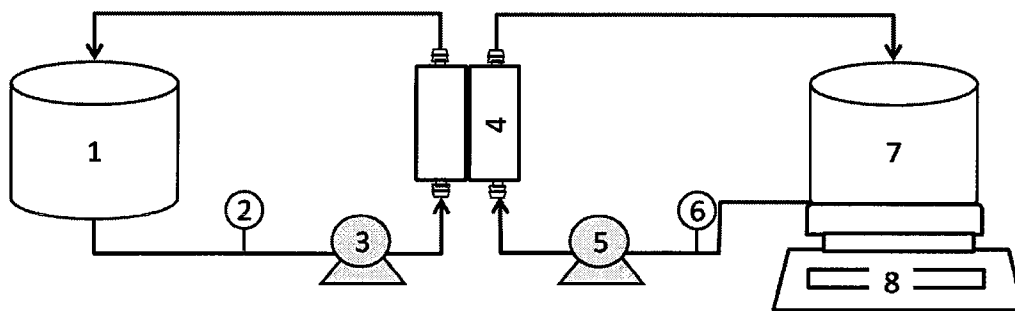


FIG. 15

Table 6 Characteristics of substrates prepared for TFC flat-sheet FO membranes

Description	Thickness (μm)	Contact angle ($^{\circ}$)	Porosity (%)	Pure water flux ($\text{L}/\text{m}^2 \cdot \text{h} \cdot \text{bar}$)	Mean flow pore diameter (nm)
1 Substrate without mesh	67.95	49.01	77.20	205	75.3
2 Substrate with mesh	163	52.30	64.12	509	68.1

FIG. 16**Table 7** Intrinsic separation properties and FO performance of TFC flat-sheet FO membranes synthesized

Description	Water permeability (10^{-12} m/s.Pa)	Salt permeability (10^{-8} m/s)	Water flux (Draw: 0.5M NaCl) (L/m ² .h)		Water flux (Draw: 2.0M NaCl) (L/m ² .h)		Salt flux (Draw: 0.5M NaCl) (g/m ² .h)		Salt flux (Draw: 2.0M NaCl) (g/m ² .h)	
			AL-DS	AL-FW	AL-DS	AL-FW	AL-DS	AL-FW	AL-DS	AL-FW
1 FO membrane without mesh	6.57	3.78	20.50	12.00	54.29	22.18	5.93	4.91	19.59	30.68
2 FO membrane with mesh	2.49	16.20	5.89	4.34	14.45	5.81	2.64	1.12	2.32	2.67

FIG. 17