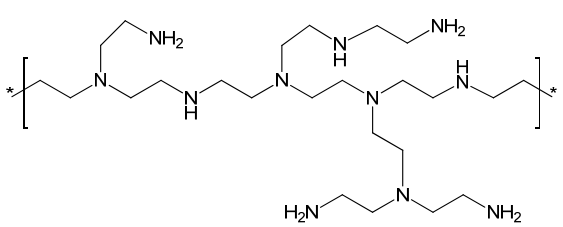
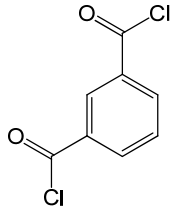


(a) Torlon® 4000T-MV polyamide-imide (PAI)



(b) Hyperbranched polyethyleneimine (HPEI)



(c) Isophthaloyl chloride (IPC)

FIG. 1

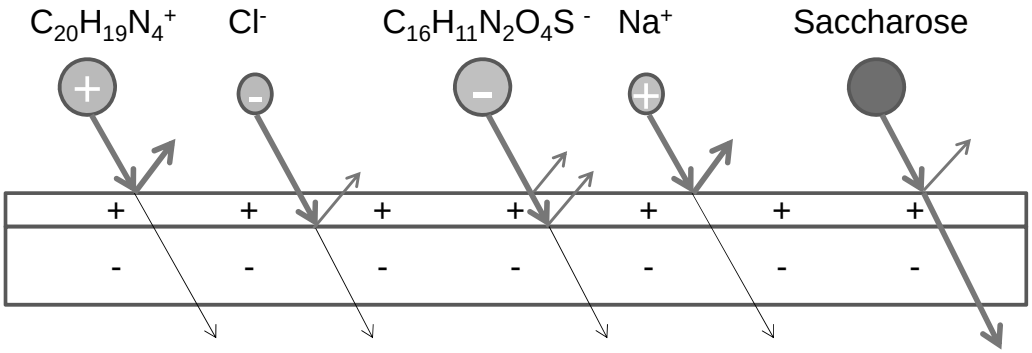
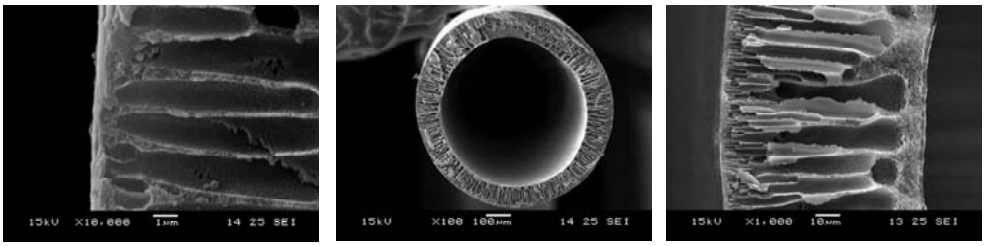


FIG. 2



Outer edge ×10K | Cross section ×100 | Cross section ×1K

Outer surface ×10K | Inner surface ×2K | Inner edge ×5K

FIG. 3

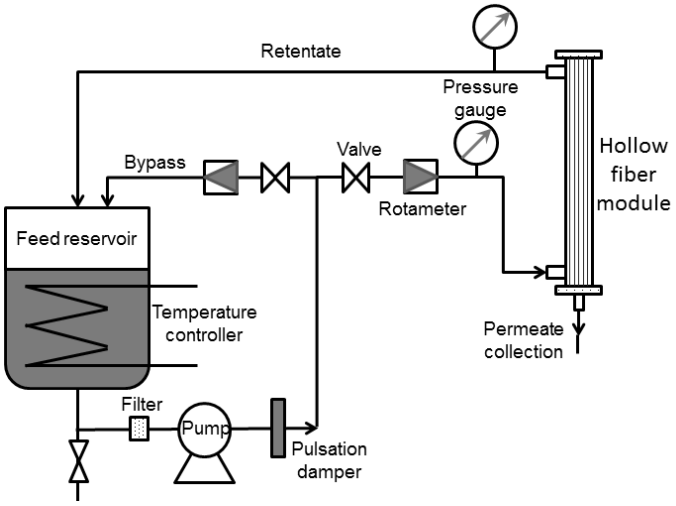


FIG.4

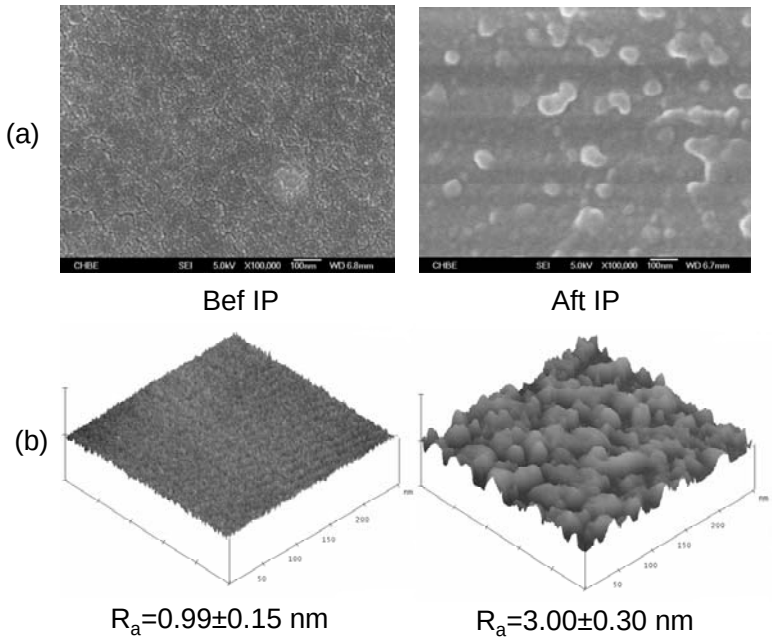

(a)
Bef IP
Aft IP
(b)
R_a=0.99±0.15 nm
R_a=3.00±0.30 nm

FIG. 5

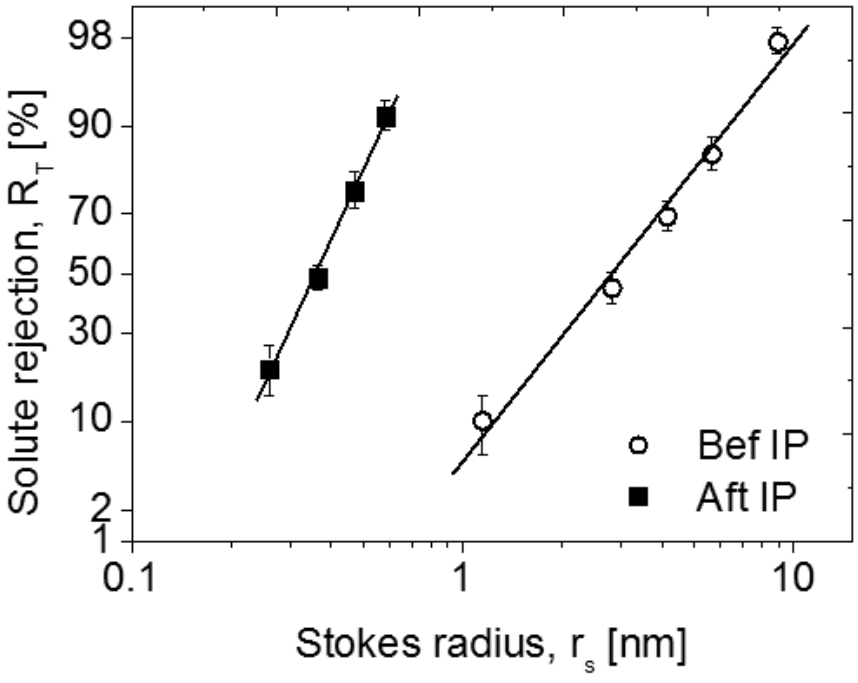

Solute rejection, R_T [%]
98
90
70
50
30
10
2
1
0.1
1
10
Stokes radius, r_s [nm]
Bef IP
Aft IP

FIG. 6

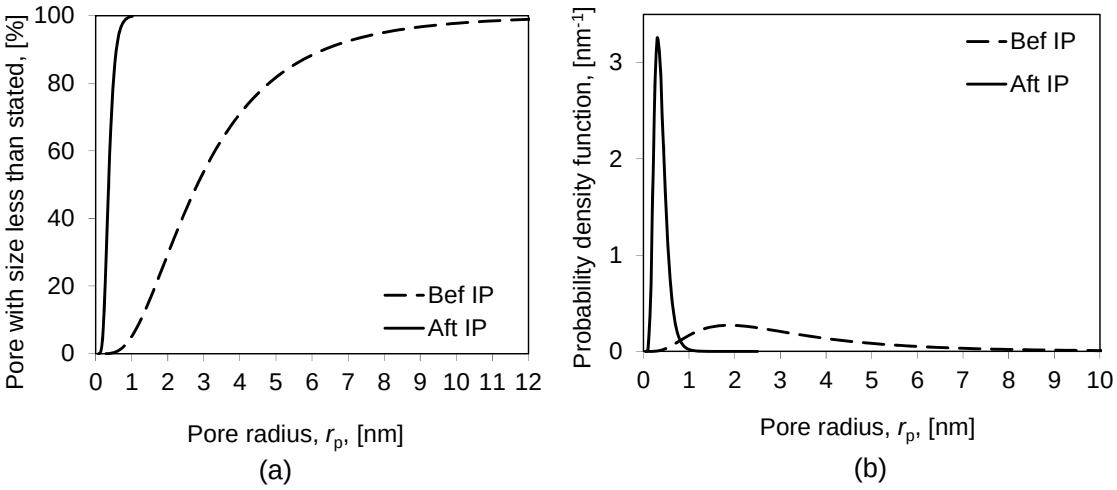

Pore with size less than stated, [%]
100
80
60
40
20
0
0 1 2 3 4 5 6 7 8 9 10 11 12
Pore radius, r_p, [nm]
Bef IP
Aft IP
(a)
Probability density function, [nm^{-1}]
3
2
1
0
0 1 2 3 4 5 6 7 8 9 10
Pore radius, r_p, [nm]
Bef IP
Aft IP
(b)

FIG. 7

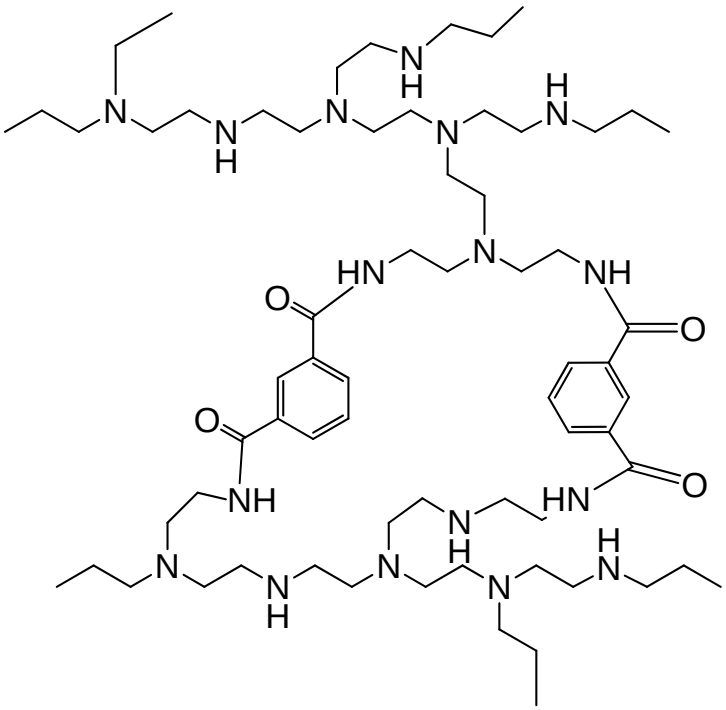


FIG. 8

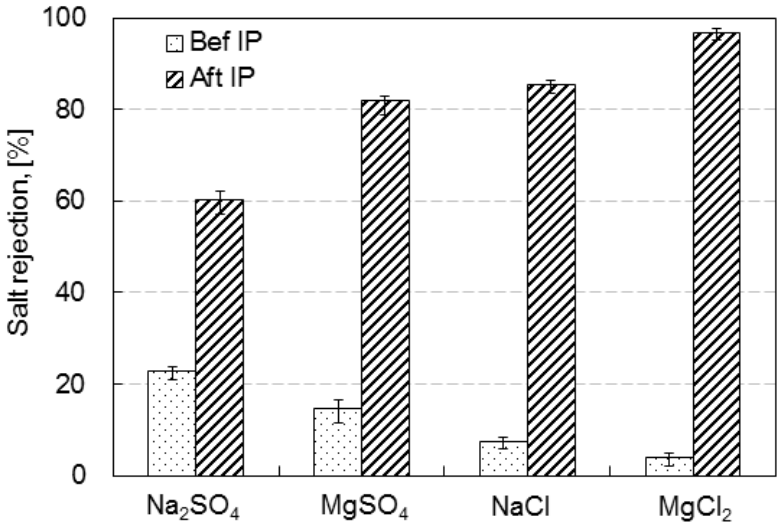
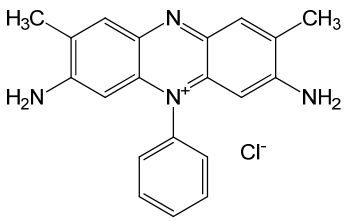


FIG. 9

(a) Safranin O

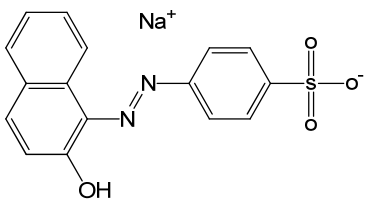




$C_{20}H_{19}N_4^+$, Cl^-, 350.84 Da

(b) Orange II sodium salt





$C_{16}H_{11}N_2O_4S^-$, Na^+, 350.32 Da

FIG. 10

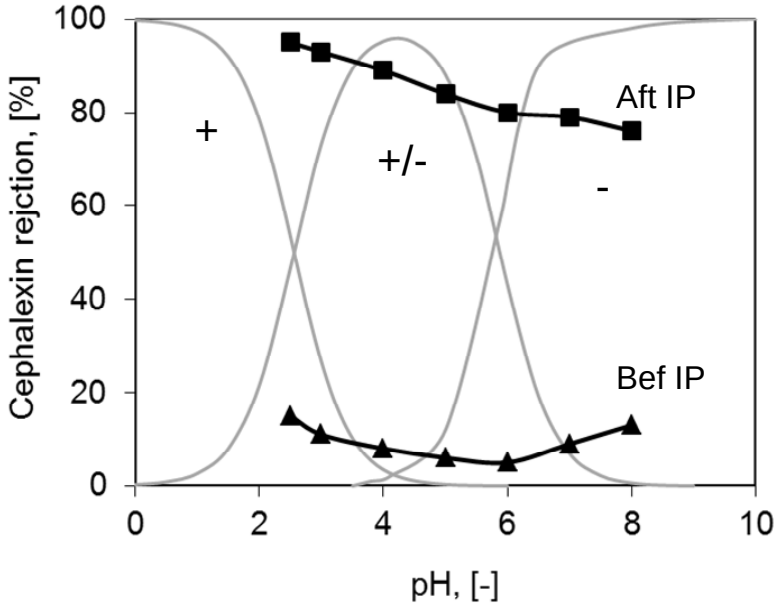


FIG. 11

Outer dope composition (wt%):	PAI/Methanol/NMP: 20.0/10.0/70.0
Inner dope composition (wt%):	PAI/PEG2K/NMP: 15.0/5.0/80.0
Bore fluid composition (wt%):	NMP/Water=80/20
External coagulant:	Water
Outer dope flow rate (ml/min)	0.5
Inner dope flow rate (ml/min)	4.0
Bore fluid flow rate (ml/min)	3.0
Air Gap (cm)	2.5
Take-up speed (m/min)	10
Spinneret dimension (mm):	0.84/1.0/1.58/1.74/2.0
Spinneret temperature (ºC):	26

TABLE 1

Solute	MW [g·mol^{-1}]	D_s [$\times 10^{-9}$ m^2·s^{-1}]	r_s [nm]
Solutes used for calculating the pore size of NF membranes:			
Glycerol	92	0.78	0.260
Glucose	180	0.67	0.365
Saccharose	342	0.52	0.471
Raffinose	504	0.42	0.584
Solutes used for calculating the pore size of the support:			
PEG 2K	2 000	-	1.15
PEG 10K	10 000	-	2.82
PEG 20K	20 000	-	4.16
PEG 35K	35 000	-	5.68
PEO 100K	100 000	-	8.99

TABLE 2

HPEI MW (Da)	HPEI concentration (wt%)	IPC concentration (wt%)	PWP ($lm^{-2}bar^{-1}h^{-1}$)	Raffinose rejection (%)	$MgCl_2$ rejection (%)
HPEI_2K	1	0.5	8.17	79.32	83.05
HPEI_60K	1	0.5	5.87	86.29	92.55
HPEI_60K	2	0.5	4.85	90.01	96.17
HPEI_60K	4	0.5	1.91	91.36	96.99

Raffinose concentration: 200ppm, $MgCl_2$ concentration: 1mM. pH 5.75. Pressure:5 bar.

TABLE 3

ID	r_p (nm)	σ_p (-)	MWCO (Da)	PWP ($lm^{-2}bar^{-1}h^{-1}$)
Bef IP	2.82	1.89	42602	43.25
Aft IP	0.36	1.44	489	4.85

(The feed solution concentration: 200ppm, pH 5.75. Pressure:5 bar)

TABLE 4

Solute	Safranin O	Orange II sodium salt	Saccharose
Molecular formula	$C_{20}H_{19}N_4^+,Cl^-$	$C_{16}H_{11}N_2O_4S^-,Na^+$	$C_{12}H_{22}O_{11}$
MW (Da)	350.84	350.32	342.30
Size (nm^3)	1.10×0.95×0.49	1.10×0.63×0.70	1.05×0.66×0.73
Rejection, (%)	99.80	98.75	76.39
Flux, ($L\ m^{-2}h^{-1}$)	22.71	20.60	21.35
J/J_0, (%)	93.65	84.95	88.04

J_0=24.25 $L\ m^{-2}h^{-1}$

TABLE 5