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Recent advances in polymer and polymer composite membranes for reverse and forward osmosis processes

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ABSTRACT

Semipermeable membranes are the core elements for membrane water desalination technologies such as commercial reverse osmosis (RO) process and emerging forward osmosis (FO) process. Structural and chemical properties of the semipermeable membranes determine water flux, salt rejection, fouling resistance, and chemical stability, which greatly impact energy consumption and costs in osmosis separation processes. In recent years, significant progress has been made in the development of high-performance polymer and polymer composite membranes for desalination applications. This paper reviews recent advances in different polymer-based RO and FO desalination membranes in terms of materials and strategies developed for improving properties and performances.

Contents

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Nomenclature

AA	acrylic acid
AAPTS	*N*-[3-(trimethoxysilyl) propyl] ethylenediamine
ABA	poly-(2-methyloxazoline)-poly-(dimethylsiloxane)-poly-(2-methyloxazoline)
AEPPS	*N*-aminoethyl piperazine propane sulfonate
AL-DS	a mode of active layer facing the draw solution; also called as pressure retarded osmosis (PRO)
AL-FS	a mode of active layer facing the feed solution; also called as forward osmosis mode (FO)
AQP	aquaporin
BWRO	brackish water reverse osmosis
CA	cellulose acetate
CAP	cellulose acetate propionate
CFIC	chloroformyloxyisophthaloyl chloride
CLSM	confocal laser scanning microscopy
CNTs	carbon nanotubes
CP	concentration polarization
CSA	camphorsulfonic acid
CTA	cellulose triacetate
CTAC	cetyltrimethylammonium chloride
DABA	3,5-diamino-*N*-(4-aminophenyl) benzamide
DMAc	dimethylacetamide
DMMPD	*N*,*N*′-dimethyl-*m*-phenylenediamine
DOTAP	1,2-dioleoyl-3-trimethylammo-nium-propane (chloride salt)
DOPC	1,2-dioleoyl-sn-glycero-3-phosphocholine
DTAB	dodecyl trimethyl ammonium bromide
E. coli	*Escherichia coli*
FO	forward osmosis
GMA	glycidyl methacrylate
gMH	g/m^2 h
HTI	Hydration Technologies Inc.
ICP	internal concentration polarization
iCVD	initiated chemical vapour deposition
IP	interfacial polymerization
IPC	isophthaloyl chloride
IU	imidazolidinyl urea
LbL	layer-by-layer
LCST	lower critical solution temperature
L-DOPA	3-(3,4-dihydroxyphenyl)-L-alanine
LMH	L/m^2 h
MMMs	mixed matrix membranes
MOF	metal-organic framework
MPD	*m*-phenylenediamine
MWCNTs	multi-walled carbon nanotubes
NIPAM	*N*-isopropylacrylamide
NMP	*N*-methylpyrrolidone
o-ABA-TEA	*o*-aminobenzoic acid-triethylamine salt
PAA	poly(acrylic acid)
PAH	poly(allylamine hydrochloride)
P(Am-co-AA)	poly(acrylamide-*co*-acrylic acid)
PAI	poly(amide-imide)
PAN	polyacrylonitrile
PBI	polybenzimidazole
PCTE	polycarbonate tracked-etched
PD	*p*-phenylene diamine
PDA	polydopamine
PDADMAC	poly(diallyl-dimethylammonium chloride)
PEG	polyethylene glycol
PEI	polyethyleneimine
PES	polyethersulfone
PESU-co-sPPSU	sulfonated copolymer made of polyethersulfone and polyphenylsulfone
PET	polyester
PETA	polyethylene terephthalate
PI	polyimide
PIP	piperazine
PLL	poly-L-lysine
PMOXA-PDMS-PMOXA	poly(2-methyloxazoline)-*block*-poly(dimethylsiloxane)-*block*-poly(2-methyloxazoline)
PNIPAM	poly(*N*-isopropylacrylamide)
P(NIPAM-co-Am)	poly(*N*-isopropylacrylamide-*co*-acrylamide)
POSS	polyhedral oligomeric silsesquioxane
PPD	*p*-phenylenediamine
PPENK	poly(phthalazione ether nitrile ketone)
PRO	pressure retarded osmosis
PSf	polysulfone
PSS	poly(sodium 4-styrenesulfonate)
PTA-POD	polytriazole-*co*-polyoxadiazole
P. putida	*Pseudomonas putida*
PVA	polyvinyl alcohol
PVDF	polyvinylidene fluoride
PVP	polyvinylpyrrolidone
rGO	reduced graphene oxide
SEM	scanning electron microscopy
SDS	sodium dodecyl sulfate
SLS	sodium lauryl sulfate
SPEK	sulphonated poly(ether ketone)
sPPSU	sulfonated polyphenylsulfone
SPSf	sulfonated polysulfone
S_t	structural parameter
S. aureus	*Staphylococcus aureus*