Progress in Polymer Science 57 (2016) 1–31

Contents lists available at ScienceDirect

Progress in Polymer Science

journal homepage: www.elsevier.com/locate/ppolysci

Recent membrane development for pervaporation processes

Yee Kang Ong[a], Gui Min Shi[a], Ngoc Lieu Le[a,b], Yu Pan Tang[a], Jian Zuo[a], Suzana P. Nunes[b], Tai-Shung Chung[a,b,*]

[a] *Department of Chemical & Biomolecular Engineering, National University of Singapore, 4 Engineering Drive 4, Singapore 117585, Singapore*

[b] *Water Desalination & Reuse (WDR) Center, King Abdullah University of Science and Technology, Thuwal 23955-6900, Saudi Arabia*

ARTICLE INFO

Article history:
Received 14 April 2015
Received in revised form 28 January 2016
Accepted 23 February 2016
Available online 11 March 2016

Keywords:
Pervaporation
Review
Membranes
Hydrophobic
Hydrophilic
Organics

ABSTRACT

Pervaporation has been regarded as a promising separation technology in separating azeotropic mixtures, solutions with similar boiling points, thermally sensitive compounds, organic–organic mixtures as well as in removing dilute organics from aqueous solutions. As the pervaporation membrane is one of the crucial factors in determining the overall efficiency of the separation process, this article reviews the research and development (R&D) of polymeric pervaporation membranes from the perspective of membrane fabrication procedures and materials.

Contents

* Corresponding author at: Department of Chemical & Biomolecular Engineering, National University of Singapore, 4 Engineering Drive 4, Singapore 117585, Singapore. Tel.: +65 6516 6645; fax: +65 6779 1936.
E-mail address: chencts@nus.edu.sg (T.-S. Chung).

http://dx.doi.org/10.1016/j.progpolymsci.2016.02.003

Nomenclature

A	membrane area (m^2)
f	fugacity (kPa)
J	flux (kg/m^2h)
l	membrane selective layer thickness (μm)
M	molar mass (g/mol)
P	permeability ($g\,m/m^2\,h\,kPa$)
p^{sat}	saturated vapor pressure (kPa)
P/l	permeance ($g/m^2\,h\,kPa$)
Q	weight of the collected permeate
t	time (h)
x	mass fraction in liquid feed solution
y	mass fraction in the permeate

Greek Letter

α	selectivity
β	separation factor
γ	activity coefficient

Subscript

evap	evaporation
f	feed
i	component *i* at feed or permeate
j	component *j* at or permeate
p	permeate
pervap	pervaporation

Abbreviations

6-FDA	4,4′-(hexafluoroisopropylidene)diphthalic anhydride
ABE	acetone–butanol–ethanol
Al_2O_3	alumina oxide
BuOH	*n*-butanol
β-CD	β-cyclodextrin
CMS	carbon molecular sieve
COF	covalent organic framework
CS	chitosan
DABA	3,5-diaminobenzoic acid
DM	dimethylcarbonate
DMAc	*N*,*N*-dimethylacetamide
DMF	*N*,*N*-dimethylformamide
DMSO	*N*,*N*-dimethylsulfoxide
EDA	ethylenediamine
EG	ethylene glycol
ETBE	ethyl tert-butyl ether
EtOH	ethanol
FFV	fractional free volume
GA	glutaraldehyde
GFT	Gesellschaft für Trenntechnik
GO	graphene oxide
HF	hydrofluoric acid
HPEI	hyper-branched polyethyleneimine
HTPB	hydroxyl-terminated polybutadiene
I^2PS	immiscibility induced phase separation
ICD	ionic complexation degree
IPA	isopropanol
IPN	interpenetrating polymer network
LBL	layer-by-layer
MDEGMA	methyl diethylene glycol methacrylate
MeOH	methanol
MgO	magnesium oxide
MMM	mixed matrix membrane
MOFs	metal organic frameworks
MPD	m-phenylenediamine
MPDSA	sulfonated MPD
mPEEK	modified poly(ether ether ketone)
MTBE	methyl tert-butyl ether
MTR	Membrane Technology & Research
MWCNT	multiwalled carbon nanotubes
NaAlg	sodium alginate
NaCMC	sodium carboxymethyl cellulose
NDA	1,5-naphthalene diamine
NF	nanofiltration
NR	natural rubber
NRF	National Research Foundation
NTAC	5-nitrobenzene-1,3-dioyl dichloride
OA	octa-anion
OAPS	octa-aminophenyl
OAS	octa-ammonium
ONPS	octa-nitrophenyl
P(AANa-co-SSNa)	poly(sodium acrylate-co-sodium sytyrenesulfonate)
PAA	polyacrylic acid
PAN	poly(acrylonitrile)
PAS	positron annihilation spectroscopy
PBI	polybenzimidazole
PBO	polybenzoxazole
PBOZ	polybenzoxazinone
PBPP	poly[bis(phenoxy)phosphazene]
PDDA	poly(diallyldimethylammonium chloride)
PDMC	poly(2-methacryloyloxy ethyl trimethylammonium chloride)
PDMS	polydimethylsiloxane
PEBA	polyether-block-polyamide