# Electronic Supplementary Material

## $CO_2$ capture using membrane contactors: a systematic literature review

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## Appendix A ‘Carbon Dioxide Main Characteristics Post Membrane Type Reactor Removal’

Table 1. The table depicts the studies included in the systematic review, with the extracted data on membrane material, reactor type, flow configuration, solvent, wetting, average calculated flux, gas flow rate, liquid flow rate and percentage of $CO_2$ in the feed stream.

| Authors | Membrane material | Reactor type | Flow configuration | Solvent (with molarity) | Wetting (+ = hydrophilic; - = hydrophobic) | Average flux (mol/ min cm$^2$) | Gas flow rate (ml/min) | Liquid flow rate (ml/min) | Feed vol % $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| Niwa, Ohya [1] | porous ceramic | ceramic membranes | concurrent | 3 M HCL | - | 9E-06 | - | - | 50 |
| Saha and Chakma [2] | polymeric membrane. | - | counter current flow | 3 M DEA | - | 3.14E-12 | - | - | - |
| Langevin, Pinoche [3] | - | facilitated transport membrane | counter current flow | Monoethanolamine (MEA) | | 1.75E-16 | 0.03 - 0.33 | 0.5 | 41 |
| Tokuda, Fujisawa [4] | cardo polyimide | hollow fibre membrane | co and counter current flow | N-Methyl-2-pyrrolidon (NMP), N,N-Dimethylacetamide (DMAc) | - | 3.19E-06 | - | - | - |
| Li and Teo [5] | silicone rubber or polyethersulphone | hollow fibre membrane | co and counter current flow | NaOH 2.5 M | - | 1.32E-04 | - | - | 4 |
| Suzuki, Tanaka [6] | Poly (ethylene oxide)-containing polyimide | composite hollow fibre membranes | concurrent flow | p-chlorophenol | - | 1.97E-04 | - | - | - |
| Chen, Kovvali [7] | glycerol | based immobilized liquid membranes (ilms) | parallel flow | glycine-Na-glycerol solution (2.5M) | - | 9.66E-05 | - | - | - |
| Lee, Noble [8] | potassium carbonate | hollow fibre membrane | parallel flow | - | | - | - | 9.6 - 100.2 | - |
| Mizukami, Takaba [9] | - | zeolite membranes | - | - | - | - | - | - | - |
| Vu, Koros [10] | carbon molecular sieve (CMS) hollow fibre membranes | - | concurrent flow | - | | 1.52E-04 | - | - | 10 |
| Xu, Zhang [11] | PVDF-PVA hydrogel | hydrogel membranes | concurrent flow | - | - | - | - | - | 0.6 - 1.3 |
| Zhang, Wang [12] | - | polymeric membranes | - | - | - | 4.69E-06 | - | - | 35 |
| Kapantaidakis, Koops [13] | polyimide and polyethersulfone blends | hollow fibre membrane | counter current flow | 1-methyl-2-pyrrolidone (NMP) | - | 7.32E-05 | 160 | - | 55 |

| Authors | Membrane material | Reactor type | Flow configuration | Solvent (with molarity) | Wetting (+ = hydrophilic; - = hydrophobic) | Average flux (mol/ min $cm^2$) | Gas flow rate (ml/min) | Liquid flow rate (ml/min) | Feed vol % $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| Kim, Park [14] | poly (ether sulfone) (PES) membrane | - | - | 2-ethoxyethanol | - | - | - | - | - |
| Jordal, Bredesen [15] | Pd membranes | - | counter current and cross flow | - | | - | - | - | - |
| Kim and Lee [16] | - | hollow fibre membrane | - | - | | - | - | - | 38 |
| Li, Falconer [17] | SAPO-34 | - | - | H3PO4 (85 wt.% aqueous solution) | | 1.33E-04 | 60 | - | 50 |
| Moon, Ahn [18] | tetrapropylammonium bromide (TPABr)-templating silica sols | silica/alumina composite membrane | - | TEOS: EtOH:H2O: HCl of 1.0 : 3.8 : 5.0 : 0.0053 | - | 6.00E-03 | - | - | - |
| Teramoto, Kitada [19] | - | facillated transport membrane | concurrent flow | monoethanolami/ne (MEA), diethanolamine (DEA) and 2- amino-2-methyl-1-propanol | | 4.4E-02 | 100 | 25-150 | - |
| Wang, Li [20] | - | hollow fibre membrane contactor | counter current flow | 2-amino-2-methyl-1-propanol (AMP), diethanolamine (DEA) and methyldiethanoamine (MDEA) | | 2.12E-05 | - | - | - |
| Johannessen and Jordal [21] | - | catalytic membrane reactor | counter-current flow | - | | - | - | - | - |
| Jordal, Bolland [22] | Pd membrane | - | counter current flow | - | | - | - | - | - |
| Li, Alvarado [23] | SAPO-34 | - | parallel flow | tetraethylammonium hydroxide (TEAOH) | | 2.02E-04 | - | - | 50 |
| Li, Martinek [24] | SAPO-34membranes | - | cross-flow | - | | 6.48E-04 | 150 | - | - |
| Liu, Chakma [25] | poly(ether block amide) (PEBA) | hollow fibre membrane | counter current flow | 1-butanol | - | 4.20E-05 | - | - | 62 |
| Qin, Chung [26] | 6FDA-Durene/1,3-phenylenediamine (mPDA) copolyimide | hollow fibre membranes | - | 6 FDA-Durene/mPDA (PI), N-methyl-pyrrolidone (NMP) and tetrahydrofuran (THF) with a weight ratio of 20:50:30 | - | 2.44E-04 | - | 0.1 | - |
| Wang, Zhang [27] | polypropylene | hollow fibre membrane | concurrent flow | 2 MDEA | - | 3.60E-06 | - | - | 20 |
| Gong, Wang [28] | - | hollow fibre membrane | counter current flow | methyldiethanolamine/monoethanolamine (MDEA/MEA) aqueous solutions and distilled water | | 1.65E-05 | 157 | 20-50 | - |

| Authors | Membrane material | Reactor type | Flow configuration | Solvent (with molarity) | Wetting (+ = hydrophilic; - = hydrophobic) | Average flux (mol/ min cm$^2$) | Gas flow rate (ml/min) | Liquid flow rate (ml/min) | Feed vol % $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| Ismail and Yaacob [29] | asymmetric polysulfone | hollow fibre membranes | concurrent flow | N,N-dimethylacetamide | - | 2.38E-06 | - | - | - |
| Okabe, Nakamura [30] | polyolefin | - | cross-flow | - | | - | - | - | - |
| Zhang, Wang [31] | - | hollow fibre membrane | concurrent flow | diethanolamine (DEA) solution 2M | - | 1.77E-06 | - | - | 20 |
| Francisco, Chakma [32] | poly(vinyl alcohol) matrix | - | concurrent flow | monoethanolamine (MEA), 2-amino-2-methyl-1-propanol (AMP), diethanolamine (DEA) and N-methyldiethanolamine (MDEA) | - | 1.1E-01 | - | - | - |
| Himeno, Tomita [33] | deca-dodecasil 3R (DD3R) | hydrophobic ddr-type zeolite membrane | concurrent flow | - | - | 4.32E-04 | - | - | 50 |
| Kelman, Lin [34] | poly(ethylene oxide) [PEO] material | polymeric membranes | concurrent flow | 1-hydroxylcyclohexylphenyl ketone (HCPK) | - | 5.50E-04 | - | - | 45 |
| Kwon, Kim [35] | zeolite membrane : silica/aluminophophate(SAPO-4) | - | - | - | - | 3.60E-09 | - | - | - |
| Ohta, Takaba [36] | zeolite-like porous membranes | - | counter current flow | - | - | - | - | - | - |
| Sakamoto, Nagata [37] | mesoporous silica membranes | - | concurrent flow | NaOH | - | 4.95E-04 | - | - | 20 |
| Shim, Lee [38] | - | hollow fibre membrane | - | - | - | - | - | - | - |
| Sridhar, Suryamurali [39] | poly(ether-block-amide) (PEBAX-1657) | - | continuous flow | 2,4-toluylene diisocyanate (TDI) | - | 3.70E-06 | - | - | - |
| Wang, Zhu [40] | - | - | - | - | | - | - | - | - |
| Xiao, Feng [41] | trimesoyl chloride | crosslinked chitosan membranes | - | sodium hydroxide aqueous solution (1 mol/L) | | 7.86E-05 | - | - | - |
| Yan, Fang [42] | polypropylene (PP) | hollow fibre membrane | counter current flow | monoethanolamine (MEA) and methyldiethanolamine (MDEA) | - | 2.66E-06 | - | - | - |
| Yegani, Hirozawa [43] | 2,3-diaminopropionic acid (DAPA) | - | counter current flow | - | | 5.5E-01 | 2.24E-02 | - | 3.65 |

| Authors | Membrane material | Reactor type | Flow configuration | Solvent (with molarity) | Wetting (+ = hydrophilic; - = hydrophobic) | Average flux (mol/ min $cm^2$) | Gas flow rate (ml/min) | Liquid flow rate (ml/min) | Feed vol % $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| Al-Marzouqi, El-Naas [44] | polypropylene (PP) | hollow fibre membrane reactor | concurrent flow | monoethanol amine (MEA) and sodium hydroxide (NaOH) solutions | - | - | 200-600 | 200-600 | 10 |
| Al-Marzouqi, El-Naas [45] | PTFE | hollow fibre membrane (hfm) contactor | concurrent flow | Mathematical Modelling Exercise | - | 3.00E-03 | 200-500 | 200-500 | 10 |
| Kai, Kouketsu [46] | poly(amidoamine) (PAMAM) dendrimer composite membrane | - | concurrent flow | - | - | 2.42E-05 | - | - | 5 |
| Keshavarz, Fathikalajahi [47] | polypropylene and polytetrafluoroethylene (PTFE) | hollow fibre membrane | counter current flow | diethanolamine (DEA) | - | 3.90E-06 | - | - | 20 |
| Kosuri and Koros [48] | Torlon®, a polyamide–imide polymer | - | - | - | - | 1.22E-05 | - | - | 90 |
| Li, Falconer [49] | silicoaluminophosphate (SAPO) membranes | - | cross flow | NaOH | - | 1.34E-03 | - | - | 50 |
| Low, Xiao [50] | copoly(4,4′-diphenylene oxide/1,5-naphthalene-2,2′-bis(3,4-dicarboxylphenyl)hexafluoropropanediimide (6FDA-ODA/NDA) d | polymeric membranes | concurrent flow | dimethylformamide (DMF) | - | 5.14E-06 | - | - | - |
| Modigell, Schumacher [51] | - | polymeric membranes | counter current flow | - | | - | - | - | - |
| Paul, Ghoshal [52] | - | flat sheet membrane | concurrent flow | monoethanolamine(MEA),diethanolamine(DEA),N-methyldiethanolamine (MDEA) and 2-amino-2-methyl-1-propanol (AMP) | | 8.40E-05 | - | - | - |
| Yan, Fang [53] | polypropylene (PP) | polymeric hollow fibre membranes | concurrent flow | - | - | - | - | - | - |
| Zhang, Wang [54] | polypropylene (PP) and polyvinylidene fluoride (PVDF) | hollow fibre membrane | concurrent flow | diethanolamine (DEA) | - | 1.50E-03 | - | - | - |
| Zhao, Cao [55] | cross-linker, poly(propylene glycol) block poly(ethylene | mixed matrix membranes (mmms) | - | tetrahydrofuran (THF) | - | 2.46E-05 | - | - | - |

| Authors | Membrane material | Reactor type | Flow configuration | Solvent (with molarity) | Wetting (+ = hydrophilic; - = hydrophobic) | Average flux (mol/ min cm$^2$) | Gas flow rate (ml/min) | Liquid flow rate (ml/min) | Feed vol % $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| | glycol) block poly(propylene glycol) diamine (PPG/PEG/PPGDA) | | | | | | | | |
| Faiz and Al-Marzouqi [56] | polyvinyllidene fluoride (PVDF) | hollow fibre membrane (hfm) contactors | counter current flow | MEA (0.005 - 2M) | - | 1.41E-06 | 200-500 | 200-600 | 25 – 90 |
| Ji, Cao [57] | - | hollow fibre composite membrane | concurrent flow | - | | 1.22E-05 | - | 0.7 | - |
| Kai, Kazama [58] | - | cesium-incorporated carbon membranes | - | 1-methyl-2-pyrrolidone (NMP) | | 1.34E-07 | 100-20 | - | 5 |
| Kosuri and Koros [59] | poly(tetrafluoroethylene | - | concurrent flow | - | - | 1.72E-17 | - | - | 30 |
| Li, Rui [60] | samarium-doped ceria (SDC)–Li/Na/K2CO3 (43.5/31.5/25 mol%) and SDC–Li/Na2CO3 | ionic-conducting ceramic/carbonate composite membrane | concurrent flow | - | - | | - | - | - |
| Lu, Zheng [61] | - | amino acid membrane contractor | counter current flow | - | | - | - | - | - |
| Nistor, Shishatskiy [62] | 3-glycidoxypropyl trimethoxysilane (GPTMS) | - | concurrent flow | tetrahydrofuran (THF) | | - | - | - | - |
| Piroonlerkgul, Laosiripojana [63] | - | - | concurrent flow | - | | - | - | - | 40 |
| Rezvani, Huang [64] | - | - | - | - | | - | - | - | - |
| Safari, Ghanizadeh [65] | glassy polymeric: 6FDA-2,6-DAT membrane | - | cross-flow | - | - | - | - | - | 5-20 |
| Sandru, Kim [66] | polyvinyl amine (PVAm) casted on two polysulfone (PSf) | fixed-site-carrier (fsc) membranes | - | - | - | 1.13E-01 | - | - | 10 |
| Simons, Nijmeijer [67] | porous PP | hollow fibre membrane | cross-flow | MEA | - | 7.84E-07 | 10 | 160 | - |
| Watanabe, Keskin [68] | Cu(hfipbb)(H2hfipbb) 0.5 (H2hfipbb = 4,40- | metal organic framework | - | - | - | - | - | - | - |

| Authors | Membrane material | Reactor type | Flow configuration | Solvent (with molarity) | Wetting (+ = hydrophilic; - = hydrophobic) | Average flux (mol/ min cm$^2$) | Gas flow rate (ml/min) | Liquid flow rate (ml/min) | Feed vol % $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| | (hexafluoroisopropylidene) bis(benzoic acid)) | | | | | | | | |
| Xing and Ho [69] | crosslinked polyvinylalcohol (PVA)/polyethyleneglycol (PEG) blend membrane | - | - | - | - | 1.67E-04 | 60-30 | - | - |
| Yang, Wang [70] | - | - | concurrent flow | - | | - | - | - | - |
| Yave, Car [71] | poly(trimethylene terephthalate)-block-poly(ethylene oxide (PTT-b-PEO) copolymers as CO2-philic membrane | - | - | 5wt.% of trifluoroacetic acid | - | 5.77E-07 | - | - | - |
| Ahmad, Lau [72] | - | - | - | - | | - | - | - | - |
| Cong and Yu [73] | aminosilane-modified poly(ethylene glycol) (PEG), PEG-block-poly(propylene glycol) (PPG)-block-PEG (PEPEG), and PPG-block-PEG-block-PPG (PPEPG) diacrylate polymer membrane | - | - | triethylamine, THF | - | 1.95E-04 | - | - | - |
| Constantinou and Gavriilidis [74] | Metal (nickel) microstructure mesh | Flat sheet | co-current flow | 2M NaOH | + | 1.20E-10 | 177-354 | 1.28-2.56 | 20 |
| El-Naas, Al-Marzouqi [75] | polypropylene hollow fibre membrane | hollow fibre membrane contactor | parallel flow | MEA (0.01 M) | - | - | - | - | 10 |
| Franz and Scherer [76] | - | single membrane module | co and counter current flow | - | - | - | - | - | 61-67 |
| Hudiono, Carlisle [77] | SAPO-34 | ionic liquids (poly(rtil)), rtil and zeolite membranes | - | divinylbenzene | - | | - | - | - |
| Kumar, Yuan [78] | S. platensis UTEX LB 2340 | hollow fibre membrane | continuous flow | | | - | - | - | 2 – 15 |
| Li and Fan [79] | SAPO-34 membrane | - | - | tetraethylammonium hydroxide (TEAOH) | | 9.94E-04 | - | - | 50 |
| Li, Carreon [80] | SAPO-34 membrane | - | - | dipropylamine | | 4.14E-04 | - | - | 50 |

| Authors | Membrane material | Reactor type | Flow configuration | Solvent (with molarity) | Wetting (+ = hydrophilic; - = hydrophobic) | Average flux (mol/ min $cm^2$) | Gas flow rate (ml/min) | Liquid flow rate (ml/min) | Feed vol % $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| Li and Chung [81] | Pebax ☐ a | mixed matrix membranes (mmms) | - | N-methyl-2-pyrrolidone (NMP) | | 2.22E-04 | - | - | - |
| Liu, Hu [82] | ZIF-69 membranes | - | counter current flow | | | 2.34E-05 | 100 | - | 50 |
| Lu, Ji [83] | polypropylene (PP) | hollow fibre membrane | counter current flow | amino acid salt | - | 1.38E-05 | 8.33E-04 | 30-120 | - |
| Mansourizadeh and Ismail [84] | polyvinylidene fluoride (PVDF) | polymeric hollow fibre membranes | concurrent flow | 1-methyl-2-pyrrolidone (NMP) | - | 2.85E-06 | - | 200 | - |
| Mansourizadeh, Ismail [85] | porous polyvinylidene fluoride (PVDF) | hollow fibre membrane | counter current flow | NaOH (1 M) | - | 1.65E-04 | 200 | 1.5 | - |
| Mansourizadeh, Ismail [86] | porous polyvinylidene fluoride (PVDF) | polymeric hollow fibre membranes | counter current flow | 1-methyl-2-pyrrolidone (NMP) | - | 1.95E-06 | - | 320 | 20 |
| Marzouk, Al-Marzouqi [87] | polytetrafluoroethylene (PTFE) | hollow fibre membrane | counter current flow | 5 M aqueous solutions of MEA, DEA and TETA | - | 2.10E-04 | 200 | 100 | 9.5 |
| Park, Han [88] | poly(1-methylsilyl-1-propyne) (PTMSP) | - | - | N-methyl-2-pyrrolidone (NMP) | - | 1.02E-04 | - | - | - |
| Reijerkerk, Knoef [89] | poly(ethylene glycol) and poly(dimethyl siloxane) | - | continuous flow | ethanol | - | 1.27E-04 | 40-25 | 40-25 | 50 |
| Sandru, Haukebø [90] | poly(phenylene oxide) (PPO) and polysulfone (PSf) | hollow fibre membrane | counter current flow | - | - | 7.33E-03 | - | - | 10 |
| Scholes, Smith [91] | metallic, polymeric and organic membranes | - | - | - | - | 2E-02 | - | - | - |
| Simons, Nijmeijer [92] | amino Acid | membrane contractors | counter current flow | monoethanolamine=Monoethanolamine (MEA) (0.5–3M) | | 5.04E-03 | - | 160 | 20 |
| Tiscornia, Kumakiri [93] | microporous titanosilicate ETS-10 membranes | - | - | 10 NaOH:4 KF:1 TiO2:10 SiO2: 675 H2O | - | 3.06E-05 | 60 | - | 50 |
| Yave, Car [94] | poly(ethylene oxide)-poly(butyleneterephthalate) multiblock copolymer | polymeric membranes | - | - | - | 1.3E-01 | - | - | - |
| Yave, Szymczyk [95] | segmented poly(butylene terephthalate)-poly(ethylene oxide) | thin film composite membranes | - | - | - | 3E-02 | - | - | 20 |

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|---|---|---|---|---|---|---|---|---|---|
| | (PBT–PEO) block copolymers, | | | | | | | | |
| Yu, Wang [96] | polymerization of 3,3-Diamino-N-methyldipropylamine (DNMDAm) and trimesoylchloride (TMC) on the polysulfone (PS) | thin film composite membranes | co and counter current flow | 3,3-Diamino-N-methyldipropylamine (DNMDAm) | - | 3.82E-05 | - | - | 20 |
| Zhang, Xiao [97] | 4,40-(hexafluoroisopropylidene) diphthalic anhydride (6FDA) and 4,40-oxydianiline (ODA) | polymeric membranes | - | N-methyl-pyrrolidone | - | 3.1E-02 | - | 1 | - |
| An, Swenson [98] | zeolite membrane: natural clinoptilolite material | - | concurrent flow | - | - | 2.70E-05 | - | - | - |
| Banihashemi, Pakizeh [99] | Silicalite-1 and ZSM-5 zeolites membrane | - | - | n-hexane | - | 4.77E-05 | - | - | - |
| Boributh, Assabumrungrat [100] | - | hollow fibre membrane contactor | counter current flow | - | + | - | 5.70E-03 | 3.42 - 9.45 | 100 |
| Chen, Qiu [101] | polyimide, 6 FDA-DAM:DABA. | hollow fibre membrane | asymmetric | THF and ethanol | - | 1.18E-04 | - | - | 50 |
| Chew, Ahmad [102] | H-SAPO-34 zeolite membrane | - | - | tetraethylammonium hydroxide | | 2.23E-04 | - | - | - |
| Couling, Prakash [103] | - | - | counter current flow | - | | - | - | - | - |
| Erucar and Keskin [104] | IRMOF-1/Matrimid and CuBTC/Matrimid | metal-organic frameworks (mofs) | - | - | | - | - | - | 10 - 50 |
| Eslami, Mousavi [105] | polytetra-fluoroethylene (PTFE) hollow fibre membrane | - | counter current flow | potassium glycinate (PG) aqueous solution | - | 5.83E-08 | - | - | 14 |
| Favre and Pierre [106] | nylon-SiO2 membrane | biocatalytic hybrid membranes | counter current flow | aqueous carbonic anhydrase solution (1M) | - | 1.27E-05 | 3140 | - | 10 |
| Iarikov, Hacarlioglu [107] | | ionic liquids (rtils) membranes | - | 1-butyl-4-methylpyridinium tetrafluoroborate or methyltrioctylammonium | | 6.12E-06 | - | - | 20-90 |

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|---|---|---|---|---|---|---|---|---|---|
| | | | | bis(trifluoromethylsulfonyl)imid | | | | | |
| Jin, Han [108] | hydroxylcontaining polyimide | hollow fibre membrane | co and counter current | - | - | - | - | - | - |
| Jindaratsamee, Shimoyama [109] | polypropylene (PP) | liquid membranes of amine liquids | concurrent flow | amine/glycol mixture - Monoethanolamine (MEA) | - | 4.98E-10 | - | 1000 | - |
| Khaisri, deMontigny [110] | polytetrafluoroethylene (PTFE) | hollow fibre membrane | - | Monoethanolamine (MEA) | - | - | 10-18.6 | 0.5 - 3.5 | - |
| Khan, Li [111] | sulfonated aromatic poly(ether ketone) (S-PEEK) | polymeric membranes | - | 3,3',5,5'-tetramethyl diphenyl-4,4'-diol | - | 3.09E-05 | 1000 | - | 100 |
| Khan, Li [112] | poly(ether etherketone) (S-PEEK) blend membranes | - | - | DMA | - | 4.12E-05 | - | - | - |
| Kim, Baek [113] | 1-ethyl-3-methylimidazolium-bis(trifluoromethylsulfonyl) imide ([emim][Tf2N]) and polyvinylidene fluoride (PVDF) | polymeric hollow fibre membranes | - | 40 vol% methanol | - | 1.86E-04 | - | - | - |
| Kim, Uddin [114] | polyvinylamine (PVAm) | polymer composite membranes | - | - | - | 3.33E-09 | - | - | 10 |
| Kumbharkar, Liu [115] | polybenzimidazole (PBI) based asymmetric | hollow fibre membrane | concurrent flow | (DMAc, >99.5%) | - | 6.92E-08 | 0.5 | - | - |
| Kwisnek, Heinz [116] | UV-cured PEG-diacrylate | polymer membranes | - | 2,2-dimethoxy-2-phenylacetophenone (DMPA) | - | 2.78E-05 | - | - | - |
| Lee, Kim [117] | Pd-Cu membrane | hybrid membranes | concurrent flow | - | - | - | - | - | 5-15 |
| Li, Pramoda [118] | 1-vinyl-3-butylimidazolium bis (trifluoromethylsulfonylimide) ([vbim][Tf2N]) | ionic liquid (rtil) | - | - | - | 1.07E-03 | - | - | 50 |
| Li, Remias [119] | (NF/RO) membrane–ammonia | zeolite membranes | concurrent flow | - | | - | - | - | - |

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|---|---|---|---|---|---|---|---|---|---|
| Lotrič, Sekavčnik [120] | - | membrane reactor | counter current flow | - | | - | - | - | 5.2 |
| Mansourizadeh and Ismail [121] | porous polyvinylidene fluoride (PVDF) | hollow fibre membrane | counter current flow | 1-methyl-2-pyrrolidone (NMP) | - | 8.70E-11 | 1-5 | 60 | - |
| Mansourizadeh and Ismail [122] | polyvinylidene fluoride (PVDF) | hollow fibre membrane | counter current flow | 1-methyl-2-pyrrolidone (NMP) | - | 4.68E-06 | - | - | - |
| Martin, Dijkstra [123] | - | membrane reformer | counter current flow | - | | - | - | - | 1.8 |
| Nguyen, Lasseuguette [124] | thin skin (Teflon AF®, PTMSP) coated on a porous support (PP) | hollow fibre membrane | concurrent flow | monoethanolamine (MEA) | - | 2.85E-04 | - | - | 30 |
| Ostwal, Singh [125] | 3-aminopropyltriethoxysilane | inorganic membranes | - | - | - | 1.78E-08 | - | - | - |
| Peters, Hussain [126] | PVAm/PVA (polyvinyl amine and polyvinyl alcohol) | - | counter current flow | diethanolamine (DEA) | - | 2.3E-05 | 1180* | - | - |
| Reijerkerk, Jordana [127] | hydrophilic, poly(ethylene oxide) membranes | - | - | - | - | 2.30E-05 | - | - | 14 |
| Reijerkerk, Wessling [128] | poly(ethylene glycol) | - | - | ethanol | - | 5.40E-04 | - | - | - |
| Sanaeepur, Amooghin [129] | polymeric membranes | - | - | - | - | 1.15E-06 | - | - | - |
| Sandström, Sjöberg [130] | MFI film on a graded alumina support | zeolite membrane | continuous flow | ethanol | | 9E-02 | - | - | - |
| Sohrabi, Marjani [131] | - | hollow-fibre membrane contactor | parallel flow | MEA, DEA, MDEA, AMP and K2CO3 (10wt%) | - | 4.10E-08 | - | - | 10 |
| Spadaccini, Mukerjee [132] | PMDA-ODA | - | - | - | | - | - | - | - |
| Tuinier, Hamers [133] | - | - | - | - | - | - | - | - | - |
| Venna and Carreon [134] | SAPO-34 seeds and membranes | - | cross-flow | - | | 2.94E-04 | - | 100 | - |
| Wade, Lee [135] | carbonate electrolyte membrane | - | counter current flow | organic solvents | + | 7.92E-06 | 100 | 100 | - |
| Xia, Liu [136] | poly(ethylene glycol) (PEG) | - | - | water/ethanol (30/70 wt %) | - | 2.16E-03 | - | - | - |
| Xing and Ho [137] | polyvinylalcohol–polysiloxane/fumed silica | mixed matrix membranes (mmms) | - | - | - | 3.95E-03 | 30 | 163 | 20 |

| Authors | Membrane material | Reactor type | Flow configuration | Solvent (with molarity) | Wetting (+ = hydrophilic; - = hydrophobic) | Average flux (mol/ min $cm^2$) | Gas flow rate (ml/min) | Liquid flow rate (ml/min) | Feed vol % $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| Ahmad, Lau [138] | Polymeric membrane | - | dimensional cross flow | - | - | - | - | - | - |
| Bengtson, Neumann [139] | polymeric PIM-1 membranes | - | - | amine chloride | - | - | - | - | - |
| Boributh, Rongwong [140] | polyvinylidenefluoride (PVDF) | hollow fibre membrane contactor | counter current flow | monoethanolamine (MEA) (1-0.25M) | - | 8.85E-06 | 500 | - | 40-50 |
| Chabanon, Roizard [141] | microporous PTFE and PMP skin composite membrane | - | concurrent flow | monoethanolamine (MEA) aqueous solution | - | - | - | - | - |
| Constantinou, Barrass [142] | silicon nitride mesh | Mesh contractor | counter current flow | 2M NaOH or 2M DEA solutions | - | 8.70E-03 | 160–246 | 1.28–2.56 | 20 |
| Hasan, Baliban [143] | - | - | - | monoethanolamine (MEA) | | - | 0.1 – 10* | - | 1-70 |
| Ghasem, Al-Marzouqi [144] | polyethersulfone (PES) | hollow fibre membranes | concurrent flow | 0.5M NaOH | - | 1.80E-06 | - | - | 9 |
| Han, Kwon [145] | poly(o-hydroxylamides) (PHAs) and thermally rearranged polybenzoxazoles (TR-PBOs). | - | - | d N,N-dimethylaminopyridine (DMAP) | - | - | - | - | - |
| Hwang, Nam [146] | polysulfone (PSf) | hollow-fibre membrane | counter current flow | teterahydrofuran (THF) | - | - | - | - | 50 |
| Khan, Klaysom [147] | aromatic poly(ether ketone) (SPEEK) and –SO3 functionalized mesoporous MCM-41 | mixed matrix membranes (mmms) | - | NaOH | - | 4.23E-05 | - | - | - |
| Kim and Lee [148] | Polymer membrane | - | concurrent flow | - | - | - | - | - | 14 |
| Lau, Paul [149] | polyther diamine derived | silicon based nannostrcutre membranes | - | HCl | - | 3E-02 | - | - | 50 |
| Lee, Kim [150] | - | multilayer membrane system | concurrent flow | - | - | - | - | - | 5 |
| Li, Pieterse [151] | Pd membranes | - | - | - | | - | - | - | 19.2 |

| Authors | Membrane material | Reactor type | Flow configuration | Solvent (with molarity) | Wetting (+ = hydrophilic; - = hydrophobic) | Average flux (mol/ min cm$^2$) | Gas flow rate (ml/min) | Liquid flow rate (ml/min) | Feed vol % $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| Li, Paul [152] | 1-vinyl-3-ethylimidazolium dicyanamide ([veim][dca]), 1-vinyl-3-butylimidazolium dicyanamide ([vbim][dca]) and 1-vinyl-3-heptylimidazolium dicyanamide ([vhim][dca]) | ionic liquids (rtils) membranes | concurrent flow | - | | 1.25E-04 | - | - | 50 |
| Lively, Dose [153] | 6FDA-based polyimide — 6FDA–DAM:DABA(4:1) | hollow fibre membrane | counter current flow | 3,5-diaminobenzoic acid (DABA) | - | 8.29E-05 | 740 | - | 20 |
| Madhusoodana, Patil [154] | - | ceramic membranes | - | - | - | - | - | - | 15.4 |
| Marzouk, Al-Marzouqi [155] | expanded poly(tetrafluoroethylene) (ePTFE) and poly(tetrafluoroethylene-co-perfluorinated alkylvinyl ether) (PFA) | hollow fibre membrane | concurrent flow | 2.0 M NaOH | - | 1.08E-05 | 100-600 | 10-25 | 5 |
| Merkel, Wei [156] | - | - | counter current flow | - | | 4.91E-04 | - | - | 40-20 |
| Modarresi, Soltanieh [157] | polysulfone gas-separation membranes | - | - | N-methyl-2-pyrrolidone | - | 5.53E-09 | - | - | - |
| Naim, Ismail [158] | microporous polyvinylidene fluoride (PVDF) | hollow fibre membrane | counter current flow | dimethylacetamide (DMAc) | - | 9.66E-05 | - | 60 | - |
| Naim, Ismail [159] | microporous polyvinylidene fluoride (PVDF) | hollow fibre membrane | counter current flow | N-methyl-2-pyrrolidione (NMP) | - | 2.42E-04 | - | 110 | - |
| Rahbari-Sisakht, Ismail [160] | polysolfone (PSf) | hollow fibre membrane | concurrent flow | 1-methyl-2-pyrrolidone | - | 1.05E-06 | 200 | 50-200 | - |
| Rahbari-Sisakht, Ismail [161] | modified polyvinylidene fluoride (PVDF) | hollow fibre membrane | cross-flow | 1-methyl-2-pyrrolidone (NMP) | - | 4.62E-06 | 100 | 300 | - |
| Rahbari-Sisakht, Ismail [162] | modified Polysulfone (PSf) | polymeric hollow fibre | concurrent flow | 1-methyl-2-pyrrolidone (NMP) | - | 3.48E-06 | 100 | 50-300 | - |

| Authors | Membrane material | Reactor type | Flow configuration | Solvent (with molarity) | Wetting (+ = hydrophilic; - = hydrophobic) | Average flux (mol/ min $cm^2$) | Gas flow rate (ml/min) | Liquid flow rate (ml/min) | Feed vol % $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| | | membranes | | | | | | | |
| Rongwong, Boributh [163] | - | capillary membrane | counter current flow | monoethanolamine (MEA) 0.5 M | | 3.60E-06 | 500 | - | 20-40 |
| Scholes, Simioni [164] | - | - | concurrent flow | 30 wt.% monoethanolamine (MEA) | - | - | - | - | - |
| Shirazian, Marjani [165] | - | hollow-fibre membrane contactor | parallel flow | amines aqueous solutions (MEA & MDEA) | | 4.01E-08 | 50 | 50 | 50 – 100 |
| Smart, Vente [166] | 255 EtOH:4 TEOS:1 Co(NO3)2.6H2O:9H2O2 : 40H2O | - | - | - | | 1.65E-04 | - | 1.7-122 | 50 |
| Uddin and Hägg [167] | PVAm/PVA blend composite membrane | - | concurrent flow | - | - | 2E-02 | - | - | 2 - 10 |
| Yilmaz and Keskin [168] | ZIF-8 + poly(1,4-phenylene ether-ether-sulfone) (PPEES) | mixed matrix membranes | - | - | - | - | - | - | - |
| Zhang, Hu [169] | polybenzimidazole (PBI) and zeolitic imidazolate-framework-7 (ZIF-7) | mixed matrix membranes (mmms) | - | - | - | - | - | - | - |
| Zhao and Ho [170] | poly-N-isopropylallylamine | fixed site carrier | counter-current flow | monoethanolamine (MEA) and other amine solvents | - | 2.65E-03 | 60-30 | 0.03 | - |
| Bae and Long [171] | nanocrystals of M2 (dobdc) (M = Mg, Ni, Zn; dobdc4- = 1,4-dioxido-2,5-benzenedicarboxylate) | - | - | - | | 1.02E-03 | - | - | - |
| Cao, Tao [172] | CAU-1-NH2 and poly(methyl methacrylate) polymer membrane | metal organic structures | counter current flow | chloroform solvent | | - | - | - | - |
| Choi, Park [173] | Pd-Cu membrane | - | - | - | | - | - | - | - |
| Duan, Taniguchi [174] | hybrid membrane of poly(amidoamine) (PAMAM) dendrimer/cross-linked poly(vinyl alcohol) (PVA) membrane | flat sheet membrane | - | - | - | 3.38E-11 | 10 | - | 80 |

| Authors | Membrane material | Reactor type | Flow configuration | Solvent (with molarity) | Wetting (+ = hydrophilic; - = hydrophobic) | Average flux (mol/ min $cm^2$) | Gas flow rate (ml/min) | Liquid flow rate (ml/min) | Feed vol % $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| Ghadiri, Marjani [175] | - | polymeric membrane contactor | - | monoethanolamine (MEA) aqueous solution | | 3.00E-06 | - | - | - |
| Ghasem, Al-Marzouqi [176] | polyvinylidene fluoride (PVDF) | hollow fibre membrane | counter current flow | - | - | 3.06E-06 | - | - | 10 |
| Hao, Li [177] | zeolite imidazolate framework-8 (ZIF-8) nanoparticles | - | - | N,N0-methylenebis(acrylamide) | | 9.55E-14 | - | - | 50 |
| Hassanlouei, Pelalak [178] | - | hollow-fibre membrane | parallel flow | MEA, MDEA and potassium glycinate | | 9.30E-03 | 200-900 | 200-900 | 10 |
| Hu, Dong [179] | poly(2,6-dimethyl-1,4-phenylene oxide) (PPE) membrane | - | - | - | - | 2.36E-05 | - | - | 22 |
| Kai, Taniguchi [180] | poly(amidoamine) Dendrimer/polyme | flat sheet membrane | concurrent flow | - | - | 4.53E-10 | 100 | - | 80 |
| Kanehashi, Kishida [181] | 1-butyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide ([BMIM][Tf2N]) | polymeric and ionic liquid composite membranes | - | 1-butyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide ([BMIM][Tf2N]) | - | | 60 | 60 | - |
| Kangas, Sandström [182] | - | zeolite membranes | - | - | | 1E-02 | - | - | - |
| Khan, Klaysom [183] | polysulfone acrylate | mixed matrix membranes (mmms) | concurrent flow | Amino functional groups | - | 1.84E-05 | - | - | - |
| Kim, Abouelnasr [184] | - | iza zeolite structures | - | - | - | 1.01E-03 | - | - | 50 |
| Kim, Ingole [185] | PEBAX/PEI | composite hollow fibre membranes | counter current flow | n-butanol | - | 8.41E-06 | - | - | - |
| Kim, Vrålstad [186] | polyvinyamine (PVAm) Fixed-Site-Carrier (FSC) composite membrane | - | - | 0.1 M KOH | - | 1.5E-01 | - | - | 4 |
| Koutsonikolas, Kaldis [187] | polymeric, ceramic and metallic | - | - | - | - | - | - | - | - |
| Lee, Lee [188] | Pd-Au composite | Pd-Au composite membrane | - | aluminium nitrate | | - | - | - | 40 |
| Li, Wang [189] | diethylene glycol bis(3-aminopropyl) ether (DGBAmE) and diaminopolyethylene glycol (DAmPEG) | thin film composite (tfc) membranes | - | PDMS solution | - | 2.64E-04 | - | - | 15 |

| Authors | Membrane material | Reactor type | Flow configuration | Solvent (with molarity) | Wetting (+ = hydrophilic; - = hydrophobic) | Average flux (mol/ min $cm^2$) | Gas flow rate (ml/min) | Liquid flow rate (ml/min) | Feed vol % $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| Lin, Chen [190] | mesoporous Fluorocarbon-Modified Silica Aerogel | SiO2 eorgel membrane | - | - | - | - | - | - | - |
| Sainan, Gongping [191] | polydimethylsiloxane (PDMS) and poly (ethylene glycol) diacrylate (PEGDA) | polymeric composite membranes | - | - | - | 2.75E-06 | - | - | 25-90 |
| Mehdipour, Karami [192] | - | hollow fibre membrane | concurrent flow | - | | 1.13E-06 | 75 | - | - |
| Moghadassi, Rajabi [193] | carbon nano tubes (MWCNTs) as nanofillers and poly ethylene glycol (PEG) as second polymer was prepared by solution casting method. Both raw-MWCNTs (R-MWCNTs) and functionalized carboxyle-MWCNTs (C-MWCNTs) | mixed matrix membranes | concurrent flow | - | - | 1.80E-05 | - | - | - |
| Mondal and Mandal [194] | crosslinked poly(vinyl alcohol)/poly (allylamine)/2-amino-2-hydroxymethyl-1,3-propanediol/polysulfone | polymeric membranes | counter current flow | n,n-dimethylacetamide (DMAc) | - | 2.27E-04 | 28 | 30 | 20 |
| Nagumo, Iwata [195] | - | membrane separation technology | concurrent flow | - | | - | - | - | - |
| Naim and Ismail [196] | microporous polyvinylidene fluoride (PVDF) | hollow fibre membrane contractor | counter current flow | dimethylacetamide (DMAc) | - | 1.35E-06 | - | 2 | - |
| Nasir, Mukhtar [197] | PES-DEA and PES-MDEA | - | - | monoethanolamine (MEA), diethanolamine (DEA), and methyldiethanolamine (MDEA) | - | 6.80E-05 | - | - | - |
| Peydayesh, Asarehpour [198] | SAPO-34 zeolite loaded Matrimid® 5218 | mixed matrix membranes (mmms) | concurrent flow | 1-Methyl-2-pyrrolidone | | 3.71E-05 | - | - | - |

| Authors | Membrane material | Reactor type | Flow configuration | Solvent (with molarity) | Wetting (+ = hydrophilic; - = hydrophobic) | Average flux (mol/ min cm$^2$) | Gas flow rate (ml/min) | Liquid flow rate (ml/min) | Feed vol % $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| Qiao, Wang [199] | polyvinylamine (PVAm) | composite membrane | concurrent flow | - | - | 7E-02 | - | - | - |
| Rahbari-Sisakht, Ismail [200] | modified polyvinylidene fluoride (PVDF) | hollow fibre membrane | - | 1-Methyl-2-pyrrolidone (NMP) | - | 3.24E-05 | - | 300 | - |
| Rahman, Filiz [201] | PEBAX | - | - | ethanol/water (70/30 wt%) | - | 2.41E-05 | - | - | - |
| Razavi, Razavi [202] | - | nanoporous membrane contactor | counter current flow | 2-amino-2-methyl-1-propanol and piper-azine | - | - | 200 | 100-400 | - |
| Ryi, Lee [203] | Pd-based composite | pd-based composite membrane | concurrent flow | - | | - | - | - | 40 |
| Sandru, Kim [204] | polymeric polyvinylamine | polymeric membranes | concurrent flow | - | - | - | - | - | - |
| Shao, Dal-Cin [205] | - | - | - | - | | - | - | - | 5-10 |
| Shen, Yu [206] | carboxymethyl chitosan and polyethylenimine | facilitated transport membranes | concurrent flow | - | - | 1E-02 | - | - | - |
| Stanislowski, Holmes [207] | - | - | - | - | | - | - | - | - |
| Tomé, Patinha [208] | | ionic liquid membranes (silms) | - | 1-ethyl-3-methylimidazolium bis (trifluoromethylsulfonyl) imide ([C2mim][NTf2]) | | 8.55E-07 | - | - | - |
| Tseng, Itta [209] | SBA-15/CMS | polyphenylene oxide (ppo)-derived composite cms membranes | - | - | - | 3.53E-04 | 50 | - | - |
| Tzialla, Veziri [210] | zeolitic imidazolate framework ZIF-69 membranes | - | - | N,N-dimethylformamide | | 5.58E-08 | - | - | 44 |
| Wang, Zhang [211] | polypropylene (PP) and polyvinylidene fluoride (PVDF) | hollow fibre membrane contactor | cross-flow | MEA solution (1 mol L-1) | - | 3E-02 | 2667 | 145 | 15 |
| Wang, Wang [212] | 3,5-diaminobenzoate on a cross-linked polydimethylsiloxane coating polysulfone membrane | - | concurrent flow | diethylene glycol bis(3-aminopropyl) ether | - | 1.29E-03 | - | - | 15 |

| Authors | Membrane material | Reactor type | Flow configuration | Solvent (with molarity) | Wetting (+ = hydrophilic; - = hydrophobic) | Average flux (mol/ min cm$^2$) | Gas flow rate (ml/min) | Liquid flow rate (ml/min) | Feed vol % $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| Wang, Fang [213] | - | hollow fibre membrane | cross-flow | monoethanolamine (MEA) 20 - 30wt% | - | - | - | - | 50 |
| Wang, Fang [214] | hydrophobic microporous polypropylene (PP) | membrane vacuum regeneration (mvr) | concurrent flow | triethylenetetramine (TETA) and N-methyldiethanolamine (MDEA) | - | - | 2000 | 20 | - |
| Wang, Fang [215] | polypropylene (PP) | hollow-fibre membrane | cross-flow | monoethanolamine (MEA) (3.2M) | - | 3.69E-12 | 6667 | 100 | 20 |
| Yin, Chu [216] | porous alumina | thin zeolite t/carbon composite membranes | - | TMAOH (Tetramethylammonium hydroxide) | | 3.60E-05 | 100 | - | - |
| Yoshimune and Haraya [217] | sulfonated poly(phenylene oxide) (SPPO) | hollow fibre membrane | concurrent flow | - | - | 8.40E-06 | - | - | 50 |
| Zhang, Zou [218] | yttria stabilized bismuth oxide (YSB) membranes | - | concurrent flow | - | - | 7E-01 | - | 100 | - |
| Zhu, Chai [219] | triazine-framework-based membranes | - | - | NaOH | - | 1.04E-07 | - | - | - |
| Ahmadpour, Shamsabadi [220] | poly (amide e 6 e b e ethylene oxide) (Pebax MH 1657) copolymer | - | concurrent flow | DMF | - | - | - | - | 10-50 |
| Amrei, Memardoost [221] | PTFE | hollow fibre membrane reactor | counter current flow | Monoethanolamine (MEA) aqueous solution 0.5 - 1M | 10% | 2.37E-05 | 1000 | 25 | 15 |
| Chen, Thong [222] | Pebax/poly(dimethylsi loxane)/polyacrylonitri le (Pebax/PDMS/PAN) | composite hollow fibre membrane | counter current flow | ionic liquid (RTIL), 1-ethyl-3-methylimidazolium tetrafluoroborate [emim] [BF4] | - | 1.94E-04 | 3 | 1.5 | 50 |
| Constantinou, Barrass [223] | PTFE | flat membrane | concurrent | 2M NaOH | - | 8.00E-03 | 354 | 2.56 | 20 |
| Deng and Hägg [224] | carbon nanotube (CNT) reinforced polyvinyl amine/polyvinyl alcohol (PVAm/PVA) blend | nanocomposit e membrane | - | hydrophilic PVAm/PVA blended solution | - | 3E-02 | - | - | - |
| Ghasem, Al-Marsouqi [225] | polyvinylidene fluoride (PVDF) | hollow fibre membrane | counter current flow | sodium hydroxide | - | 5.40E-06 | - | - | - |
| He, Kim [226] | polyvinylamine (PVAm)/polyvinylalco hol (PVA) | hybrid fixed-site-carrier (fsc) membranes | - | 5 wt% PVAm aqueous solution | - | 1.3E-01 | 50 | - | 10-50 |

| Authors | Membrane material | Reactor type | Flow configuration | Solvent (with molarity) | Wetting (+ = hydrophilic; - = hydrophobic) | Average flux (mol/ min cm$^2$) | Gas flow rate (ml/min) | Liquid flow rate (ml/min) | Feed vol % $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| Huang, Chen [227] | Zn(BDC) (TED)0.5 (BDC¼benzenedicarboxylate, TED ¼ triethylenediamine) | metal–organic frameworks (mofs) | - | N,N-dimethylformamide | - | 1.59E-03 | - | - | - |
| Hussain, Nasir [228] | polyimides, polyetherurethaneurea, polyphenylene oxide, cellulose acetate and polyamide ether | - | concurrent and cross flow | - | - | - | - | - | 9.5-2.9 |
| Junaidi, Khoo [229] | SAPO-34 | zeolite membranes | - | ethanol or isopropanol | | 3.96E-04 | - | - | - |
| Jusoh, Lau [230] | - | - | concurrent flow | - | | - | - | - | 25 |
| Kimball, Al-Azki [231] | PTFE fibre | hollow fibre membrane | counter current flow | 30%Monoethanolamine (MEA) | - | - | - | - | 12-15 |
| Kosinov, Auffret [232] | High-silica (gel Si/Al ¼ 100) SSZ-13 | zeolite membranes | - | - | - | 1.08E-03 | 200 | 200 | - |
| Kundu, Chakma [233] | - | hybrid membranes | cross-flow | Monoethanolamine (MEA) | | - | - | - | 70-100 |
| Li, Wang [234] | - | fixed carrier membranes | - | 3,3′diamino-N-methyldipropylamine (DNMDAm) | | 4.20E-04 | - | - | - |
| Lin, He [235] | polyester | thin film composite membranes | cross-flow | - | - | 4.20E-04 | - | - | 1-40 |
| Lin, Ko [236] | Sol–gel preparation of polymethylsilsesquioxane aerogel | - | cross-flow | ethanol | - | 8E-02 | - | - | - |
| Lindqvist, Roussanaly [237] | - | polymeric membranes | - | monoethanolamine (MEA) | - | - | - | - | - |
| Lu, Lu [238] | | ionic liquid membranes (silms) | co and counter current flow | 1-butyl-3-methyl-imidazolium tetrafluoroborate ([bmim][BF4]) and 1-(3-aminopropyl)-3-methyl-imidazolium tetrafluoroborate ([apmim][BF4]) | | 2.11E-06 | 200 | 100 | - |
| Ma and Koros [239] | ester-crosslinked | hollow fibre membranes | counter current flow | DABA | - | 2.77E-04 | - | - | 50 |
| Ma, Qiao [240] | methylcarbamate (MC) | polymeric membrane | - | - | - | 1.73E-03 | - | - | 10-40 |
| Maghsoudi and | α-alumina | zeolite | concurrent flow | N, N, N-trimethyl-1- | | 3.75E-05 | - | - | 2.13 |

| Authors | Membrane material | Reactor type | Flow configuration | Solvent (with molarity) | Wetting (+ = hydrophilic; - = hydrophobic) | Average flux (mol/ min cm$^2$) | Gas flow rate (ml/min) | Liquid flow rate (ml/min) | Feed vol % $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| Soltanieh [241] | | membranes | | adamantylammonium hydroxide | | | | | |
| Makhloufi, Lasseuguette [242] | Teflon (AF2400) and commercial (TPX) | hollow fibre membrane | counter current flow | monoethanolamine (MEA) | - | 3.23E-09 | - | - | - |
| Mansourizadeh, Aslmahdavi [243] | hydrophobic polyvinylidene fluoride (PVDF) | hollow fibre membrane | counter current flow | dimethylacetamide (DMAc) | - | 1.62E-08 | 100 | 40-300 | - |
| Mansourizadeh and Pouranfard [244] | microporous polyvinylidene fluorid | polymeric hollow fibre membranes | counter current flow | 1-methyl-2-pyrrolidone (NMP) | - | 2.70E-07 | - | 110 | - |
| Masoumi, Keshavarz [245] | 4-diethylamino-2-butanol (DEAB) in a amino alcohol | hollow fibre membrane contactor | cross-flow | monoethanolamine (MEA), diethanolamine (DEA), methyl-diethanolamine (MDEA) and DEAB solutions | - | 5.40E-05 | - | - | 20 |
| Mohshim, Mukhtar [246] | polyethersulfone-SAPO-34 | mixed matrix membranes (mmms) - flat sheet membrane | - | N-methyl-pyrroline (NMP) | - | 1.31E-03 | - | - | - |
| Mondal and Mandal [247] | poly(vinyl alcohol) (PVA)/polyvinylpyrrol idone (PVP) | - | - | KOH | - | 7.96E-04 | 30 | 0.02 - 0.075 | 20 |
| [248] | poly (vinyl alcohol) (PVA)/polyvinylpyrrol idone (PVP) blend membrane | - | - | tetraethylenepentamine | - | 3.79E-04 | - | 0.02-0.075 | - |
| Nabian, Ghoreyshi [249] | polysulfone (PSF) | flat sheet membrane | counter current flow | dimethylformamide(DMF) | - | 4.20E-07 | 3-12 | 9.7 | - |
| Nafisi and Hägg [250] | PEBAX-2533 | mixed matrix membrane | - | ethanol | - | 1.29E-03 | - | - | 10 |
| Patel, Kim [251] | amphiphilic PCZ-r-PEG | - | - | THF | | 2.07E-05 | - | - | - |
| Pedram, Omidkhah [252] | diethanolamine-impregnated cross-linked polyvinylalcohol/glutaraldehyde | - | counter current flow | Diethanolamine (DEA) | - | 1.01E-02 | - | - | 15 |
| Rabiee, Soltanieh [253] | poly(ether-b-amide6) (Pebax1657)/ glycerol triacetate (GTA) gel membrane | - | cross-flow | glycerol triacetate | - | 2.11E-03 | - | - | - |

| Authors | Membrane material | Reactor type | Flow configuration | Solvent (with molarity) | Wetting (+ = hydrophilic; - = hydrophobic) | Average flux (mol/ min $cm^2$) | Gas flow rate (ml/min) | Liquid flow rate (ml/min) | Feed vol % $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| Rahbari-Sisakht, Rana [254] | polyvinylidene fluoride (PVDF) | hollow fibre membrane | counter current flow | - | - | 1.26E-05 | 50-200 | 200 | - |
| Rahim, Ghasem [255] | polyvinylidenefluoride (PVDF) | hollow fibre membrane | counter current flow | monoethanolamine (MEA), diethanolamine (DEA), and 2-amino-2-methyl-1-propanol (AMP) | - | 4.20E-04 | 600 | 10-50 | - |
| Rezaei, Ismail [256] | PVDF/montmorillonit e | hollow fibre membrane | - | 0.02M sodium hydroxide (NaOH) | - | 1.13E-05 | 150 | 25-200 | - |
| Rodenas, van Dalen [257] | NH 2 -MIL-53(Al) | mixed matrix membranes (mmms) | - | - | - | 6.93E-06 | - | - | 50 |
| Rodenas, van Dalen [258] | polysulfone (PSF) and polyimide (PI) polymers | mixed matrix membranes (mmms) | - | N,N-dimethylformamide | - | 1.31E-06 | - | - | 50 |
| Roh, Kim [259] | mesoporous TiO2 hollow nanospheres (f-MTHS) | matrix membranes (mmms) | - | - | - | 1.83E-05 | - | - | - |
| Ryi, Lee [260] | nickel membrane | - | - | - | | - | - | - | 0-20 |
| Salih, Yi [261] | Polyether | thin film composite (tfc) membrane | concurrent flow | polyetheramine (PEA) and Trimesoyl Chloride (TMC) | - | 1.91E-04 | 400-450 | - | 20 – 10 |
| Scholes, Ho [262] | poly(benzoxazole) (PBO) membrane | - | cross-flow | 3,30-dihydroxy-4,40-diamino-biphenyl (HAB) | - | 5.13E-04 | - | - | - |
| Scholes, Ribeiro [263] | polymeric membranes | - | - | - | - | - | - | - | 12 |
| Shi [264] | SAPO-34 zeolite membranes | - | - | - | | 1.93E-03 | - | - | 50 |
| Taniguchi and Fujikawa [265] | poly(amidoamine) (PAMAM) | - | counter current flow | N,N-dimethylethylenediamine | - | 2.27E-10 | - | - | - |
| Thompson, Vaughn [266] | zeolitic imidazolate framework (ZIF) | mixed matrix membranes (mmms) | counter current flow | methanol | | 1.04E-05 | 6 | - | - |
| Tseng, Chang [267] | homogeneous PPO membrane | - | - | N-methyl-2 pyrrolidone (NMP) | - | 5.93E-05 | 50 | - | - |
| Wang, Li [268] | poly(ether block amide) (Pebax 1657) composite membrane | - | - | - | - | 1.51E-05 | - | - | - |
| Wang, Liu [269] | Pebax–PEG–MWCNT | - | - | ethanol/water mixture (70/30wt%) | - | 1.49E-03 | - | - | 20 - 30 |
| Wang, Fang [270] | polypropylene (PP) and Polyvinylidene fluoride (PVDF) | - | - | 20 wt% MEA | - | - | - | 1.5 | - |

| Authors | Membrane material | Reactor type | Flow configuration | Solvent (with molarity) | Wetting (+ = hydrophilic; - = hydrophobic) | Average flux (mol/ min $cm^2$) | Gas flow rate (ml/min) | Liquid flow rate (ml/min) | Feed vol % $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| Wickramanayake , Hopkinson [271] | fabricated utilizing Matrimids and Torlons | hollow fibre membrane | - | N-methyl-2-pyrrolidone (NMP) | - | 6.73E-06 | 3.2 | 60-90 | - |
| Wu, Maurin [272] | porous Zr-carboxylate | metal organic framework | - | - | | - | - | - | 10-15 |
| Wu, Wang [273] | alumina-supported AlPO-18 | - | - | 1.0 Al2O3:3.16 P2O5: 6.32 tetraethyl ammonium hydroxide (TEAOH): 186 H2O | | 1.12E-04 | - | - | - |
| Xin, Wu [274] | TiO2 | mixed matrix membranes (mmms) | counter current flow | N,N-Dimethyl acetamide (DMAc) | | 3.27E-04 | 20 | - | 10 - 30 |
| Xiong, Gu [275] | hydroxide-exchange membrane | - | concurrent flow | KOH | | - | - | - | 10 |
| Yan, He [276] | amino acid salt, potassium L-argininate (PA) | membrane contractor | counter current flow | monoethanolamine (MEA) | | - | - | - | - |
| Yan, Zhang [277] | - | hollow fibre membrane | counter current flow | MDEA/PZEA [methyldiethanolamine/2 -(1-piperazinyl)- ethylamine] 0.5mol/L | | 1E-01 | - | - | 14 |
| Yin, Wang [278] | amino-functionalized MOF membrane: tubular CAU-1 membrane | metal organic structures | - | - | | 8.04E-04 | - | - | 1-9 |
| Zaidiza, Billaud [279] | - | hollow fibre membrane | counter current flow | MEA | | - | - | - | 15 |
| Zhang and Wang [280] | porous polyetherimide (PEI) | hollow fibre membranes | concurrent flow | 2M sodium taurinate | - | 9.00E-06 | - | - | - |
| Zhang, Gong [281] | Al2O3 | silver carbonate membranes | counter current flow | - | | - | - | - | - |
| Zhang, Gong [282] | silver-carbonate | silver carbonate membranes | concurrent flow | - | | - | - | - | - |
| Zhang, Seames [283] | PETE | membrane contractor | - | MEA and NaOH | - | - | 120 | 120 | - |
| Zhang, Yan [284] | - | gas liquid hollow fibre membrane contactor (hfmc) | counter current flow | MDEA/PZEA 0.3:0.7 mol/L | | - | - | - | 14 |

| Authors | Membrane material | Reactor type | Flow configuration | Solvent (with molarity) | Wetting (+ = hydrophilic; - = hydrophobic) | Average flux (mol/ min cm$^2$) | Gas flow rate (ml/min) | Liquid flow rate (ml/min) | Feed vol % $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| Zhang, Yan [285] | polypropylene (PP) | hollow fibre membrane contactor (hfmc) | counter current flow | monoethanolamine (MEA) | - | - | - | - | - |
| Zhao, Ren [286] | Poly(amide-6-b-ethylene oxide)/SAPO-34 | mixed matrix membranes (mmms) | - | - | - | 1.15E-04 | - | - | - |
| Zhao, Jung [287] | polyvinylalcohol | multiwalled carbon nanotubes (mwnts) | - | - | - | 2.59E-03 | 30 | - | - |
| Zhou, Tran [288] | Perfluorocyclobutyl polymer | thin film composite membranes (tfcs) | - | methanol | - | 4.82E-03 | - | - | - |
| Zhou, Korelskiy [289] | Zeolite SAPO-34 | zeolite membranes | - | - | | 3E-02 | - | - | 50 |
| Azizi and Mousavi [290] | polyurethane membrane | - | - | - | - | 1.64E-04 | - | - | - |
| Carapellucci, Giordano [291] | Polyactive® PEBAX®/PDMS-PEG TR-PBI | one-dimensional hollow-fibre model | - | monoethanolamine (MEA) | - | - | - | - | - |
| Dong, Sun [292] | PEBA2533 | metallo-supramolecular polymers membrane | - | - | - | - | - | - | - |
| Farjami, Moghadassi [293] | polyvinylidene fluoride (PVDF) | hollow fibre membrane contactor | counter current flow | distilled water | - | 7.50E-05 | - | - | - |
| Fazaeli, Razavi [294] | - | hollow-fibre membrane | - | tetramethylammonium glycinate ([N1111][Gly]) | | - | 175 - 475 | 100 | 15 |
| Gilassi and Rahmanian [295] | polytetrafluoroethylene (PTFE) | flat sheet membrane | cross-flow | - | - | - | - | - | - |
| Goyal, Suman [296] | micro-porous Poly-propylene (PP) | hollow-fiber membrane module (hfmm) | concurrent flow | diethanolamine (DEA) | - | 3.51E-06 | - | - | - |
| Hwang, Chi [297] | polystyrene (PS) core and ZIF-8 shel | mixed matrix membranes | - | MeOH | - | 1.25E-04 | - | - | - |
| Kammakakam, Nam [298] | 6FDA–durene polyimide (PI) | - | - | . 1,4-Dibromobutane | - | 1.92E-04 | - | - | - |

| Authors | Membrane material | Reactor type | Flow configuration | Solvent (with molarity) | Wetting (+ = hydrophilic; - = hydrophobic) | Average flux (mol/ min cm$^2$) | Gas flow rate (ml/min) | Liquid flow rate (ml/min) | Feed vol % $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| Khalilinejad, Sanaeepur [299] | poly (ether-6-block amide) (Pebax-1657) on a polyvinylchloride (PVC) | thin film composite membranes (tfcs) | - | - | - | 1.24E-05 | - | - | - |
| Kim, Jeon [300] | poly(dimethylsiloxane )-g-poly(oxyethylene methacrylate) (PDMS-g-POEM) | - | - | EtOH | - | 4.55E-05 | - | - | - |
| Konruang, Sirijarukul [301] | polysulfone (PSF) membranes | - | counter current flow | - | - | 3.90E-02 | - | - | - |
| Lee, Magnone [302] | fluoroalkylsilanized Al2O3 | hollow fibre membrane | concurrent flow | - | | 2.6E-01 | 10-50 | 20-50 | 20 |
| Lee, Choi [303] | PSf | hollow fibre membrane | concurrent flow | - | - | 7.24E-05 | - | - | - |
| Li, Wang [304] | hydrophilic membrane amino group-rich polyvinylamine (PVAm) | - | - | - | + | 1.12E-03 | - | 960 | - |
| Li, Wang [305] | poly(diallyldimethyla mmonium carbonate-co-vinylamine) (P(DAD-MACA-co-VAm)) | - | concurrent flow | DADMAC | - | 4.24E-03 | 20 | - | 15 |
| Li, Cheng [306] | CNTs and GO | mixed matrix membranes (mmms) | - | DMF | | 1.53E-05 | - | - | 10-30 |
| Li, Jiang [307] | polyethylenimine-functionalized graphene oxide nano-sheets (PEG−PEI−GO) | mixed matrix membranes (mmms) | - | - | - | 9.95E-04 | - | - | - |
| Li, Ma [308] | - | composite matrix membranes | - | 70 wt% ethanol and 30 wt% water | | 2.44E-03 | - | - | - |
| Li, Li [309] | calcium lignosulfonate (CaLS) | anionic surfactant-doped pebax membrane | - | ethanol | | 5.03E-09 | - | - | 10-30 |
| Li, Xin [310] | - | polymer electrolyte membrane | concurrent flow | - | | 9.05E-04 | - | - | 10 |
| Liao, Wang [311] | polyvinylamine (PVAm) fixed carrier membrane | - | concurrent flow | - | - | 3.66E-04 | - | - | 15 |

| Authors | Membrane material | Reactor type | Flow configuration | Solvent (with molarity) | Wetting (+ = hydrophilic; - = hydrophobic) | Average flux (mol/ min $cm^2$) | Gas flow rate (ml/min) | Liquid flow rate (ml/min) | Feed vol % $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| Lin, Ge [312] | NH2-MIL-101(Al) | mixed matrix membranes (mmms) | - | N,N-dimethylacetamide (DMAc) | - | 4.07E-03 | - | - | - |
| Lin, Chang [313] | hydrophobic fluorocarbon-modified silica aerogel | - | counter current flow | - | - | 3E-02 | - | - | - |
| Lock, Lau [314] | - | hollow fibre membrane module | co and counter current | - | | - | - | - | 10-60 |
| Loloei, Omidkhah [315] | polyethylene glycol (PEG 200) as a CO2-philic polymer membrane | mixed-matrix membrane (mmm) | concurrent flow | - | - | 2.35E-05 | - | - | - |
| Mahmoudi, Asghari [316] | polymer/liquid/solid (PEBA/PEG/nanozeolite X) | mixed matrix membranes (mmms) | concurrent flow | ethanol | - | 1.53E-04 | - | - | - |
| Mondal, Barooah [317] | 25wt% poly(allylamine) and 15wt% 2-amino-2-hydroxymethyl-1,3-propanediol | polymeric membranes | counter current flow | water | - | 1.04E-05 | 0.05 | 0.03 | - |
| Mulukutla, Chau [318] | polyamidoamine (PAMAM) | hollow fibre membrane | cross-flow | monoethanolamine (MEA) | - | - | - | - | - |
| Nabian, Ghoreyshi [319] | polysulfone (PSF) | flat sheet membrane | counter current flow | N,N-di-methylformamide (DMF) | - | 1.92E-07 | 1000 | 3-12.5 | - |
| Nasir, Mukhtar [320] | polyethersulfone (PES) and PES/carbon molecular sieve (CMS) | mixed matrix membranes | - | N-Methyl-2-pyrrolidone (NMP) | - | 4.91E-05 | - | - | - |
| Nasir, Mukhtar [321] | polyethersulfone (PES) membrane | - | counter current flow | diethanolamine (DEA) | - | 4.96E-05 | - | - | - |
| Nordin, Racha [322] | zeolitic imidazole framework 8 (ZIF-8) | metal–organic frameworks (mofs) | - | tetrahydrofuran (THF) and methanol | | 2.03E-05 | - | - | - |
| Nwogu, Kajama [323] | - | inorganic membranes | concurrent flow | - | | - | - | - | - |
| Park, Lee [324] | poly(ethylene glycol) behenyl ether methacrylate (PEGBEM) and poly(oxyethylene methacrylate) (POEM) | - | - | 2-methylpropionitrile | - | 1.17E-04 | - | - | - |

| Authors | Membrane material | Reactor type | Flow configuration | Solvent (with molarity) | Wetting (+ = hydrophilic; - = hydrophobic) | Average flux (mol/ min $cm^2$) | Gas flow rate (ml/min) | Liquid flow rate (ml/min) | Feed vol % $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| Park, Lee [325] | Poly(methoxy(polyethyleneoxy)propyl-co-methacryloxypropyl) silsesquioxane membranes | - | - | - | - | 2.47E-03 | - | - | 50 |
| Qiao, Wang [326] | amines (SMAs) (ethanediamine (EDA), piperazine (PIP), monoethanolamine (MEA) and diethanol amine (DEA)) | - | - | monoethanolamine (MEA) | | 1E-02 | 960 - 30 | - | - |
| Rabiee, Alsadat [327] | poly(amide-12-b-ethyleneoxide)(Pebax1074)/SAPO-34 | mixed matrix membranes (mmms) | cross-flow | 1-Butanol | - | 1.80E-12 | - | - | - |
| Rahim, Ghasem [328] | PVDF | hollow fibre membrane | counter current flow | MEA and NaOH | - | 3.90E-04 | 10-100 | 10 - 40 | 10 |
| Rezaei, Ismail [329] | l montmorillonite and Cloisite 15A | mixed matrix membranes (mmms) | concurrent flow | 0.02M sodium hydroxide (NaOH) | | 6.00E-06 | 140 | 20-350 | - |
| Sadoogh, Mansourizadeh [330] | PVDF | hollow fibre membrane | - | 1 methyl-2-pyrrolidone (NMP) (1 M) | - | 6.75E-05 | - | - | - |
| Scofield, Gurr [331] | poly(dimethylsiloxane)-b-poly(ethylene glycol) copolymer | thin film composite membranes (tfcs) | - | n-butanol | - | 7.04E-04 | - | 1 | - |
| Seoane, Coronas [332] | - | mixed matrix membranes (mmms) | cross and counter current flow | - | | - | - | - | - |
| Shen, Liu [333] | - | - | - | - | | - | - | - | - |
| Shin, Hwang [334] | Pd-based membrane | - | counter current flow | - | | - | - | - | 40 |
| Skorek-Osikowska, Bartela [335] | - | - | - | - | | - | - | - | - |
| Sorribas, Comesaña-Gándara [336] | ETS-10 | mixed matrix membranes | - | - | | 2.10E-05 | - | - | - |
| Sun, Wen [337] | - | nanoporous graphene | - | - | | - | - | - | - |
| Taniguchi, Kai | Poly(amidoamine) | - | - | - | - | 1.34E-17 | - | - | - |

| Authors | Membrane material | Reactor type | Flow configuration | Solvent (with molarity) | Wetting (+ = hydrophilic; - = hydrophobic) | Average flux (mol/ min cm$^2$) | Gas flow rate (ml/min) | Liquid flow rate (ml/min) | Feed vol % $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| [338] | (PAMAM) | | | | | | | | |
| Tong, Zhang [339] | ceramic-carbonate dual-phase | ceramic membranes | concurrent flow | - | - | - | 15-50 | 120 | - |
| Vakharia, Ramasubramanian [340] | crosslinked polyvinylalcohol (PVA) matrix | polymeric facilitated transport membranes | counter current flow | - | - | - | - | - | 20-31 |
| Wang, Sun [341] | faujasite/polyethersulfone composite | - | - | Tetramethylammonium hydroxide (25% aqueous) | - | 3.6E-11 | - | - | - |
| Wang, Mundstock [342] | Amine-modified Mg-MOF-74/CPO-27-Mg membrane | - | - | N-dimethylformamide | | 5.43E-06 | 50 | 50 | - |
| Wang, Tian [343] | Poly(ethylene glycol)-containing polymeric sub microspheres (PEGSS) membranes | - | - | N,N-dimethylformamide (DMF) and ethanol | - | 3.12E-05 | 20 | - | - |
| Xin, Gao [344] | graphene oxide (GO-DA-Cys) nanosheets into a sulfonated poly(ether ketone) (SPEEK) polymer | - | - | 2-(3,4-dihydroxyphenyl)-ethylamine (dopamine) | | 1.90E-04 | - | - | - |
| Xin, Li [345] | sulfonated poly(ether ketone) | mixed matrix membranes (mmms) | - | N-dimethylformamide | - | 2.66E-04 | 20 | - | 10 - 30 |
| Xing, Peters [346] | - | molten carbonate dual phase membranes | counter current flow | - | | - | - | - | - |
| Zaidiza, Belaissaoui [347] | polypropylene (PP), polyvinylidene fluoride (PVDF) and polytetrafluoroethylene (PTFE) | hollow fibre membrane | counter current flow | 30wt% Monoethanolamine (MEA) | - | 8E-02 | - | - | - |
| Zhang, Qu [348] | Polypropylene | membrane contractor | counter current flow | Monoethanolamine (MEA) | - | - | - | - | - |
| Zhang, Qu [349] | polypropylene | hollow fibre membranes | - | - | - | - | - | - | 14 |
| Zheng, Hu [350] | SSZ-13 membranes - all silica and zeolite | - | - | N,N,N, trimethtyl-1-adamantammonium hydroxide and tetraethylammonium hydroxide | - | 2.40E-04 | - | - | - |

| Authors | Membrane material | Reactor type | Flow configuration | Solvent (with molarity) | Wetting (+ = hydrophilic; - = hydrophobic) | Average flux (mol/ min cm$^2$) | Gas flow rate (ml/min) | Liquid flow rate (ml/min) | Feed vol % $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| Zhou, Wang [351] | SSZ-13 | - | - | N,N,N-trimethtyl-1-adamantammonium | - | 2.28E-04 | 150 - 400 | - | - |
| Zhou, Luo [352] | Pebax | mmms | - | ethanol/water (70/30 wt%) | - | 6.03E-05 | 50 | 20 | - |
| Adewole and Ahmad [353] | polymeric membranes: 6FDA-DAM:DABA 2: 1 | - | cross flow | - | - | - | - | - | 23.58 – 50 |
| Amooghin, Omidkhah [354] | nano-porous sodium zeolite-Y | mixed matrix membranes | - | - | - | 5.93E-06 | - | - | 10 |
| Arias, Mussati [355] | - | - | cross and counter flow | - | | 2.11E-04 | - | - | 13 |
| Hosseinzadeh Beiragh, Omidkhah [356] | nanoporous ZSM5 | mixed matrix membrane | - | water/ethanol (30/70 wt. %) | - | 1.54E-04 | - | - | - |
| Chang and Kang [357] | poly(vinylidene fluoride-co-hexafluoropropylene) (PVDF-HFP) | polymeric membrane | - | tetrafluoroboric acid solution | - | - | - | - | - |
| Chen and Ho [358] | polyvinylamine (PVAm)/piperazine glycinate (PG) membrane | - | counter current flow | - | - | 2.29E-05 | - | - | - |
| Dai, Bai [359] | thin film composite (TFC) membrane | - | - | Ethanol (96 wt%), toluene and n-hexane | - | 1.71E-06 | - | - | 10 |
| Dong, Hou [360] | hyperbranched polyethylenimine (HPEI), and trimesoyl chloride (TMC) coating on a polysulfone membrane | fixed carrier composite membrane | - | - | - | 1.95E-06 | 0.5 | - | 10 |
| Dong, Zhang [361] | porous graphene-based macroscopic membrane | reduced graphene nanosheets | - | 70 wt% ethanol and 30 wt% water | | 3.22E-05 | - | - | - |
| Dong, Zhang [362] | montmorillonite (MMT) functionalized with poly(ethylene glycol) methyl ether (PEG) and aminosilane coupling agents in a PEBA membrane | - | - | 2 wt % in n-butanol | - | 9.01E-05 | - | - | - |
| Dong, Liu [363] | MIL-68(Al) (MIL5Material of Institute Lavoisier) | mixed matrix membrane (mmm) | - | DMF | - | 5.71E-05 | 50 | - | 50 |

| Authors | Membrane material | Reactor type | Flow configuration | Solvent (with molarity) | Wetting (+ = hydrophilic; - = hydrophobic) | Average flux (mol/ min cm$^2$) | Gas flow rate (ml/min) | Liquid flow rate (ml/min) | Feed vol % $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| Ebrahimi, Mollaiy-Berneti [364] | mixed matrix membranes (MMMs) using polyethersulfone (PES) | - | concurrent flow | - | - | - | - | - | - |
| Fan, Xie [365] | [Choline][Pro]/poly-ethylene glycol 200 (PEG200) | ionic liquid membranes (silms) | concurrent flow | ~45 wt% in methanol | | 3.87E-04 | - | - | 10 – 14 |
| Gilassi and Rahmanian [366] | - | hollow fibre membrane | - | monoethanolamine (MEA) | - | 3.02E-04 | - | - | 20 |
| Jeon, Kim [367] | poly(dimethylsiloxane )-graf t-poly(4-vinylpyridine) (PDMS-g-P4VP) | - | - | - | - | 3.32E-07 | - | - | - |
| Jomekian, Behbahani [368] | ZIF-8/Pebax 1657/PES | hollow fibre membrane | - | Dimethylformamide (99.99%, DMF) | - | 3.04E-04 | - | - | - |
| Jusoh, Lau [369] | - | - | - | - | | - | - | - | 25 |
| Kang, Peng [370] | poly(ether imide) (Ultem) or polybenzimidazole (PBI) | mixed matrix membranes (mmms) | - | - | - | - | - | - | - |
| Karamouz, Maghsoudi [371] | PEBAX-1074. Membranes | - | concurrent flow | Dimethylformamide (DMF) | - | 8.32E-04 | - | - | - |
| Karimi, Korelskiy [372] | acetate-functionalized silica | silica membranes | - | - | - | 1E-02 | - | - | - |
| Kertik, Khan [373] | polyimide (PI) Matrimid® and ZIF-8, ZIF-7 and NH2-MIL-53(Al) | mixed matrix membranes (mmms) | - | chloroform and methanol | - | - | - | - | - |
| Kim, Choi [374] | poly(2-ethyl-2-oxazoline) (POZ) and semicrystalline poly(amide-6-b-ethylene oxide) (PEBAXVR MH 1657) | mixed matrix membranes (mmms) | - | ethanol | - | 1.61E-06 | - | - | - |
| Kim, Fu [375] | polyethylene glycol(PEG) matrix | mixed matrix membrane | - | - | - | 2.41E-06 | 0.6-6.3 | - | 30 |
| Kim, Fu [376] | polyethylene glycol (PEG)-based ultra-thin film composite | mixed matrix membranes (utfc-mmms) | - | tris(2-aminoethyl amine) | - | 1.49E-03 | - | - | - |
| Kim, Park [377] | polypropylene (PP) | polymeric hollow fibre membranes | counter current flow | - | - | 2.33E-06 | 150-300 | 200–800 | - |

| Authors | Membrane material | Reactor type | Flow configuration | Solvent (with molarity) | Wetting (+ = hydrophilic; - = hydrophobic) | Average flux (mol/ min $cm^2$) | Gas flow rate (ml/min) | Liquid flow rate (ml/min) | Feed vol % $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| Kim, Chi [378] | poly(1-trimethylgermyl-1-propyne) (PTMSP) | mixed matrix membrane (mmm) | - | THF | - | 3E-02 | - | - | - |
| Koolivand, Sharif [379] | graphene-oxide nanosheet | mixed matrix membranes (mmms) | - | tetrahydrofuran (THF) and N-methyl-2-pyrrolidone (NMP) solvents | - | 5.07E-03 | - | - | - |
| Korelskiy, Grahn [380] | sub-micron (ca. 0.5 mm) b-oriented MFI zeolite | zeolite membranes | - | - | | 4E-02 | - | - | - |
| Krea, Roizard [381] | copolyetherimide polymers (PEI) | mixed matrix membranes | - | DMAC | - | 1.28E-04 | - | - | - |
| Lee, Jung [382] | PEDOT-PSS embedded comb copolymer | polymeric membranes | - | N,N-dimethylformamide (DMF) | - | 7.55E-06 | - | - | - |
| Li, Zheng [383] | graphene-based | mof | concurrent flow | - | - | - | - | - | - |
| Li, Zhang [384] | - | graphene oxide membranes | - | - | | - | - | - | - |
| Liao, Wang [385] | poly(diallyldimethylammonium carbonate) (PDDACA) | fixed carrier membranes | - | ethanol | - | 1.49E-03 | - | - | - |
| Lin and Kuo [386] | mesoporous bis(trimethoxysilyl)hexane (BTMSH)/tetraethylorthosilicate (TEOS)-based hybrid silica aerogel | - | cross-flow | ethanol | - | 8E-02 | - | - | - |
| Liu, Liu [387] | polyvinylidene Fluoride (PVDF) | ionic liquid membranes (silms) | concurrent flow | bis ((trifluoromethyl)sulfonyl)imide ([BMIM][NTf2]) | | 3.59E-03 | - | - | - |
| Lu, Khan [388] | polysulfone (PSf) | ionic liquids (ils) membrane | - | - | | 7.14E-04 | - | - | 50 |
| Moradi, Chenar [389] | PDMS coated TFC-RO membranes | thin film composite (tfc) membrane | concurrent flow | n-hexane | - | - | - | - | - |
| Mosleh, Mozdianfard [390] | polyethersulfone (PES) | - | concurrent flow | DMAc | - | 5.23E-05 | - | - | - |

| Authors | Membrane material | Reactor type | Flow configuration | Solvent (with molarity) | Wetting (+ = hydrophilic; - = hydrophobic) | Average flux (mol/ min $cm^2$) | Gas flow rate (ml/min) | Liquid flow rate (ml/min) | Feed vol % $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| Mubashir, Yeong [391] | tetrapropylammonium bromide (TPABr)-templating silica sols | - | concurrent flow | - | - | 1.48E-03 | - | - | 10 |
| Nematollahi, Dehaghani [392] | alumina nano particles (Al2O3) and poly(4-methyl-1-pentyne) | mixed matrix membranes (mmms) | - | - | | 4.01E-04 | - | - | - |
| Nematollahi, Dehaghani [393] | Al2O3 nanoparticles | mixed matrix membranes (mmms) | - | - | | 5.51E-03 | - | - | - |
| Nguyen, Gong [394] | Ca-A zeolite | mixed matrix membranes | - | dichloromethane (DCM) | | 4.62E-05 | - | - | 50 |
| Otani, Zhang [395] | tetrabutylphosphonium 2-cyanopyrrolide ([P4444][2-CNpyrr]) | facilitated transport membrane | - | - | | - | - | - | - |
| Pohlmann, Bram [396] | PolyActiveTM | thin film multilayer composite membrane | counter current flow | - | - | - | - | - | 14.5 |
| Qin, Lv [397] | SPEEK/amino acid salt membranes | - | concurrent flow | . N,N-Dimethyl acetamide (DMAc) | | 1.19E-04 | - | - | - |
| Rafiq, Deng [398] | cross-linked poly (ethylene oxide) (PEO) | facilitated transport membranes | - | - | - | 7.11E-05 | - | - | 10-20 |
| Rahmani, Kazemi [399] | organic matrices (polymer matrices) | mixed matrix membranes (mmms) | cross flow | chloroform | + | 1.63E-05 | 0.01 | - | - |
| Razavi, Shirazian [400] | - | hollow fibre membrane contractors | counter current flow | DEA | | - | - | - | - |
| Rui, James [401] | 1 (IRMOF-1) | metal-organic framework (mof) membranes | - | - | | 6.2E-01 | - | - | - |
| Saedi, Seidi [402] | amino-cellulose (AC) | - | cross-flow | N,N-dimethyl aminopropylamin | + | 7.19E-06 | - | - | 30 |
| Saeed and Deng [403] | PVA-mimic enzyme | carbon nanotube composite membrane | - | NaOH | + | 9.24E-05 | - | - | - |
| Sanaeepur, Kargari [404] | nano-porous sodium zeolite Y (NaY) | mixed matrix membranes (mmms) | concurrent flow | - | - | 4.07E-06 | - | - | - |

| Authors | Membrane material | Reactor type | Flow configuration | Solvent (with molarity) | Wetting (+ = hydrophilic; - = hydrophobic) | Average flux (mol/ min $cm^2$) | Gas flow rate (ml/min) | Liquid flow rate (ml/min) | Feed vol % $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| Sánchez-Laínez, Zornoza [405] | d ZIF-11 (nZIF-11 and ZIF-11, respectively) | nano and micro sized polymeric mixed matrix membrane | - | DMAc solvent | - | - | - | - | - |
| Sánchez-Laínez, Zornoza [406] | ZIF-8 | mixed matrix membranes (mmms) | - | MeOH | - | - | - | - | - |
| Scofield, Gurr [407] | poly(ethylene glycol)-block-poly(pentafluoropropyl acrylate) diblock copolymers | - | - | n-butanol | - | 1.69E-03 | - | 1 | - |
| Shen, Liu [408] | graphene oxide (GO)-polyether block amide (PEBA) | mixed matrix membranes | - | - | - | 6.63E-05 | - | - | - |
| Shen, Zhang [409] | UiO-66-polyether block amide | mixed matrix membranes | - | N,N-dimethylformamide (DMF) | | 7.84E-05 | - | - | - |
| Shen, Wang [410] | MoS2 | mixed matrix membranes (mmms) | - | - | | 3.16E-05 | - | - | - |
| Solimando, Lherbier [411] | Pebax | - | - | N,N-dimethylformamide (DMF) | - | 3.90E-04 | - | - | - |
| Sumer and Keskin [412] | polymeric membranes (Ultem, Matrimid, 6FDA-DAM, and modified PDMS) | mixed matrix membranes (mmms) | - | - | - | - | - | - | - |
| Sun, Srivastava [413] | faujasitic (FAU) | zeolite membrane | - | tetramethylammonium hydroxide solution (TMAOH, SACHEM) | | 3.44E-04 | - | - | 20 |
| Waheed, Mushtaq [414] | polysulfone | mixed matrix membranes (mmms) | concurrent flow | 4-aminophenazone (4-AMP) | - | 1.71E-04 | - | - | - |
| Wang, Li [415] | - | polymeric membranes | concurrent flow | - | | 6.51E-04 | - | - | - |
| Wang, Yang [416] | - | nanoporous graphene membranes | - | - | | - | - | - | 15 |
| Wong, Goh [417] | - | nanocomposite membrane | cross-flow | - | | - | - | - | - |
| Woo, Dong [418] | poly(benzoxazole-co-imide) | hollow fibre membranes | cross-flow | hydroxyl polyimide-co-polyimide (HD5) | - | 3.38E-04 | 6000 | - | 14 - 80 vol% |

| Authors | Membrane material | Reactor type | Flow configuration | Solvent (with molarity) | Wetting (+ = hydrophilic; - = hydrophobic) | Average flux (mol/ min $cm^2$) | Gas flow rate (ml/min) | Liquid flow rate (ml/min) | Feed vol % $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| Wu, Zhao [419] | nanoporous polyethersulfone (PES) membranes | - | counter current flow | PES/N-methyl-2-pyrrolidone (NMP)/2-methoxyethanol (2-ME) | - | 1.00E-04 | 60-30 | - | - |
| Xiang, Pan [420] | poly(ether-block-amide) | mixed matrix membranes (mmms) | concurrent flow | water/ethanol (30/70 wt %) | - | 1.13E-04 | - | - | - |
| Xin, Zhang [421] | poly(ether-block-amide) (Pebaxs 1657) | mixed matrix membranes (mmms) | - | tris(hydroxymethyl) amino methane (Tris) | - | 6.49E-05 | 20 | - | - |
| Xin, Zhang [422] | sulfonated poly(ether ketone) (SPEEK) | mixed matrix membranes (mmms) | - | DMF | - | 2.56E-04 | - | - | 10 - 30 |
| Zaidiza, Wilson [423] | - | hydrophobic microporous hollow fibre memebrane | counter current flow | | | 2E-02 | - | - | 14-24.2 |
| Zhang, Guo [424] | N-isopropylacry-lamide hydrogel (NIPAM-CNTs) | mixed matrix membranes (mmms) | concurrent flow | N,N,N′,N″,N″-pentmethyldiethylenetriamine | | 6.33E-04 | - | - | - |
| Zhang, Li [425] | Polypropylene | hollow fibre membrane | counter current flow | monoethanolamine (MEA) | - | 3.00E-14 | 8333 | 400 | 12 |
| Zhang, Tong [426] | M microstructure of an ALD-ZrO2 | silver carbonate membranes | cross-flow | - | | - | - | - | - |
| Zhong, Bu [427] | aluminophosphate (AlPO)-17 and silicoaluminophosphate (SAPO)-17 | - | - | - | - | 5.76E-04 | - | 8000 | - |
| Alavi, Kargari [428] | polydimethylsiloxane/ zeolite 4A (PDMS/zeolite 4A) | mixed matrix membranes | - | N,N-dimethylformamide (DMF) and hexane | - | 2.10E-03 | - | - | - |
| Azizi, Arzani [429] | polymeric nanocomposite membranes (PNMs) | - | cross-flow | dimethylacetamide (DMA), Dimethylformamide (DMF) and 1-Butanol | - | 7.90E-05 | - | - | - |
| Azizi, Mohammadi [430] | polymeric nano-composite membranes (PNMs) | - | - | - | - | 3.98E-04 | - | - | 20 |
| Azizi, Mohammadi [431] | poly (ether-block-amide) (Pebax 1074, Pebax 1657 and Pebax 2533) ) | nanocomposite membranes - modified multi-walled carbon nanotubes | cross-flow | - | - | 1.26E-04 | - | - | - |

| Authors | Membrane material | Reactor type | Flow configuration | Solvent (with molarity) | Wetting (+ = hydrophilic; - = hydrophobic) | Average flux (mol/ min cm$^2$) | Gas flow rate (ml/min) | Liquid flow rate (ml/min) | Feed vol % $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| | | (mwcnts | | | | | | | |
| Benito, Sánchez - Laínez [432] | poly[1-(trimethylsilyl)-1-propyne] (PTMSP) | - | - | - | - | 4.46E-05 | - | - | 10 |
| Brunetti, Cersosimo [433] | polybenzoxazole-co-imide (TR-PBOI) | mixed matrix membrane | - | N-Methyl-2-pyrrolidone (NMP) | - | 1.02E-04 | - | - | - |
| Cheng, Wang [434] | copper 1,4-benzenedicarboxylate nanosheets, CuBDC-ns | mixed matrix membranes, metal organic structure | - | - | - | 8.18E-05 | - | - | - |
| Galaleldin, Mannan [435] | titanium dioxide (TiO2) nanoparticles: 5 % loading of TiO2 | mixed matrix membranes | - | - | | 5.25E-06 | - | - | - |
| Ghadiri, Marjani [436] | 2-amino-2-metyl-1-propanol (AMP) | hollow-fibre contactor | counter current flow | - | | - | 170 | 10-130 | - |
| Hosseini and Mansourizadeh [437] | polypropylene | hollow fibre membrane contactor (hfmc) | cross-flow | monoethanolamine (MEA) | - | - | - | - | - |
| Hu, Cheng [438] | SAPO 34 | ionic liquids membranes | concurrent flow | ethanol/water solvent (70/30, weight ratio) | | 8.22E-05 | - | - | 50 |
| Hussain [439]2017) | PVAm (polyvinylamine) and PVA (polyvinyl alcohol) blended membrane layer on a polysulfone support | - | - | - | | - | - | - | 9.5-2.9 |
| Ilyas, Muhammad [440] | ionic liquids membrane | - | cross-flow | 3-aminopropyl) trimethoxysilane and acetic acid | | 5.43E-05 | - | - | - |
| Isfahani, Sadeghi [441] | Poly (ethylene glycol) (PEG)-based polyurethane (PU) membranes | - | - | - | - | 1.26E-04 | - | - | - |
| Jin, Huang [442] | gas-liquid membrane contractor (GLMC): Poly(vinylidene fluoride) (PVDF) | hollow fibre membrane | cross-flow | water, monoethanolamine (MEA, primary amine), potassium carbonate (K2CO3, inorganic salt), potassium hydroxide (KOH, inorganic salt), | - | 1.17E-06 | 250 | 50-140 | 40 |

| Authors | Membrane material | Reactor type | Flow configuration | Solvent (with molarity) | Wetting (+ = hydrophilic; - = hydrophobic) | Average flux (mol/ min cm$^2$) | Gas flow rate (ml/min) | Liquid flow rate (ml/min) | Feed vol % $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| | | | | and potassium sarcosine (PS, organic salt) | | | | | |
| Jo, An [443] | 1,3–cyclohexanebis–methylamine (CHMA) and trimesoyl chloride(TMC) | thin film composite (tfc) hollow fibre membrane | concurrent flow | N-hexane | - | 6.03E-06 | - | - | 70 |
| Jung, Park [444] | copolymer comprising of poly(ethylene-alt-maleic anhydride) (PEMA) main chains and poly(propylene glycol) (PPG) side chains | - | - | butanol (BuOH) | - | 1.79E-05 | - | - | - |
| Jusoh, Yeong [445] | (ZIF-8) nanofiller and 6FDA-durene polymer | mixed matrix membranes (mmms) | - | triethylamine (TEA) | - | 6.57E-04 | - | - | 90 |
| Kang, Chan [446] | poly(vinylidene fluoride) (PVDF) | hollow fibre membrane | cross-flow | methyldiethanolamine (aMDEA) | - | 4.80E-06 | 4500 | 100 | 70 |
| Karousos, Labropoulos [447] | 1-alkyl-3-methylimidazolium | ionic liquid membranes (silms) | concurrent flow | - | | 8.10E-07 | - | - | 1-50 |
| Karunakaran, Villalobos [448] | ultrathin graphene oxide (GO) | ionic liquid ultrathin composite membranes | - | 1-ethyl-3-methylimidazolium acetate ([EMIM][Ac]) and 1-ethyl-3-methylimidazolium tetra □uoroborate ([EMIM][BF4]) | | 7.44E-06 | - | - | - |
| Kgaphola, Sigalas [449] | nanocomposite SAPO-34 membranes | - | - | - | | 1.38E-05 | - | - | - |
| Khakpay, Rahmani [450] | nanoporous graphene (NPG) and graphene oxide (NPGO) | - | - | - | | 1.11E-06 | - | - | - |
| Khalilinejad, Kargari [451] | hydrophilic/hydrophobic silica nanoparticles (0–10 wt%) | mixed matrix membranes | - | ethanol and water | - | 1.28E-04 | - | - | - |
| Khosravi, Omidkhah [452] | CuBTC and NH2-CuBTC | mixed matrix membranes (mmms) | - | ethanol | | 2.52E-10 | - | - | - |
| Kim, Park [453] | poly(glycidyl methacrylate-g-poly(propylene glycol))-co- | - | - | ethanol/water mixed solvent (70/30 wt %) | - | 1.01E-04 | - | - | - |

| Authors | Membrane material | Reactor type | Flow configuration | Solvent (with molarity) | Wetting (+ = hydrophilic; - = hydrophobic) | Average flux (mol/ min cm$^2$) | Gas flow rate (ml/min) | Liquid flow rate (ml/min) | Feed vol % $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| | poly(oxyethylene methacrylate) (PGP−POEM) combcopolymer | | | | | | | | |
| Kim, Kim [454] | - | hollow fibre membrane | counter current flow | - | | 8.49E-04 | - | 2600 - 4000 | 14 |
| Kline, Weidman [455] | crosslinked poly(ethylene oxide) (PEO) membranes | - | - | 3.4 mL DMAc | - | 6.28E-04 | - | - | - |
| Lai, Yeong [456] | (ZIF)-8 | zeolite membranes | - | methanol | | 1.66E-05 | 30 | 200 | 36 |
| Lai, Yeong [457] | zeolitic imidazolate framework-8 (ZIF-8) membrane | - | - | - | | 4.80E-05 | - | - | 15,50,90 |
| Lee, Park [458] | zeolitic imidazolate framework-8 (ZIF-8) | - | - | - | | 9.83E-05 | - | - | 50 |
| Lee, Lee [459] | poly (benzoxazole-co-imide) (XTR-PBOI) | hollow fibre membrane | concurrent flow | - | - | 1.25E-04 | 130-140 | - | 14 |
| Lee, Binns [460] | - | hollow fibre membrane | counter current flow | - | | 2.88E-04 | - | - | 14 |
| Li, Ding [461] | porous graphene (PG) | - | - | sodium hydroxide (NaOH) | | 2.26E-07 | - | - | - |
| Li, Pyrzynski [462] | PEEK | hollow fibre membrane | counter current flow | methyldiethanolamine (aMDEA) | - | - | 330000–775000 | 3400 –5900 | 6.4–16.6 |
| Liu, Zhou [463] | [TESPMIM][BF4] | ionic liquids (rtils) | cross-flow | tetraethylammonium hydroxide | | 1.20E-04 | 150-400 | - | - |
| Liu, Li [464] | poly(amide-b-ethylene oxide) (Pebax MH 1657) | mixed-matrix membrane (mmm) | concurrent flow | polydopamine | - | 9.05E-05 | 30 | 30 | 10 |
| Lu, Ge [465] | Potassium glycinate (PGLY) | ionic liquid membranes (silms) | counter current flow | monoethanolamine glycinate ([MEA][GLY]) | | 3E-02 | 500 | 200 | - |
| Mahdavi, Azizi [466] | Pebax1657/PEG1000/ γ-Al2O3 membrane | - | cross-flow | DMF | - | 8.30E-05 | - | - | - |
| Mannan, Mohshim [467] | polyethersulfone (PES) | ionic liquid membranes | - | 1-methyl-2-pyrrolidone EMPLURA1 (NMP) | | 4.57E-06 | - | - | - |
| Marti, Wickramanayake [468] | polymeric porous Hollow Fiber membrane | - | - | - | - | 6.92E-06 | - | 0.23 - 013 | 20 |
| Martin-Gil, López [469] | ETS-10, TS-1 having Si/Ti=100 and TS-1 using Si/Ti=25 | mixed matrix membranes | - | N-methyl-2-pyrrolidinone, NM | - | 1.17E-05 | - | - | 50 |

| Authors | Membrane material | Reactor type | Flow configuration | Solvent (with molarity) | Wetting (+ = hydrophilic; - = hydrophobic) | Average flux (mol/ min $cm^2$) | Gas flow rate (ml/min) | Liquid flow rate (ml/min) | Feed vol % $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| Mirfendereski and Mohammadi [470] | polypropelyene porous | hollow fibre membrane | counter current flow | methyldiethanolamine (MDEA) (0.5mol/L) | - | - | 360000 | 11.7 | 4-12 |
| Monteiro, Nabais [471] | - | metal organic framework | - | - | | - | - | - | - |
| Morris, Jacques [472] | PIM-1 | mofs | - | - | | 4.65E-03 | - | - | - |
| Nordin, Ismail [473] | modified ZIF-8 | mixed matrix membranes | - | N,N-methylpyrrolidone (NMP), tetrahydrofuran (THF) and ethanol | - | 3.22E-05 | - | - | - |
| Park, Lee [474] | MgCO3-crystal- | mixed matrix membranes (mmms) | - | ethanol | - | 6.29E-06 | - | - | - |
| Peng, Wang [475] | graphene oxide (GO) nanosheets | - | - | dopamine (DA) solution | | 5.54E-05 | - | - | - |
| Prasad and Mandal [476] | polymeric (CS-TEPA) membrane | - | concurrent flow | - | - | 7.6E-01 | 0.05 | 0.03 | 20 |
| Qu, Li [477] | nitrogen-rich membranes, g-C3N4, g-C3N3,C2N-h2D, g-C12N8, and p-BN | - | - | - | | - | - | - | - |
| Quan, Li [478] | cross-linked poly (ethylene oxide) (PEO) | mixed matrix membranes (mmms) | - | - | - | 5.03E-10 | - | - | - |
| Rahmawati, Nurkhamidah [479] | hydrophobic polypropylene | polymeric hollow fibre membranes | cross-flow | - | - | 1.48E-05 | 400 | 400 | - |
| Ranjbaran, Kamio [480] | ionic liquid (IL)-based gel membrane | - | concurrent flow | N,N′-methylenebis(acrylamide) (MBAA) | | 2.94E-03 | 100 | - | 50 |
| Ur Rehman, Rafiq [481] | triethanolamine formate (TEAF) and triethanolamine acetate (TEAA) | ionic liquid membranes | - | triethanolamine | | 7.52E-05 | 200 | - | - |
| Ricci, Minelli [482] | polyimide membrane (Matrimid®) | polymeric membranes | - | 5(6)-amino-1-(4′aminophenyl)-1,3,-trimethyl indane | - | - | - | - | - |
| Rudaini, Naim [483] | PVDF polymer | hollow fibre membrane | counter current flow | monoethanolamine (MEA) | - | 4.07E-04 | 200 | 50 | - |
| Saidi [484] | polytetrafluoroethylene (PTFE), polypropylene (PP) and polyvinylidene fluoride (PVDF) | hollow fibre membrane | counter-current flow | diethanolamine (DEA) | - | - | 150 | 100 | - |

| Authors | Membrane material | Reactor type | Flow configuration | Solvent (with molarity) | Wetting (+ = hydrophilic; - = hydrophobic) | Average flux (mol/ min cm$^2$) | Gas flow rate (ml/min) | Liquid flow rate (ml/min) | Feed vol % $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| Saidi [485] | 4−diethylamino−2−butanol (DEAB) | hollow fibre membrane | cross-flow | MEA, DEA, TEA, MDEA | - | 2.26E-07 | - | - | 20 |
| Selyanchyn and Fujikawa [486] | MTR PolarisTM | - | counter current flow | monoethanolamine (MEA) | - | 1.1E-01 | - | - | - |
| Shafie, Man [487] | polycarbonate-Silica | - | - | 3-aminopropyl trimethoxysilane and N(2 aminoehtyl) 3-amino-propyltrimethoxysilane | - | 1.33E-03 | - | - | - |
| Shamsabadi, Seidi [488] | TiO2 nanoparticles | polymer matrix membrane | - | 3-aminopropyl-diethoxymethylsilane | | 4.85E-05 | - | - | - |
| Shin, Chi [489] | PVC-POEM/ZIF-8 | mixed matrix membranes | - | 1,1,4,7,10,10hexamethyl triethylene tetramine (HMTETA, 99%) | - | 6.48E-06 | - | - | - |
| Song, Liu [490] | - | hyrbid cryogenic memebrane process | concurrent flow | - | | - | - | - | 15-84 |
| Song, Qiu [491] | ZIF, ZIF-8, pore size, ~ hybrid polysulfone (PSF) and (ZIF, ZIF-8 | - | - | - | - | 2.73E-05 | - | - | - |
| Taniguchi, Kinugasa [492] | olydimethylsiloxane (PDMS) | thin film composite membranes | - | methanol | - | 1.52E-03 | 0.8 | - | - |
| Taniguchi, Wada [493] | poly(amidoamine)s (PAMAMs) incorporated into a cross-linked poly(ethylene glycol) | - | concurrent flow | monoethanolamine (MEA) | | 7.65E-05 | 100 | 100 | 40 |
| Tong and Ho [494] | poly(N-vinylamine)s, namely poly(N-methyl-N-vinylamine), poly(N-isopropyl-N-vinylamine), and poly(N-tertiary-butyl-N-vinylamine) | - | counter current flow | - | - | 1.39E-03 | 60 and 30 | - | 20 |
| Tseng, Chuang [495] | mesopore SBA-15 | mixed matrix membranes (mmms) | - | HCL solution | - | 2.18E-08 | - | - | - |
| Turi, Ho [496] | - | - | counter current flow | - | | - | - | - | - |

| Authors | Membrane material | Reactor type | Flow configuration | Solvent (with molarity) | Wetting (+ = hydrophilic; - = hydrophobic) | Average flux (mol/ min $cm^2$) | Gas flow rate (ml/min) | Liquid flow rate (ml/min) | Feed vol % $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| Usman, Dai [497] | 1-Butyl-3-methylimidazolium Tricyanomethanide ([Bmim][TCM]) | tubular membrane contractor: hybrid technology | counter current flow | - | - | 4.47E-06 | 56 | 20 | 45 |
| Wang, Li [498] | stacked graphene oxide (GO) membranes | - | counter current flow | - | | - | - | - | - |
| Wang, Xie [499] | graphene oxide membranes | - | concurrent flow | - | | 7.06E-05 | - | - | 50 |
| Wang, Ren [500] | NH2-UiO-66 | mixed matrix membranes | - | DMF | | 1.69E-03 | - | - | 30 – 70 |
| Xiang, Sheng [501] | amino-functionalized zeolitic imidazolate framework ZIF-7 (ZIF-7-NH2) | zeolite membranes | - | - | | 3.02E-06 | - | - | 50 |
| Yoon, Kim [502] | 1-Butyl-3-methylimidazolium tetrafluoroborate/zinc oxide | ionic liquid membranes | concurrent flow | - | | | - | - | - |
| Zainab, Iqbal [503] | polyamide 6/carbon nanotube (PA/CNT) nano-fibre/net | polymeric membranes | - | ethanol or isopropanol | - | - | 200 | - | - |
| Zhang, Zhang [504] | polyvinyl acetate (PVAc) | poly(ionic liquid) membranes | - | tetrahydrofuran (THF) | | 8.70E-06 | - | - | - |
| Zhang, Wang [505] | Polyimide(PI) | hollow fibre membranes | - | - | - | 1.36E-04 | - | 6667 | 12 |
| Zhang, Tu [506] | four diamine-monocarboxylate-based protic | ionic liquids (pils) | - | N, N, N′,N′-Tetramethyl-1,3-propanediamine | | 4.23E-05 | - | - | - |
| Zhang, Wang [507] | montmorillonite (MMT) and Mg-Al hydrotalcite (HT) | - | - | sodium hydroxide (NaOH) | | 2.23E-06 | - | - | - |
| Zhao, Ren [508] | Pebaxs membranes /CNTs/GTA | mixed matrix membranes (mmms) | concurrent flow | ethanol/water (70/30 wt%) | - | 3.52E-04 | - | - | - |
| Zhao, Sang [509] | d diacetylenic linkages with heteroatoms hydrogen, fluorine, and oxygen (GDY X, X = H, F, and O) | - | - | - | - | 6.09E-05 | - | - | 50 |
| Zhou, Tien [510] | graphene oxide | hollow fibre membranes | - | - | | - | - | - | 15 |

| Authors | Membrane material | Reactor type | Flow configuration | Solvent (with molarity) | Wetting (+ = hydrophilic; - = hydrophobic) | Average flux (mol/ min cm$^2$) | Gas flow rate (ml/min) | Liquid flow rate (ml/min) | Feed vol % $CO_2$ |
|---|---|---|---|---|---|---|---|---|---|
| Zhu, Swihart [511] | poly[2,20-(m-phenylene)-5,50-bisbenzimidazole] (PBI | - | counter current flow | n N,N-dimethylacetamide (DMAc) | - | 2.03E-07 | - | - | 50 |
| Ahmad, Navarro [512] | MOF based Nanoparticles of $CO_2$-philic UiO-66 (Zr-BDC) | metal organic structures | - | Poly(amic) PPA solution | | 3.08E-05 | - | - | 50 |
| Baghban and Azar [513] | | hollow fibre membrane | - | - | | - | - | - | 10-50 |
| Constantinou, Barrass [514] | Nickel | flat membrane | concurrent | NaOH | + | 3.00E-03 | 230 | 1.66 | 20 |
| Fu, Li [515] | polyetheramine (PEA) and methyl-containing polyisophthalamides (MPA) | copolymer membranes | - | polyetheramine (PEA) and methyl-containing polyisophthalamides (MPA) | - | 2.53E-04 | - | - | 10 |
| Hu, Cheng [516] | polydimethylsiloxane (PDMS) membranes | - | - | - | - | 7.44E-04 | - | - | 40 |
| Hu, Cheng [517] | polyacrylonitrile polydimethylsiloxane (PDMS) | hollow fibre-supported membrane | - | 3-aminopropyltriethoxysilane | - | 9.81E-04 | - | - | - |
| Ko [518] | - | hollow fibre membrane | counter current flow | - | | - | - | - | 10 |
| Ovalle-Encinia, Pfeiffer [519] | Ce 0.85 Sm 0.15 O2-Sm 0.6S r 0.4 Al 0.3Fe 0.7O3 composite | ceramic membranes | counter current flow | - | | 3.60E-10 | 60 | 60 | 15 |
| Pang, Gong [520] | polyvinylidenefluoride (PVDF) | hollow fibre membrane | counter current flow | 2-Pyrrolidone (NMP) | - | 7.86E-06 | 130 | 70 | 19 |
| Ramli, Hashim [521] | polypropylene (PP) | ionic liquids (ils) membranes | concurrent flow | 1-Ethyl-3-methylimidazolium bis(trifluoromethylsulfonyl) imide [emim] [NTf2] | - | | - | - | - |
| Russo, Prpich [522] | polydimethylsiloxane (PDMS) membrane | - | counter current flow | - | - | 1.06E-03 | - | 5000 - 10000 | 10 |
| Wang, Kang [523] | polytetrafluoroethylene (PTFE) | hollow fibre membrane | counter current flow | - | - | - | 1.75 | 0.2-0.8 | 20-50 |
| Yu, Kanezashi [524] | amine-silica membranes | - | - | HCl and EtOH | - | 4.50E-03 | 50 | - | - |
| Zhang, Peng [525] | (SP-Zn2+) | - | - | anhydrous ethanol (C2H5OH) | | 1.69E-04 | 30 | - | - |

* Flow in kmol/hr

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