Supplemental Information for: Water Electrolysis: From textbook knowledge to the latest scientific strategies and industrial developments

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Table S1. Chemical and mechanical properties of selected AEMs.

Membrane	Polymeric backbone	Functional group	Properties								Conductivity measurement temp. (ºC)	Applied in EW	Refs.
			IEC[a]	Conductivity (mS/cm)	Water uptake (wt%)	Swelling ratio (%)	Thickness (µm)	Tensile strength (Mpa)	Elongation (%)	Young's modulus (MPa)			
PTP-75	[(terphenyl piperidinium)-co-(oxindole terphenylylene)]	Piperidinium	2.10	48.6	31.4	4.9[b]	45	29.2	6.8	466.7	20	+	1
PTP-85	[(terphenyl piperidinium)-co-(oxindole terphenylylene)]	Piperidinium	2.38	59.6	37.0	5.9[b]	45	34.2	24.2	620.2	20	+	1
PTP-90	[(terphenyl piperidinium)-co-(oxindole terphenylylene)]	Piperidinium	2.52	64.4	39.7	7.4	45	36.5	25.2	777.6	20	+	1
FAA3-30 (OH-) (FumaTech)[b]	N/A	N/A	1.7-2.1	40	N/A	N/A	25-35	25-40	20-40	N/A	N/A	-	2
FAA3-50 (OH-) (FumaTech) [b]	N/A	N/A	1.59, 1.85	40	17	9	47–53	25-40	20-40	N/A	N/A	+	2, 3
QMSV-0.16	poly(ST-co-VBC	TMA	1.04	0.264	16.7	10.9	60	N/A	N/A	N/A	25	+	4
QMSV-0.33	poly(ST-co-VBC	TMA	2.14	6.80	127.4	15.9	60	N/A	N/A	N/A	25	+	4
PFOTFPh-TMA-C6	(fluorene-alt-tetrafluorophenylene	trimethylammonium (TMA)	3.2	156	122	97	20-30	26.8	8	N/A	70	+	5, 6
PFOTFPh-TMA-C8	(fluorene-alt-tetrafluorophenylene	trimethylammonium (TMA)	2.9	117	74[d]	39	20-30	28.5	8	N/A	70	+	5, 6
PFOTFPh-TMA-C10	(fluorene-alt-tetrafluorophenylene	trimethylammonium (TMA)	2.7	101	67[d]	33	20-30	40.9	10	N/A	70	+	5, 6
GT69[c]	poly (norbornene) (PNB)	N,N,N′,N′- tetramethyl-1,6-hexanediamine (TMHDA),	3.38	178	115	N/A	N/A	N/A	N/A	N/A	80	+	7
GT72-5[c]	poly (norbornene) (PNB)	N,N,N′,N′- tetramethyl-1,6-hexanediamine (TMHDA),	3.50	175	96	N/A	N/A	N/A	N/A	N/A	80	+	7
GT74[c]	poly (norbornene) (PNB)	N,N,N′,N′- tetramethyl-1,6-hexanediamine (TMHDA),	3.56	160	103	N/A	35 50	N/A	N/A	N/A	80	+	7
PAP-TP-85	poly(aryl piperidinium) hydroxide	piperidinium	2.37	193	65	12	10-25	67	117	N/A	95	+	8, 9, 10
PAP-TP-85-MQN	poly(aryl piperidinium) hydroxide	piperidinium	3.2	150[d]	N/A	N/A	20	N/A	N/A	N/A	RT	+	8
PBI1-PVBC1-NMPD/OH	poly(vinylbenzyl chloride) (PVBC) cross-linked by	N-methylpiperidine	2.31	83	48	11	50	37.5[e]	16.2[e]	N/A	80	+	11

Membrane	Polymeric backbone	Functional group	Properties								Conductivity measurement temp. (ºC)	Applied in EW	Refs.
			IEC[a]	Conductivity (mS/cm)	Water uptake (wt%)	Swelling ratio (%)	Thickness (µm)	Tensile strength (Mpa)	Elongation (%)	Young's modulus (MPa)			
	polybenzimidazole (PBI) and quaternized by N-methylpiperidine (NMPD) i												
PAni-0.87	Polyaniline	3,30 - iminobis(N,Ndimethylpropylamine	0.87	54.9	13.8	10.3		N/A	N/A	N/A	80	-	12
PAni-0.92	Polyaniline	3,30 - iminobis(N,Ndimethylpropylamine	0.92	90.1	18.1	11.7		N/A	N/A	N/A	80	-	12
PAni-1.03	Polyaniline	3,30 - iminobis(N,Ndimethylpropylamine	1.03	105	22.3	18.7	N/A	N/A	N/A	N/A	80	+	12
IPA [b]	N/A	N/A	1.27	32.4	23.1	15.6	N/A	N/A	N/A	N/A	80	+	12
AMB [b]	N/A	N/A	1.06	3.3	24.3	N/A	N/A	N/A	N/A	N/A	80	+	12
Tokuyama- A201 [b]	N/A	N/A	1.8	42	30	N/A	28[e]	96.4 [g]	61.7[g]	1123 [g]	(26,41)	+	2, 10, 13, 14
AEMION™-AF1-HNN8-50-X [b]	N/A	N/A	2.1-2.5	102	N/A	N/A	50	60 (dry I)	85-110 [j]	N/A	50	+	2, 15
AEMION™-AF1-HNN8-25-X [b]	N/A	N/A	2.1-2.5	131	N/A	N/A	25	60 (dry I)	85-110 [g]	N/A	50	+	2, 15
AEMION™-AF1-HNN5-50-X [b]	N/A	N/A	1.4-1.7	40	N/A	N/A	50	60 (dry I)	85-110 [g]	N/A	50	+	2
AF1-HNN5-25-X [b]	N/A	N/A	1.4-1.7	56	N/A	N/A	25	60 (dry I)	85[g]	N/A	50	+	2, 15
SUSTAINION® Sustainion 37–50 [b]	Copolymer of styrene and vinyl benzyl chloride	Tetramethyl Imidazole	N/A	80 [f]	N/A	cracks when dry	50	cracks when dry	cracks when dry	N/A	30	+	2, 19, 16, 17, 18, 19, 20, 21, 22, 23
HDPE-AEM	High density polyethylene	TMA	2.44	214 [g, i]	155 [g]	38	29	35	283	N/A	80	-	24, 25
LDPE-AEM	Low density polyethylene	TMA	2.54	290 201 304	149	27	28	23	69	N/A	110 105 120	-	25 , 24, 26, 27, 28, 29
C4-AEM	ETFE	pyrrolidinium	1.51	30	85	59	N/A	N/A	N/A	N/A	60	-	25, 30
SEBS-BTMA	polystyrene-b-poly(ethylene-co-butylene)-b-polystyrene (SEBS)	TMA	1.04	32	40	25.1	60	2.0	180.1	N/A	80	-	25, 31

Membrane	Polymeric backbone	Functional group	Properties								Conduct-ivity meas-urement temp. (ºC)	Applied in EW	Refs.
			IEC[a]	Conduc-tivity (mS/cm)	Water uptake (wt%)	Swelling ratio (%)	Thickness (µm)	Tensile strength (Mpa)	Elonga-tion (%)	Young's modulus (MPa)			
SEBS-CH2-QA-1.5	SEBS	Long flexible alkyl spacer	1.35	56	48	29.6	60	3.3	345.7	N/A	80	-	25, 31
XL100-SEBS-C5-TMA-0.8	SEBS	TMA with different degree of functionalization and cation tether length	1.50	65	28	10	60	7.0	400	N/A	80	-	25, 32
1:1 DCPD:1	a tetraalkylammonium-functionalized norbornene with dicyclopentadiene (DCPD)	tetraalkylammonium	1.40	28	N/A	N/A	N/A	2.3	26	N/A	50	-	25, 33
P1.25-OH	poly(norbornene)	pendant trimethylammonium cations	1.25	177	82	N/A	N/A	N/A	N/A	N/A	80		25, 34
XL35-rPNB-X60-Y40	Poly(bromopropyl norbornene)-blockpoly(butyl norbornene) diblock copolymers	TMHDA	2.20	109	100	28	N/A	2.5	52	N/A	80	-	25, 35
HC-$[1]_{498}$ $[2]_{200}$	PE	Imidazolium	1.69	134	115	17	N/A	N/A	N/A	N/A	80	-	25, 36
PNB-X62-Y38	The tetrablock copolymer, consisting of alternating butyl norbornene (BuNB) and bromopropyl norbornene (BPNB) blocks (two blocks each)	norbornene	2.21	102	71	N/A	50	N/A	N/A	N/A	80	-	25, 37
H22C9N	poly(olefin)s	trimethylamine with the alkyl group	1.43	70[l]	177	40	N/A	N/A	N/A	N/A	80	-	25, 38
F20C9N	poly(olefin)s	trimethylamine with the alkyl group	1.21	91[l]	109	26	70	N/A	N/A	N/A	80	-	25, 38
ATMPP	poly(phenylene)s	benzylic cations	2.39	18	156	N/A	N/A	N/A	N/A	N/A	22	-	25, 39
HTMA-DAPP	polyphenylene	hexamethyl trimethyl ammonium	2.6	120	58	N/A	26	>20	N/A	N/A	80	+	25, 40
QPAF (C6)-2	perfluoroalkylene and phenylene groups	TMA	1.14	96	45	N/A	50	24	218	N/A	80	-	25, 41
QP-QAF3	quinquephenylene and fluorene groups	pendant hexyltrimethylammonium	2.21	134	85	N/A	22	35	28	6	80	-	25, 42
PAImEE (12)	poly(arylimidazoliums)	Ethyl as alkyl chains	2.65	46[g]	28j	26.1	25	64	28.7	1075	80	+	25, 43
BPN1	biphenyl	trifluoromethyl	2.61	122	130	40	25	35	140	N/A	80	-	25, 44, 45
p-TPN1	Para- terphenyl	trifluoromethyl	2.15	81	43	6	25	24	20	N/A	80	-	25, 44, 45
m-TPN1	meta-terphenyl	trifluoromethyl	2.15	127	45	10	25	30	38	N/A	80	-	25, 44, 45
FLN-55	Quaternized poly(fluorene)s	TMA	2.50	120	180	60	30	N/A	N/A	N/A	80	-	25

Membrane	**Polymeric backbone**	**Functional group**	**Properties**								**Conductivity measurement temp. (ºC)**	**Applied in EW**	**Refs.**
			IEC[a]	**Conductivity (mS/cm)**	**Water uptake (wt%)**	**Swelling ratio (%)**	**Thickness (µm)**	**Tensile strength (Mpa)**	**Elongation (%)**	**Young's modulus (MPa)**			
PTPipQ6	poly(arylene)	piperidinium	2.04	111	44	N/A	60	N/A	N/A	N/A	80	-	25, 46
PTPipQ1	poly(arylene)	piperidinium	2.38	89	145	N/A	60	N/A	N/A	N/A	80	-	46
PVBC-MPy/15%PEK-cardo	poly(vinyl benzyl chloride) (PVBC-MPy) and poly(ether ketone-cardo)	methylpyrrolidinium	3.47	50.3	132	110	60	4.5	31.3	20.7	80	-	47
PVBC-MPy/25%PEK-cardo	(PVBC-MPy) and poly(ether ketone-cardo)	methylpyrrolidinium	3.10	37.7	59	61	60	9.5	33.3	30.9	80	-	47
PVBC-MPy/35%PEK-cardo	(PVBC-MPy) and poly(ether ketone-cardo)	methylpyrrolidinium	2.65	28.5	32	38	60	15.1	23.9	67.6	80	+	47
PVBC-MPy/45%PEK-cardo	(PVBC-MPy) and poly(ether ketone-cardo)	methylpyrrolidinium	2.34	15.4	24	26	60	22.1	19.3	110	80	-	47
PSF-TMA$^+$	polysulfone (PSF)	trimethylammonium	2.05	30.5	N/A	N/A	40-80	N/A	N/A	N/A	50	+	48, 49
PSF-DMP$^+$	polysulfone (PSF)	1,4-dimethylpiperazinium	1.51	14.4	230	N/A	40-80	N/A	N/A	N/A	50	-	49
xQAPS	PSF	Trimethylammonium Dimethyl diethyl ammonium as cross linker	1.34	60.5	N/A	4	N/A	N/A	N/A	N/A	80	+	50, 51, 52
PPO24-BIM (bromide form)	oly-(2,6-dimethyl-1,4-phenylene oxide)	mesityl-benzimidazole (BIM)	1.9	12	27	N/A	23	45.9	6.0	951	60	+	13
FAA3-PK-75 (bromide form) [b]	N/A	N/A	N/A	N/A	N/A	N/A	87	26.9	12.1	983	60	+	13, 53
PSEBS-CM-DABCO	polystyrene-block-poly(ethylene-ran-butylene)-block-polystyrene (PSEBS	1,4-diazabicyclo[2.2.2]octane (DABCO)	0.76	75	N/A	N/A	100	N/A	N/A	N/A	30	+	54
PAEK-APMP75	Poly (arylene ether) ketone	1-(3-aminopropyl)-4-methylpiperazin	1.10	6.82	38	N/A	55	12.6	30.4	N/A	60	+	55
PAEK-APMP100	Poly (arylene ether) ketone	1-(3-aminopropyl)-4-methylpiperazin	1.32	9.94	48	N/A	55	9.7	41	N/A	60	+	55
QPDTB	three monomers of methacrylate:2-dimethylaminoethyl methacrylate (DMAEMA), 2,2,2,-tri-fluoroethyl methacrylate (TFEMA), and butyl methacrylate (BMA)	Trimethyl amine	1.275	59	N/A	N/A	300	7.629	45.8	226	50	+	56, 57

Membrane	Polymeric backbone	Functional group	Properties								Conductivity measurement temp. (ºC)	Applied in EW	Refs.
			IEC[a]	Conductivity (mS/cm)	Water uptake (wt%)	Swelling ratio (%)	Thickness (µm)	Tensile strength (Mpa)	Elongation (%)	Young's modulus (MPa)			
LDPE-g-VBC-Dab	Low density polyethylene (LDPE) grafted vinylbenzyl chloride (VBC	,4-diazabicyclo(2.2.2)octane (Dabco)	1.5	25	81	N/A	N/A	N/A	N/A	N/A	60	+	58
SEBS-Pi-73%	Polystyrene-block-poly (ethylene-ran-butylene)-block-polystyrene	N-Methylpipridine	1.19	10.09	59.13	25.03	N/A	4.2	600	N/A	30	+	59
PBP-ASU-PPO	poly(biphenyl piperidinium) (PBP)/6-azaspiro[5.5]undecane (ASU)-functionalized polyphenyl ether (ASU-PP	Piperidinium and ASU	2.61	128	120	21	50	N/A	N/A	N/A	80	+	60
Tokuyama- A901 [b]	N/A	N/A	1.8	N/A	N/A	N/A	9	N/A	N/A	N/A	N/A	+	61
FAA-3-PP-75	N/A	N/A	N/A	38	140	13-15	80	N/A	N/A	N/A	60	+	62
SEBS	polystyrene-b-poly (ethylene/butylene)-b-polystyrene	Trimethyl amine	1.9	140	N/A	N/A	120	N/A	N/A	N/A	50	+	63
PTFE+qPDTB-OH$^-$	Polytetrafluoroethylene (PTFE)	Quaternary ammonium Poly(DMAEMA-co-TFEMA-co-BMA) (quaternary ammonium polymethacrylate)	1.02	34	N/A	146	30	10	10	406	50	+	64
mm-qPVBz/OH$^-$	Methylated melamine grafted poly vinyl benzylchloride (mm-qPVBz/Cl$^-$)	Amination with methylated melamine	N/A	27	N/A	N/A	70	12.1	14	142	60	+	65, 66
BPN1-100	poly(arylene)	N,N,N-trimethylpentan-1-ammonium	2.61	122	124	66	N/A	N/A	N/A	N/A	80	+	67
TPN1-100	poly(arylene)	N,N,N-trimethylpentan-1-ammonium	2.15	112	70	23	N/A	N/A	N/A	N/A	80	+	67
PAImEE(12)	poly(aryl)	Imidazolium	2.65	21.3	28.1	26.1	25	64.0	28.7	1075	22	+	43
PAImBB(14)	poly(aryl)	Imidazolium	2.3	8.5	12.2	14.0	20	65.2	20.4	1095	22	+	43
QPC-TMA	poly(carbazole)	polymer (poly(9-(6-(trimethylammonium bromide)hexyl)-9H-carbazole-co-1,1,1-trifluoroisopropane)	2.08 2.00	125	76	15	50	N/A	N/A	N/A	70	+	68
PVBC-MPy M2	poly(vinyl benzyl)	methylpyrrolidinium	2.02	32.8	28.5	23.8	80	9.4	16.5	N/A	80	+	69
PVBC-MPy M4	poly(vinyl benzyl)	methylpyrrolidinium	2.01	29.8	19.8	20.4	80	30.9	11.1	N/A	80	+	69

Membrane	**Polymeric backbone**	**Functional group**	**Properties**								**Conductivity measurement temp. (ºC)**	**Applied in EW**	**Refs.**
			IEC^a	**Conductivity (mS/cm)**	**Water uptake (wt%)**	**Swelling ratio (%)**	**Thickness (µm)**	**Tensile strength (Mpa)**	**Elongation (%)**	**Young's modulus (MPa)**			
PVBC-MPy M6	poly(vinyl benzyl)	methylpyrrolidinium	1.97	30.5	21.5	17.0	80	20.6	8.9	N/A	80	+	69
MES-PBI (25 wt% KOH)	polybenzimidazole	poly(2,2' -(m-mesitylene)-5,5' -bibenzimidazole)	N/A	100	N/A	54	60	N/A	N/A	N/A	80	+	70
PPO-TMA	polyphenylene oxide (PPO)	trimethylamine (TMA)	2.1	52	104	N/A	N/A	6.3	1.9	N/A	70	+	71, 72
PPO-ABCO	polyphenylene oxide (PPO)	1-Azabicyclo[2.2.2]octane (ABCO)	1.9	39	147	N/A	N/A	10.3	2	N/A	70	+	71, 72
PISPVA46	poly(1-vinyl-3-imidazole-co-styrene) (PIS) co-poly(vinyl alcohol) (PVA)	imidazolium	1.65	90	101.1	18.6	55	15.5	316.5	N/A	60	+	73
PISPVA37	poly(1-vinyl-3-imidazole-co-styrene) (PIS) co-poly(vinyl alcohol) (PVA)	imidazolium	1.41	82	78.9	19.7	55	27.6	295.1	N/A	60	+	73
PISPVA28	poly(1-vinyl-3-imidazole-co-styrene) (PIS) co-poly(vinyl alcohol) (PVA)	imidazolium	1.13	74	49.7	18.7	55	30.8	216.9	N/A	60	+	73
QMter-co-Mpi-60%	ether-free polyarylene	piperidinium	1.65	8	37.15	11.89	N/A	N/A	N/A	N/A	30	-	74
QMter-co-Mpi-80%	ether-free polyarylene	piperidinium	2.10	21	49.39	17.77	N/A	N/A	N/A	N/A	30	-	74
QMter-co-Mpi-100%	ether-free polyarylene	piperidinium	2.42	37	78.92	29.00	N/A	11	24	N/A	30	+	74
BPi	PPO	piperidinium	1.94	18	29.0	9.5	50	32.7	2.7	N/A	20	-	75
SCPi	PPO	piperidinium	1.67	25	41.7	11	50	48.4	3.5	N/A	20	+	75
LSCPi	PPO	piperidinium	1.57	29	39.6	10.3	50	35.6	2.0	N/A	20	+	75
BTMA	PPO	Benzyltrimethyl ammonium	2.04	26	65.7	12	50	39.4	4.4	N/A	20	-	75
SCQA	PPO	side-chain-type	1.80	41	79.0	15	50	40.5	8.0	N/A	20	-	75
LSCQA	PPO	long side-chain-type	1.67	39	55.7	12	50	39.0	2.1	N/A	20	+	75
PSU-PVP75%	poly(arylene ether sulfone) and poly(vinylpyrrolidone)	pyrrolidone	N/A	N/A	N/A	N/A	A wide range	5	75	130	N/A	+	76
BPI-c-PVBC/OH 1:2	poly[2-2'-(m-phenylene)-5-5'-bibenzimidazole] co-poly(vinylbenzyl chloride) (PVBC)	DABCO	1.74	30	45	23	N/A	N/A	N/A	N/A	80	+	77

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			IEC[a]	Conductivity (mS/cm)	Water uptake (wt%)	Swelling ratio (%)	Thickness (µm)	Tensile strength (Mpa)	Elongation (%)	Young's modulus (MPa)			
BPI-c-PVBC/OH 1:3	poly[2-2'-(m-phenylene)-5-5'-bibenzimidazole] co-poly(vinylbenzyl chloride) (PVBC)	DABCO	1.97	44	52	24	N/A	N/A	N/A	N/A	80	+	77
ABPBI-c-PVBC/OH 1:2	Poly(2,5-benzimidazole) (ABPBI) co - poly(vinylbenzyl chloride) (PVBC)	DABCO	1.70	56	51	90	N/A	N/A	N/A	N/A	90	+	77
C-PVAf·ABPBI	Polyvinyl alcohol (PVA) nanofiber/ABPBI	polyvinyl alcohol (PVA) nanofibers crosslinked with glutaraldehyde (GA)	N/A	41	55	17	30-45	5.0	6	1033	80	+	78
C-PVA·ABPBI	Polyvinyl alcohol (PVA) /ABPBI	polyvinyl alcohol (PVA) nanofibers crosslinked with glutaraldehyde (GA)	N/A	48	67	14	30-45	2.8	16	64	80	-	78
QPAF-4	perfluoroalkylene and fuorene	hexyltrimethylammonium groups	1.47	86.2	105	N/A	50	22.7	269	N/A	80	-	79
PP-BTMA	Aryl-Ether	Polyaromatics	2	10	116	N/A	20-40	N/A	N/A	N/A	30	-	80
PP-HTMA	Aryl-Ether	Polyaromatics	2.4	14	109	N/A	20-40	N/A	N/A	N/A	30	-	80
PPA-HTMA	Aryl-Ether	Polyaromatics	2.1 Polyaromatics	15	453	N/A	20-40	N/A	N/A	N/A	30	-	80
PSBFP-TMA	poly(2,2' -spirobifluorene-alt-1,3-phenylene)	Trimethyl ammonium	1.2	23.1	11.1	17	N/A	N/A	N/A	N/A	70	-	81
PSBFBP-TMA	poly(2,20 -spirobifluorene-alt-4,4' -biphenylene)	Trimethyl ammonium	2.3	86.2	24.5	38	N/A	N/A	N/A	N/A	70	-	81
F-PAE	polyaromatics	BTMA	2.7	46	99	N/A	N/A	30	9.8	N/A	80	+	82
ATM-PP	polyaromatics	BTMA	1.7	37	70	N/A	N/A	42	27	N/A	80	+	82
PBI linear	Polybenzimidazol	Polybenzimidazol	N/A	50	N/A	19	N/A	94	74	2554	22	+	83
CL PBI (crosslinked)	Polybenzimidazol	Polybenzimidazol	N/A	50	N/A	N/A	N/A	36	1.7	2907	22	+	83
Thermally cured PBI	Polybenzimidazol	Polybenzimidazol	N/A	50	N/A	47	N/A	139	59	2914	22	+	83

Membrane	Polymeric backbone	Functional group	Properties								Conductivity measurement temp. (ºC)	Applied in EW	Refs.
			IEC[a]	Conductivity (mS/cm)	Water uptake (wt%)	Swelling ratio (%)	Thickness (µm)	Tensile strength (Mpa)	Elongation (%)	Young's modulus (MPa)			
L-ABPBI (C_{KOH}= 1.9 M)	ABPBI	ABPBI	N/A	7	37.8	50	90-120	N/A	N/A	N/A	22	+	84
LC-ABPBI (C_{KOH}= 1.9 M	ABPBI	ABPBI	N/A	8	33.8	50	90-120	N/A	N/A	N/A	22	+	84
PQDP-1	poly (quinquephenylene-co-diphenylene	piperidinium	1.77	67.2	33	4.2	20-30	43	9.8	880	80	-	85
PQDP-3	poly (quinquephenylene-co-diphenylene	piperidinium	2.44	140.5	90	36.5	20-30	41	16.6	980	80	-	85
SDQEO	PPO	alkoxyl- extender-containing dual quaternary ammonium	1.13	87.3	120	30	50	10.5	27.3	N/A	80	-	86
PFTP	poly(fluorenyl aryl piperidinium)	piperidinium	2.81	208	45	16	20	84.5	25.6	1580	80	-	87
m-PTP-20Q	oly(aryl piperidinium) (PAP	piperidinium	3.06	144.2	51	6.25	60-70	N/A	N/A	N/A	80	-	88
O-PDQA-3	aryl-ether free poly(aryl piperidinium) (PBP)	piperidinium cations and ethylene oxide spacers	1.93	106	46.1	12.5	N/A	N/A	N/A	N/A	80	-	89
PP80N20	tetrakis(bromomethyl) monomers	spirocyclic QA	3.2	51.3	266	11	N/A	N/A	N/A	N/A	80	-	90
Q-CLP1	poly(benzimidazolium-imide)-	triazolium	1.36	84	58	17	N/A	15.37	7.80	N/A	80	-	91
BiPyBPEEK-50%	polyetheretherketone (PEEK)	pyridine	3.51	36.99	16	4.4	N/A	66.0	4.5	2400	80	-	92
QPAES/QBGO-3.0	poly (arylene ether sulfone) (QPAES)	1,4-diazabicyclo [2,2,2]octane and 1,6-dibromohexane, and subsequently used to preparemulti-cationic oligomer brushes-decorated graphene oxide	1.68	58.7	103	13.6	60	32.4	9.1	1360	80	-	93
PAEK-HQACz-0.7	poly(arylene ether ketone) copolymers	Long alkyl densely quaternized carbazole derivative pendant	1.88	98.1	46.4	13.5	N/A	32.5	43.5	N/A	80	-	94
PBP-BOP-ASU 8%	poly(4-((1,1′-biphenyl)-4-yl)piperidine)(PBP)	long-chain 3-(3-(1-(8-bromooctyl) piperidin-4-yl) propyl)- 6-azaspiro[5.5] undecan-6-ium bromide(BOP-ASU)	2.65	117	140	32	N/A	N/A	N/A	N/A	80	-	95
PBP-ASU	poly(4-((1,1′-biphenyl)-4-yl)piperidine)(PBP)	ASU	2.82	91	132.98	26	N/A	N/A	N/A	N/A	80	-	95

Membrane	**Polymeric backbone**	**Functional group**	**Properties**								**Conduct-ivity meas-urement temp. (ºC)**	**Applied in EW**	**Refs.**
			IEC[a]	**Conduc-tivity (mS/cm)**	**Water uptake (wt%)**	**Swelling ratio (%)**	**Thickness (µm)**	**Tensile strength (Mpa)**	**Elonga-tion (%)**	**Young's modulus (MPa)**			
CP2	poly(styrene-b-(ethylene-co-butylene)-b-styrene) (SEBS poly(styrene-b-(ethylene-co-butylene)-b-styrene) (SEBS poly(styrene-b-(ethylene-co-butylene)-b-styrene) (SEBS) Poly(styrene-b-(ethylene-co-butylene)-b-styrene) (SEBS)	branch polyethyleneimine (BPEI)	3.34	66.63	18.16	5.5	N/A	26.17	443	N/A	80	-	96
CP3	SEBS	BPEI	2.47	19.87	15.67	4.89	N/A	28.78	511	N/A	80	-	96
PPEEK:PEG 80:20	poly(ether ether ketone) (QPPEEK) and poly (ethylene glycol) (PEG) as the crosslinke	quaternary phosphonium	1.01	102	139	20	100	13.7	48	338	80	-	97
MPyPPO	PPO	N-methylpyrrolidinium	1.73	84	92.9	23.9	N/A	15.52	25.45	N/A	80	-	98
qPBPTT-5	Poly(biphenyl N-methyl-4- piperidone 1,1,1-Trifluoroacetone 1,3,5-Triphenylbenzene)	piperidine	1.93	116.92	61.71	19.41	30	10.89	8.26	N/A	80	-	99
m-TPNPiQA	poly(terphenylene) backbone	tethered with piperidinium groups	2.66	68.7	2.54	52.25	50	N/A	N/A	N/A	80	-	100
HyAEM-MP-180	polychloromethylstyrene-b-polyethylene-b-polychloromethylstyrene (PCMS-b-PE-b-PCMS)	benzylmethylpiperidinium	2.1	179	33	16.5	N/A	23.9	29.4	39.0	80	-	101
PPO-DMP	PPO	six-membered dimethyl piperidinium	1.98	71.8	125.7	29.6	50	43.7	2.7	N/A	80	-	102
PPO-ASU	PPO	ASU	1.85	76.5	148.6	42.0	50	20.4	1.3	N/A	80	-	102
NPPO-2QA-1.85	Azide-modified PPO (NPPO)	Alkyne side chain precursor containing terminal doubleQA groups (TABB)	1.85	47.22	33.70	8.93	N/A	N/A	N/A	N/A	30	-	103
AEM-9.09	benzonorbornadiene derivative (BenzoNBD-Bis(ImþBr?-ImþI?)) grafted	multi- imidazolium cations side-chains combined the rigid alkyl spacer and flexible alkoxy spacer	1.41	100.74	52	35.3	58	24.7	53.8	318.1	80	-	104
NAPAEK-Q-100	poly(arylene ether ketone)s	Naphthalene	1.46	74	24.3	4.5	N/A	44.43	6.39	2009	100	-	105

Membrane	**Polymeric backbone**	**Functional group**	**Properties**								**Conductivity measurement temp. (ºC)**	**Applied in EW**	**Refs.**
			IEC^{a}	**Conductivity (mS/cm)**	**Water uptake (wt%)**	**Swelling ratio (%)**	**Thickness (μm)**	**Tensile strength (Mpa)**	**Elongation (%)**	**Young's modulus (MPa)**			
VIB5/PMS2/PBI 0.5	N,N-butylvinylimidazolium with p-methylstyrene and polybenzimidazole,	Imidazolium	2.06	147	320.19^{j}	10.77^{j}	70	N/A	N/A	N/A	100	-	106
QPAE/GO-(APTS-c-PTMA) 0.7 wt%	quaternary ammonium functionalized graphene oxide (Q-GO) into quaternized poly(arylene ether) (QPAE) random copolymer containing 3-aminopropyl)triethoxysilane (APTS) and (3-bromopropyl)trimethyl ammonium bromide (PTMA)	PTMA	1.45	114.2	31.2	13.2	27	14.1	5.3	N/A	90	-	107
PDPF-DMP	PDPF	DMP	2.15	124	111	30	N/A	N/A	N/A	N/A	80	-	108
Q-PAES/PPO-55	Quaternized poly(arylene ether sulfone)/PPO belnded	triethylamine (TEA)	1.79	90.9	45.4	25.7		N/A	N/A	N/A	90	-	109
A-PEI-8	Alkalized poly(ether imide)	imidazolium	1.23	44.2	40.3	19.2	31	30.2	9.4	1400	90	-	110
PPO-22-3QA8F	a tri-quaternary ammonium side chain to the poly(phenylene oxide) (PPO) backbone	Terminal alkyne-containing 3-[(2-perfluorooctyl)ethoxy]prop-1- yne	1.58	83	10.2	3.7	20-30	N/A	N/A	N/A	90	-	111
QN-PAEK/rGO5.0wt %	poly(arylene ether ketone) (PAEK)/ reduced graphene oxide (rGO)	bearing fluorenyl group	1.32	116.8	79	26	30	40.8	4.9	400	90	-	112
QPAEK-CN-0.5	PAEK with various g-C3N4nanosheetsconten	alkaline quaternary ammonium groups and amine/imine groups	1.31	38.6	30.2	6.1	N/A	35.3	86	1370	90	-	113
GT82-5	poly (norbornene) (PNB)	N,N,N′,N′- tetramethyl-1,6-hexanediamine (TMHDA),	3.84	212	122	N/A	N/A	N/A	N/A	N/A	80	-	114
PPO5-4QPip-2.6	PPO	piperidinium	2.6	221	115	N/A	50	N/A	N/A	N/A	80	-	115
QPAF-DMBA	quaternaized aromatic/perfluoroaklyl copolymer (QPAF)	dimethylbutylamine (DMBA)	1.33	152	53	N/A	45	N/A	N/A	N/A	80	-	116
T20NC6NC5N	PPO	hexyl and pentyl spacers	2.52	176	135	18	100	N/A	N/A	N/A	80	-	
PBP-20Q4	PBP	Piperidinium	3.64	155	242	42	60	35	45	N/A	80	-	117
BeC30%-P	polyvinyl alcohol	grafted bis-crown ether	3.51	235	133						80	-	118

Table S2. *Ex-situ* alkaline stability data of selected AEMs.

Membrane	Temperature [$^\circ$C]	OH^- conc. [M]	Durability or half life time [h]	%degradation	Measurement Method	Applied in EW	Ref.
PTP-75	80	1	934	41	Conductivity	+	1
	80	1	934	47	NMR		
PTP-85	80	1	934	40	Conductivity	+	1
	80	1	934	36	NMR		
PTP-90	80	1	934	73	Conductivity	+	1
	80	1	934	62	NMR		
PAni-0.87	80	1	48	4	Dry weight ionic, conductivity, IEC	-	12
PAni-0.92	80	1	48	4		-	12
PAni-1.03	80	1	48	4		+	12
PFOTFPh-TMA-C6	80	8	168	13.8	conductivity	+	6
HDPE-AEM	80	RH ¼ 100% N_2 atmosphere	500	8	conductivity	-	25, 24
LDPE-AEM	80	RH ¼ 100% N_2 atmosphere	500	6.2	conductivity	-	25, 24, 26
C4-AEM	80	1	672	13	IEC		25
SEBS-BTMA	60	1	360	13.6	conductivity		25
SEBS-CH2-QA-1.5	60	1	360	7.7	conductivity		25
XL100-SEBS-C5-TMA-0.8	80	1	500	2.4	conductivity		25
P1.25-OH	80	0.1	239	53	conductivity		25
XL35-rPNB-X60-Y40	80	1	576	1.4	conductivity		25
HC-[1]498 [2]200	80	1	720	4.2	conductivity		25
PNB-X62-Y38	80	1	1200	0.8	conductivity		25
H22C9N	80	1	500	9.6	conductivity		25
F20C9N	80	1	500	8.9	conductivity		25
ATMPP	22	4	336	33	conductivity		25
HTMA-DAPP	80	4	336	4.6	conductivity		40, 25
	80	4	336	0	IEC		40, 25
	80	4	3000	39	conductivity		25
	80	4	3000	8	IEC		25
	80	0.5	11,160	72	conductivity		25

Membrane	Temperature [◦C]	OH$^-$ conc. [M]	Durability or half life time [h]	%degradation	Measurement Method	Applied in EW	Ref.
QPAF (C6)-2	60	1	400	90	conductivity		25
QP-QAF3	80	1	1000	15	conductivity		25
PAImEE (12)	80	10	240	6.1	NMR		43, 25
BPN1	95	1	1440	8	IEC		25
m-TPN1	95	1	1440	2	Conductivity		25, 119
FLN-55	80	1	500	2	IEC		25
PTPipQ6	90	2	720	64	NMR		25
PAP-TP-85	100	1	2000	3	IEC		9, 25
PTPipQ1	90	2	360	5	IEC		46
PVBC-MPy/15%PEK-cardo	60	1	432	15	Conductivity	-	47
	80	1	432	9			
	60	6	432	16			
PVBC-MPy/25%PEK-cardo	60	1	432	5	Conductivity	-	47
	80	1	432	15			
	60	6	432	20			
PVBC-MPy/35%PEK-cardo	60	1	432	9	Conductivity	+	47
	80	1	432	15			
	60	6	432	19			
PVBC-MPy/40%PEK-cardo	60	1	432	7	Conductivity	-	47
	80	1	432	11			
	60	6	432	25			
PST-TMA$^+$	60	1	168	10	NMR	+	49
	60	1	168	37	Conductivity		
	60	2	168	44	Conductivity		
	60	6	168	13	NMR		
PST-DMP$^+$	60	1	168	25	NMR	+	49
	60	1	168	49	Conductivity		
	60	2	168	67	Conductivity		
	60	6	168	38	NMR		
PPO24-BIM (bromide form)	80	1	336	65	Conductivity	+	13
FAA-30	80	1	336	8	Conductivity	+	13
Tokuyama A201	80	1	336	0	Conductivity	+	13
PSEBS-CM-DABCO	50	3.8	168	13	Conductivity	+	54

Membrane	**Temperature [◦C]**	**OH$^-$ conc. [M]**	**Durability or half life time [h]**	**%degradation**	**Measurement Method**	**Applied in EW**	**Ref.**
	50	3.8	168	8	IEC		
	60	3.8	168	47	Conductivity		
	60	3.8	168	33	IEC		
PAEK-APMP75	60	5.3	672	15	IEC	+	55
PAEK-APMP100	60	5.3	672	25	IEC	+	55
SEBS-Pi-73%	80	1	576	25	Conductivity	+	59
				22	IEC		
PBP-ASU-PPO	80	1	2000	13.6	IEC	+	60
BPN1-100	95	1	1440	11	IEC	+	25, 67
	95	1	1440	8	NMR		
TPN1-100	95	1	1440	9	IEC	+	25, 44
	95	1	1440	2.3	NMR		
PAImBB(14)	80	10	240	2.3	NMR	+	43
QPC-TMA	80	1	1000	0	NMR IEC	+	68
PVBC-MPy M2	80	1	600	13	Conductivity	+	69
PVBC-MPy M4	80	1	600	22	Conductivity	+	69
PVBC-MPy M6	80	1	600	18	Conductivity	+	69
PISPVA46	*60*	0.5	240	56.2	Conductivity	+	73
PISPVA37	60	0.5	240	44.9	Conductivity	+	73
PISPVA28	60	0.5	240	39.7	Conductivity	+	73
QMter-co-Mpi- 100%	60	1	43	6	IEC	+	74
	60	1	43	8	Conductivity		
BPi	80	1	560	48	Conductivity	-	75
SCPi	80	1	560	57	Conductivity	+	75
LSCPi	80	1	560	2	Conductivity	+	75
SCQA	80	1	560	71	Conductivity	-	75
LSCQA	80	1	560	16	Conductivity	+	75
BPI-c-PVBC/OH 1:2	60	1	480	10	IEC	+	77
BPI-c-PVBC/OH 1:3	60	1	480	16	IEC	+	77
ABPBI-c-PVBC/OH 1:2	60	1	480	7	IEC	+	77
QPAF-4	80	1	1000	0	Conductivity	-	78
PSBFP-TMA	80	1	168	0	Conductivity	-	81
PSBFBP-TMA	80	1	168	0	Conductivity	-	81
F-PAE	80	0.5	2	61% backbone	NMR	+	82

Membrane	Temperature [◦C]	OH^- conc. [M]	Durability or half life time [h]	%degradation	Measurement Method	Applied in EW	Ref.
				12% benzylic position			
ATM-PP	80	0.5	2	0	NMR	+	82
PPO-TMA	60	1	720	70	IEC	+	71, 72
	60	6	720	83	IEC		
PPO-ABCO	60	1	720	74	IEC	+	71, 72
PPO-ABCO	60	6	720	92	IEC		
PBI linear	85	6	4224	100	Conductivity	+	83
CL PBI (crosslinked)	85	6	4224	50	Conductivity	+	83
Thermally cured PBI	85	6	4224	0	Conductivity	+	83
MES-PBI (25 wt% KOH)	88	9.5	4968	3	Relative mass	+	70
PQDP-1	80	1	720	3	NMR	-	85
SDQEO	60	1	192	25	Conductivity	-	86
PFTP	80	1	2000	4	NMR	-	120
PFTP	80	5	2000	20	NMR	-	120
m-PTP-20Q	80	2	1600	10.55	Conductivity	-	88
O-PDQA-3	80	2	1080	4	Conductivity	-	89
O-PDQA-3	80	2	1080	2.8	IEC	-	89
PP80N20	80	1	1000	30.8	Conductivity	-	90
PP80N20	80	5	1000	41.1	Conductivity	-	90
Q-CLP1	80	2	300	46	Conductivity	-	121
BiPyBPEEK-50%	22	1	750	11	Conductivity	-	92
QPAES/QBGO-3.0	60	1	240	27	Conductivity	-	93
PAEK-HQACz-0.7	22	4	168	3.9	Conductivity	-	94
PBP-BOP-ASU 8%	80	2	1400	15.59	NMR	-	95
PBP-ASU	80	2	1400	11.37	NMR	-	95
CP3	60	2	480	20	NMR	-	96
PPEEK:PEG 80:20	80	1	400	15	Conductivity	-	97
MPyPPO	60	1	720	42	Conductivity	-	98
PPO-TMA	22	0.6 (λ=4)	646	8	NMR	-	122
qPBPTT-5	80	1	480	13.29	Conductivity	-	99
m-TPNPiQA	80	5	240	6	IEC	-	100
HyAEM-MP-180	22	9	168	50	IEC	-	101
NPPO-2QA-1.85	60	1	168	28	NMR	-	103
AEM-9.09	60	1	504	50	Conductivity	-	104

Membrane	**Temperature [◦C]**	**OH$^-$ conc. [M]**	**Durability or half life time [h]**	**%degradation**	**Measurement Method**	**Applied in EW**	**Ref.**
ETFE-AEM	80	1	168	12	IEC	-	123
NAPAEK-Q-100	22	4	168	0.7	IEC	-	105
VIB5/PMS2/PBI0.5	25	2	204	25	Conductivity	-	106
QPAE/GO-(APTS-c-PTMA) 0.7 wt%	90	2	480	20	IEC	-	107
PDPF-DMP	90	2	2400	8.4	NMR	-	108
Q-PAES/PPO-55	50	2	1000	14.7	IEC	-	109
A-PEI-8	90	1	200	72.3	Conductivity	-	110
PPO-22-3QA8F	80	1	504	49	Conductivity	-	111
QN-PAEK/rGO5.0wt%	70	2	600	25	Conductivity	-	112
QPAEK-CN-0.5	60	1	240	11	Conductivity	-	113
GT82-15	80	1	1000	1.43	Conductivity	-	114
PPO5-4QPip-2.1	90	1	240	14	Conductivity, IEC	-	115
QPAF-DMBA	60	1	1000	42	Conductivity	-	116
T20NC6NC5N	80	1	500	10	Conductivity	-	
PBP-20Q4	80	2	1800	8.2	Conductivity	-	117

Table S3. AEMs and their performance in AEMWE cells using liquid electrolyte.

Membrane electrode assembly (MEA) components				Ionomer/ binder	Feed type	Cell Voltage (V)	Current density (A/cm^2)	Cell temperature (°C)	Ref.
Anode catalyst	Membrane type	Membrane thickness, µm	Cathode catalyst						
$CuCoO_3$	Tokuyama A201	28	Ni/CeO_2–La_2O_3/C	PTFE	1% K_2CO_3/$KHCO_3$	1.9	0.47	50	10
IrO_2	Fumatech FAA-3-PK-75	75	Pt/C	PTFE	0.5 M KOH	1.8	0.48	50	53
IrO_2	Fumatech FAA-3-PK-75	75	Pt/C	PTFE	0.5 M KOH	1.8	0.61	60	53
IrO_2	Fumatech FAA-3-PK-75	75	Pt/C	PTFE	0.5 M KOH	1.8	0.625	70	53
IrO_2	Fumatech FAA-3-PK-75	75	Pt/C	PTFE	0.5 M KOH	1.8	0.87	80	53
IrO_2	Fumatech FAA-3-PK-75	75	Pt/C	PTFE	0.5 M KOH	1.8	0.98	90	53
$Li_{0.21}Co_{2.79}O_4$	QPDTB	50	Ni	QPDTB	0.2 M KOH	2.2	0.3	20	56, 124
$Li_{0.21}Co_{2.79}O_4$	QPDTB	50	Ni	QPDTB	0.2 M KOH	2.05	0.3	40	56, 124
Ni/CPs	Tokuyama A201	28	Ni/CPs	—	1 M KOH	1.9	0.15	50	125
$NiFe_2O_4$	Tokuyama A201	28	NiFeCo	5% Nafion	1 M KOH	2.21	2.13	60	126
$NiFe_2O_4$	AEMION	38	NiFeCo	5% Nafion	1 M KOH	2.26	2.13	60	126
$NiFe_2O_4$	Sustanion	50	NiFeCo	5% Nafion	1 M KOH	2.13	2.13	60	126
$CuCoO_3$	LDPE-*g*-VBC	60	Ni/CeO_2–La_2O_3/C	PTFE	1% K_2CO_3/$KHCO_3$	2.1	0.46	50	58
IrO_2	SEBS-Pi	60	Pt/C		1 M KOH	2.0	0.4	50	31, 59
IrO_2	SEBS-Pi	60	Pt/C		1 M KOH	2.0	0.5	80	31, 59
Pd/TNTA web	Tokuyama A201	28	Pt/C	PTFE	2 M NaOH	2	2	80	127
$CuCoO_x$ (on Ni foam) Acta’s 3030	Tokuyama A201	28	Ni/(CeO_2–La_2O_3)/C on carbon paper Acta’s 4030	I2	1% K_2CO_3	1.91	0.4	60	62

Membrane electrode assembly (MEA) components				**Ionomer/ binder**	**Feed type**	**Cell Voltage (V)**	**Current density (A/cm^2)**	**Cell temperature (°C)**	**Ref.**
Anode catalyst	**Membrane type**	**Membrane thickness, µm**	**Cathode catalyst**						
CuCoO$_x$ (on Ni foam)	Fumatech FAA-3	40	Ni/(CeO$_2$–La$_2$O$_3$)/C on carbon paper	I2	1% K$_2$CO$_3$	1.91	0.4	60	62
CuCoO$_x$ (on Ni foam)	Fumatech FAA-3-PP-75	80	Ni/(CeO$_2$–La$_2$O$_3$)/C on carbon paper	I2	1% K$_2$CO$_3$	1.99	0.4	60	62
CuCoO$_x$ (on Ni foam)	Tokuyama A901	10	Ni/(CeO$_2$–La$_2$O$_3$)/C on carbon paper	I2	1% K$_2$CO$_3$	2.1	0.5	50	61
NiCo$_2$O$_4$	Polyethylene based radiation grafted		Pt	Polystyrene-*b*-poly (ethylene/butylene) -*b*-polystyrene	0.1 M KOH	1.65	0.1	60	63
NiAl	HMT-PMBI	34	NiAlMo	—	1 M KOH	2.1	2	60	128
IrO$_2$	PTP-90	45	Pt/C		1 M NaOH	2.2	0.91	55	129
IrO$_2$	PTP-90	45	Pt/C		1 M NaOH	2.2	1	75	129
IrO$_2$	PTP-85	45	Pt/C		1 M NaOH	2.2	0.83	55	129
IrO$_2$	PTP-75	45	Pt/C		1 M NaOH	2.2	0.76	55	129
IrO$_2$	Sustainion 37-50	50	Pt/C		1 M KOH	1.63	1	60	16
NiFe	Sustainion 37-50	50	NiFeCo		1 M KOH	1.9	1	60	16
RANEYs-type-Ni	m-PBI	40	RANEYs-type-Ni Mo		24 wt% KOH	1.8	1.7	80	130
PtRu	PAImEE	13	Pt/C	PAI	6 M KOH	2.3	0.4	80	43
IrO$_2$	HTMA-DAPP	26	PtRu/C	9 wt%TMA	0.1 M NaOH	1.8	0.95	60	40
NiFe	HTMA-DAPP	26	PtRu/C	20 wt% TMA	0.1 M NaOH	1.8	3.2	60	40
NiFe	HTMA-DAPP	26	PtRu/C	20 wt%TMA	1 M NaOH	1.8	5.3	60	40
IrO$_2$	QPC-TMA	50	Pt/C	QPC-TMA	1 M KOH	1.9	3.5	70	68
IrO$_2$	GT74	50	Pt/C	GT-18	3 wt% KOH	1.59	0.1	50	7
IrO$_2$	GT74	50	Pt/C	GT-32	3 wt% KOH	1.62	0.1	50	7
IrO$_2$	GT74	50	Pt/C	GT-0	3 wt% KOH	1.69	0.1	50	7
IrO$_2$	GT74	50	Pt/C	GT-100	3 wt% KOH	1.83	0.1	50	7
IrO$_2$	GT74	50	Pt/C	GT-75	3 wt% KOH	2.08	0.1	50	7

Membrane electrode assembly (MEA) components				Ionomer/ binder	Feed type	Cell Voltage (V)	Current density (A/cm^2)	Cell temperature (°C)	Ref.
Anode catalyst	**Membrane type**	**Membrane thickness, µm**	**Cathode catalyst**						
IrO_2	GT74	50	Pt/C	GT-82	3 wt% KOH	2.11	0.1	50	7
NiFe	PVBC- MPy M2	80	NiMo	--------	1 M KOH	1.9	0.5	80	69
NiFe	PVBC- MPy M4	80	NiMo	--------	1 M KOH	1.9	0.4	80	69
NiFe	PVBC- MPy M6	80	NiMo	--------	1 M KOH	1.9	0.6	80	69
$NiFe_2O_4$	Sustainion 37–50		NiFeCo	PFOTFPh-TMA C6	1 M KOH	2.09	0.94	50	17
IrO_2	PFOTFPh-TMA C6	20-30	Pt/C	PFOTFPh-TMA C8	1 M KOH	1.77	1	80	5, 6
IrO_2	PFOTFPh-TMA C8	20-30	Pt/C	PFOTFPh-TMA C10	1 M KOH	1.79	1	80	5, 6
IrO_2	PFOTFPh-TMA C10	20-30	Pt/C	PFOTFPh-TMA C6	1 M KOH	1.84	1	80	5, 6
NiFe2O4	Sustainion™ X37-50	50	NiFeCo		1 M KOH	1.9	1	60	18
IrO_2	Sustainion™ X37-50	50	Pt/C		1 M KOH	1.63	1	60	18
$CuCoO_x$	Tokuyama A201	28	Pt/C	AS-4	0.1 wt% K_2CO_3	2.22	0.8	50	14
$CuCoO_x$	Tokuyama A201	28	Pt/C	AS-4	1 wt% K_2CO_3	2.05	0.8	50	14
$CuCoO_x$	Tokuyama A201	28	Pt/C	AS-4	10 wt% K_2CO_3	1.87	0.8	50	14
$CuCoO_x$	Tokuyama A201	28	Pt/C	AS-4	0.01 M KOH	2.06	0.8	50	14
Ir black	AF1-HNN8-25 Aemion™	25	Pt/C	Aemion™ AP1-HNN8	1 M KOH	1.75	1	50	15
Ir black	AF1-HNN8-50 Aemion™	50	Pt/C	Aemion™ AP1-HNN8	1 M KOH	1.8	1	50	15
Ir black	AF1-HNN5-25 Aemion™	25	Pt/C	Aemion™ AP1-HNN8	1 M KOH	1.81	1	50	15
Ir black	AF1-HNN5-50 Aemion™	50	Pt/C	Aemion™ AP1-HNN8	1 M KOH	1.92	1	50	15
Ir black	AF1-HNN8-25 Aemion™	25	Pt/C	Aemion™ AP1-HNN8	0.1 M KOH	1.85	1	50	15
Ir black	AF1-HNN8-50 Aemion™	50	Pt/C	Aemion™ AP1-HNN8	0.1 M KOH	1.9	1	50	15
Ir black	AF1-HNN5-25 Aemion™	25	Pt/C	Aemion™ AP1-HNN8	0.11 M KOH	1.98	1	50	15
Ir black	AF1-HNN5-50 Aemion™	50	Pt/C	Aemion™ AP1-HNN8	0.1 M KOH	2.13	1	50	15

Membrane electrode assembly (MEA) components				**Ionomer/ binder**	**Feed type**	**Cell Voltage (V)**	**Current density (A/cm^2)**	**Cell temperature (°C)**	**Ref.**
Anode catalyst	**Membrane type**	**Membrane thickness, µm**	**Cathode catalyst**						
Ir black	Fumatech FAA-3-PE-30	20-30	NiMo	Fumion FAA-3-solute-10	1 M KOH	1.9	1	50	131
Ir black	Fumatech FAA-3-PE-30	20-30	Pt/C	Fumion FAA-3-solute-10	1 M KOH	1.8	1	50	131
CuCoOx	Mg-Al LDH	300	Ni/(CeO_2-La_2O_3)/C	PTFE	0.1 M NaOH	2.1	0.16	60	132
CuCoOx	Mg-Al LDH	300	Ni/(CeO_2-La_2O_3)/C	PTFE	0.1 Na_2CO_3	2.1	0.1	60	132
$NiFe_2O_4$	Sustainion®37-50	50	NiFeCo	Nafion	1 M KOH	1.9	1	60	19
$NiFe_2O_4$	Fumatech FAS-50	50	NiFeCo	Nafion	1 M KOH	1.9	0.5	60	19
$NiFe_2O_4$	Fumatech FAPQ	68-82	NiFeCo	Nafion	1 M KOH	1.9	0.17	60	19
$NiFe_2O_4$	Neosepta ACM	110	NiFeCo	Nafion	1 M KOH	1.9	0.05	60	19
$NiFe_2O_4$	AMI 7001	18000	NiFeCo	Nafion	1 M KOH	1.9	0.15	60	19
$NiFe_2O_4$	Celazole®PBI		NiFeCo	Nafion	1 M KOH	1.9	0.07	60	19
IrO_2	Tokuyama A201	28	Pt/C	PTFE	0.5 M KOH	2	1.31	50	133
IrO_2	Sustainion™		Pt	PTFE	1 M KOH	1.9	4.6	60	134
Plain nickel foam	mes-PBI	64	Plain nickel foam		25 wt% KOH	2.3	0.7	80	70
Plain nickel foam	mes-PBI	60	Plain nickel foam		15 wt% KOH	2.3	0.42	80	70
Plain nickel foam	mes-PBI	62	Plain nickel foam		5 wt% KOH	2.3	0.01	80	70
Plain nickel foam	m-PBI	40	Plain nickel foam		20 wt% KOH	2.3	0.9	80	70
Ni foam	L-ABPBI (linear)	90-120	Ni foam		1.9 M KOH	2	0.155	50	84
Ni foam	C-ABPBI (cross-linked)	90-120	Ni foam		1.9 M KOH	2	0.18	50	84
Ni foam	L-ABPBI	90-120	Ni foam	PTFE	1.9 M KOH	2	0.18	70	84
Ni foam	C-ABPBI	90-120	Ni foam	PTFE	1.9 M KOH	2	0.22	70	84
Ni	L-PBI	90-120	Ni	PTFE	30 wt% KOH	2	0.15	80	83
Ni	C-PBI	90-120	Ni	PTFE	30 wt% KOH	2	0.12	80	83

Membrane electrode assembly (MEA) components				**Ionomer/ binder**	**Feed type**	**Cell Voltage (V)**	**Current density (A/cm^2)**	**Cell temperature (°C)**	**Ref.**
Anode catalyst	**Membrane type**	**Membrane thickness, µm**	**Cathode catalyst**						
CE-CCO, CuCo-oxide on nickel foam	X37-50 Grade T	50	Pt/C	PTFE	1 M KOH	1.8	1.39	45	22
IrO_2	Sustainion X37-50 Grade T	50	Pt/C	PTFE	1 M KOH	1.8	0.9	45	22
Cu0.5Co2.5O4	Sustainion X37-50 Grade T	50	Pt/C	PTFE	1 M KOH	1.8	1.3	45	23
IrO_2	Sustainion X37-50 Grade T	50	Pt/C	PTFE	1 M KOH	1.8	1.03	45	23
Ni foam	Sustainion X37-50 Grade T	50	Pt/C	PTFE	1 M KOH	1.8	0.35	45	23
IrO_2	PISPVA46	55	Pt/C	PTFE	0.5 M KOH	2	0.55	60	135
IrO_2	PISPVA37	55	Pt/C	PTFE	0.5 M KOH	2	0.41	60	135
IrO_2	PISPVA28	55	Pt/C	PTFE	0.5 M KOH	2	0.15	60	135
IrO_2	QMter-co-Mpi		Pt/C		0.6 M KOH	2	0.25	50	74
IrO_2	QMter-co-Mpi		Pt/C		1 M KOH	2	0.31	50	74
$NiCo_2O_4$	PSEBS-CM-DABCO	100	$NiFe_2O_4$	PSEBS-CM-DABCO	1 wt% KOH	2	0.065	40	54
$NiCo_2O_4$	PSEBS-CM-DABCO	100	$NiFe_2O_4$	PSEBS-CM-DABCO	5 wt% KOH	2	0.105	40	54
$NiCo_2O_4$	PSEBS-CM-DABCO	100	$NiFe_2O_4$	PSEBS-CM-DABCO	10 wt% KOH	2	0.128	40	54
$NiCo_2O_4$	PSEBS-CM-DABCO	100	$NiFe_2O_4$	PSEBS-CM-DABCO	15 wt% KOH	2	0.15	40	54
$NiFe_2O_4$	Sustainion® 37–50	50	NiFeCo		1 M KOH	1.9	1	60	19
$NiFe_2O_4$	Fumatech FAS-50	50	NiFeCo		1 M KOH	1.9	0.5	60	19
$NiFe_2O_4$	Fumatech FAPQ	75	NiFeCo		1 M KOH	1.9	0.16	60	19
$NiFe_2O_4$	AMI-7001	450	NiFeCo		1 M KOH	1.9	0.11	60	19
NiFe-LDH/NF	PVBC-MPy/35%PEK-cardo	60	MoNi/NF	PTFE	1 M KOH	2	0.5	60	47
IrO_2	Fumatech FAA-3-50	50	Pt/C		1 M KOH	2	0.63	60	136

Membrane electrode assembly (MEA) components				Ionomer/ binder	Feed type	Cell Voltage (V)	Current density (A/cm^2)	Cell temperature (°C)	Ref.
Anode catalyst	Membrane type	Membrane thickness, µm	Cathode catalyst						
g-CN-CNF-800	Fumatech FAA-3-50	50	Pt/C		1 M KOH	2	0.98	60	136
FeNiMo-based	Sustainion X37-50 Grade T	50	NiMo-based	Nafion	1 M KOH	1.57	1	80	20
FeNiMo-based	Sustainion X37-50 Grade T	50	NiMo-based	Nafion	1 M KOH	1.62	1	60	20
FeNiMo-based	Sustainion X37-50 Grade T	50	NiMo-based	Nafion	1 M KOH	1.68	1	40	20
FeNiMo-based	Sustainion X37-50 Grade T	50	NiMo-based	Nafion	1 M KOH	1.69	0.6	20	20
APS NiAl-AA	NEOSEPTA (Astom)	220	APS NiAlMo-AA		1 M KOH	1.88	0.5	65	137
APS NiAl-AA	NEOSEPTA (Astom)	220	APS NiAlMo-AA		0.7 M KOH	1.93	0.5	65	137
APS NiAl-AA	NEOSEPTA (Astom)	220	APS NiAlMo-AA		0.5 M KOH	1.95	0.5	65	137
APS NiAl-AA	NEOSEPTA (Astom)	220	APS NiAlMo-AA		0.3 M KOH	2	0.5	65	137
APS NiAl-AA	NEOSEPTA (Astom)	220	APS NiAlMo-AA		0.1 M KOH	2.14	0.5	65	137
NiFe2O4	Sustainion Grade T, PTFE reinforced	50	Raney nickel		1 M KOH	1.8	0.84	60	21
NiFe2O4	Sustainion X37-50	50	Raney nickel		1 M KOH	1.8	0.74	60	21
NiFe	PSU-PVP	120	NiMo		20 wt% KOH	1.9	0.5	80	76
Ni-doped FeOOH	Sustainion X37-50 Grade T	50	Pt/C	Nafion	1 M KOH	1.7	0.92	50	138
Ni-doped FeOOH	Sustainion X37-50 Grade T	50	Pt/C	Nafion	1 M KOH + 0.5 M NaCl	1.7	0.74	50	138
Ni-doped FeOOH	Sustainion X37-50 Grade T	50	Pt/C	Nafion	1 M KOH + seawater	1.7	0.73	50	138
IrO$_2$	Sustainion X37-50 Grade T	50	Pt/C	PTFE	1 M KOH + seawater	1.7	0.47	50	138
Ni foam	PBI-c-PVBC/OH (1:3)	24	Ni foam		1 M KOH	1.98	0.38	50	77

Membrane electrode assembly (MEA) components				**Ionomer/ binder**	**Feed type**	**Cell Voltage (V)**	**Current density (A/cm^2)**	**Cell temperature (°C)**	**Ref.**
Anode catalyst	**Membrane type**	**Membrane thickness, µm**	**Cathode catalyst**						
Ni foam	ABPBI-c-PVBC/OH (1:2)	90	Ni foam		1 M KOH	1.98	0.38	50	77
Ni foam	C-PVAf·ABPBI	30-45	Ni foam		15 wt% KOH	2	0.24	50	139
Ni foam	C-PVAf·ABPBI	30-45	Ni foam		15 wt% KOH	2	0.27	70	139
Graphene	Selemion AMV	120	Graphene		Water	2	0.09	30	140
$NiCo_2O_4$	AMB-commercial (now Pure Water Technologies)		$NiCo_2O_4$		1 M KOH	2	0.25	50	12
$NiCo_2O_4$	IPA- commercial (CSIR-CSMCRI)		$NiCo_2O_4$		1 M KOH	2	0.16	50	12
$NiCo_2O_4$	PAni-1.03	100	$NiCo_2O_4$		1 M KOH	2	0.4	50	12
PGM	BPN1-100		PGM	AS4	0.5 M NaOH	2.1	0.4	50	67
PGM	TPN1-100		PGM	AS4	0.5 M NaOH	2.35	0.36	50	67
$NiMn_2O_4$	Fumatech FAA3-50	50	Pt/KB		1 M KOH	2	0.24	40	3
$NiMn_2O_4$	Fumatech FAA3-50	50	Pt/KB		1 M KOH	2	0.37	50	3
$NiMn_2O_4$	Fumatech FAA3-50	50	Pt/KB		1 M KOH	2	0.47	60	3
$NiMn_2O_4$	Fumatech FAA3-50	50	Pt/KB		1 M KOH	2	0.53	80	3
IrO_2	HTMA-DAPP	50	PtRu/C	HTMA-DAPP	0.05 M KOH	2	0.7	60	141
IrO_2	HTMA-DAPP	50	PtRu/C	HTMA-DAPP	0.1 M KOH	2	1.22	60	141
IrO_2	HTMA-DAPP	50	PtRu/C	HTMA-DAPP	0.5 M KOH	2	1.4	60	141
IrO_2	HTMA-DAPP	50	PtRu/C	HTMA-DAPP	1 M KOH	2	1.74	60	141

Table S4. AEMs and their performance in AEMWE cells fed with pure water (no liquid electrolyte).

Membrane electrode assembly (MEA) components				**Ionomer/binder**	**Feed type**	**Cell Voltage (V)**	**Current density A cm^{-2}**	**Cell temp. °C**	**Ref.**
Anode catalyst	**Membrane type**	**Membrane thickness, µm**	**Cathode catalyst**						
$Pb_2Ru_2O_{6.5}$	PSF-TMA	50	Pt black	PSF-TMA$^+$Cl$^-$	Water	1.8	0.4	50	48
Ni–Fe	xQAPS	70	Ni–Mo	xQAPS	Water	1.85	0.4	70	52
$NiCoO_x$:Fe	Fumatech FAA-3	130	Pt/C	FAA-3	Water	2.0	0.37	50	142
IrO_2	Tokuyama A201	28	Pt black	As-4	Water	1.6	0.1	50	148
$Cu_{0.7}CO_{2.3}O_4$	QPDTB	50	Nano Ni	Poly(DMAEMA-*co*-TFEMA-*co*-BM)	Water	1.9	0.1	22	57
IrO_2	SEBS-Pi	60	Pt/C		Water	2	0.1	50	31, 59
$Ce_{0.2}MnFe_{1.8}O_4$	Fumatech FAA-3-PK-130	110-130	Pt on Ti	—	Water	1.8	0.3	—	143
$NiCo_2O_4$ on steel mesh	Homemade, not specified		Acta 4030	Homemade, not specified	Water	1.86	0.4	60	144
$Cu_xCo_{3-x}O_4$	PTFE-qPDTB-OH-	25	Pt/C	q-ammonium polymethacrylate	Water	2.0	0.4	22	64
IrO_2	HTMA-DAPP	26	PtRu/C	9 wt% TMA	Water	1.8	0.48	60	40
IrO_2	HTMA-DAPP	26	PtRu/C	9 wt% TMA	Water	1.8	0.79	85	40
NiFe	HTMA-DAPP	26	NiMo/C	20 wt% TMA	Water	1.8	0.9	85	40
NiFe	HTMA-DAPP	26	PtRu/C	20 wt% TMA	Water	1.8	2.7	85	40
NiFe-BTC-GNPs MOF	FAA-3-PK-130	130	MoNi4/MoO2		Water	1.85	0.54	70	145
IrO_2	Fumatech FAA-3-50	50	Pt/C	FAA-3-B	Water	1.85	0.12	50	146
IrO_2	QPC-TMA	50	Pt/C	QPC-TMA	Water	1.9	0.3	70	68
IrO_2	PFOTFPh-TMA C6	20-30	Pt/C	PFOTFPh-TMA C8	Water	1.94	1	80	5, 6
IrO_2	PFOTFPh-TMA C8	20-30	Pt/C	PFOTFPh-TMA C10	Water	1.95	1	80	5
IrO_2	PFOTFPh-TMA C10	20-30	Pt/C	PFOTFPh-TMA C6	Water	2.14	1	80	5, 6
$CuCoO_x$	Tokuyama A201	28	Pt/C	AS-4	Water	2.2	0.1	50	14

Membrane electrode assembly (MEA) components				**Ionomer/binder**	**Feed type**	**Cell Voltage (V)**	**Current density A cm^{-2}**	**Cell temp. °C**	**Ref.**
Anode catalyst	**Membrane type**	**Membrane thickness, μm**	**Cathode catalyst**						
$Cu_{0.7}Co_{2.3}O_4$	mm-qPVBz/Cl-	70	Ni nano powder	qPVB/Cl-	Water	2.19	0.1	25	65
$Cu_{0.7}Co_{2.3}O_4$	mm-qPVBz/Cl-	70	Ni nano powder	qPVB/Cl-	Water	2.05	0.1	40	65
$Cu_{0.7}Co_{2.3}O_4$	mm-qPVBz/Cl-	70	Ni nano powder	qPVB/Cl-	Water	1.99	0.1	55	65
CuCoOx	Mg-Al LDH	300	Ni/(CeO_2-La_2O_3)/C	PTFE	Water	2.1	0.02	60	132
IrO_2	PPO-TMA	40	Pt/C		Water	1.8	0.24	50	72
IrO_2	PPO-ABCO	40	Pt/C		Water	1.8	0.075	50	72
IrO_2	PISPVA46	55	Pt/C	PTFE	Water	2	0.06	60	135
IrO_2	QMter-co-Mpi		Pt/C		Water	2	0.06	50	74
IrO_2	LSCPi	50	Pt/C	LSCPi	Water	1.8	0.3	50	75
IrO_2	SCPi	50	Pt/C	SCPi	Water	1.8	0.2	50	75
Graphene	Selemion AMV	120	Graphene		Water	2	0.09	30	140
NiMPL-PTL	Sustainion X37-50 Grade T	50	NiMPL-PTL		Water	1.9	0.5	60	147
IrO_2	HTMA-DAPP	50	PtRu/C	HTMA-DAPP	Water	2	0.44	60	141

Table S5. AEMs and their performance stability in operando AEMWE cells.

Membrane	**Anode catalyst**	**Cathode catalyst**	**Electrolyte**	**Temperature (°C)**	**Current density (A cm^{-2})**	**Durability (h)**	**Ref.**
QMter-co-Mpi	IrO_2	Pt/C	5.6 wt% KOH	50	0.2	500 (2.1 V)	74
Tokuyama A201	IrO_2	Pt	Water	50	0.2	535 (2.25 V)	148
Tokuyama A201	Acta's 3030	Acta's 4030	1 wt% $K_2CO_3/KHCO_3$	43	0.47	1000 (2.05 V)	10
PSF-TMA	$Pb_2Ru_2O_{6.5}$	Pt	Pure water	50	0.2	6 (133.3 mV h^{-1})	48
xQAPS	Ni–Fe	Ni–Mo	Water	70	0.4	8 (1.8 V)	52
mes-PBI	Ni foam	Ni foam	25 wt% KOH	80	0.2	72 (1.95 V)	70
PSEBS-CM-DABCO	$NiCo_2O_4$	$NiFe_2O_4$	10 wt% KOH	50	0.3	150 (2.267 V)	54
Sustainion® 37–50	$NiFe_2O_4$	NiFeCo	5.6 wt% KOH	60	1	2000 (1.9 V)	19
Fumatech FAS-50	$NiFe_2O_4$	NiFeCo	5.6 wt% KOH	60	1	200 (400 μV h^{-1})	19
PAImEE(12)	Pt/C	Pt/C	33.6 wt% KOH	60	0.4	48 (2.6 V)	43
LSCPi	IrO_2	Pt/C	Water	50	0.2	35 (16.3 μV h^{-1})	75
PVBC-MPy/35%PEK-cardo	NiFe-LDH/NF	MoNi/NF	5.6 wt% KOH	60	0.5	46 (2.0 V)	47
SEBS-Pi	IrO_2	Pt/C	5.6 wt% KOH	50	0.4	100 (2.08 V)	59
Fumatech FAA-3	Acta's 3030	Acta's 4030	1 wt% K_2CO_3	60	0.5	31 (2.04 V)	62
Fumatech FAA-3-PP-75	Acta's 3030	Acta's 4030	1 wt% K_2CO_3	60	0.5	200 (2.38 μV h^{-1})	62
NEOSEPTA	APS NiAl-AA	APS NiAlMo-AA	1 M KOH	65	0.5	112 (350 μV h^{-1})	137
Sustainion Grade T	NiFe2O4	Raney nickel	1 M KOH	60	1	12180 (0.7 μV h^{-1})	21
Sustainion X37-50	NiFe2O4	Raney nickel	1 M KOH	60	1	10100 (0.7 μV h^{-1})	21
Fumatech FAS-50	NiFe2O4	Raney nickel	1 M KOH	60	1	140 (655 μV h^{-1})	21
AF1-HNN8-25X	IrO_2	Pt/C	1 M KOH	50	0.5	17 (2390 μV h^{-1})	15
ATM-PP	IrO_2	Pt/C		50	0.2	2100	82
PSU-PVP	NiFe	NiMo	20 wt% KOH	80	0.5	700	76
PTP-85	IrO_2	Pt/C	1 M NaOH	55	0.4	120 (1.61 mV h-1)	129
Sustainion X37–50	$NiFe_2O_4$	NiFeCo	1 M KOH	50	0.2	1000	17
X37-50 Grade T	Ni-doped FeOOH	Pt/C	1 M KOH + seawater	50	0.5	15 (1.72 V)	138
HTMA-DAPP	NiFe	PtRu/C	Water	60	0.2	170 (2.1 V)	40
PFOTFPh-TMA C8	IrO_2	Pt/C	Water	80	0.2	130	5
PFOTFPh-TMA C10	IrO_2	Pt/C	1 M KOH	80	0.2	150	5
Sustainion X37-50 Grade T	CCO-11	Pt/C	1 M KOH	45	0.4	100	23

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