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Two water-rich amphiphilic and hydrophilc coordination polymers: syntheses, structures and proton conduction behaviors in Nafion composite membranes

Zhipeng Huan, Huiqi Zou, Na Wang, Jing Lu, Houting Liu*, Suna Wang*, Yunwu Li*

Table S1 The selected bond lengths and angels of compounds **1**-**2**.

Compound **1**			
Cd(1)-O(7)	2.268(4)	Cd(1)-O(1)	2.284(4)
Cd(1)-O(4)#1	2.348(5)	Cd(1)-O(3)#1	2.486(4)
Cd(1)-O(2)	2.650(4)	Cd(1)-N(1)	2.338(6)
Cd(1)-N(2)	2.324(6)	Cd(2)-O(9)	2.284(5)
Cd(2)-O(5)	2.219(4)	Cd(2)-O(8)	2.314(5)
O(7)-Cd(1)-O(1)	98.88(17)	O(7)-Cd(1)-N(2)	93.00(18)
O(1)-Cd(1)-N(2)	137.69(18)	O(7)-Cd(1)-N(1)	162.3(2)
O(1)-Cd(1)-N(1)	88.2(2)	N(2)-Cd(1)-N(1)	71.2(2)
O(7)-Cd(1)-O(4)#1	103.31(17)	O(1)-Cd(1)-O(4)#1	83.95(15)
N(2)-Cd(1)-O(4)#1	132.37(17)	N(1)-Cd(1)-O(4)#1	93.6(2)
O(7)-Cd(1)-O(3)#1	88.43(15)	O(1)-Cd(1)-O(3)#1	136.85(16)
N(2)-Cd(1)-O(3)#1	83.57(17)	N(1)-Cd(1)-O(3)#1	97.51(18)
O(4)#1-Cd(1)-O(3)#1	53.11(14)	O(7)-Cd(1)-O(2)	81.15(14)
O(1)-Cd(1)-O(2)	52.00(14)	N(2)-Cd(1)-O(2)	90.64(16)
N(1)-Cd(1)-O(2)	90.72(17)	O(4)#1-Cd(1)-O(2)	135.59(14)
O(3)#1-Cd(1)-O(2)	167.81(14)	O(5)-Cd(2)-O(9)#2	88.33(19)
O(5)-Cd(2)-O(8)	91.63(17)	O(5)-Cd(2)-O(9)	91.67(19)
O(5)#2-Cd(2)-O(8)	88.37(17)	O(9)#2-Cd(2)-O(8)	88.9(2)
O(9)-Cd(2)-O(8)	91.1(2)	O(5)-Cd(2)-O(8)#2	88.37(17)
Compound **2**			
Zn(1)-O(1)	1.992(4)	Zn(1)-O(2)	2.144(4)
Zn(1)-O(3)	2.156(3)	Zn(2)-O(5)	2.040(3)
Zn(2)-O(6)	2.102(3)	Zn(2)-O(7)	2.141(3)
Zn(2)-O(8)	2.101(3)	Zn(2)-O(9)	2.170(3)
Zn(2)-O(10)	2.032(3)		
O(1)#1-Zn(1)-O(1)	104.0(4)	O(1)-Zn(1)-O(2)#1	94.12(16)
O(1)-Zn(1)-O(2)	83.86(16)	O(2)#1-Zn(1)-O(2)	176.7(2)
O(1)-Zn(1)-O(3)#1	156.35(18)	O(2)#1-Zn(1)-O(3)#1	95.97(15)
O(2)-Zn(1)-O(3)#1	86.85(14)	O(1)-Zn(1)-O(3)	98.3(2)
O(2)-Zn(1)-O(3)	95.97(15)	O(3)#1-Zn(1)-O(3)	61.04(17)
O(10)-Zn(2)-O(5)	173.76(15)	O(10)-Zn(2)-O(8)	89.94(13)
O(5)-Zn(2)-O(8)	93.80(14)	O(10)-Zn(2)-O(6)	90.50(13)

O(5)-Zn(2)-O(6)	86.10(13)	O(8)-Zn(2)-O(6)	176.11(15)
O(5)-Zn(2)-O(7)	90.99(13)	O(7)-Zn(2)-O(9)	178.83(15)
O(6)-Zn(2)-O(7)	87.93(14)	O(8)-Zn(2)-O(7)	88.18(14)
O(5)-Zn(2)-O(9)	88.93(14)	O(8)-Zn(2)-O(9)	92.99(14)
O(6)-Zn(2)-O(9)	90.90(14)	O(10)-Zn(2)-O(9)	85.89(14)
O(10)-Zn(2)-O(7)	94.12(14)		

Symmetry codes: compound **1** #1 x-1, y, z; #2 -x+2, -y+2, -z+1; #3 x+1, y, z; compound **2** #1 -x+2, y, -z+1.

Table S2 The hydrogen bond parameters of compounds **1** and **2**.

D-H···A	d(H···A)	<DHA	d(D···A)
	Compound **1**		
O7-H···O6[a]	1.862	169.18	2.702
O7-H···O10	1.879	177.55	2.728
O8-H···O6	2.281	115.28	2.754
O8-H···O2[b]	2.204	133.27	2.855
O10-H···O4[c]	2.052	147.73	2.808
O10-H···O1[d]	2.390	115.02	2.855
	Compound **2**		
O1-H···O12[e]	2.012	175.47	2.860
O1-H···O6[f]	1.850	158.37	2.658
O2-H···O12[g]	2.044	163.17	2.868
O2-H···O8[h]	2.365	120.19	2.888
O6-H···O11	2.088	113.54	2.549
O6-H···O12[i]	2.272	123.57	2.832
O7-H···O11[j]	1.831	176.25	2.680
O7-H···O9[k]	2.428	160.99	3.243
O8-H···O3[l]	2.210	138.24	2.900
O8-H···O4	2.012	127.17	2.614
O9-H···O4[m]	1.915	165.12	2.745
O9-H···O12[n]	2.332	149.03	3.092

Symmetry codes: compound **1** a -x+1, -y+1, -z+1; b x, y+1, z; c -x+2, -y+1, -z+1; d -x+1, -y+1, -z+1; e x+1/2, y+3/2, z; f -x+2, y+1, -z+1; g -x+3/2, y+3/2, -z; h -x+3/2, y+1/2, -z; i -x+3/2, y+1/2, -z; j -x+3/2, y+1/2, -z; k x, y, z-1; l x-1/2, y-1/2, z; m -x+3/2, y-1/2, -z+1; n -x+3/2, y+1/2, -z+1.

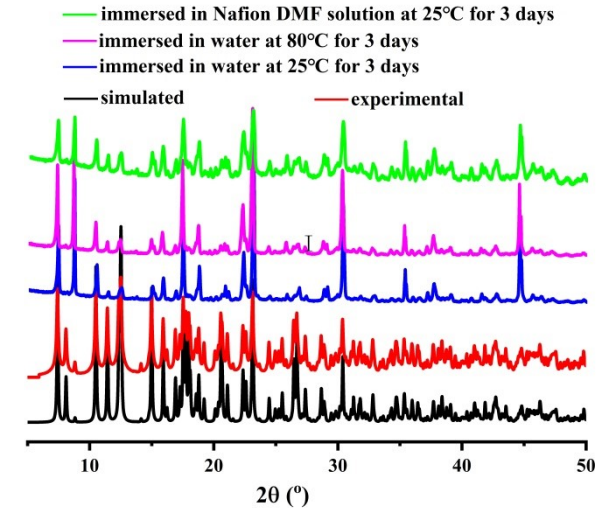
Table S3. Proton conductivities ($S \cdot cm^{-1}$) of pure Nafion membrane and **1**/Nafion-x composite membranes at different temperatures

T（K）	pure Nafion	**1**/Nafion-3	**1**/Nafion-5	**1**/Nafion-7
308	2.55×10^{-3}	2.42×10^{-3}	6.02×10^{-3}	3.90×10^{-3}
313	2.95×10^{-3}	2.47×10^{-3}	6.21×10^{-3}	4.54×10^{-3}
318	3.48×10^{-3}	3.59×10^{-3}	6.85×10^{-3}	5.05×10^{-3}
323	4.19×10^{-3}	4.55×10^{-3}	7.73×10^{-3}	4.79×10^{-3}
328	4.76×10^{-3}	5.55×10^{-3}	8.26×10^{-3}	5.37×10^{-3}
333	5.43×10^{-3}	6.62×10^{-3}	8.50×10^{-3}	6.20×10^{-3}
338	6.26×10^{-3}	7.64×10^{-3}	9.19×10^{-3}	6.11×10^{-3}
343	7.00×10^{-3}	8.51×10^{-3}	9.39×10^{-3}	7.12×10^{-3}
348	7.45×10^{-3}	9.32×10^{-3}	10.20×10^{-3}	7.91×10^{-3}
353	8.48×10^{-3}	9.86×10^{-3}	10.92×10^{-3}	8.81×10^{-3}

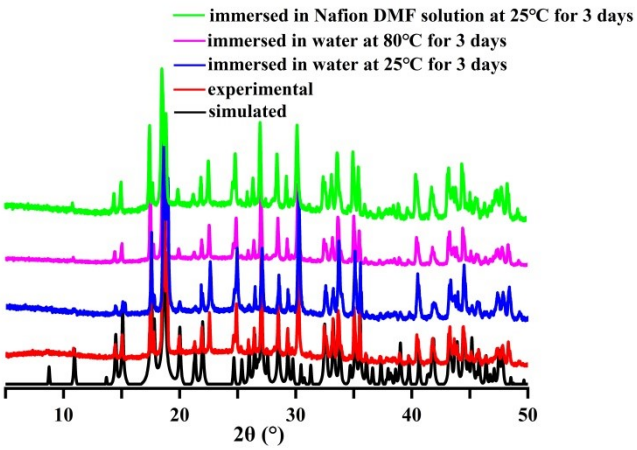
Table S4. Proton conductivities ($S \cdot cm^{-1}$) of pure Nafion membrane and **2**/Nafion-x composite membranes at different temperatures

T（K）	pure Nafion	**2**/Nafion-1	**2**/Nafion-3	**2**/Nafion-5
308	2.55×10^{-3}	2.95×10^{-3}	4.44×10^{-3}	4.36×10^{-3}
313	2.95×10^{-3}	3.99×10^{-3}	5.03×10^{-3}	4.85×10^{-3}
318	3.48×10^{-3}	4.75×10^{-3}	5.62×10^{-3}	5.26×10^{-3}
323	4.19×10^{-3}	5.20×10^{-3}	6.03×10^{-3}	5.73×10^{-3}
328	4.76×10^{-3}	6.38×10^{-3}	6.73×10^{-3}	6.43×10^{-3}
333	5.43×10^{-3}	6.97×10^{-3}	7.79×10^{-3}	7.30×10^{-3}
338	6.26×10^{-3}	7.65×10^{-3}	8.94×10^{-3}	7.83×10^{-3}

343	7.00×10^{-3}	8.36×10^{-3}	10.42×10^{-3}	9.02×10^{-3}
348	7.45×10^{-3}	9.42×10^{-3}	12.10×10^{-3}	9.94×10^{-3}
353	8.48×10^{-3}	10.65×10^{-3}	13.18×10^{-3}	11.41×10^{-3}



(a)



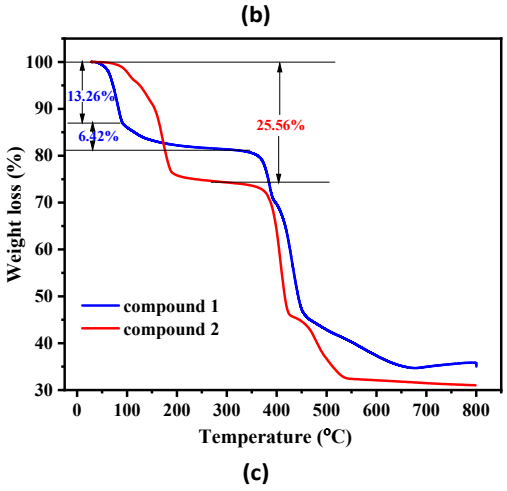
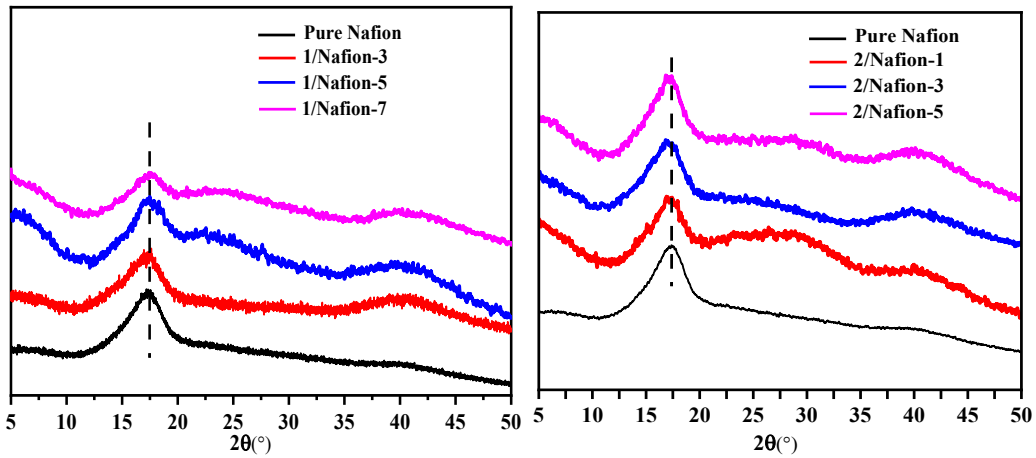
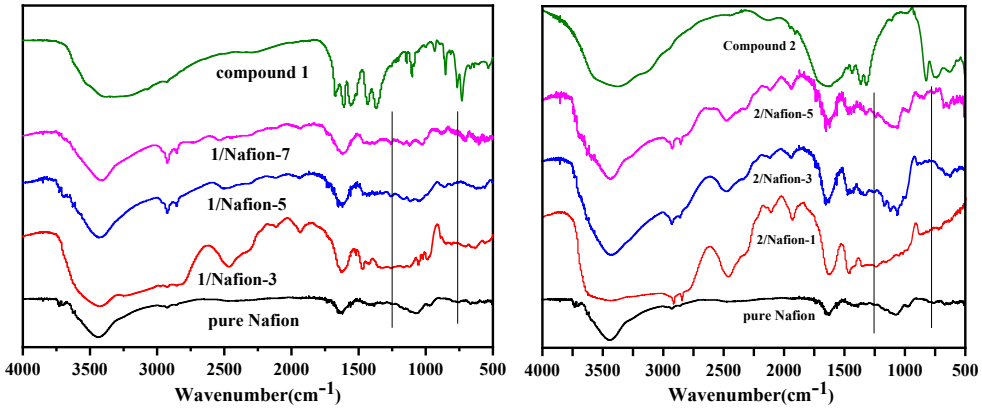


Fig. S1 Simulated, experiment water treatment and Nafion DMF treatment sample PXRD patterns of compounds **1** (a) and **2** (b); the TG curves of of compounds **1** and **2** (c).



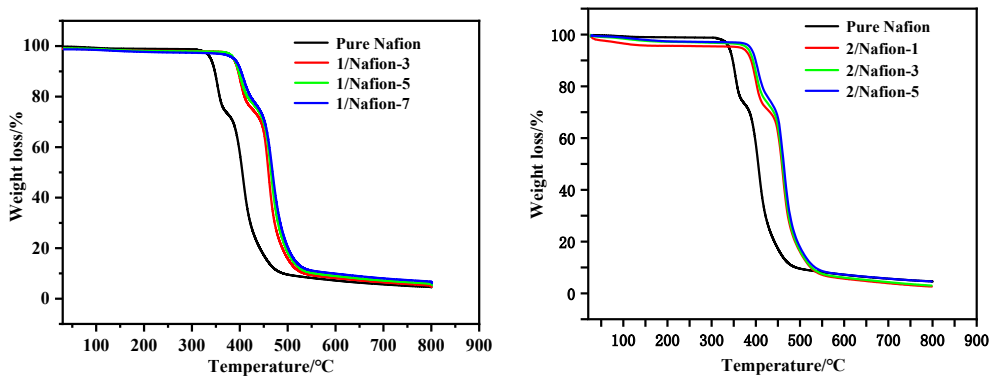
(a) (b)

Fig. S2 PXRD of pure Nafion and **1**/Nafion-x (a) and PXRD of pure Nafion and **2**/Nafion-x (b).



(a) (b)

Fig. S3 IR spectra of pure Nafion and **1**/Nafion-x (a) and PXRD of pure Nafion and **2**/Nafion-x (b).



(a) (b)

Fig. S4 TG curves of pure Nafion and **1**/Nafion-x (a) and PXRD of pure Nafion and **2**/Nafion-x (b).

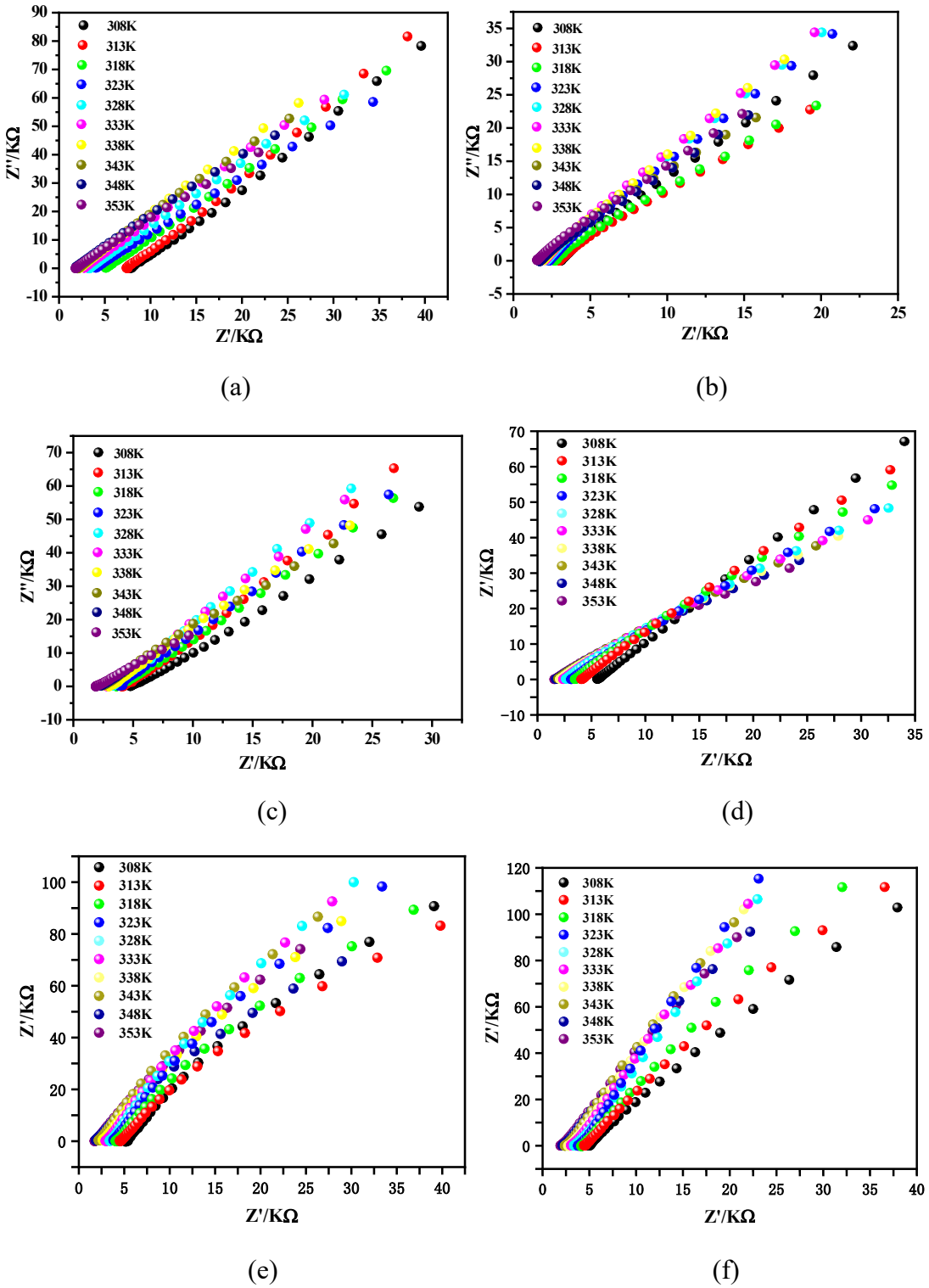


Fig. S4 Nyquist curves of **1**/Nafion-3(a), **1**/Nafion-5(b), **1**/Nafion-7(c), **2**/Nafion-1(d), **2**/Nafion-3(e) and **2**/Nafion-5(f) composite membranes at different temperatures.