

parameters used in fitting the model (Eq. 1) with the experiments for all membranes are presented in Table 1-3. The conductivity and power of membrane strongly depend by temperature. Conductivity and power increase with temperature as shows in Table 1-3 and Figure. 2 (a-b) below.

Table 1 Optimization parameter of membrane performance and hydrogen crossover at temperature 90°C and at 40% RH

Membrane	E_o (mV)	b (mV)	R ($\Omega \text{ cm}^2$)	γ (mV) ($\omega=0.01$)	i_{max} mA cm ⁻²	P_{max} (wat)	σ S cm ⁻¹ 10 ³
N112	895.40	43.40	6.01	150.60	31.4	0.5	1.16
NS10W	890.91	35.59	2.79	135.57	42.7	0.86	2.51
NS15W	935.87	18.40	2.45	30.00	88.6	2.66	2.85
NS20W	912.49	16.55	3.01	49.66	69.5	1.81	2.32

Table 2 Optimization parameter of membrane performance and hydrogen crossover at temperature 80°C and at 40% RH

Membrane	E_o (mV)	b (mV)	R ($\Omega \text{ cm}^2$)	γ (mV) ($\omega=0.01$)	i_{maks} (mA cm ⁻²)	P_{maks} (wat)	σ (S cm ⁻¹) 10 ³
N112	800.42	44.61	4.56	100.51	33.90	0.55	1.53
NS10W	803.85	40.99	2.90	107.10	39.80	0.73	2.41
NS15W	815.86	30.99	2.85	55.10	59.15	1.266	2.37
NS20W	800.97	37.43	3.31	125.00	42.24	0.77	2.12

Table 3 Optimization parameter of membrane performance and hydrogen crossover at temperature 60°C and at 40% RH

Membrane	E_o (mV)	b (mV)	R ($\Omega \text{ cm}^2$)	γ ($\omega=0.01$)	i_{maks} (mA cm ⁻²)	P_{maks} (wat)	σ S cm ⁻¹ 10 ³
N112	800.42	55.03	4.21	70.99	37.5 (0.34)	0.65	1.66
NS10W	805.72	48.40	3.01	40.98	60.9 (0.37)	1.13	2.32
NS15W	806.05	49.74	3.15	45.10	51.6 (0.39)	1.02	2.22
NS20W	802.61	51.34	3.35	48.90	42.7 (0.34)	0.73	2.09

In comparing the current density, resistivity, Tafel slope, proton conductivity and P_{max} of the cell, the order of performance of the composite membranes at 90 °C and 40% RH, starting from the best to worst is as follows: NS15W, NS20W, NS10W, NS15, N112. This trend can clearly be rationalized by considering the physico-chemical and electrochemical properties of the membrane as indicated in the SEM, TEM, WUR and UV-VIS analysis (Mahreni et al. 2008). The low water uptake rate observed with NS20W when compared to that of NS15W is perhaps due to the fact that the particle sizes of SiO₂ and PWA are bigger than that of the ionic cluster, such that the inorganic particles were adsorbed on the outer surface of the cluster.