0.5/0.38 while the hydrogen and oxygen pressures were fixed at 1 atm. The operating temperature of the cell was (60-90^{0}C at 40% RH). The relative humidity (RH) was controlled by using the water temperature of the H_2 and O_2 gas humidifiers. During the (V-I) measurement, the testing system was stabilized for about 1 h in order to obtain constant value for all the parameters of interest and the resistance of the membranes was measured by optimizing the (V-I) experiments. The mathematical model for polarization curve was used to correlate voltage and current (V-I) at 40 % RH using least square method. In the (V-I) model, all resistance parameters were used based on a single fuel cell system, which include the flooding parameter as in Eq 1 (Baschuk et al. 2000).

$$E = E_o - b\,log(i) - R(i) - \gamma\,exp\,(\omega i) \quad (1)$$

where E, E_o, b, R, γ and ω are the cell voltage, open circuit voltage, Tafel constant, internal resistance, flooding constant and fitting constant, respectively. The internal resistance of the cell is assumed to be same as the conductivity of the composite membrane. Hence, Eq. 2 was be used to calculate the membrane conductivity as;

$$\sigma = \left(\frac{1}{R}\right)\left(\frac{l}{S}\right) \quad (2)$$

where σ is the conductivity of the composite membrane (Scm^{-1}), R the resistance (ohm), l is thickness of the membrane (cm) and S is contact surface area of the electrode (cm^2) (Sacca et al. 2005; Sancho et al. 2007).

RESULT AND DISCUSSION

ELECTROCHEMICAL TESTING

The result of physic-chemical characterization using SEM, TEM and WUR have been presented in previous paper (Mahreni et al. 2008). The result of TEM images of NS10W, NS15W and NS20W composite membranes show that the average particles diameter for inorganic compound (Si and PWA) in the composite are 6.9, 7.86 and 12.64 *nm* for NS10W, NS15W and NS20W respectively and the solid SiO_2 and PWA are uniformly distributed within the membrane and do not form any agglomerate structures. The water uptake characteristic of the Nafion-SiO_2-PWA composite membrane is found to be improved from that of the pure Nafion membrane. The water uptake of the Nafion recast membrane is also increased when the HPA is increased. These results can be supported from the fact that the hydrophilic characters of the SiO_2 and PWA play a dominant role in the increase water uptake rate of the composite membrane. The percentages of water uptake rate for Nafion 112, NS10W, NS15, NS15W and NS20W membranes are 26.52, 30.25, 30.01, 33.43 and 32.72 and 31.96 (wt.water/wt. membrane), respectively.

Performance of the single cell MEA using all the membranes (N112, NS10W, NS15, NS15W and NS20W), was obtained for the cell voltage versus current density measurement. The results of the test at temperature in the range of (60-90) ^{0}C and 40% RH are presented in Figure 1. All the experimental data are presented together with mathematical correlation based on (Eq. 1) above with volumetric velocity of air at 4.15 L/min, volumetric velocity of H_2 at 1.15 L/min and total pressure of 1.3-1.7 atm. Interestingly, the model shows good fitting correlation with the experimental data for all the membranes under study as shows in Figure 1 (a-c). The optimized