Advanced Durability Tests for High Temperature PEM Fuel cells

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1. Introduction

Cost and durability of polymer electrolyte membrane fuel cells (PEMFCs) is a major obstacle to the commercialization of these systems for stationary and transportation applications. Also, the lifetime targets (for example, 5000 h stated objective by DOE) must be achieved while the costs of the fuel cell systems must be reduced concurrently.[1] In order to ameliorate the durability and lifetime of PEMFCs, a better analyzing of failure tools and corresponding mitigation methods are urgently required.

To evaluate the durability of a fuel cell, a steady-state lifetime test can be conducted. However, these durability tests are unpractical for application of fuel cells system because it is time-consuming and costly. Consequently, many researches prefer advanced durability test. The advanced durability test has been demonstrated to be a valuable tool for significantly reducing the extent of experiments in lifetime evaluation and degradation mode analysis. In these durability test, each of the factors are applied to the consisting of fuel cells, to determine the durability of the total cell or a particular component. These factors are main points that significantly affect cell performance. The performance decay rate and component damage level under specific operating conditions are always assessed during or after durability test, in order to better predict the fuel cell's lifetime or explain the probable degradation mechanism.[2]

In this study, the objective is a better understanding of the degradation mechanisms in the fuel cell system, and to develop a protocol to quantify the decay rate. Accelerated life-time tests (ALT) by changing the voltage sweep were developed. Further, Factors of degradation was studied by conducting the electrochemical methods and characterizations.

2. Experiment

The membrane electrode assembly (MEA) was fabricated by using Aquivion® commercial membrane (Solvay) and Pt/C(Alfa aesar) catalyst. The durability test was performed voltage sweeping test and On-Off cycling test at the condition of 120 ℃, 40 % RH.

As shown in Figure 1, voltage sweeping test was conducted by sweeping voltage from or 0.6V to 1V. The voltage range and frequency were also changed from the general ALT test from 0.3 V to 1V and to the frequency of 1/2 for 500 cycles (Total 37.5 h, 4.5 min per 1cycle).

The performance was evaluated to electrochemical methods such as polarization curve, AC impedance, linear sweep voltage (LSV) and cyclic voltammetry (CV) curve. The characterization of the MEA was confirmed by field emission scanning electron microscope (FE-SEM), HR-transmission electron microscope (HR-TEM), X-ray diffraction (XRD), Ion chromatography (IC) and Ion exchange capacity (IEC).

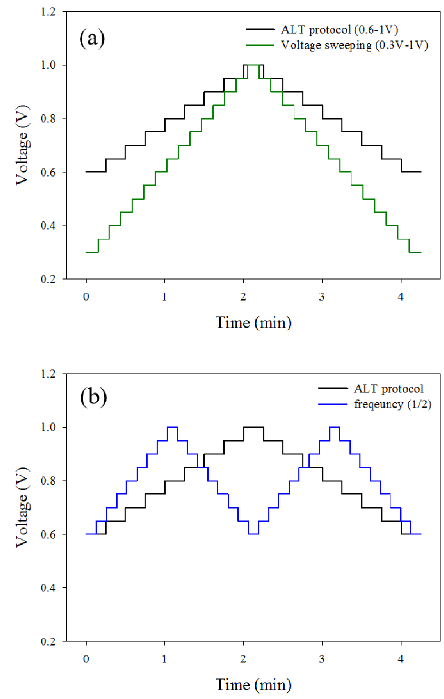

Figure 1. ALT protocols by voltage sweeping with different (a) ranges and (b) frequencies.

3. Result and discussion

The results of different voltage sweeping tests were shown in Figure 2. The 0.6 V constant mode test was also displayed as a reference. The decay rate was decreased from 0.6 V constant mode to 0.6-1V voltage sweeping test, 0.3-1V sweeping test and frequency 1/2 sweeping test, sequentially, which indicates that all the developed protocols are practical to evaluate the MEA at even shorter time than the constant mode. Although there are various factors that influence to the degradation of the MEA at high temperature, the voltage sweep during the durability test can boost the degradation due to the different voltage impact to the membrane and more to the electrode. Furthermore, the frequency of the voltage sweeping may have stronger effect to the MEA than changing the range of the voltage sweep. Consequently, the degradation mechanism for different protocols at high temperature can be concluded from the durability test results and characterization data.

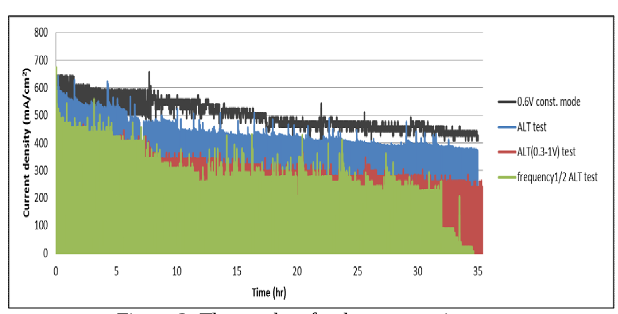

Figure 2. The results of voltage sweeping test

4. References

[1] B. Wahdame et al., Journal of Power Sources 182 (2008) 429–440
[2] S. Zhanga, et al., International journal of hydrogen energy 34 (2009) 388–404