ASSEMBLING, RUNNING AND CHARACTERIZING A 5CM^2 SINGLE CELL PEMFC.

TRA105-Fuel Cell Systems

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01. INTRODUCTION

This scope of the project was to build and characterize a 5 cm ^{2} single cell PEM-fuel cell. To characterize the fuel cell a polarization curve was obtained by measuring the potential of the cell for a range of different current. A cyclic voltammetry (CV) plot was also measured to investigate the reduction and oxidation of the catalyst (Pt) and electrolyte by doing a potential scan. These results was later compared to a aged fuel cell (15 000 cycles) of the same type to observe if there has been any degradation of the cell's performance. The aging of the fuel cell was done by an AST (accelerated stress tests) of 15000 cycles, the cycles consisted of running the cell at 0.6 V for 8 seconds and then at 1 V for 8 seconds. Finally the electrochemical surface area (ECSA) was calculated for both cells and compared.

02. ASSEMBLY OF PEMFC

The fuel cell was assembled by cutting the gaskets, membrane and gas diffusion layer using a excising template and washed with deionised water and alcohol to remove any dust or residue. The components were then assembled on top of current collectors in the following order: Gas diffusion layer, gasket, catalyst, membrane, catalyst, gasket and gas diffusion layer.

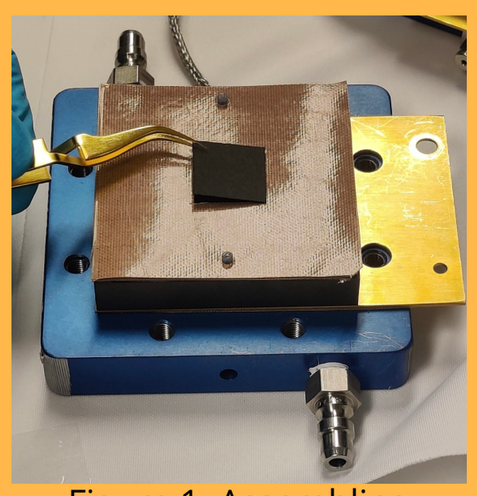

Figure 1. Assembling PEMFC

Figure 2. PEMFC mounted with connection for testing

03. MEASURED PERFORMANCE

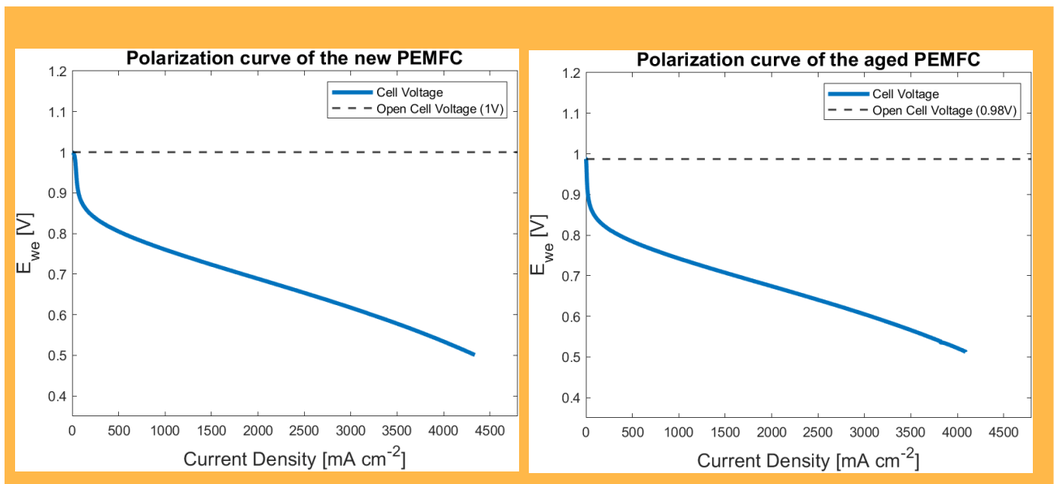

Figure 3. Polarization curve (1) new cell (2) after 15000 cycles

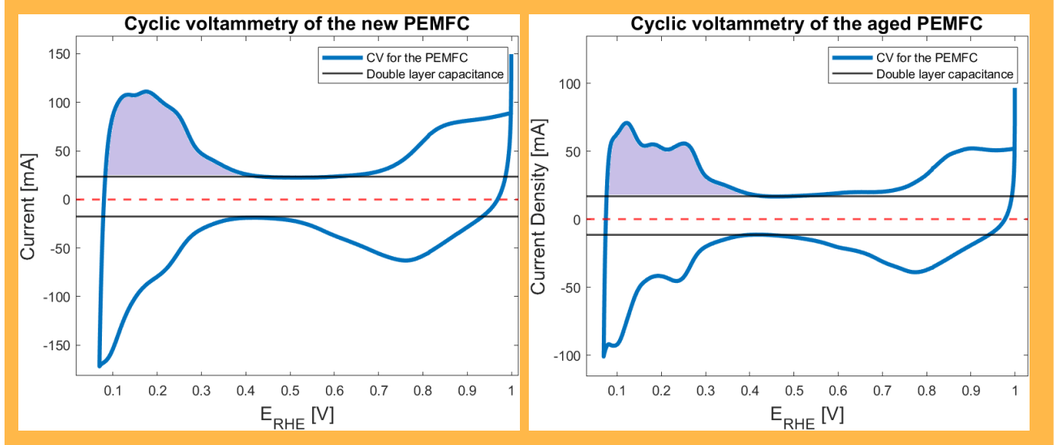

Figure 4. Cyclic voltammetry curve (1) new cell (2) after 15000 cycles

04. CALCULATIONS

The electrochemical surface area (ECSA) is calculated by the following equations:

$$\text{Total charge: } Q = \int I dt = \int I dE \frac{dt}{dE} \Longrightarrow A_{\text{ECSA}} = \frac{Q}{\theta_{\text{Pt}}} = \frac{Q}{210 \mu C/cm^2}.$$

Q refers to the total number of electrons either absorbed or released from the catalyst during the reducing or oxidisation with the double layer capacitance subtracted. The result is then divided by the surface loading of platinum (0.4 mg/cm ^{2}), L and the electrode area (5 cm ^{2}), A, to make comparisons between different fuel cells easier:

$$A_{\text{ECSA}} = \frac{Q}{\theta L A_{\text{electrode}}}$$

The power output of the cell is equal to the voltage multiplied with the current. While the operating efficiency is calculated by the fraction of the cell voltage and the theoretical maximum voltage of 1.48 V.

05. RESULT

0.51 ECSA

From the CV plot of the new fuel cell, total charge was calculated to 312.4 mC, which gives an electochemical surface area (ECSA) of 74.29 m^2/g. Compare to the aged cell which has a total charge of 180.5 mC which gives a ECSA of 42.97 m^2/g. This represents a decrease of 42.2%.

0.52 Power output

To compare the power output of the cells a current density of 600 mA per square centimeter was chosen which gives a current of 3 A. The voltage of the new cell was 0.7947 V and for the aged on it was 0.7749 V. From this the output can be calculate to be 2.38 W for the new one and 2.32 W for the aged one, which is a decrease of 2.5 %.

0.53 Efficency

The efficiency of the new fuel cell at 0.7947 V is 53.7% and the aged one at 0.7749 V is 52.4 %.

06. DISCUSSION

From the measured values, it's clear that the performance has decreased in the aged fuel cell compared to the new fuel cell but the degradation is not very huge. If the this was a stack of fuel cells instead of a single cell the effects would probably be greater and the decrease in performance would have been huge.

6.1 Activation procedure