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Half cell characteristics of high temperature PEM Fuel Cell

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Outline

The main potential loss in the proton exchange membrane (PEM) fuel cell is caused by the high activation resistance of the oxygen reduction reaction (ORR) at the cathode. Hence, the electrochemical characterisation of the electrode is an important step for the evaluation of the activity of the prepared catalyst and as a consequence the electrodes for the fuel cell.[1] Therefore the development of electrochemical test equipment and procedures is required. The electrochemical behavior of electrodes has been studied widely in a number of investigations.[2,3] In our study we used the Teflon half-cell for this purpose.

Experimental

The Teflon half-cell test was performed at ambient temperature with the catalyst as working electrode (working area is 0,785 cm^2) using a VersaSTAT 3 Potentiostat. The working electrode was fixed inside the Teflon cell setup over a piece of carbon paper in contact with a platinum ring. A three electrode setup was used (Reference electrode: saturated calomel electrode (SCE), counter electrode: Pt wire) with a 0.5M H_2SO_4 solution as electrolyte and pure oxygen under ambient pressure as oxidant. The electrolyte was in contact with the working electrode from the front side (the catalyst side) and the gas phase was in contact with working electrode from the back side (the carbon cloth side). (**Fig. 1**)

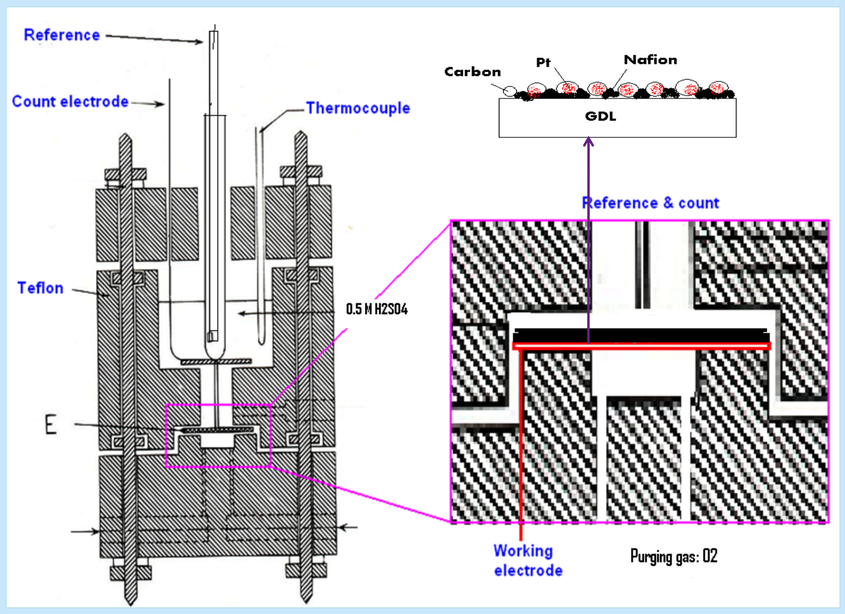

Fig. 1. The scheme of the Teflon half-cell

Sample preparation

The electrodes for tests were made by dropping deposition of the catalyst ink (mixture of catalyst, Nafion® and Ethanol) to the standard carbon cloth and letting Ethanol evaporate in a furnace for 1 hour at 120°C. Two types of Johnson Matthey (JM) catalysts were used: 40% and 60% Pt on Vulcan XC-72R carbon black. As result we got several types of electrodes (**Fig. 2**): **I**. different Pt loading (0.01, 0.02, 0.05, 0.1 and 0.5 mg/cm^2) and different thickness (40% JM); **II**. same Pt loading (0.05 mg/cm^2) and different thickness; and **III**. different Pt loading(0.01, 0.02, 0.05, 0.1 and 0.5 mg/cm^2) and same thickness (II and III both 60% JM).

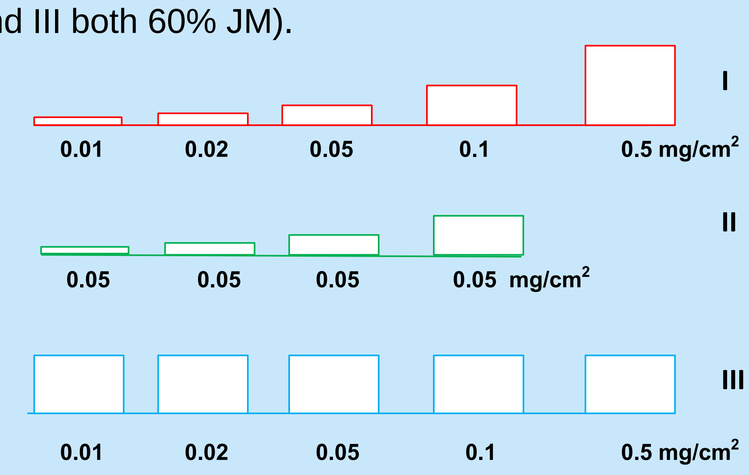

Fig. 2. The scheme of the types of electrodes with different thickness and platinum loading, mg/cm^2 as indicated by arabic numbers.

Cyclic Voltammetry results

The cyclic voltamograms were initialized with potential cycling between 0.2 V and 1.0 V vs. SCE or 0.44 and 1.24 vs. RHE at scan rate of 0.1 V/s for 20 cycles to stabilize the system. The activity of the various electrodes were then tested at different scan rates: 0.1; 0.02; 0.05 V/s with pre-conditioning of 1.0 V for 30 s or 60s and scanning range from 1.0 V to 0.2 V.

I

Fig. 3. Catalyst activity for the I type of electrodes at 0.1 V/s and pre-cond. 60s.

From **Fig. 3** it can be seen that the best catalyst utilization is obtained with lowest Pt loading when the electrode is thinnest (i.e. 0.01 mg/cm^2).

II

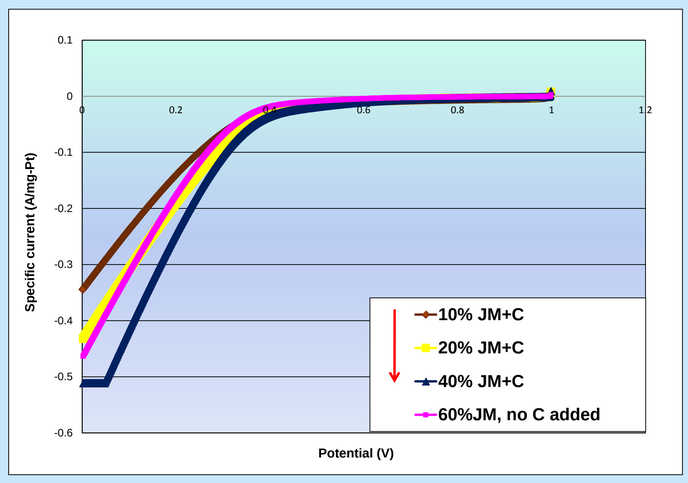

Fig. 4. Catalyst activity for the II type of electrodes at 0.1 V/s and pre-cond. 30s.

The dependence of effectiveness of the electrode according to thickness of the catalyst layer on the carbon cloth can be seen in **Fig.4**. All electrodes have the same Pt loading, but adding less carbon results in thinner electrodes, yielding better catalyst utilization (see 40%JM+C). The case with 60%Pt+40%C (no additional C to the 60% JM catalyst, as for other II type electrodes) was expected to have a highest Pt utilisation. Due to some factors it is not happen, therefore further investigations will follow.

III

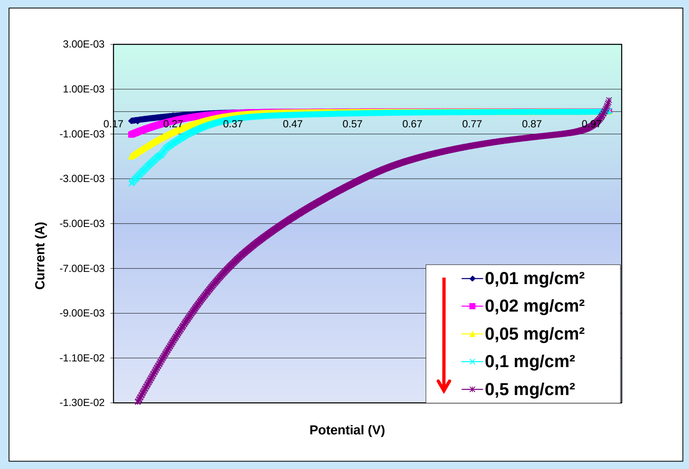

Fig. 5. Activity for the III type of electrodes at 0.1 V/s and pre-cond. 30s.

Results in **Fig.5** demonstrate a clear dependence of the electrode effectiveness on the Pt loading. The higher the Pt loading, the higher the electrode activity.

Conclusion

Teflon half-cell has shown promising well-correlated results for future electrochemical evaluations of the electrodes and the catalysts activity. The polarization curves are aligned according to the platinum loading of the electrode(Fig.1&3) and the efficiency of utilization of the catalyst varies with changing thickness of the catalyst layer(Fig.1&2) as expected. Further investigations of the Teflon half-cell are planned.

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HotMEA project partners
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