Travail de Fin d'Etudes : Characterization of Proton Exchange Membrane fuel cells with catalytic layers of various composition - determination of the cathodic layer limitations

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Characterisation of Proton Exchange Membrane fuel cells with catalytic layers of various composition – determination of the cathodic layer limitations

The proton exchange membrane (PEM) fuel cell is a promising alternative for the current power sources that work with fossil fuel. This device converts chemical energy into a direct current thanks to catalytic layers made of porous carbon and platinum. The high cost of Pt required to catalyse the chemical reactions, hampers the PEM fuel cell commercialisation. This master thesis aimed at finding the origin of the performance losses inside the cathode catalytic layer to, later, optimise the Pt distribution. To that end, PEM fuel cells with different catalyst compositions were planned to be made to discriminate between the different chemical species transports. This project is divided in three parts: (i) Pt on carbon black was synthesised to, further, dispose of catalysts with a variable Pt loading; (ii) PEM fuel cells were manufactured to assess the degree of reproducibility of the fabrication process; As the experimental work was made impossible, PEM fuel cells with various compositions could not be characterised and (iii) a 1D numerical model was developed.

Pt/C electrocatalyst was synthesised using an impregnation technique with formic acid as reducing agent. The obtained catalyst was subsequently characterised with physical and electrochemical methods. The activity of the catalyst was similar to the previous work made at the laboratory. However, the Pt particle sizes showed a large inhomogeneity due to a too fast Pt salt injection during the synthesis.

Two sets of PEM fuel cells were manufactured using the spray deposition technique. The devices were then characterised using *in situ* methods. The reproducibility of the second set was improved compared to the first one thanks to a better tuning of the spray parameters.

The 1D model model was used to simulate the species inside the cathode catalytic layer. The model data tend to the experimental behaviour previously acquired at low current but failed at larger current. This indicated that a more complex modelling of the physicochemical phenomena is required.

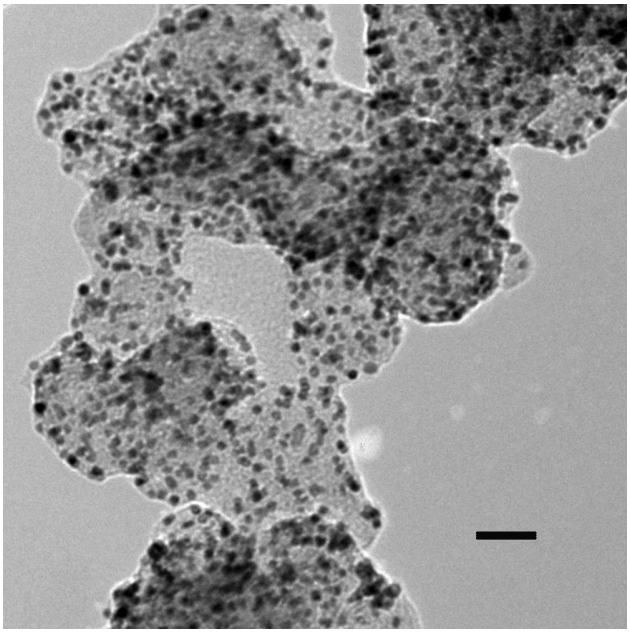

Figure 1: TEM image of platinum on carbon black synthesised with the impregnation technique using formic acid as reducing agent. The scale bar is 20 nm.

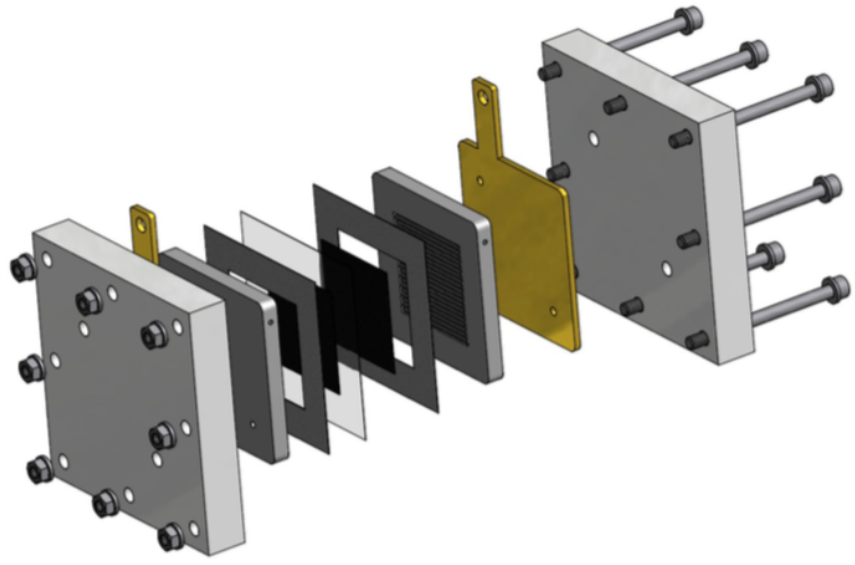

Figure 2: Schematic of the different components of the PEM fuel cells manufactured and characterised.

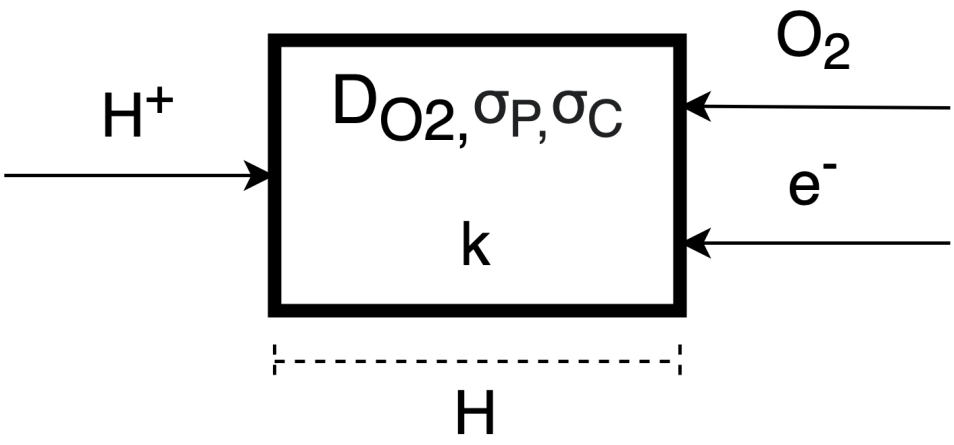

Figure 3: Schematic of the 1D cathode catalytic layer model. D_{O2}, σ_P, σ_C and k are the physicochemical parameters of the layer.