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Department Of Mechanical Engineering

Study of SOFC Stabilisation under Load Using EIS Analysis and Polarisation Curves

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Overview

- Introduction
- Experimental set-up
- Operating conditions
- Results
  - Repeatability (cell 1 and cell 2)
  - Early stages of stabilisation
- Conclusion

Introduction

- The development of solid oxide fuel cell (SOFC) technology has been built on a significant amount of research activity since the late 50s.
- These studies include several fields such as long-term performance and durability of single cells and stacks, material development, modelling and poisoning.

- In some fuel cell research, particularly the contamination and poisoning tests, it is important that the cell has reached a stabilised state, where the cell output is steady, prior to the main test. This allows the further change in the performance to be only attributed to the parameter of interest.

Introduction

- Several parameters can contribute in the cell performance such as operating temperature, fuel composition, current density, cell layers material, thermal cycles, etc. Physiochemical properties of fresh cells tend to change over time, during the first run, causing the cell output to change.

- In this study, performance and degradation of single cells over the stabilisation period, is examined using electrochemical impedance spectroscopy and characteristic curves.

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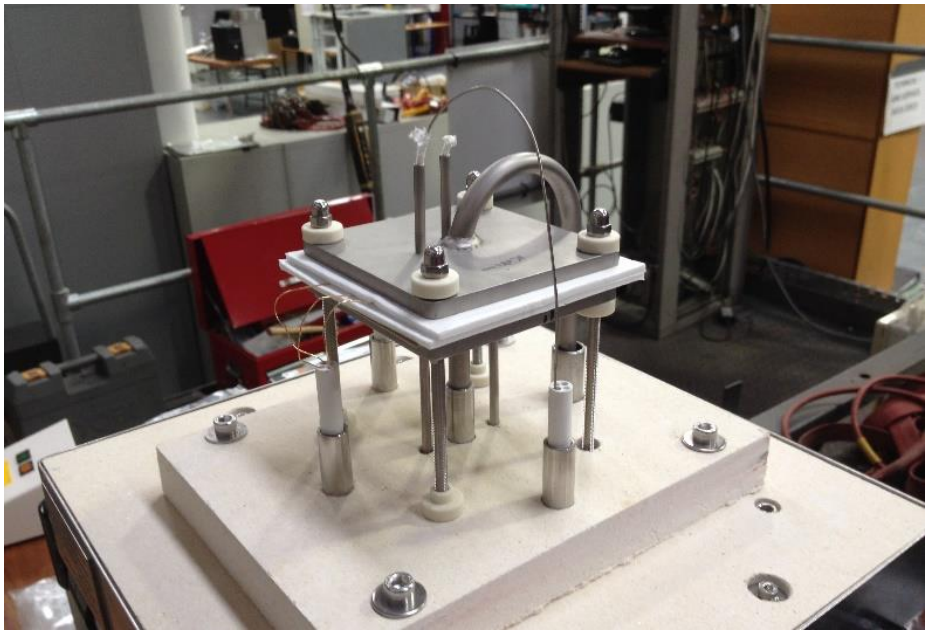
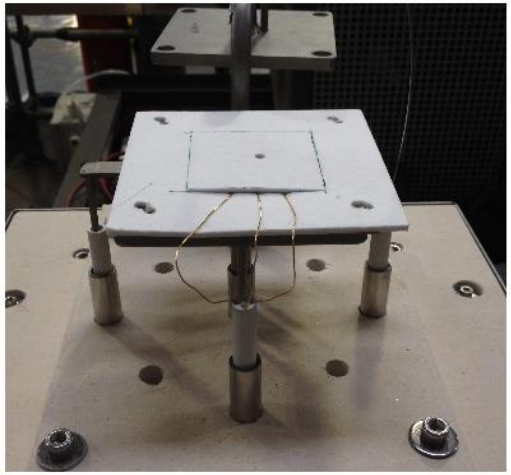
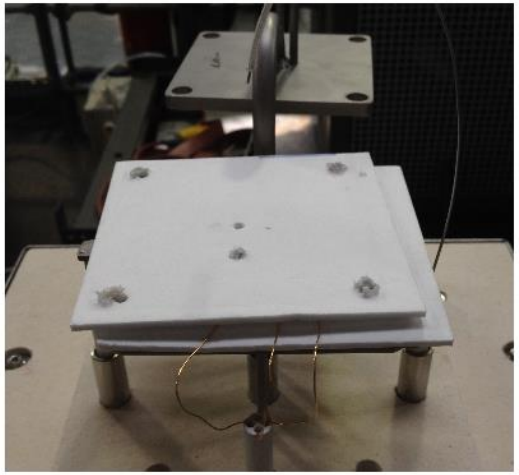
Experimental set up

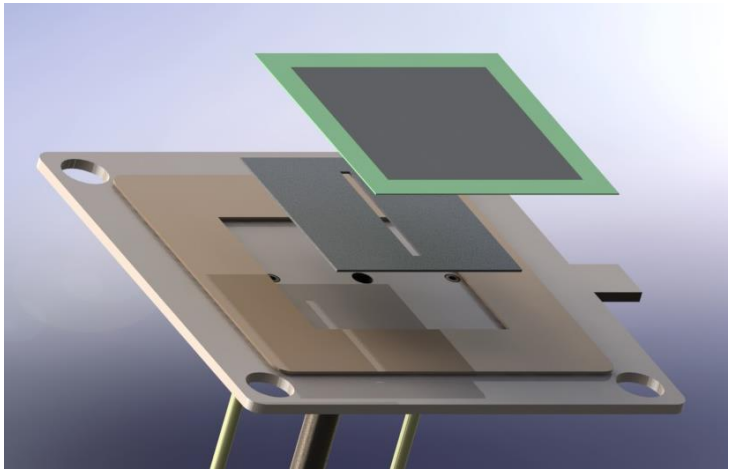
- Experimental set-up consists of two open flanges made of inconel, sandwiching the cell and current collectors.
- Anode side is manifolded; anode gas leaves the set-up through outlet tubes.
- Air leaves cathode to atmosphere.



Experimental set up







- Nickel foam is used as the current collector at the anode.
- Gold grid is used as the current collector at the cathode.
- Two layers of alumina-silica felt were used to electrically insulate the cell.

Operating conditions

- Fresh 5x5 cm^2 planar cells (active area 4x4 cm^2), anode supported cells
- Fuel composition:14.5 % H_2 (100 ml/min), 82.5 % N_2 (566.67 ml/min) and 3 % H_2O
- Operating temperature: 700 °C
- Current density: 200 mA/cm^2
- EIS and v-i curves are taken every 5 hours

Schematic of cell layers

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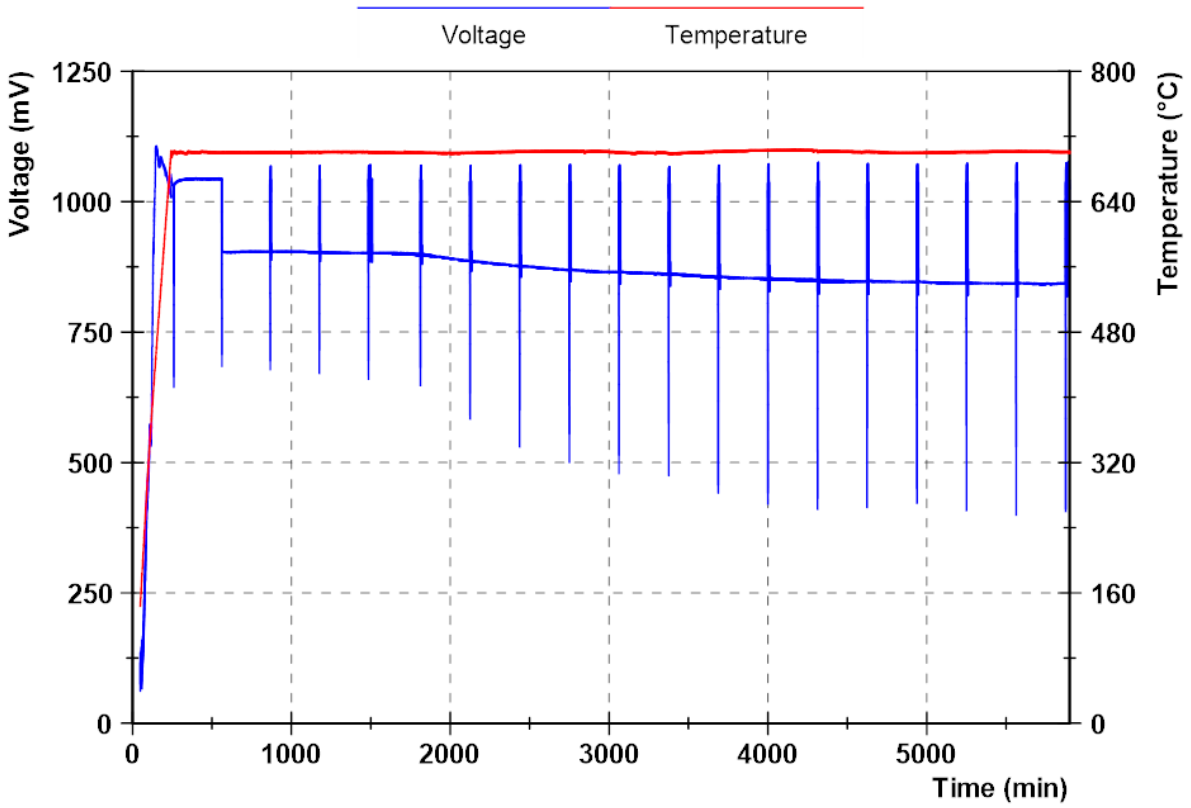
Results – cell 1



Voltage stabilized after 65 hours (846 mV) and remained almost constant for the rest of the test (at 85 hr, 843 mV).

The spikes in the voltage profile are due to the v-i curve reading. Data logger records voltage values continuously during all stages of test.

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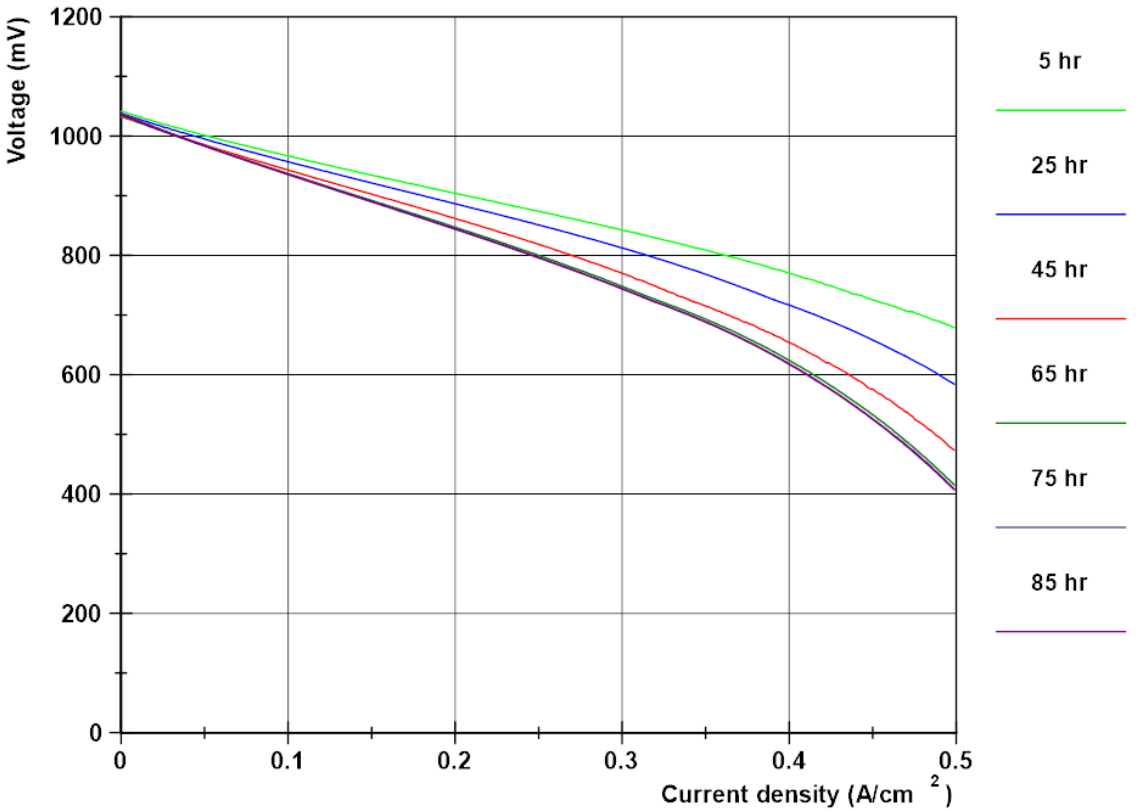
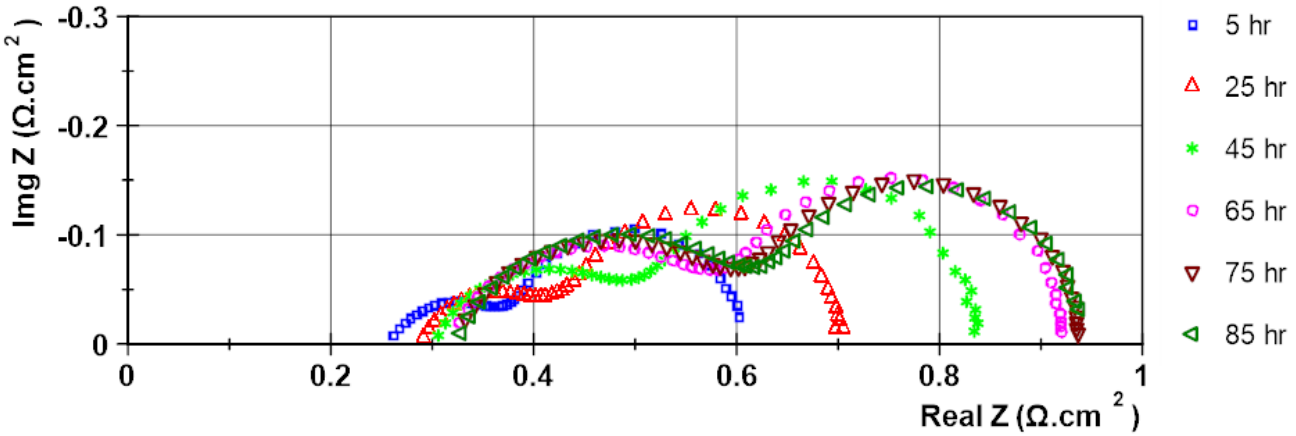
Results – cell 1



- The cell stabilized after 65 hours as v-i curves taken after 65, 75 and 85 hours are almost overlapping.
- The onset of the concentration losses area occurred at a lower current density as time elapsed, suggesting that the diffusion of the reactants and products was affected with time.

Results – cell 1



- The resistance of the cell increased over time and almost stabilized after 65 hours.
- Both ohmic and activation/concentration (electrodes) polarisations increased over time, however, the increase in the ohmic resistance is much lower than that of activation/concentration resistance.

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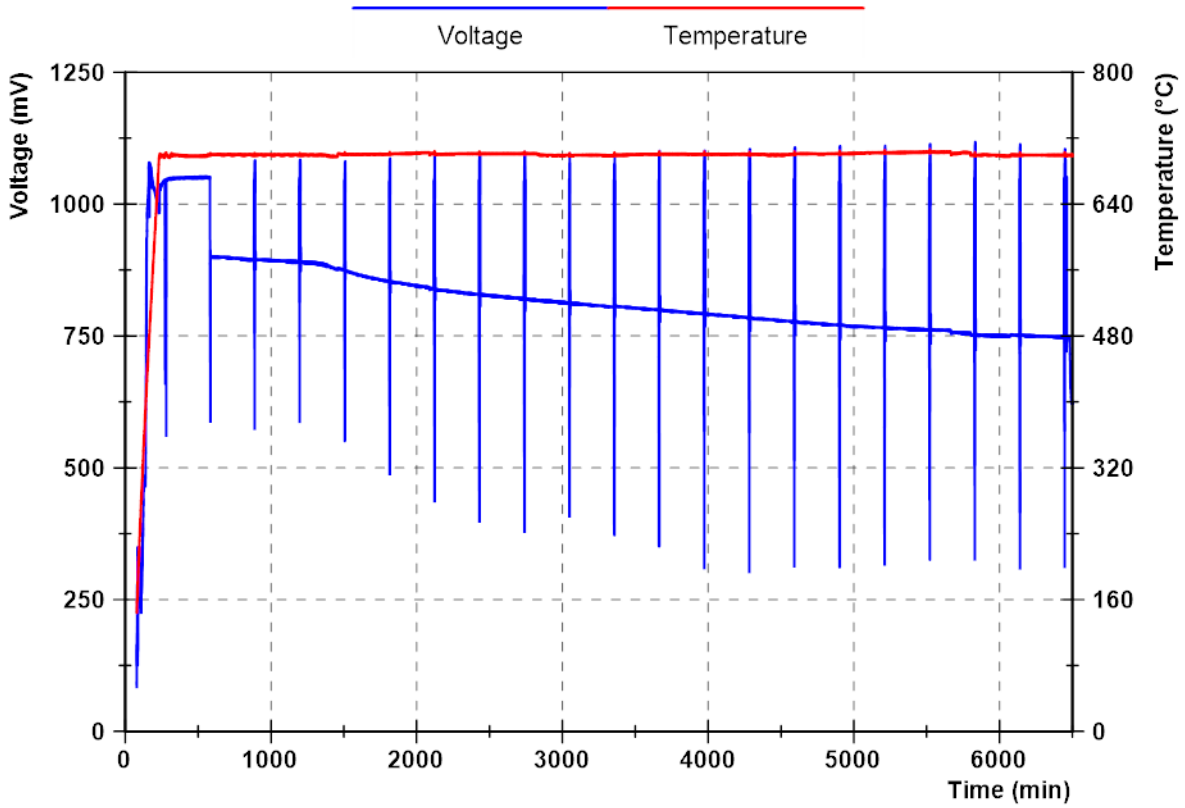
Results – cell 2



- In order to make sure that the results are repeatable, another cell was tested under the same conditions.

- The whole durability period was 95 hours.
- The voltage remained almost constant for the last 10 hours.

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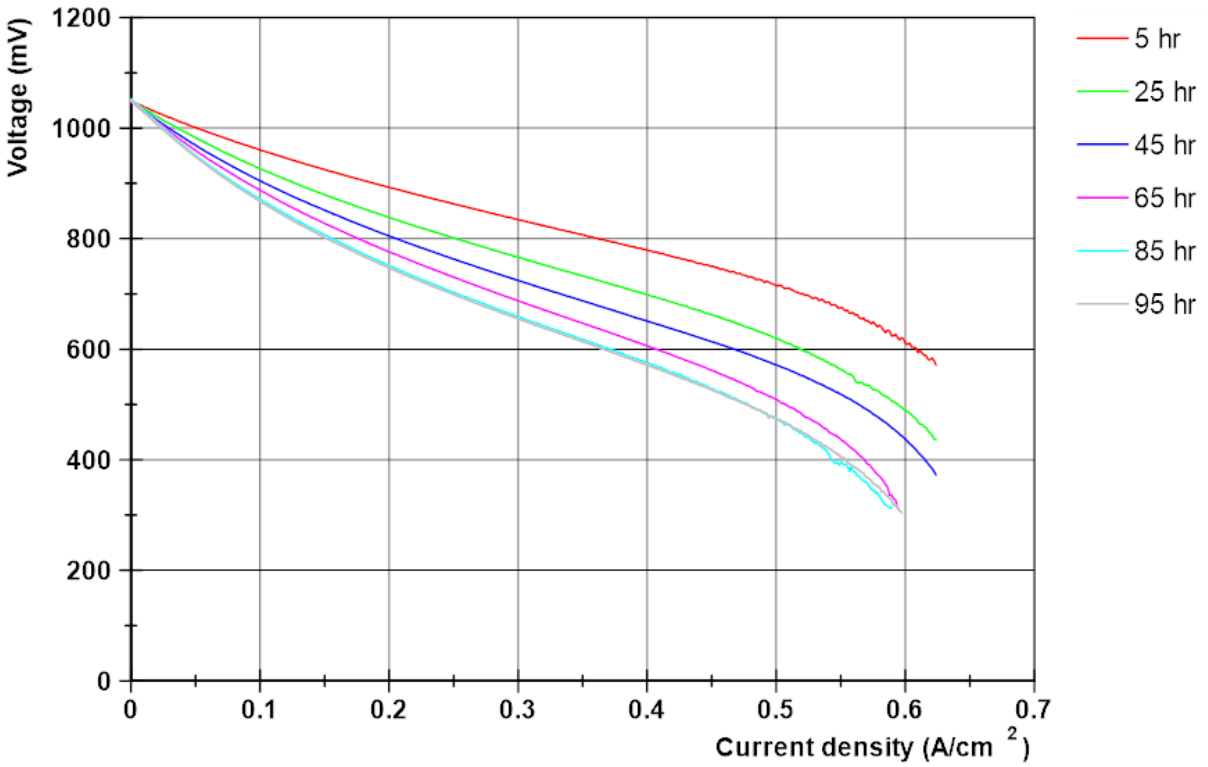
Results – cell 2



- The v-i curves after 85 and 95 hours overlapped stating that the voltage remained constant over the last 10 hours of the test period.

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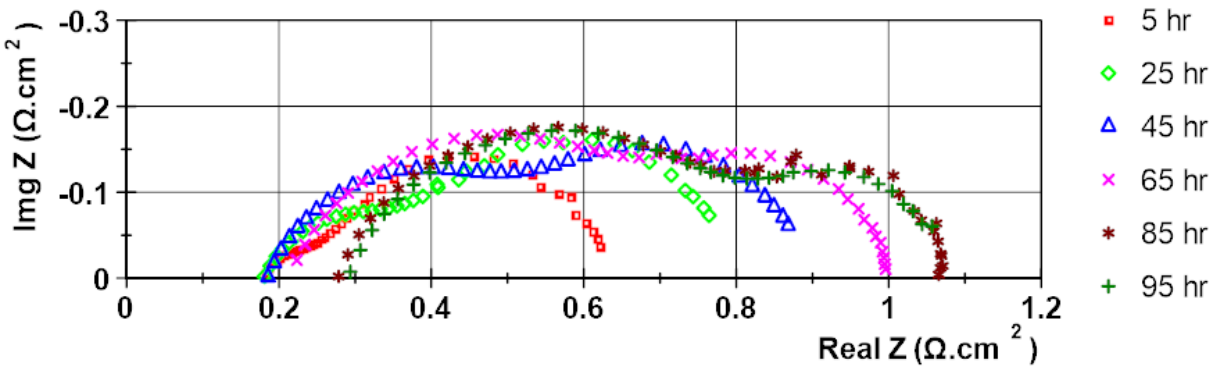
Results – cell 2

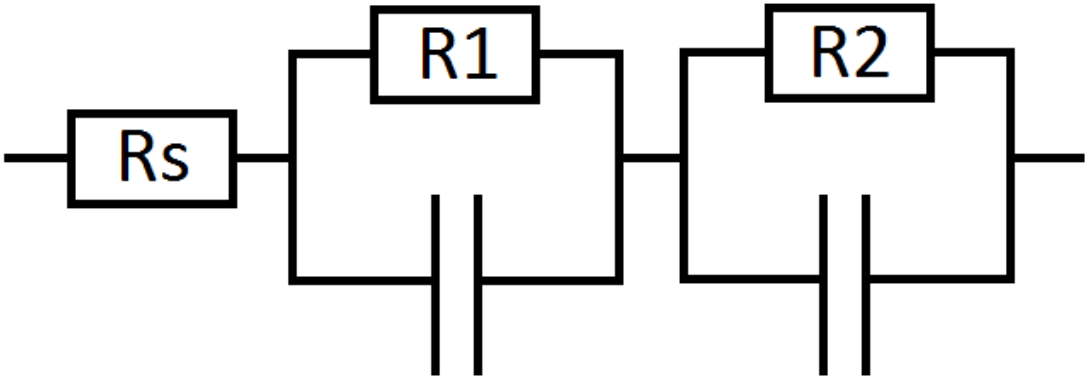


- The resistance of the cell increased over time and almost stabilized after 85 hours.
- Both ohmic and activation/concentration resistances tended to increase with time, however, the increase in the ohmic resistance is much lower than that of activation/concentration resistance.

Results

- In order to analyse the obtained data, an equivalent electrical circuit was considered for curve fitting.

- The circuit consists of an ohmic resistor and 2 sets of parallel resistor and CPE.



Results

- Cell resistance at the beginning and end of the loading period are compared.

- The results shows that the increase in the high frequency resistance was larger than the others.

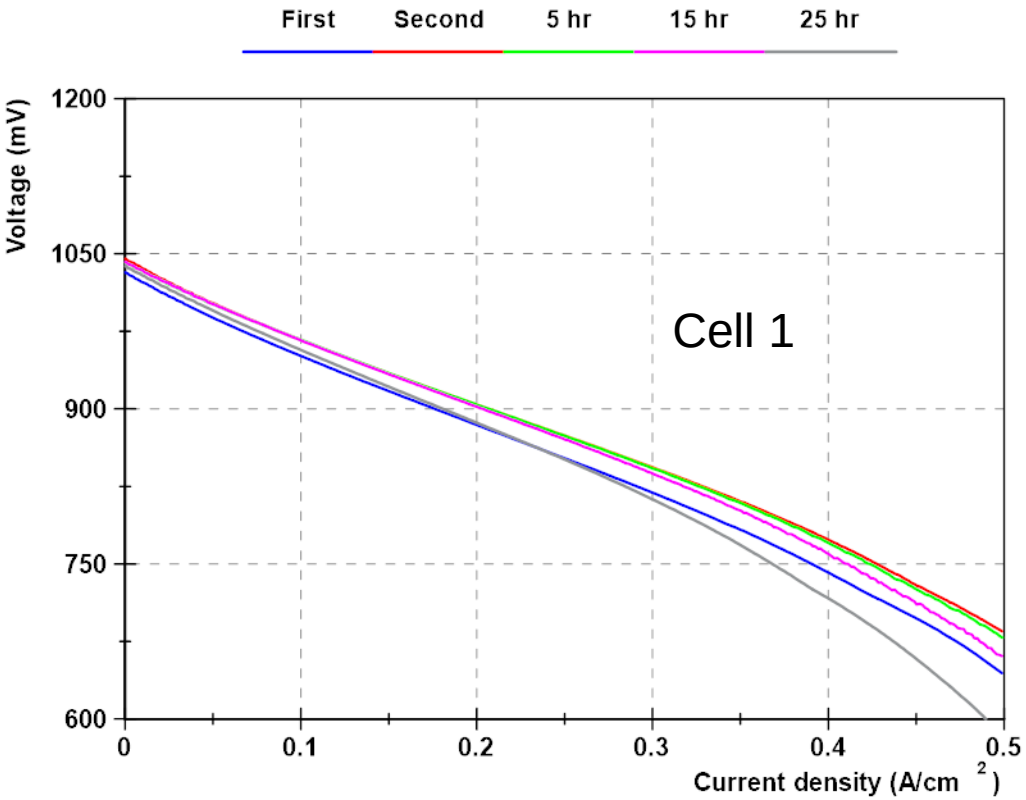
- The decrease in the performance was mostly caused by the increase in the activation losses.

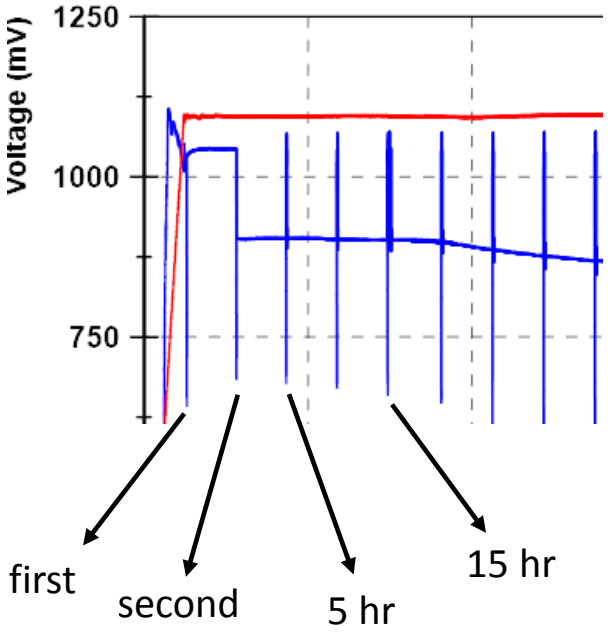
	Cell 1		
	R ohmic	R_high f	R_low f
5 hr	0.01285	0.01215	0.01298
85 hr	0.01724	0.02376	0.01804
increase %	34.16342	95.55556	38.98305

	Cell 2		
	R ohmic	R_high f	R_low f
5 hr	0.01194	0.01893	0.02034
95 hr	0.01359	0.04069	0.01296
increase %	13.8191	114.9498	-36.2832

Early stages of stabilisation

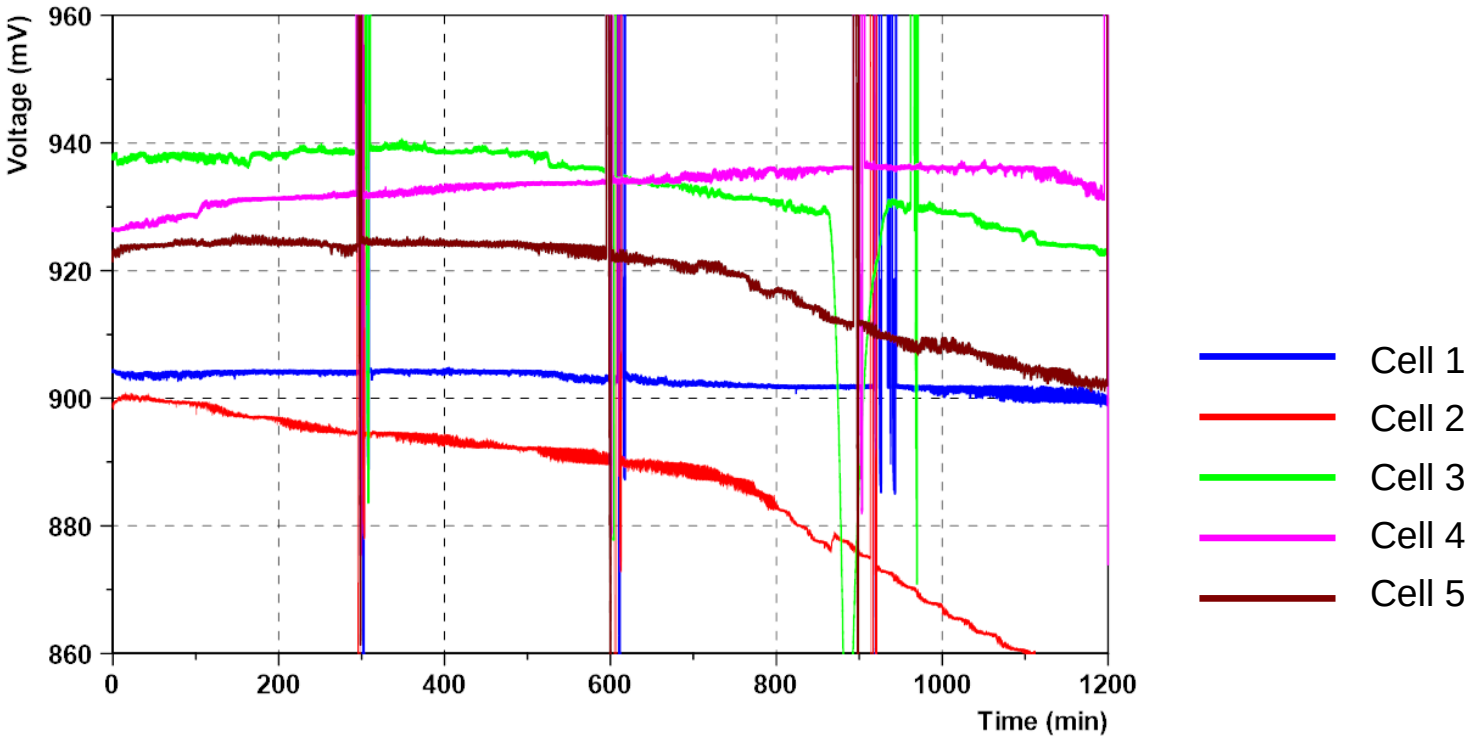
Before being loaded, the cells were operated at OCV for 5 hours. During this stage the performance slightly improved (first and second curves).





Early stages of stabilisation

The slight increase in the voltage starts during the OCV period. This trend may continue at the early stages of the loading period.



Voltage profile at early stage of stabilisation for different cells

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Conclusion

- As a general trend, the voltage of cells increased slightly at the early stages of the tests, then decreased gradually and finally, tended to stabilise.

- During the stabilisation period, both ohmic and electrode (activation and concentration) losses tended to increase.

- The increase in the activation/concentration resistance is much larger than that of the ohmic resistance.

- The decrease in the performance was mostly caused by the increase in the activation losses.

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Thank you for your attention

