Application Note AN-FC-003

燃料电池第 3 部分--利用 EIS 进行表征

In the previous application notes it was shown that fuel cells are promising power sources as they offer highly efficient and environmentally friendly solution for alternative energy. In recent years considerable research is being done to provide a better understanding of the factors that affect the performance of a fuel cell.

In this application note the use of Electrochemical Impedance Spectroscopy (EIS) for the characterisation of PEM fuel will be demonstrated. It will be shown that EIS is a powerful diagnostic tool for the determination of the following factors that can influence the performance of a PEM fuel cell:

- Electrode composition and structure
- Membrane characteristics
- Operating parameters such as, cell temperature, humidification, gas composition and pressure

The main advantage of EIS as a diagnostic tool is its capacity to resolve in the frequency domain the individual contributions of the various factors that determine the overall PEM fuel cell power losses:

- Kinetic
- Ohmic
- Mass transport

EXPERIMENTAL CONDITIONS

The experiments were done on the fuel cell test station at Electrochemistry group in the Department of Chemistry at the North Eastern University in Boston, USA.

The experiments were conducted using an AUTOLAB PGSTAT302N controlled by NOVA software. The EIS measurements were performed using the FRA32 module controlled by NOVA software. The 10 A current booster unit was used as the load.

The fuel cell used for the experiments was a single cell with a geometric surface area of 5 cm^2 comprising a Nafion polymer electrolyte membrane. The electrodes consisted of a thin-film catalyst layer. The electrodes were supplied with pure hydrogen or hydrogen with small quantity of CO at the anode and with hydrogen (for reference measurements), air or oxygen at the cathode.

The EIS experiments were done under potentiostatic control. For the cell with hydrogen at the cathode, the EIS experiments were done at OCP (0.0 V). For experiments with air and oxygen the experiments were done at the applied potential of 0.8 V, 0.6 V and 0.4 V. A frequency range of 10 kHz – 0.01 Hz was used. The amplitude of the AC perturbation was set to 10 mV.

EXPERIMENTAL RESULTS

In Figure 1 the results of the EIS experiment with H_2 at the cathode are compared with those with O_2 and air at the cathode.
When only hydrogen is at both the anode and cathode side of the electrode there is no reduction reaction that takes place at the cathode and one measures the ohmic losses across the membrane. When the hydrogen is replaced by oxygen at the cathode then the reduction of oxygen at the cathode occurs. The charge transfer resistance of the reduction reaction can therefore be measured. When oxygen is replaced by air at the cathode then the effect of mass transport can be seen. Oxygen has to diffuse through nitrogen present in air to reach the cathode surface, this result in an increase in the polarisation resistance due to the diffusion resistance as seen in Figure 1.

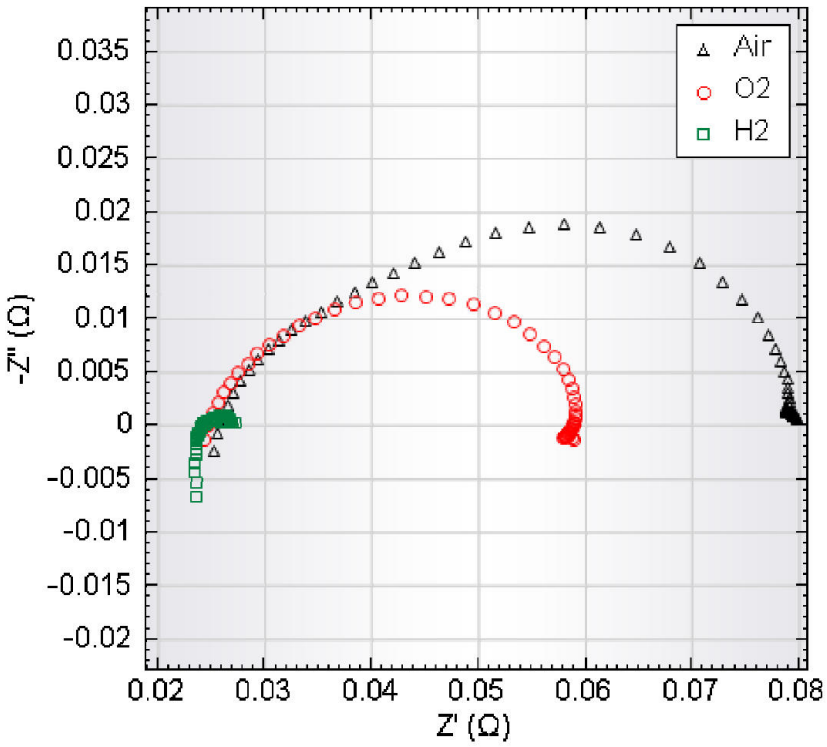


Figure 1. Results of EIS experiment on a PEM fuel cell with H2, O2 and air at the cathode

In Figure 2 the effect of the poisoning of the catalyst by CO can be seen. With the introduction of CO in air on the anode side the charge transfer resistance for the oxidation of hydrogen increases due to the poisoning of the catalyst.

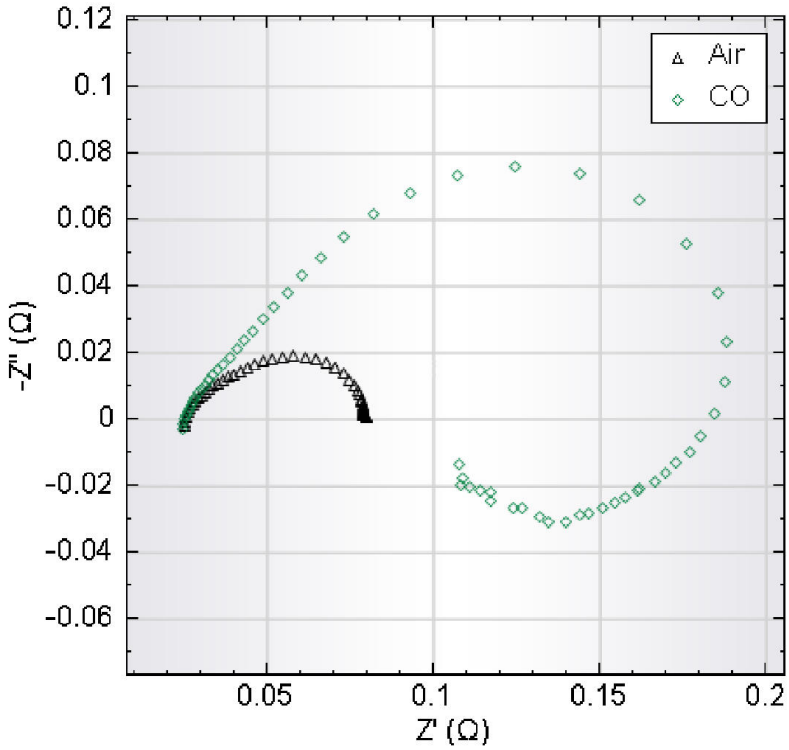


Figure 2. Results of EIS experiments on a PEM fuel cell with air and CO at the anode

With the introduction of CO in air on the anode side the charge transfer resistance for the oxidation of hydrogen increases due to the poisoning of the catalyst.

REFERENCES

1. M. Ciureanu, R. Roberge, J. Phys. Chem. B, 2001, 105, 3531-3539

CONTACT

瑞士万通中国
北京市海淀区上地东路1号
院1号楼7层702
100085 北京
marketing@metrohm.com.cn

Autolab PGSTAT204

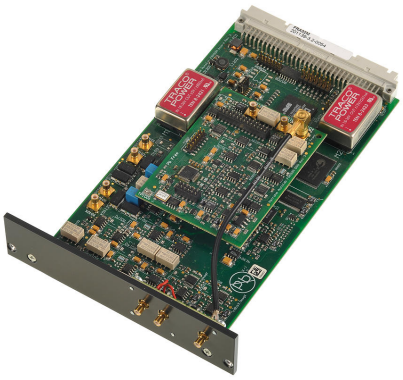
PGSTAT204 结合了小巧规格和模块化设计。该仪器包括基本恒电位仪/恒电流仪,其顺从电压为 20 V,最大电流为 400 mA 或 10 A,与 BOOSTER10A 组合使用。此恒电位仪可随时用附加模块进行扩展,例如 FRA32M 电化学阻抗谱(EIS)模块。

PGSTAT204 是一款经济实惠的仪器,可置于实验室的任何位置。具有模拟和数字输入/输出,可控制 Autolab 附件和外部设备。PGSTAT204 包括内置模拟积分器。与高性能的 NOVA 软件联用,可用于大多数标准电化学技术。

Autolab PGSTAT302N

该恒电位仪/恒电流仪,具有 30 V 顺从电压,带宽为 1 MHz,可与我们的 FRA32M 模块联用,专门针对电化学阻抗谱而设计。

PGSTAT302N 是流行的 PGSTAT30 的后继款型。最大电流为 2 A,借助 BOOSTER20A 电流范围可扩展至 20 A,当电流范围为 10 nA 时电流分辨率为 30 fA。



FRA32M 提供了用于测量阻抗的工具,与 Autolab 联用可测量电化学阻抗。该模块允许在 10 µHz 至 32 MHz 的较宽频率范围中同时进行恒电位和恒电流阻抗测量(与 Autolab PGSTAT 联用极限为 1 MHz)。除了传统的 EIS 电化学阻抗谱之外,NOVA 软件还允许用户调节其它外部信号,诸如旋转圆盘电极的转速或光源频率,以测量电-流体或光调制阻抗谱。

FRA32M 模块带有功能强大的匹配和仿真软件,可分析阻抗数据。

Booster 10A

Booster10A 模块可将 PGSTAT100N, PGSTAT128N, PGSTAT302N, PGSTAT204 或 M204 的最大电流增至 10 安培。与 Booster10A 联用时系统的顺从电压为 20 V。

凭借其快速的响应时间,结合 FRA32M 模块 Autolab Booster10A 可优化燃料电池、蓄电池和超级电容器的电化学阻抗性能。booster 既可用于主动性电池也可用于被动性电池。Booster10A 可用于测量超级电容器的充电和放电特性、燃料电池的性能测试或大面积电极上的DC或AC测量。

NOVA 是设计为通过 USB 接口控制所有 Autolab 仪器的软件包。

由电化学家针对电化学而设计,集成了超过二十余年的用户体验和最新的 .NET 软件技术,NOVA 使您的 Autolab 恒电位仪/恒电流仪拥有更强性能和灵活性。

NOVA 提供了以下的独特功能:

- 功能强大且灵活的程序编辑器
- 重要实时数据一目了然
- 强大的数据分析和绘图工具
- 集成化控制外围仪器,诸如万通 LQH 液体处理设备

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