Application 2071

Application of reference electrode array to segmented direct methanol fuel cell

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The work to be carried out during this project aims to apply the NPL reference electrode array concept to our custom-developed direct methanol macro-segmented cell setup. Among low temperature fuel cell technologies, the direct methanol fuel cell (DMFC), although very promising as a portable power generation application, is still penalized by severe performance degradation, known to show both temporary and permanent contributions [1]. The necessity of limiting temporary degradation requires the use of discontinuous operating strategies [1], periodically determining complex and highly unsteady phenomena, which are difficult to separate and investigate. Moreover, slow methanol oxidation reaction kinetics result in a non-negligible anode overpotential, whose magnitude may be comparable to that of the cathode during operation. Bi-phase mass transport and critical water management add complexity to the problem [2]. Our recent research activities have identified that local heterogeneities in operating conditions have a key influence on aging of cell components. Thus, we are currently developing customized segmented hardware to fully and independently investigate the different zones of a single cell. This innovative approach aims to divide a cell into four macro-segments, permitting a complete local electrochemical (with consolidated techniques like I-V curves, EIS, CV, LSV) and mass composition (with gas-chromatography analyses) characterization, while performing degradation tests. In this way, a detailed identification and localization of the most important degradation driving phenomena would be achieved, permitting a dedicated local optimization of each component, aiming to a lifetime improvement of the technology.

For a complete and a deeper characterization of the degradation phenomena, it is critical to separate the contribution of anode and cathode to the overall cell potential, both during operation and during very highly unsteady conditions such as OCV and air-break periods, locally, continuously and reliably. The application of a complete and reliable array of reference electrodes, one per segment, would be a major step forward. Unfortunately, reference electrode application onto solid electrolyte systems like PEMFC is a complex matter, where even the localization of the electrode connection can alter the measured potential, due to drop and/or edge effects determined by slightly misalignment of the electrodes [3,4].

NPL recently developed an innovative PEMFC reference electrode setup using an external, through-plane configuration, whose validity is demonstrated through different unsteady investigations [5,6] in array configuration. Its application to our custom developed macro-segmented cell setup, coupled with local mass composition analyses and electrochemical diagnostics, would permit an important further insight onto the highly unsteady and heterogeneous phenomena determining local performance degradation in DMFC operation, coupling two interesting innovative approaches.

With this aim, the following working tasks are proposed:

TASK 1: Development, installation and validation of single NPL reference electrode onto 25 cm2 DMFC single cell hardware.

TASK 2: Development, installation and validation of a complete array of four reference electrodes onto one of our DMFC custom macro-segmented cells (25 cm2).

TASK 3: Case study involving application of reference electrode to separate the contributions of anode and cathode in DMFCs.

The project time span will be four months, comprising 6 units of access divided between the above tasks. This will require several visits to NPL from Claudio Rabissi, PhD student at Politecnico di Milano.

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[5] G. Hinds, E. Brightman, In situ mapping of electrode potential in a PEM fuel cell, Electochemistry Communications,17,(2012),26-29
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