Innovative graphene oxide-based membranes for self-standing micro-porous layers for PEM fuel cells

Saverio Latorrata[1*], Alessandro Migliavacca[1], Paola Gallo Stampino[1], Cinzia Cristiani[1] and Giovanni Dotelli[1]

[1*]Department of Chemistry, Materials and Chemical Engineering "Giulio Natta", Politecnico di Milano, Italy
[*]saverio.latorrata@polimi.it

INTRODUCTION

Polymer electrolyte membrane fuel cells (PEMFCs) will play an important role in a future hydrogen economy since they are considered as one of the most promising devices for green-energy production for both portable and non-portable systems due to their high output power density, low operating temperature and high efficiency[1]. A crucial factor for an optimal running of such devices is a correct balanced water management[1]. In this respect, gas diffusion medium (GDM) is a fundamental component for a PEMFC. GDM is formed by a carbon cloth macro-porous substrate (gas diffusion layer, GDL) and a micro-porous layer (MPL). The MPL is a thin layer made from an ink of carbon nano-particles mixed with a hydrophobic polymeric agent. GDM must be hydrophobic in order to remove the water that is produced by the redox process within the fuel cell. MPL is usually directly coated onto GDL and the so-joined components are thermal treated for sintering polymeric agent and removing solvents. However, the development of a self-standing MPL would be desirable if thermo-labile polymeric agents are used for GDL pre-treatment. Therefore, in this work MPLs obtained from a dispersion containing graphene oxide (GO) and carbon nanotubes (CNTs) were developed, made hydrophobic and characterized, aiming to be used in a running fuel cell at lab-scale.

EXPERIMENTAL/THEORETICAL STUDY

In a typical experiment, a GO and CNTs solution was prepared, then it was vacuum filtered and the cake was dried at 35 °C for 6 hours. A membrane, which takes advantage of the self-assembling properties of the GO, was obtained, then soaked in a 12 % wt FEP (fluorinated ethylene propylene) suspension and calcined at 260 °C for 30 minutes. Static contact angle measurements were carried out in order to assess hydrophobicity of the surface. Surfaces were also analysed with an optical microscope and, particularly, cross section observation was useful to determine the thickness of the membranes. Porosity measurements of the thermal treated membranes were performed by the mercury intrusion technique. Self-standing GO-based MPLs will be assembled in a hydrogen/air lab-scale PEMFC, in order to evaluate performance in a running device at 60 and 80 °C.

RESULTS AND DISCUSSION

From Fig. 1 is clear that the new component is homogeneous and without cracks which, on the contrary, cannot be avoided in conventional carbon black-based MPLs. This could improve electrical contact between bipolar plate and catalytic layer of the FC and accordingly reduce the overall ohmic resistance of the device.

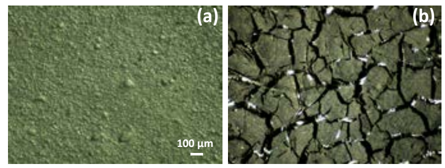

Fig. 1 Optical microscope images of GO-CNT membrane (a) and conventional carbon black-based MPL (b)

Porosity measurements proved that no significant differences exist with respect to conventional MPLs[2], since an average pore diameter of around 30 nm was obtained (Fig. 2).

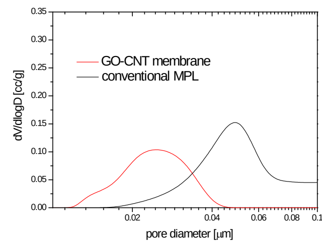

Fig. 2 Results of Hg porosimetry: pores size distribution

An average static contact angle of 129° was measured, which indicates that the treatment in the polymeric suspension was useful to make membrane hydrophobic.
This novel work is a preliminary one, therefore some measurements are still in progress; electrochemical results in terms of polarization and power density curves and Nyquist plots will be shown during the conference.

CONCLUSION

This preliminary work proved that a self-standing MPL for PEM fuel cells based on graphene oxide can be easily obtained. Carbon nanotubes were added to graphene oxide solution in order to have a better conductivity of the final product. Early characterizations showed that prepared membranes are more homogeneous than standard MPLs, sufficiently hydrophobic and micro-porous, therefore they can be tested in a running hydrogen-fed fuel cells aiming to reduce overall internal resistances.

REFERENCES

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2. S. Latorrata et al, Prog. Org. Coat. 78, 517 (2015)