Methanol crossover reduction by graphene barrier coatings

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Methanol crossover, the undesirable diffusion of fuel molecules from anode to cathode side in direct methanol fuel cells (DMFCs), is an unresolved issue since many years [1,2]. While the commonly used perfluorosulfonic acid (PFSA) membranes provide a sufficiently high proton conductivity for fuel cell operation, the methanol retention properties of the material are poor. For facilitating the wider application of DMFCs and their commercialization, the selectivity of the membrane material needs to be improved [3].

Here, we present the selective barrier effect of proton conductive electrochemically exfoliated graphene (e-G) thin films against methanol permeation. PFSA membranes are coated with aqueous dispersions of e-G, making use of a simple spray process. Membrane electrode assemblies (MEAs) with the modified membranes are fabricated (figure 1 a) and measured in a fuel cell test rig. Scanning transmission electron microscopy (STEM) and electron energy-loss spectroscopy (EELS) confirm the formation of a dense percolated graphene flake network (figure 1 b), which acts as diffusion barrier. Thus, the maximum power density in DMFC operation at high methanol feed concentration is significantly improved. The performance of e-G coated Nafion® N115 (PFSA type) is 3.9 times higher than the Nafion® N115 reference (39 vs. 10 mW cm^{-2} @ 0.3 V) at 5M methanol [4].

References

[1] A. Heinzel and V. M. Barragán, *J. Power Sources*, 84 (1) (1999) 70-74.
[2] P. Kumar; K. Dutta; S. Das; P. P. Kundu, *Int. J. Energy Res, 38 (11) (2014), 1367-1390*
[3] P. Joghee; J. N. Malik; S. Pylypenko; R. O'Hayre, *MRS Energy Sustain.*, 2 (2015).
[4] J. Ruhkopf *et al.*, submitted

Figures

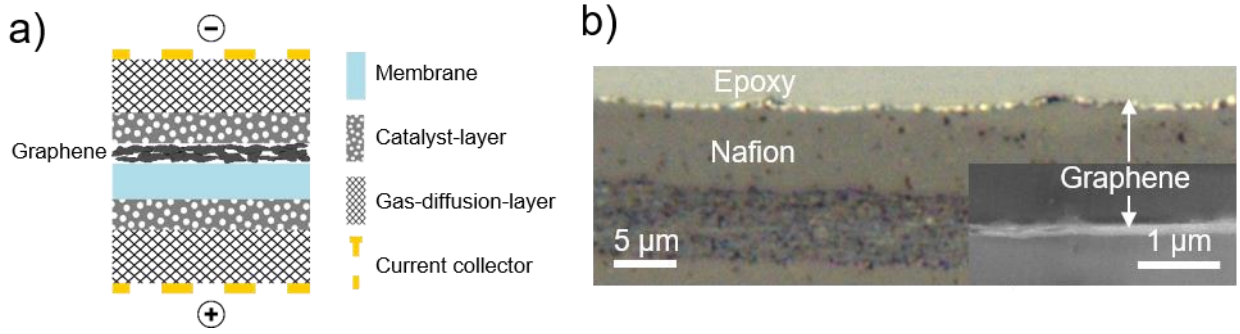

Figure 1: (a) Schematic of graphene-enhanced MEA. (b) Optical micrograph of graphene coated Nafion® membrane cross-section. Inset: STEM-ADF image of interface region.