





**D**isruptive pemfc stack with n**O**vel materia**L**s, **P**rocesses, arc**H**itecture and optimized **IN**terfaces

# Graphene coated membrane to improve performance and durability

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# What is Graphene?

European Commission

- First isolated at the University of Manchester in 2004. Nobel Prize in Physics in 2010.
- Graphene, is impermeable in the perpendicular direction to its basal plane to all atoms and molecules at ambient conditions. In contrast, the transport of thermal protons through defect-free graphene is comparatively fast.
- The rationale for using graphene in proton transport membranes is to exploit its impermeability to all atoms and molecules to increase durability, reduce gas crossover, amongst other benefits; but without decreasing its proton conductivity.



#### Graphene coated membrane



### Overview





Thin (<10 μm) or beyond PFSA membrane (CHEM) with SLG coating (UoM)

Graphene coated membrane



### Gas Permeation Tests





**Gas transport through graphene-based membranes.** Leak rate of helium through various membranes as a function of pressure. Adding single-layer graphene to the reference membrane leads to a decrease in the permeability by a factor of approximately 2 as compared to 'bare' reference. Membrane area <1 cm<sup>2</sup>.





## Introduction of Defects





**Characterisation of the defective graphene membranes**. (a) IV characteristics of graphene (in black) and defective graphene (in blue). The upper inset shows a sketch of the experimental set-up. The devices measured consist of a graphene membrane suspended over an aperture that is 2  $\mu$ m in diameter. The introduction of defects has led to an increase of over a factor of 10 in proton conductivity. (b) Areal conductivity of both the graphene and defective graphene. For reference, the setup with no graphene has a proton conductivity of ~160 S/cm<sup>2</sup>. (c) Raman characterisation of the samples showing a clear presence of the disorder-induced D peak in the defective graphene membrane.

#### Graphene coated membrane







- CEA currently testing the defective graphene.
- Trying to improve transfer of membrane onto electrode.
- Initially concerned that in this process, the graphene is being destroyed. Further optimisation required.

Graphene coated membrane





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- Graphene is a one-atom-thick material that can be used in fuel cell membranes.
- Coating the membrane with graphene has been shown to reduce gas permeation.
- Introducing defects leads to an increase in proton conductivity.
- Continue to work on testing the defective graphene and optimise this process.

Graphene coated membrane





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