INFRARED SPECTROSCOPY STUDY ON SELF-STANDING FUNCTIONALIZED GRAPHENE OXIDE MEMBRANES TO BE USED AS NOVEL PROTON CONDUCTORS IN PEM FUEL CELLS

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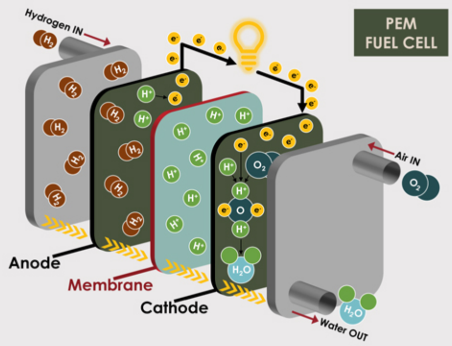
INTRODUCTION

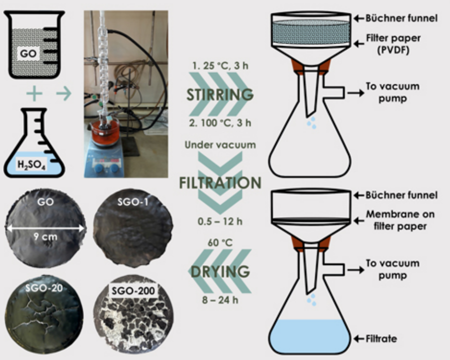
A fuel cell **membrane** separates anode and cathode, serving as **electrolyte**. Therefore, it has to exhibit a rigorous set of properties, in the case of proton exchange membrane fuel cells [1,2]: high protonic conductivity; low permeability to H_2 and O_2 gases; electrical insulation; chemical, mechanical and thermal stability.



As shown in previous works, graphene oxide (GO) appears an excellent candidate for the production of both **FREESTANDING** [3] and hybrid membranes [4], thanks to its good mechanical properties and to the presence of oxygenated functionalities that are likely to improve water retention. Its properties may also be enhanced by functionalization with some acid groups more tightly bound to its skeleton, e.g. sulfonic acid groups ($-SO_3H$) analogous to those of Nafion. Hence, this work presents an effective method for the manufacturing of **SULFONATED GRAPHENE OXIDE (SGO)** membranes, evaluated as a viable alternative to Nafion for operation at low relative humidity and high temperature.

MEMBRANES PREPARATION

A reported recipe [5] has been enhanced by testing **3** different **molar sulfonation ratios** (sulfuric acid/GO = 1; 20; 200). They have been identified by making use of an **empirical formula**, which has been derived from the elemental analysis of the commercial GO dispersion (4 g L^{-1}, supplied by Graphenea Inc.): $C_{1.5}H_{0.2}N_{0.01}S_{0.03}O$.

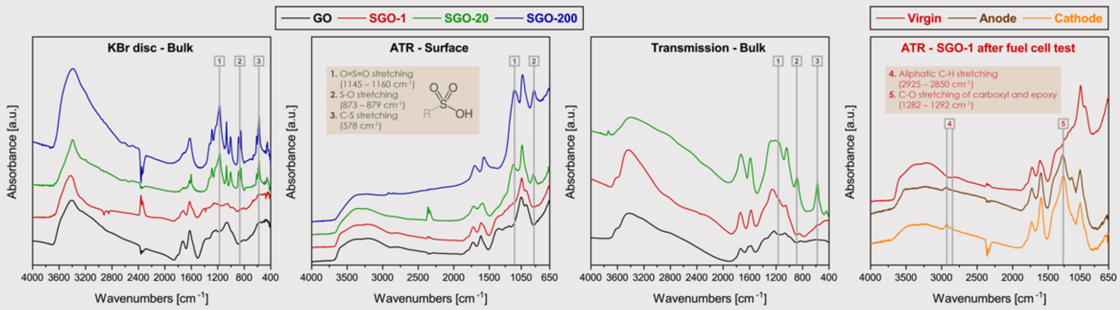


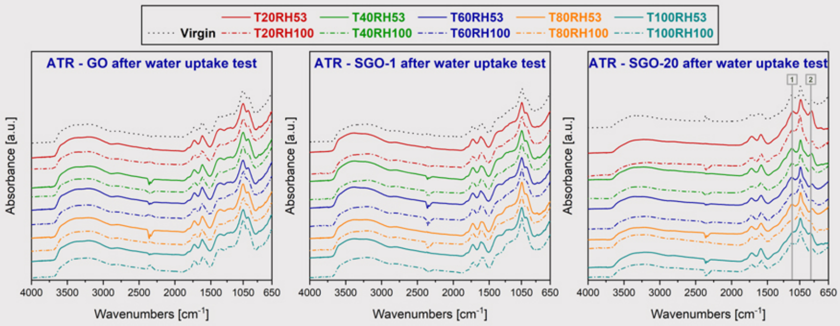
REFERENCES

[1] F. Barbir, PEM Fuel Cells: Theory and Practice, 2nd Ed., *Academic Press*, 2013
[2] Q. Li et al, *Chem. Mater.*, 15, 4896 (2003)
[3] T. Bayer et al, *J. Power Sources*, 272, 239 (2014)
[4] M. Vinothkannan et al, *Rsc Adv.*, 8, 7494 (2018)
[5] T. Cheng et al, *Ionics*, 23, 2143 (2017)
[6] M. Kumari et al, *J. Power Sources*, 398, 137 (2018)

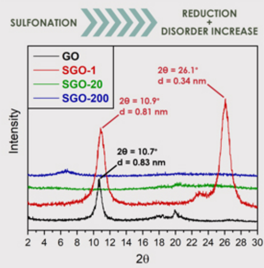
MEMBRANES CHARACTERIZATION

FOURIER-TRANSFORM INFRARED SPECTROSCOPY

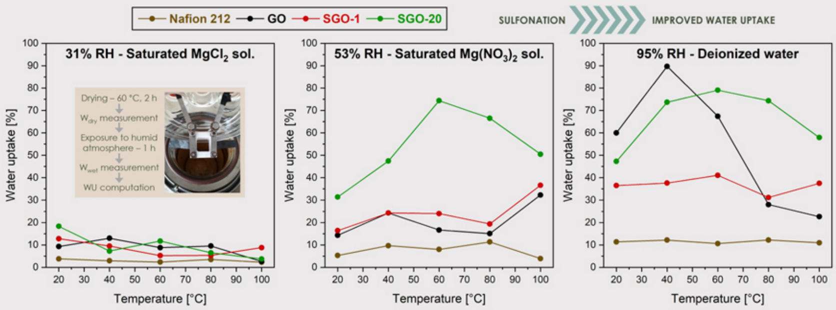




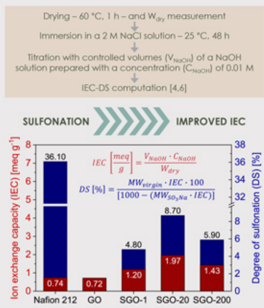
X-RAY DIFFRACTION



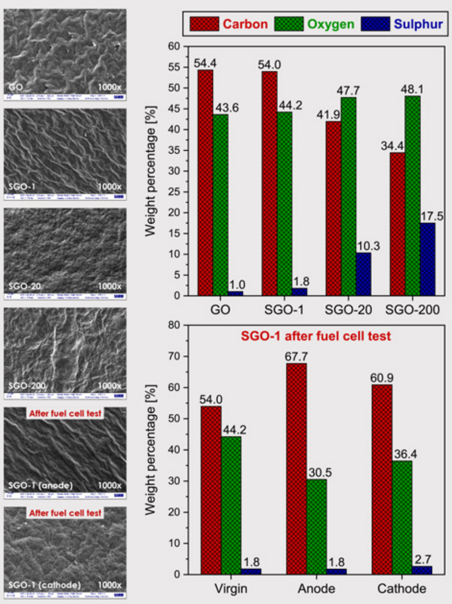
WATER UPTAKE BEHAVIOR



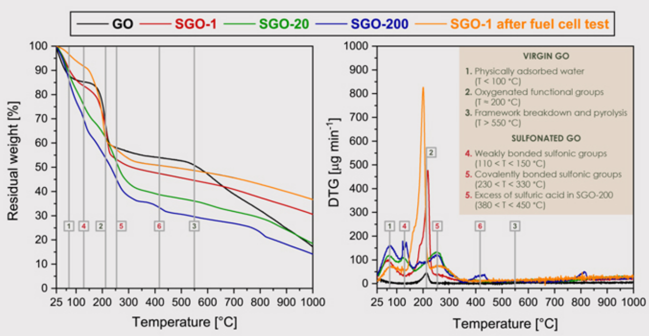
IEC-DS EVALUATION



SEM-EDX SPECTROSCOPY



THERMOGRAVIMETRY



CONCLUSION

- Functionalization seems stable after water uptake tests up to 60 °C
- Improvement in both water uptake behavior, at low T and RH, and in the ion exchange capacity, as against pristine GO and Nafion 212
- Promising resistance to compression inside the fuel cell
- Basal plane reduction and increase in the structural disorder of SGO membranes owing to both functionalization process and fuel cell test
- Low open circuit voltage (0.63 V at 40 °C) due to H_2 crossover issues

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