Borate-Reinforced Sulfonated Graphene Oxide Membranes as an Alternative Proton Conductor for PEM Fuel Cells

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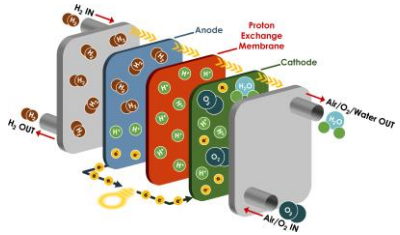
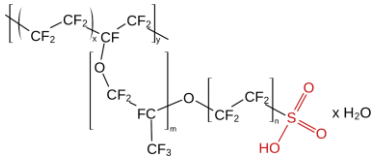
Introduction and aim of the work



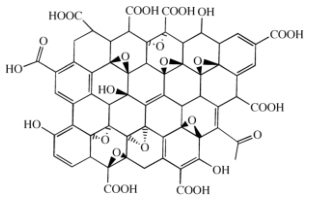
NAFION®

x = 6 – 10 y = 1000 m = 1 n = 2

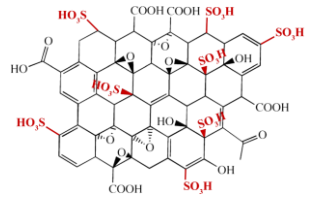


Low Humidity (< 50%)
- Better water management
- No saturators needed
- Smaller, simpler, cheaper design

GRAPHENE OXIDE (GO)



SULFONATION



FROM NAFION TO FUNCTIONALIZED GO

- low-T operating range (60 – 80 °C)
- negligible pollutant emissions
- compact/modular design
- no moving parts
- high efficiency

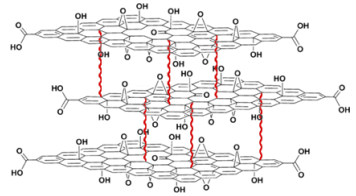
- σ > 0.1 S cm^{-1} at 100% humidity
- Durability > 60000 h
- Low gas crossover

low T_g (110 °C) ●
expensive (0.25 € cm^{-2}) ●
σ < 0.001 S cm^{-1} at 0% humidity ●

High Temperature (80 – 120 °C)
- Faster reaction kinetics
- Easier heat removal
- Lower activation polarization
- Greater tolerance to CO impurities

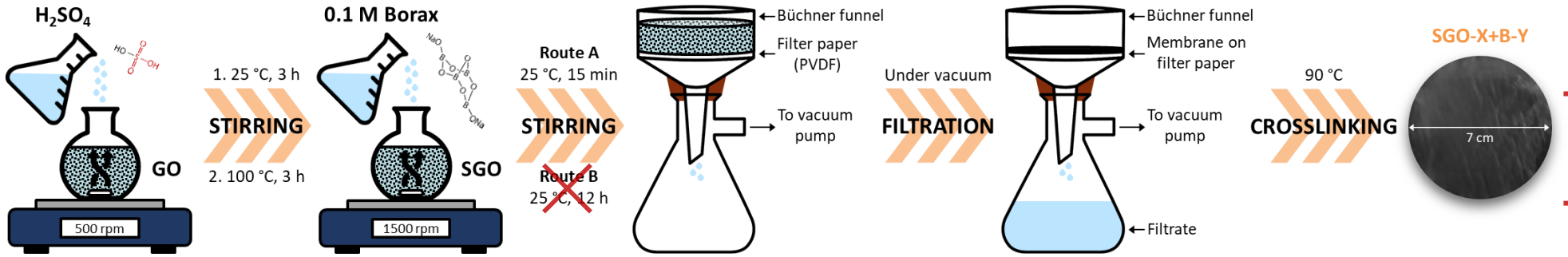
- Self-assembling, large surface area
- Hydrophilic oxygenated moieties
- Better gas crossover resistance
- Electrical insulator

Unsatisfactory durability ●
σ < 0.001 S cm^{-1} at 100% RH ●



CROSSLINKING

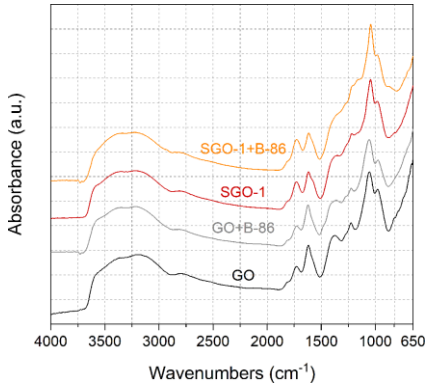
Materials and methods



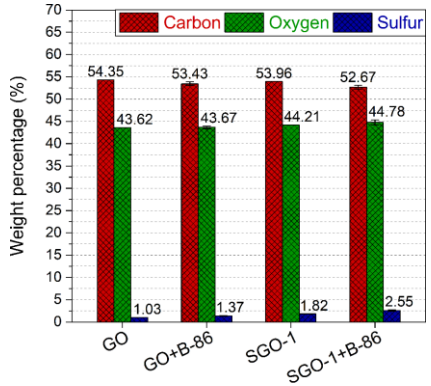
Sample	X = n_{ACID}:n_{GO}	Y = n_{GO}:n_B
GO	-	-
~~GO+B-8.6~~	~~-~~	~~8.6:1~~
GO+B-86	-	86:1
SGO-1	1	-
~~SGO-1+B-8.6~~	~~1~~	~~8.6:1~~
SGO-1+B-86	1	86:1

Results and discussion

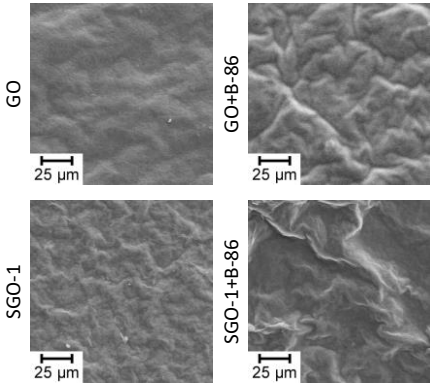
ATR-FTIR



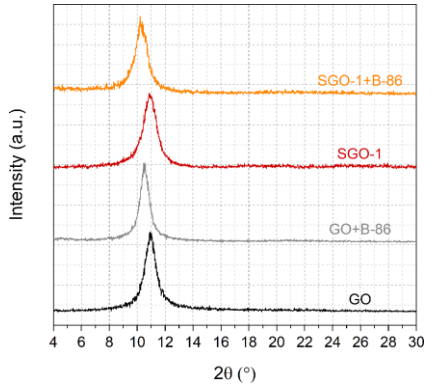
EDX SPECTROSCOPY



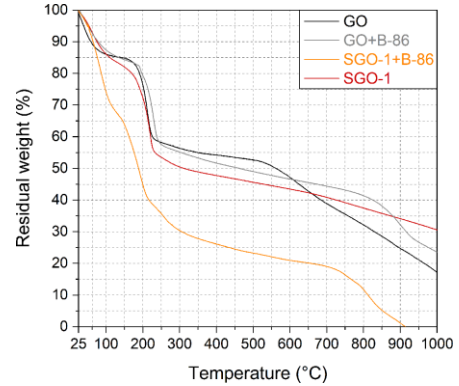
SEM



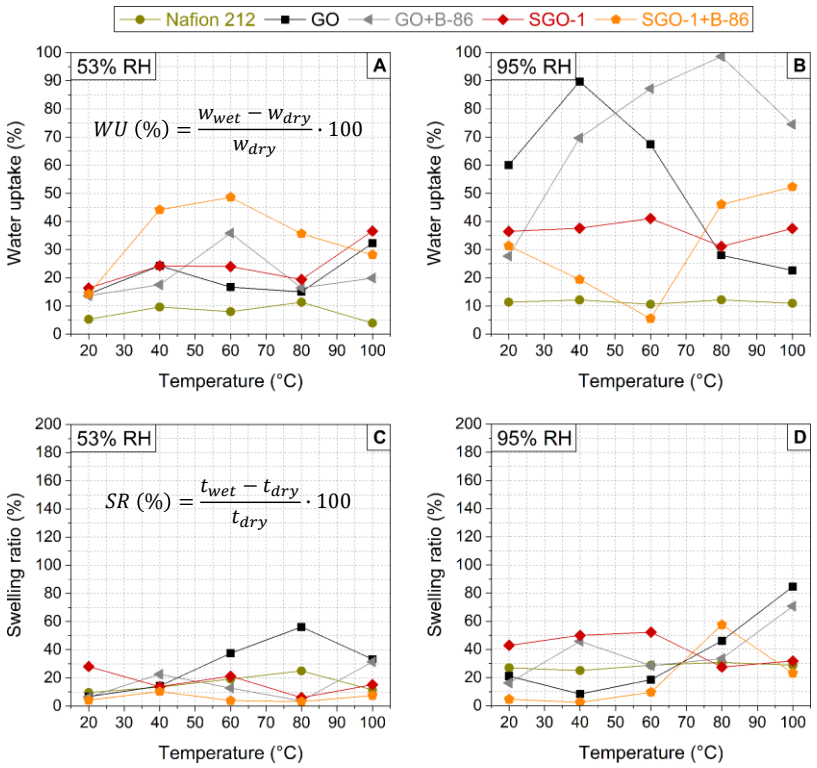
X-RAY DIFFRACTION



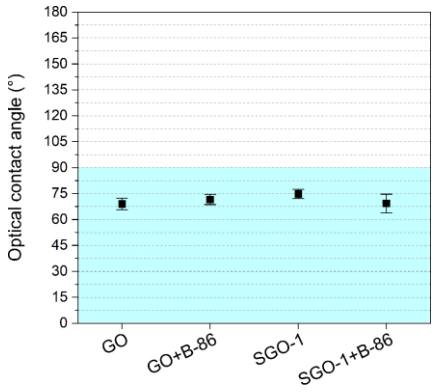
THERMOGRAVIMETRY



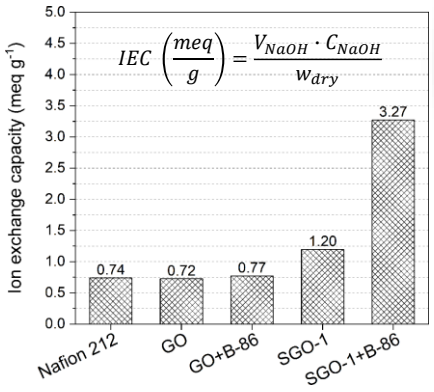
WATER UPTAKE



STATIC CONTACT ANGLE



ION EXCHANGE CAPACITY



- Improved sulfonation efficacy
- Higher ion exchange capacity
- Larger interplanar distance
- Better water uptake at 53% RH
- Lower membrane swelling

Conclusion and future developments

- Crosslinking by **sodium tetraborate decahydrate** improves **ion exchange** and **low humidity** behavior
- Preliminary **OCV** assessment: **0.64 V** for **SGO-1+B-86**, **0.63 V** for **SGO-1**, **0.24 V** for **GO**
- Study of different **GO-to-B** and **acid-to-GO** ratios to identify optimal composition
- Implementation of **plasticizing** agents to reduce **brittleness** issues

MAT4EN2
MATERIALS FOR ENERGY AND ENVIRONMENT

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