Improved Nitrogen Containing Graphitic Material (NCGM) Membrane Fabrication for the Production of Effective Large-Area Membrane

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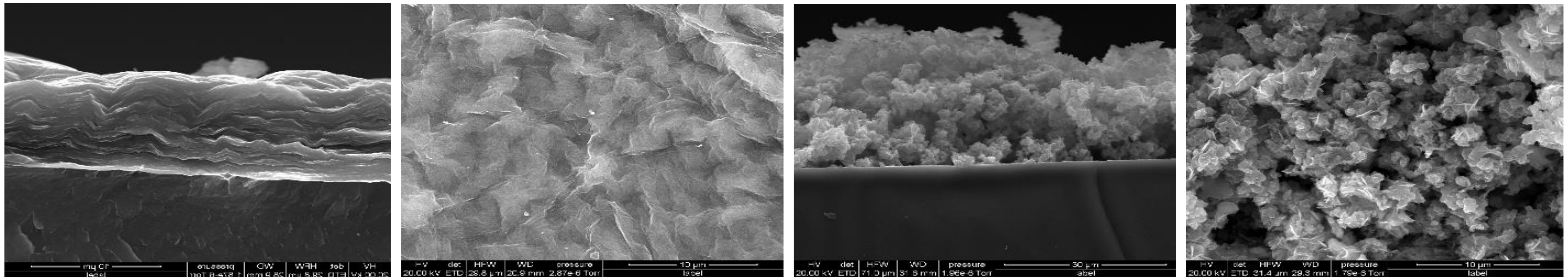
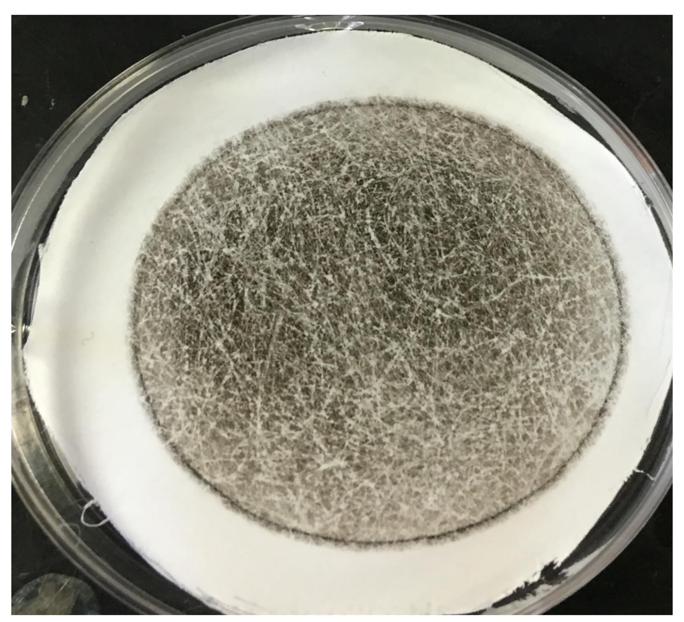
Abstract:

Recent advancements in synthetic chemistry have brought about the possibility of creating custom nanopore materials. Graphene systems are highly ordered 2-dimensional crystals with a distinct pore size in their structure. With the introduction of nitrogen into the graphene structure, the nanopores can now be lined with nitrogen atoms that are more chemically reactive with another species. These nitrogen containing graphitic materials (NCGM) are unlike normal graphene material in that, through chemical modifications, the pore size can be changed to fit a specific function.

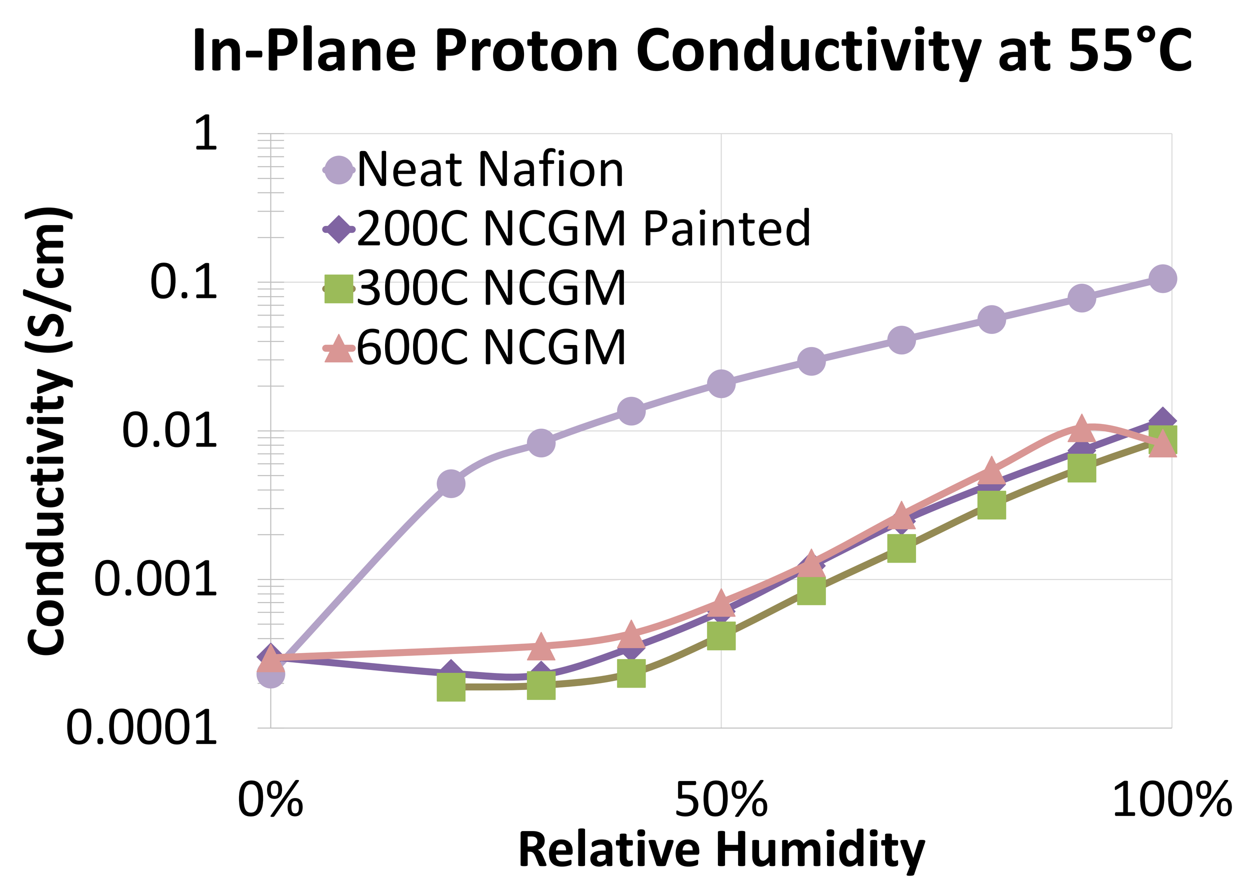
The goal of this project was to determine an appropriate method to fabricate large-area membranes from a synthesized NCGM. Multiple fabrication techniques were attempted on various membrane supports. The fabricated membranes were analyzed for in-plane proton conductivity using a Scribner Associates Inc. 850e fuel cell system and a BT-112 membrane conductivity cell, also from Scribner Associates Inc. The membranes were further analyzed using Scanning Electron Microscopy (SEM). Research is ongoing on both NCGM synthesis and membrane fabrication/analysis techniques.



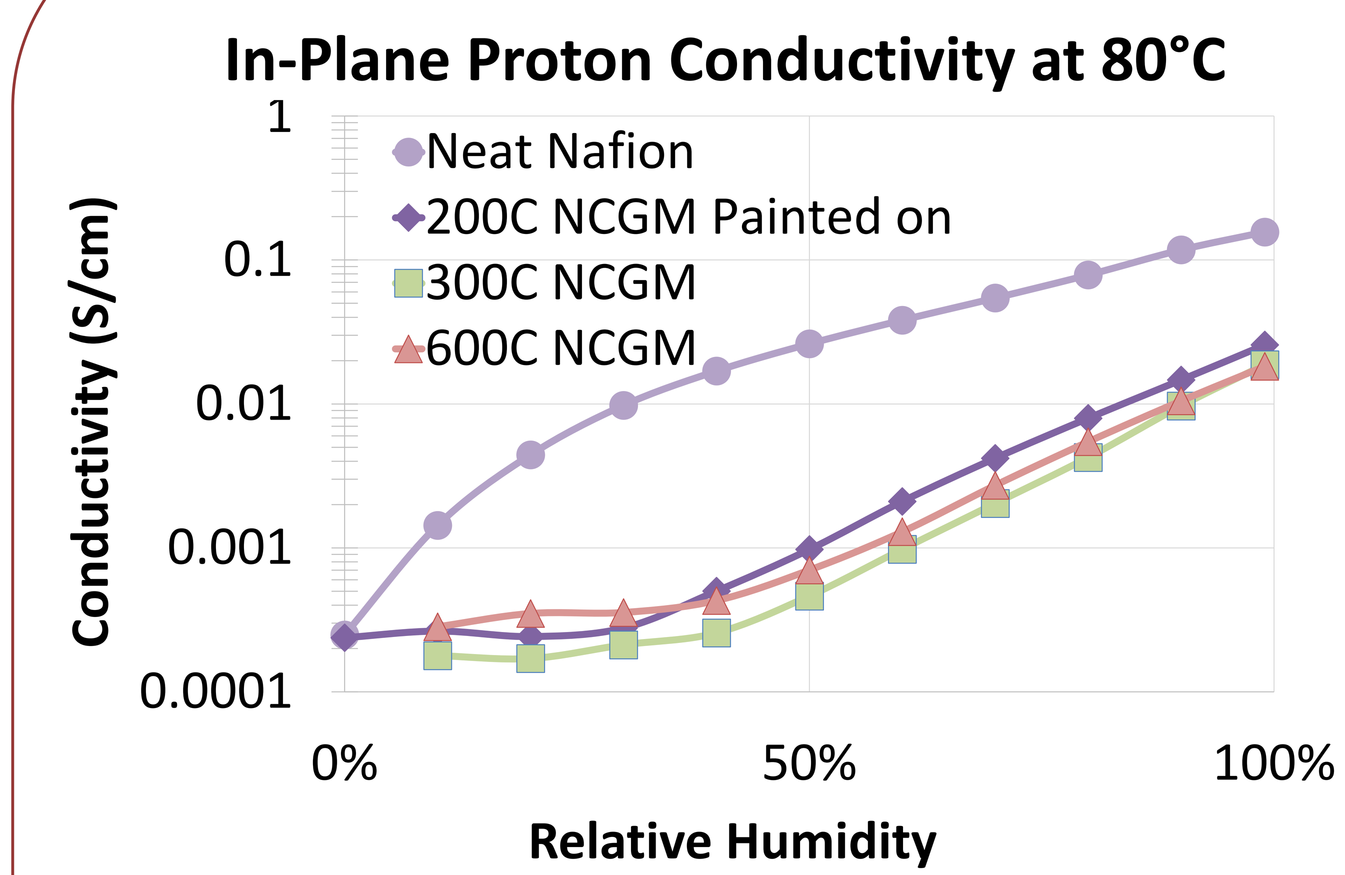
SEM images from Left to Right: side view of GO on Nafion, 10 micron scale; top view of GO on Nafion, 10 micron scale; side view of 300°C NCGM on Nafion, 30 micron scale; top view of 300°C NCGM on Nafion, 10 micron scale (unpublished data from Li Lab).



NCGM Annealed at 200°C on Nylon-66 membrane. Formed from vacuum filtration of 100 mL of 12 μg/mL solution (unpublished data from Li Lab).



Measured proton conductivity of NCGM on Nafion annealed at 200°C, 300°C, and 600°C, compared to neat Nafion (unpublished data from Li Lab).



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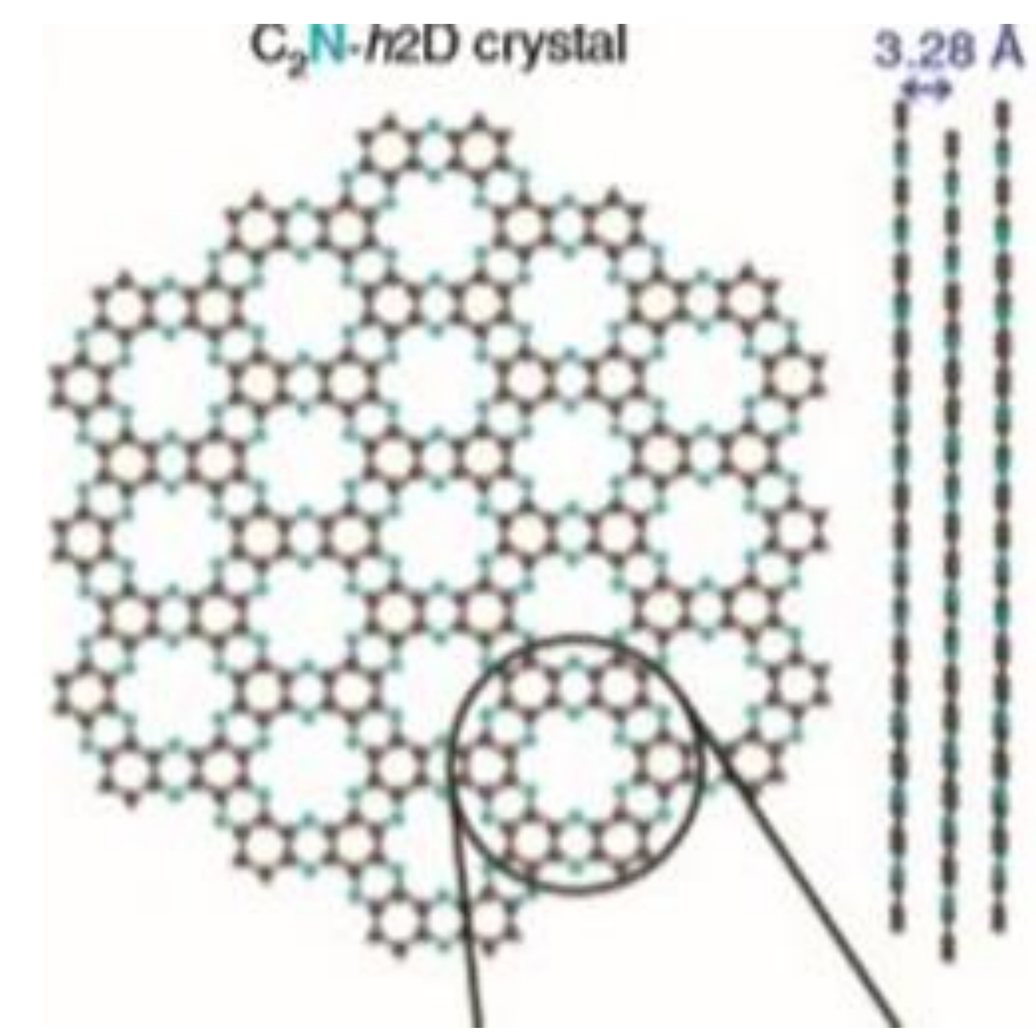
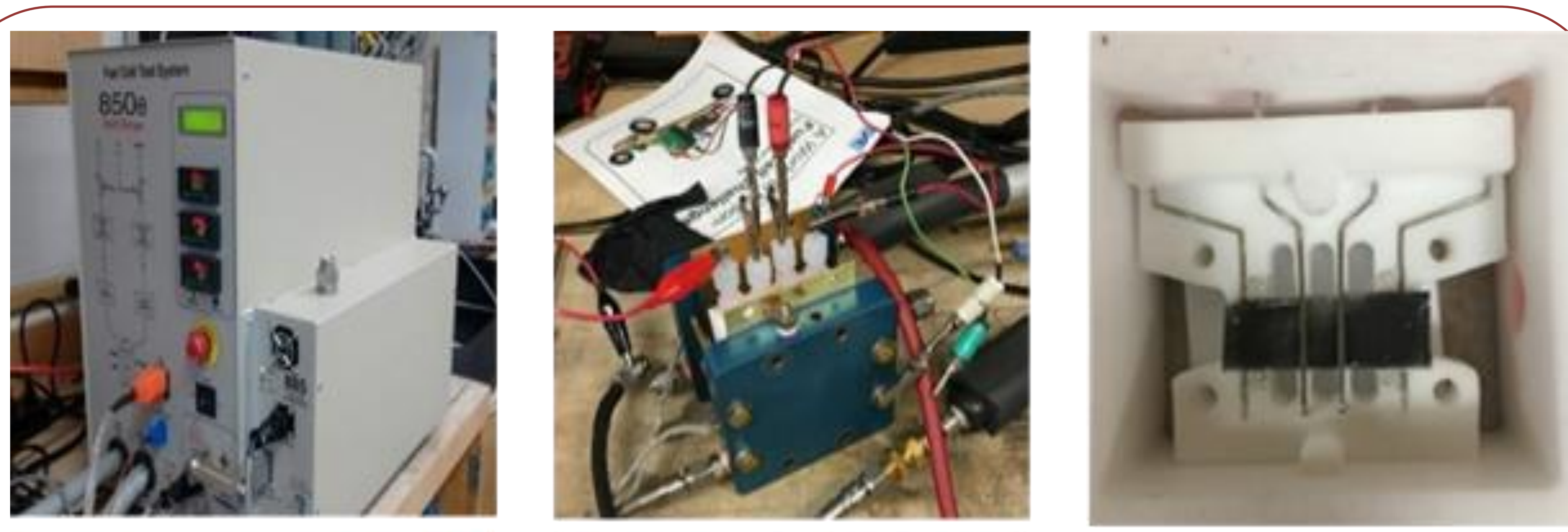


Structural representation of NCGM

Javeed M. et al. 2014. Nature Communications.



Scribner Associates Inc. 850e Fuel cell system, Assembled BT-112 conductivity cell, and inside view of BT-112 conductivity cell with NCGM coated Nafion 212.

Results:

- NCGM significantly reduced in-plane proton conductivity vs. neat Nafion;
- The most feasible membrane fabrication technique proved to be vacuum filtration of a 10mM NaOH solution used to suspend the NCGM particles;
- Research must be continued to produce uniform, consistent NCGM material
- Nafion NR-212 served as the only membrane support for in-plane proton conductivity but Track-Etched Polycarbonate (TEPC) proved better for membrane fabrication and through-plane ion-conductivity;

Problems Encountered/ Future Work:

- Only through-plane ion-conductivity (not in-plane) could prove the existence of the adjustable nanopores;
- A consistent NCGM synthesis technique was not developed during the life of this undergraduate research project and continues to be a subject of research.

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