Highly Durable, Low-Cost Membrane Electrode Assemblies for Maritime Fuel Cell Applications

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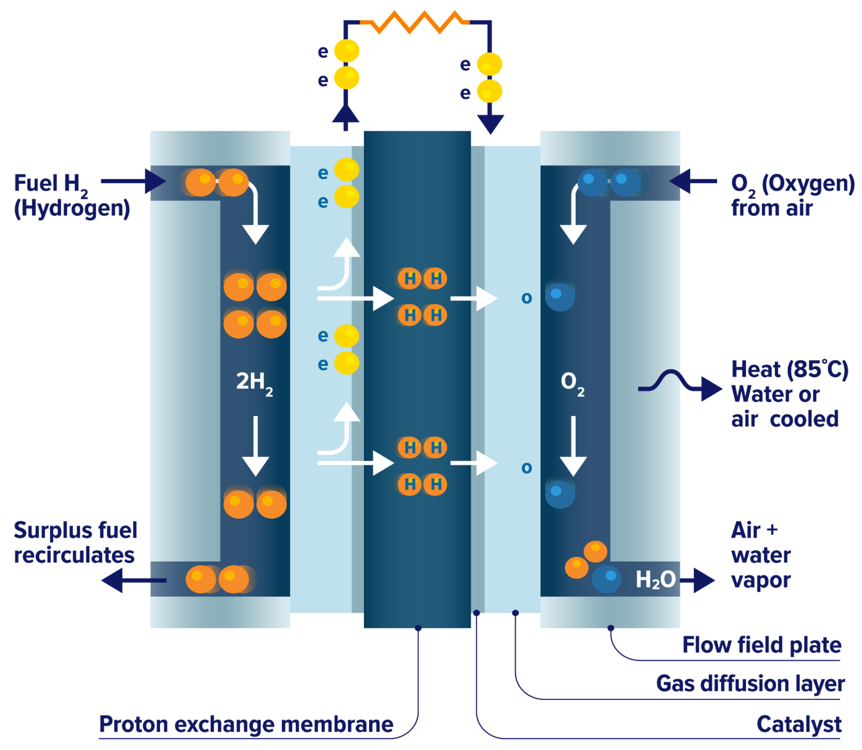
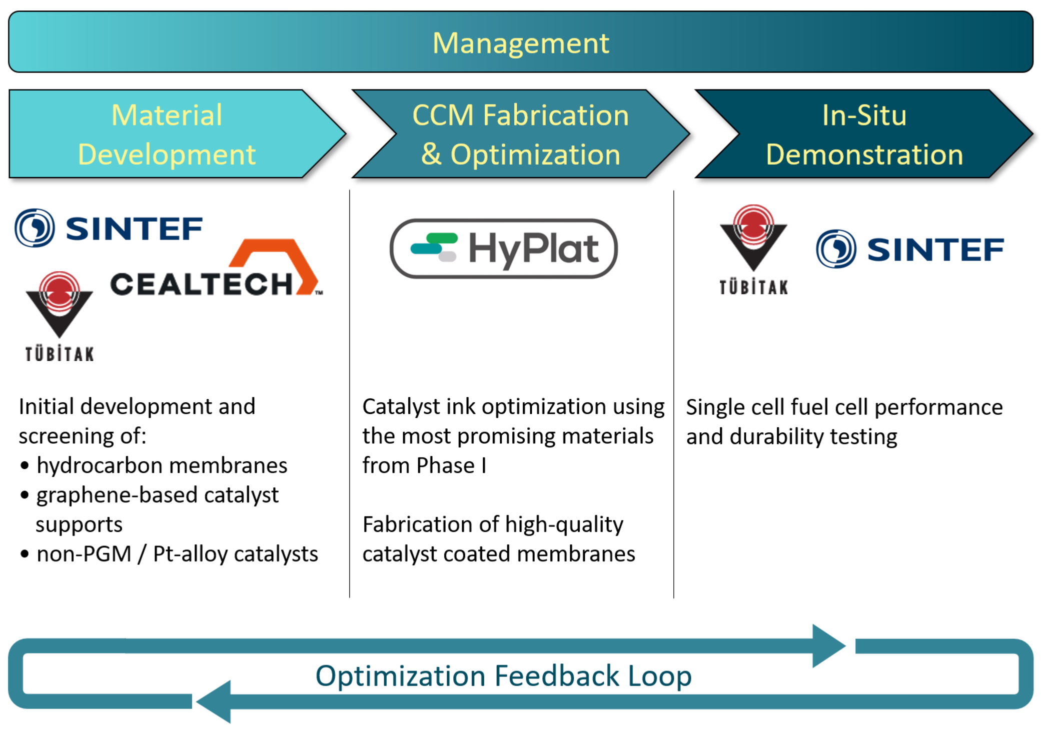
Motivation

- Maritime transport sector produces 2.5% of the total global greenhouse gas emissions
- Proton exchange membrane fuel cells (PEMFCs) could enable zero-emission maritime transport
- Current PEMFC components limited by performance, durability, and cost



Workplan

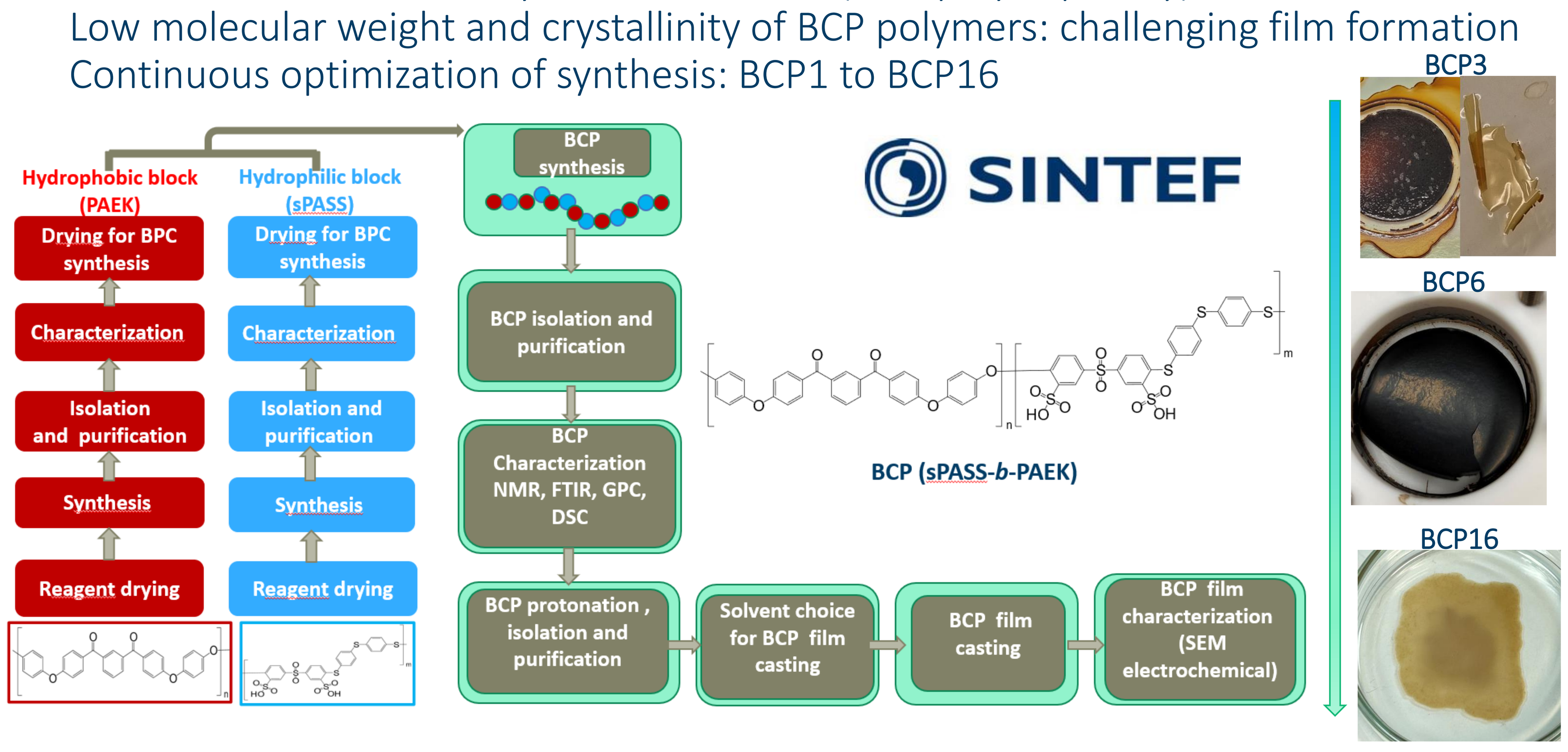


Main Objectives:

- Develop new fuel cell components with reduced cost and increased durability compared to commercial standards
- Demonstrate single-cell PEMFC performance and durability
- Targeting 1.2 W/cm² at a cell potential of 0.65 V with a total PGM loading < 0.3 g/kW

Hydrocarbon Proton Exchange Membranes

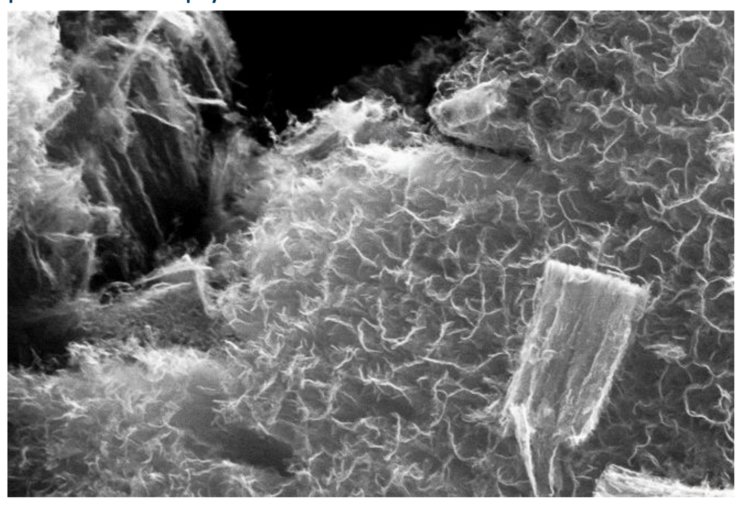
- Good control over block synthesis outcome (Mw, polydispersity)
- Low molecular weight and crystallinity of BCP polymers: challenging film formation
- Continuous optimization of synthesis: BCP1 to BCP16

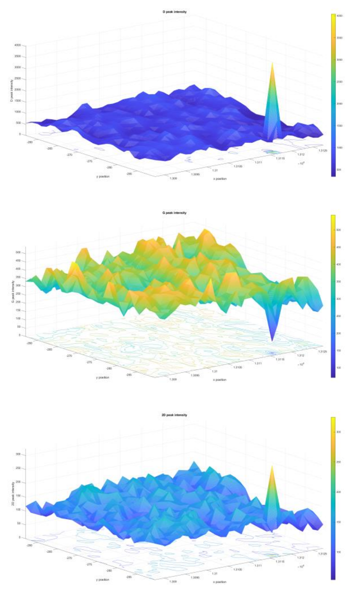


Durable Graphene Catalyst Supports

- High quality graphene produced at large scale with CealTech's FORZA™ plasma-enhanced chemical vapor deposition (PE-CVD) reactor
- Material characterization using through scanning electron microscopy and Raman spectroscopy

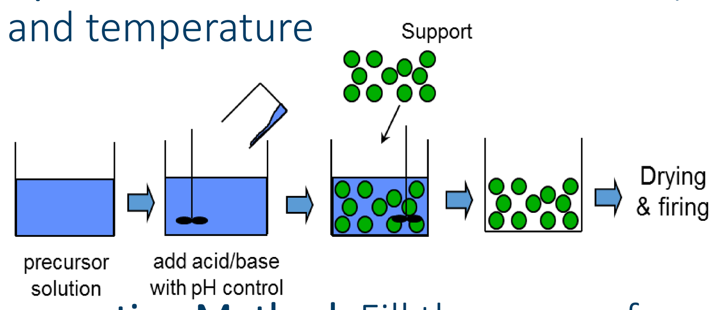

Graphene production reactor


SEM of CealTech graphene

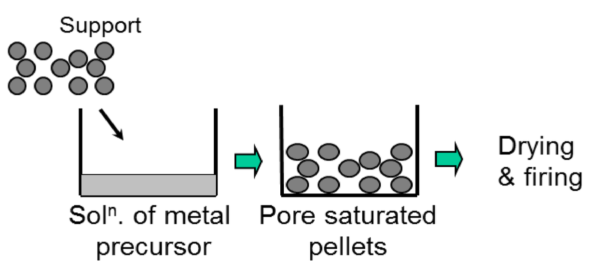

Spatially resolved Raman spectra

Non-PGM & Pt-Alloy Catalysts

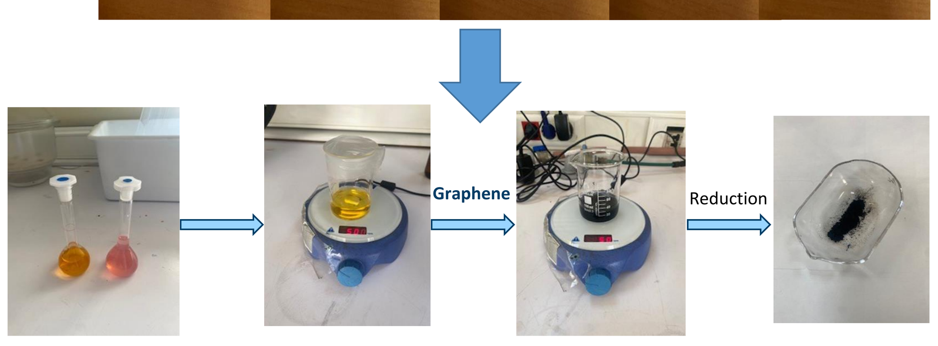
Precipitation Method: Form non-soluble precipitate by desired reactions at certain pH and temperature



Impregnation Method: Fill the pores of support with a metal salt solution of sufficient concentration to give the correct loading.



Graphene Samples Received from CealTech



PtCo/G

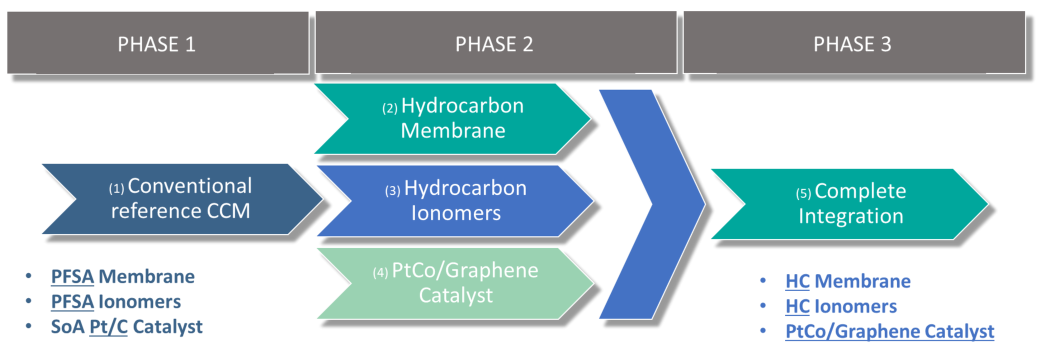
Catalyst Coated Membrane Fabrication

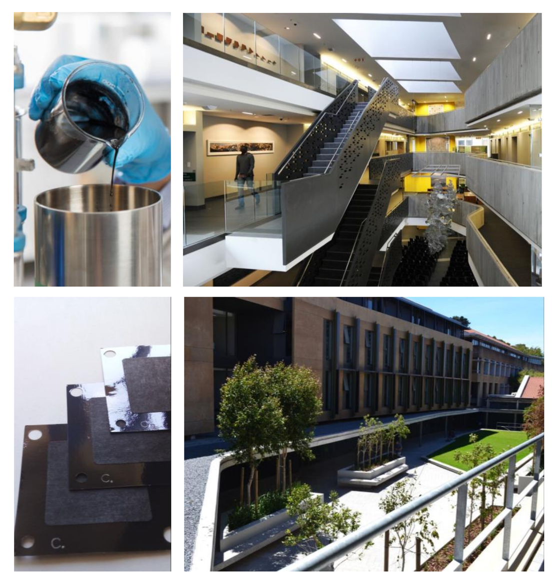
OBJECTIVE

Develop optimized catalyst ink formulations based on the next-generation polymer and catalyst materials, developed within LOCOMOTION, for the preparation of high-quality membrane electrode assemblies (MEA).

APPROACH

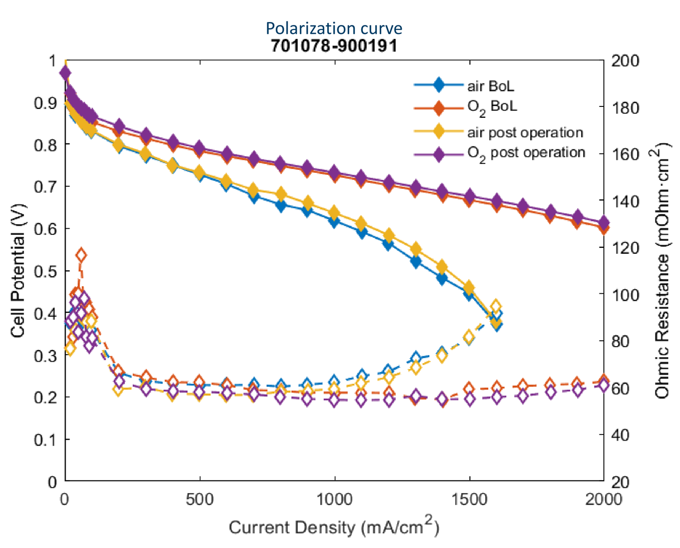
Systematic In-situ Subcomponent Qualification

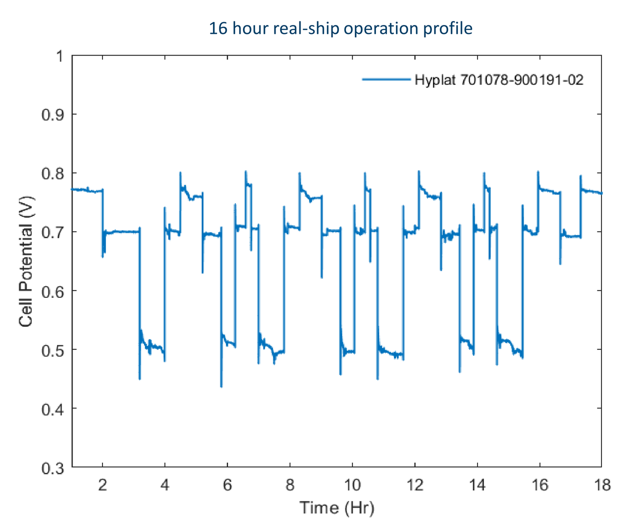


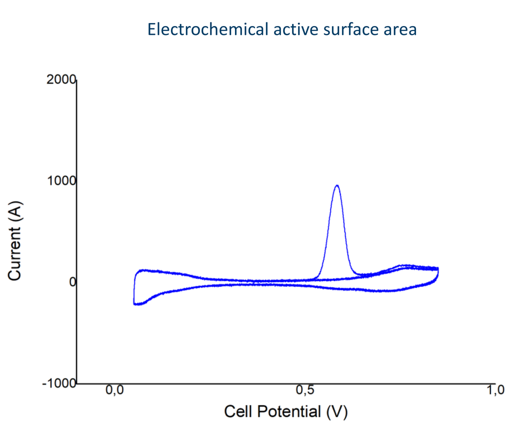


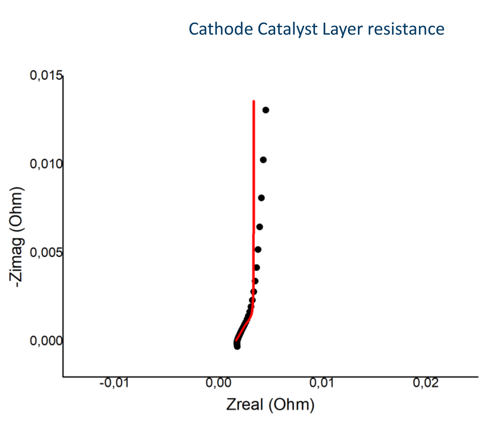
Fuel Cell Performance & Durability Testing

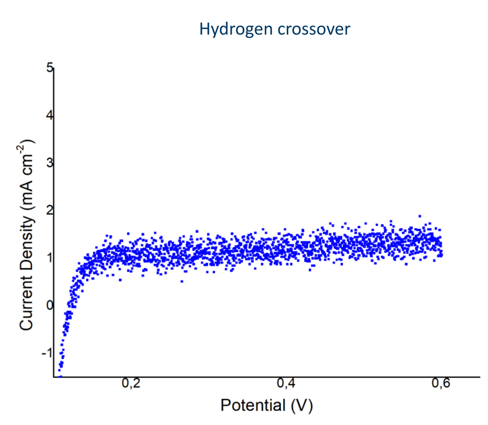
- Polarisation curves collected before and after 16-hour dynamic ship operation cycle
- Various in-situ electrochemical analysis including hydrogen crossover, cathode catalyst layer resistance, and electrochemically active surface area analysis are conducted to deconvolute the degradation mechanisms across the different fuel cell components











Conclusions

- International, multidisciplinary consortium with partners from Norway, Turkey, and South Africa
- Initial graphene support screening completed
- Graphene candidate has been successfully produced at larger scale
- Successful demonstration of PtCo nanoparticle deposition on graphene support
- Scale up of PtCo/graphene in progress
- Hydrocarbon block copolymer synthetic route has been identified and have demonstrated good control over the hydrophobic and hydrophilic block synthesis
- Hydrocarbon block copolymer coupling reaction is being optimized
- High quality catalyst coated membranes produced using commercial components
- Fuel cell testing protocols have been identified
- A representative maritime drive cycle has been selected, using real-life ship data provided by our advisory board members

Acknowledgements

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