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PhD funded by Department for the Economy

Compression-Moulded PMMA/Expanded Graphite Composites: A Scalable Approach for Manufacturing Redox Flow Battery Cell Architectures

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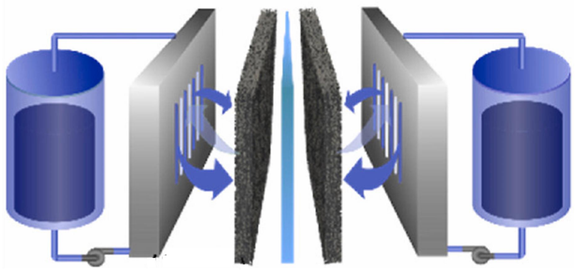
Introduction: Redox flow battery (RFB)

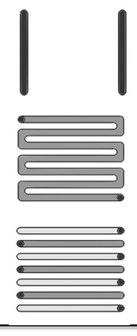
- Promising energy storage devices that pumps liquid electrolyte through an electrochemical cell
  - ☒ Poor manufacturability (e.g., flow fields)
  - ☒ Difficult to assemble and dissemble
  - ☒ High electrical contact resistances

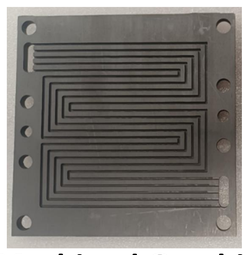
Solution: Conductive cell architectures fabricated by compression moulding of polymethyl methacrylate (PMMA) / expanded graphite composite material



RFB Schematic [1]

Flow Field Geometries [1]

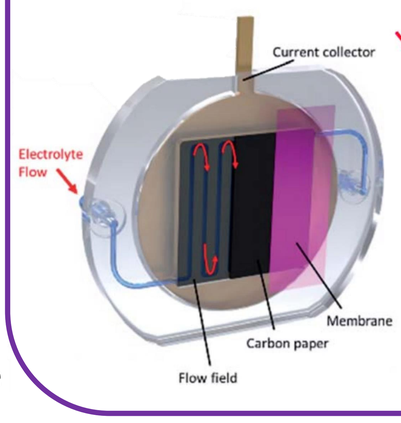


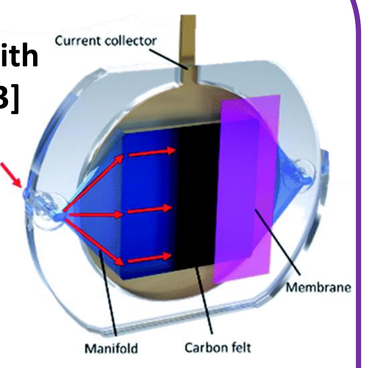


Machined Graphite Flow Field [2]

Electrochemical Cell Designs

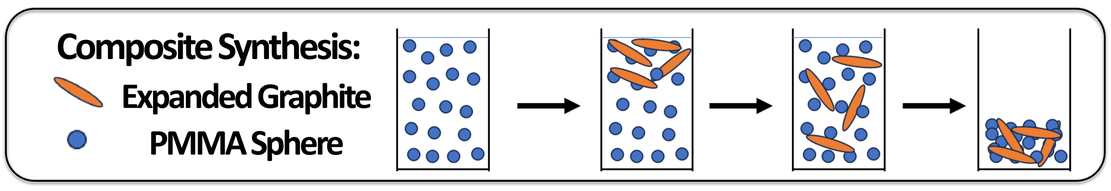
Flow-through Cell with Porous Electrode [3]

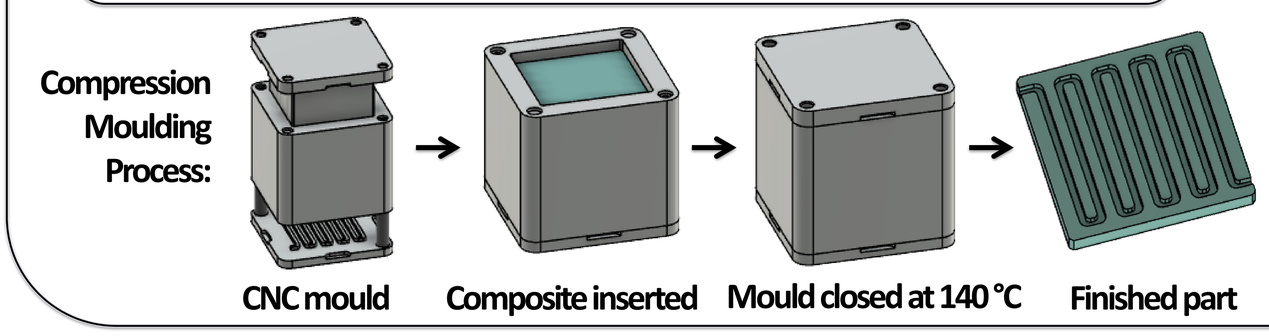




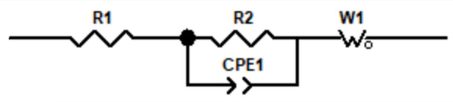
Flow-over Cell with Flow Field and Paper Electrode [3]

Composite Synthesis, Moulding, and Electrochemical Characterisation



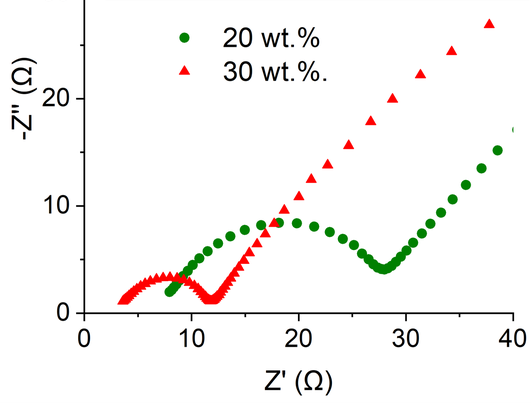


EIS Model Circuit



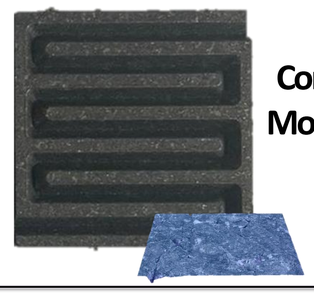
Nyquist Plot

	R1 (Ω)	R2 (Ω)
20 wt.%	6.41	24.55
30 wt.%	2.79	9.87



Electrochemical Impedance Spectroscopy (EIS)

- Composite moulded into cylinders and electrochemically tested
- 30 wt.% expanded graphite composite has lowest material (R1) and charge transfer resistance (R2)

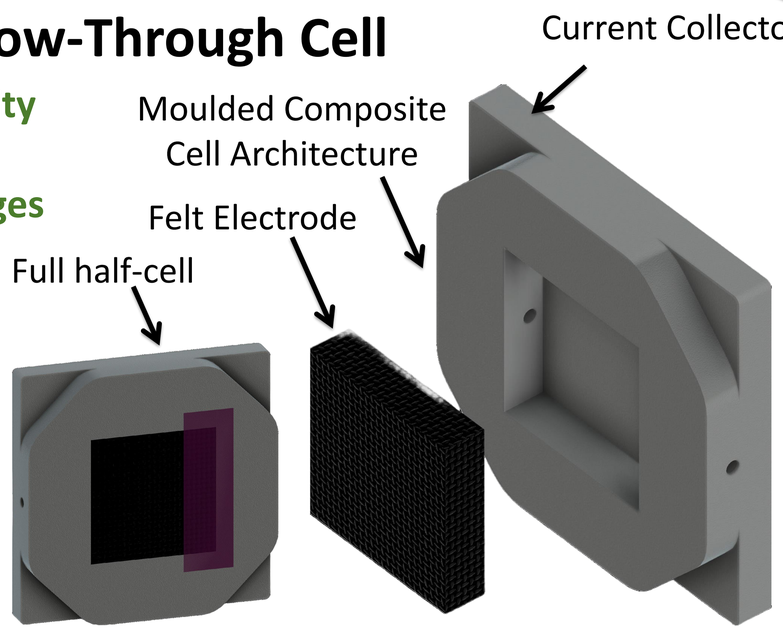


Compression Moulded Flow Field

Compression Moulded Flow-Through Cell

- ✓ Cells have a high manufacturability
- ✓ Easy to assemble and dissemble
- ✓ Successfully charges and discharges vanadium electrolyte

Compression Moulded Cell Charging Vanadium Electrolyte



Conclusions

- Shapeable, electrically conductive, electrochemically active polymer composites were developed
- Composites were shaped into RFB components with high manufacturability
- The compression moulded cell was able to charge and discharge vanadium electrolyte
- **Future work** will investigate high-capacity fade observed

References

[1] Muñoz-Perales, V., García-Salaberri, P. Á., Mularczyk, A., Enrique Ibáñez, S., Vera, M., & Forner-Cuenca, A. (2023). Investigating the coupled influence of flow fields and porous electrodes on redox flow battery performance. *Journal of Power Sources*.

[2] Gurau, V., & Kent, R. (2022). Robotic Manufacturing System for Unattended Machining and Inspection of Graphite Bipolar Flow Field Plates for Proton Exchange Membrane Fuel Cells. *Manufacturing Letters*.

[3] O'Connor, H., Bailey, J. J., Istrate, O. M., Klusener, P. A. A., Watson, R., Glover, S., Iacoviello, F., Brett, D. J. L., Shearing, P. R., & Nockemann, P. (2022). An open-source platform for 3D-printed redox flow battery test cells. *Sustainable Energy & Fuels*.