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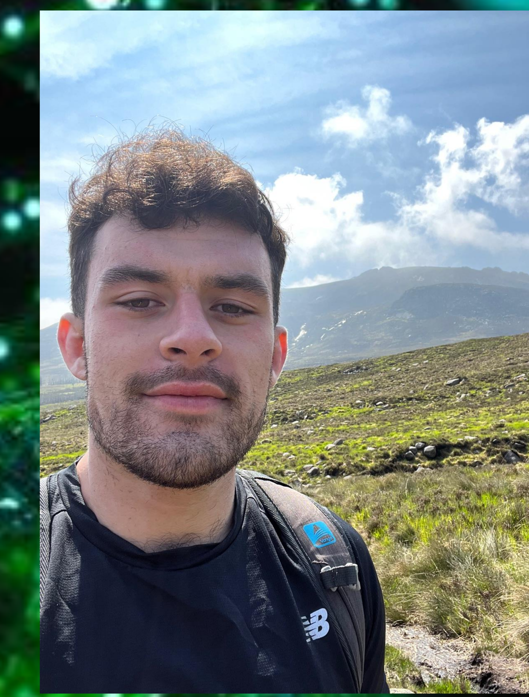

Enhancing Vanadium Redox Flow Battery Performance with Hydrothermally Grown Polyoxometalate Nanoparticles on Graphite Felt

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ABSTRACT This research explores the enhancement of vanadium redox flow batteries through the modification of (graphite felt) GF electrodes with (polyoxometalate) POM nanoparticles, known for their ability to act as catalysts in various electrochemical processes.[1] In this study, GF electrodes were decorated with tetrabutylammonium hexamolybdate nanoparticles hydrothermally for 4 h @ 120ºC. SEM, EDS, contact angle measurements and CV was used to characterise modified GF both physically and electrochemically. This research contributes to ongoing efforts to improve VRFB technology, potentially leading to more cost-effective and efficient large-scale energy storage solutions.

Vanadium Redox Flow Battery

VRFB pump V^{4+}/V^{5+} and V^{2+}/V^{3+} ions through an electrochemical cell that when oxidised and reduced accordingly, allow for the conversion of chemical to electrical energy.[2]

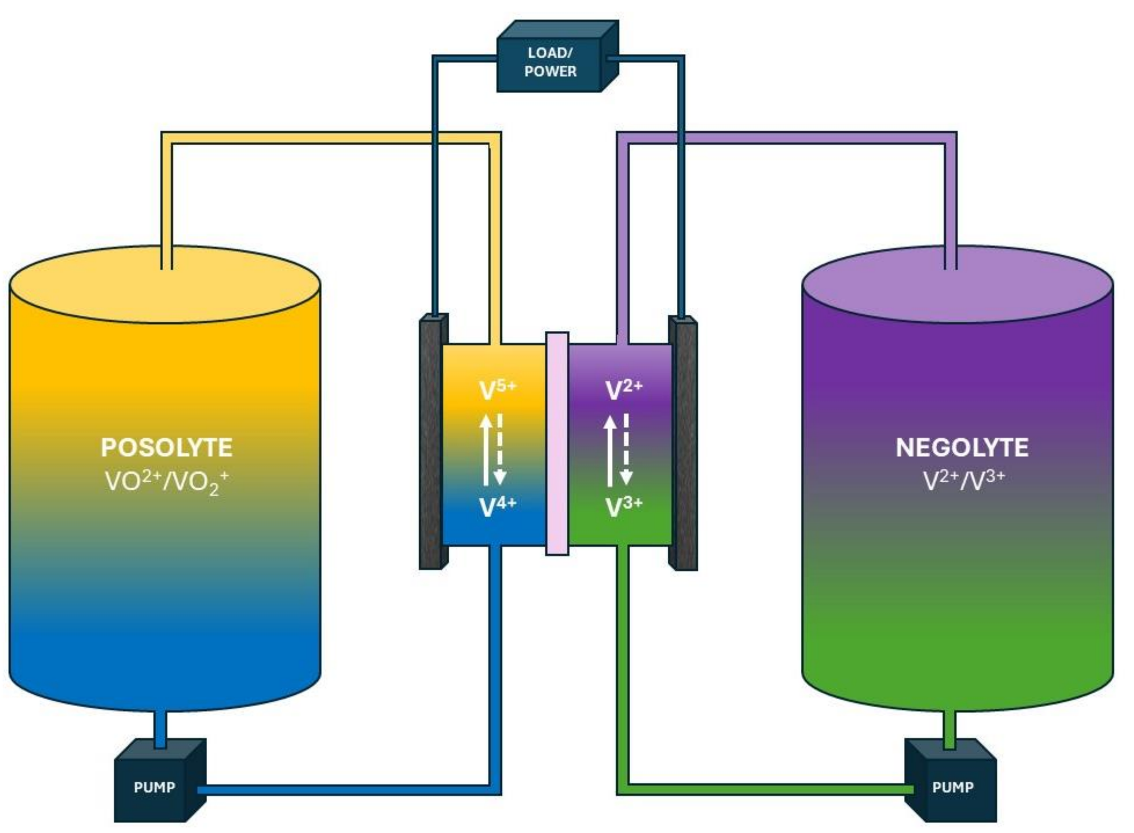


Fig 1. Vanadium redox flow battery

PROS: High safety, decoupled power and energy, mendable cross contamination, high standard cell potential (1.26V).

CONS: High/volatile cost of vanadium, relatively low efficiency, <u>high cost of cell stack.</u>

Electrode

Provides the reaction surface for active species to undergo redox reactions, making it an integral part of RFB functionality.

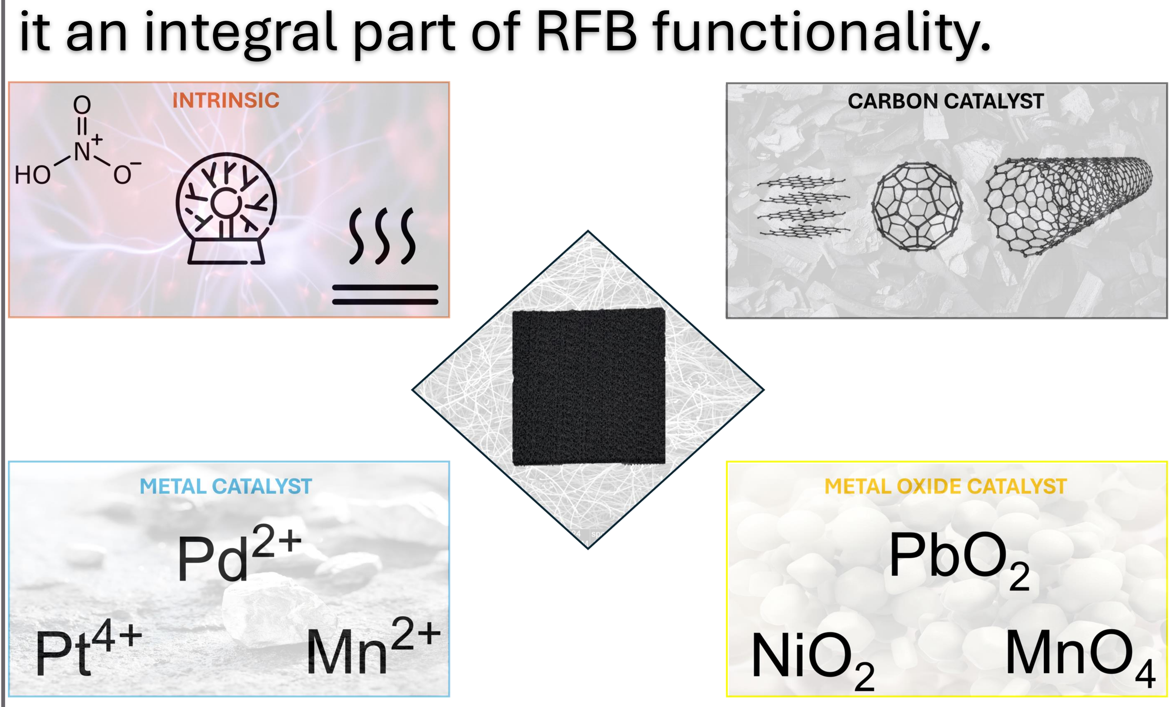


Fig 2. Graphite felt electrode and its various treatment methods

PROS: High conductivity and high chemical stability in acidic media.

CONS: Poor electrochemical activity towards vanadium half reactions caused by hydrophobic nature and lack of active sites.

Hydrothermal Deposition

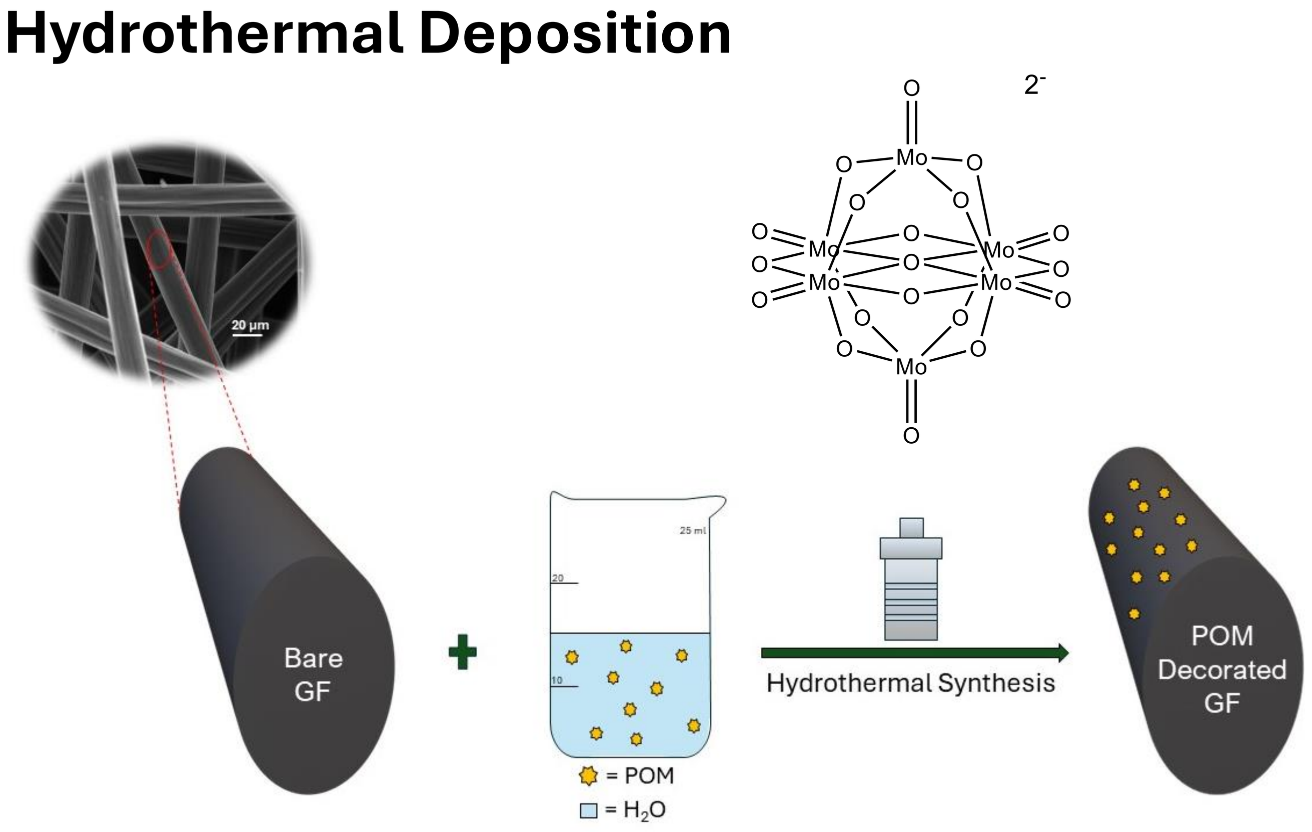


Fig 3. General hydrothermal approach

This study aims to grow $(C_4H_9N_2)_2Mo_6O_{19}$ nanoparticles on GF via hydrothermal deposition. The effects of different treatment parameters and pretreatment methods play a significant role in the loading properties of the desired material.

Concentration Investigation

Sample	A	B	C	D	E
Conc (M)	0.001	0.002	0.003	0.004	n/a

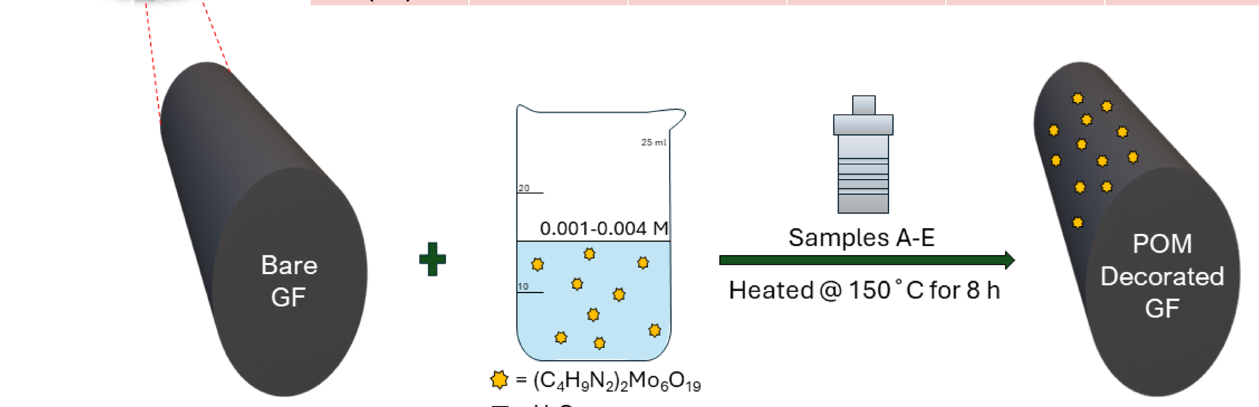


Fig 4. Hydrothermal deposition concentration investigation

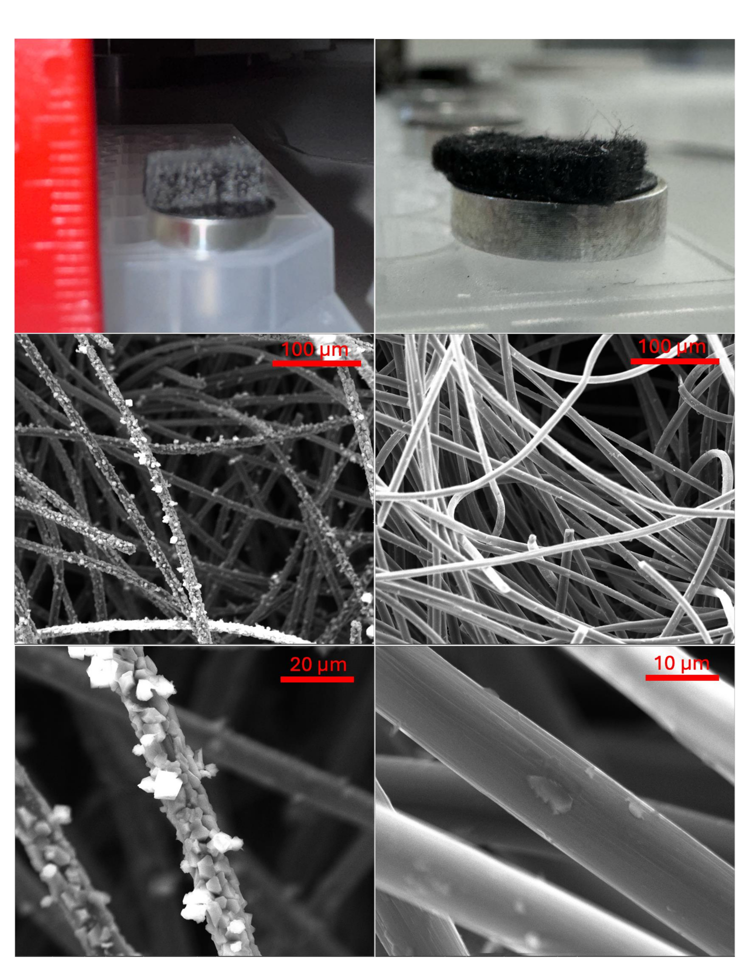


Fig 5. SEM and camera images of sample B

Sample B was subject to outer area and cross section imaging via **SEM**. Large crystals resulting in saturation of the fibres was observed on the outer area while no material was grown on fibres on in the depths of the electrode.

Thermal Pretreatment

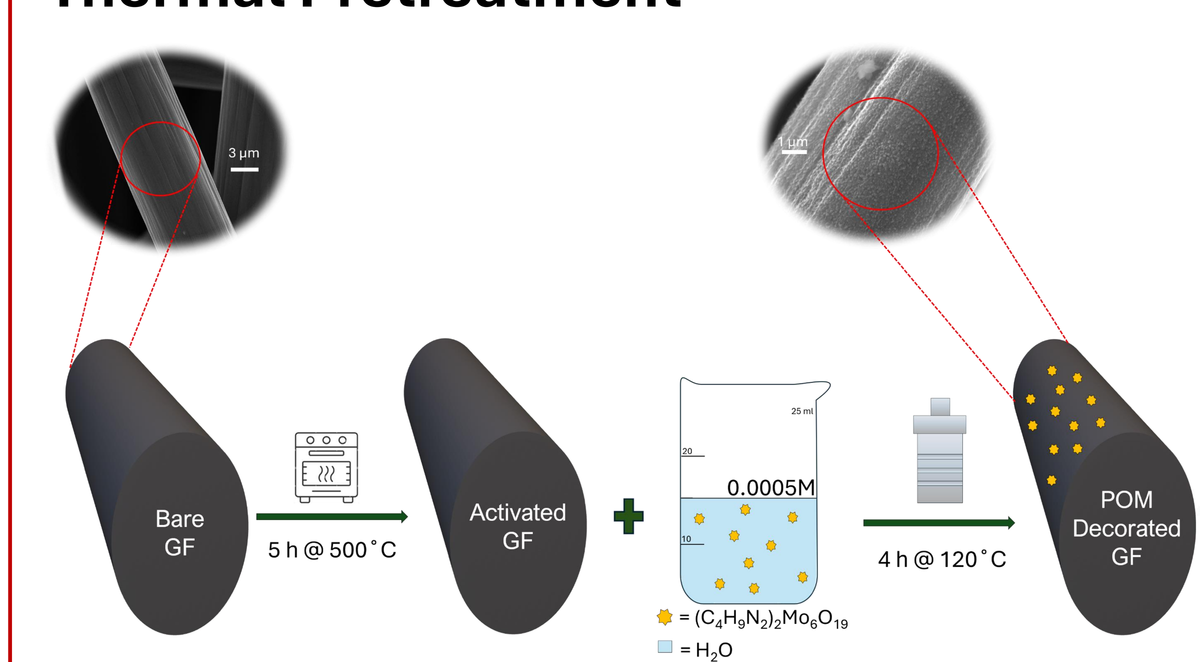
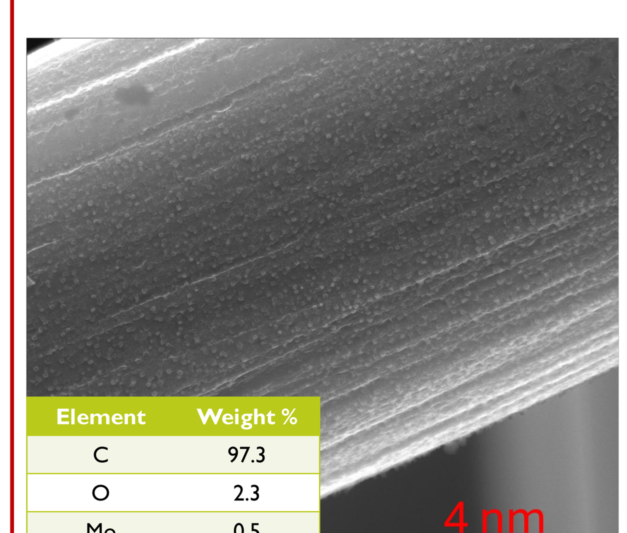


Fig 6. Hydrothermal deposition thermal activation



Element	Weight %
C	97.3
O	2.3
Mo	0.5

Fig 7. EDS mapping of POM-GF

SEM/EDS allowed for the observation of hydrothermally grown nanoparticles (47 nm) that were composed of molybdenum and oxygen species.

Contact Angle using electrolytes suggests improved physical interaction of GF in negolyte. No major improvements were observed in the posolyte

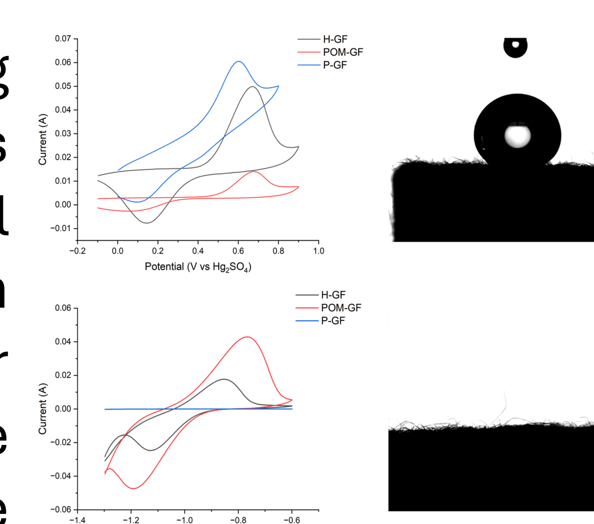


Fig 8. CV of P-GF, H-GF, POM-GF in posolyte and negolyte and contact angle of POM-GF in posolyte and negolyte

CV analysis indicated improved performance for the POM-GF compared to H-GF in negolyte with 91 % and 142 % increase in Epa and Epc and a decrease in Epa/Epc to 1.1

Future Work

- Construct VRFB cell using POM-GF as negative electrode
- Repeat similar reported treatment methods and subject to cross-sectional analysis.
- Identify other potential POM catalysts.

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