Continuous Hydrothermal Flow Synthesis (CHFS) of MXene Derivatives for Electrochemical Energy Storage (EES)

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(in collaboration with University of Limerick, Ireland)

Is MXene the future of EES Devices?
What is the originality of this research?
What are the advantages of CHFS approach over traditional methods of synthesis?

Introduction

- Due to ever-increasing energy demand, there is a need for materials with superior energy storage properties.

- MXenes (a new class of 2D laminar materials) were discovered by Gogotsi et.al in 2011 and have unique morphology, rich surface chemistry and excellent electronic properties (e.g. 9880 S/cm)[1-3].

- With a general formula of $M_{n+1}X_nT_x$, where M is an early transition metal element n = 1, 2 or 3, X = C or/and N, T_x = surface terminations such as O, OH or F, and x is the number of surface terminations [4].

- Synthesised by acid etching of "A" element from MAX phase material [1-4].

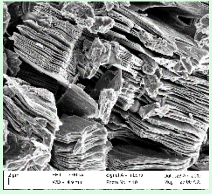

Fig. 1 : SEM Image of as-synthesised MXene

Research Findings (Electrochemical Properties)

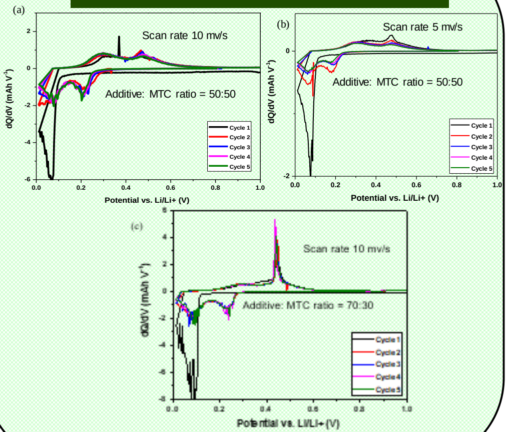

Fig. 7: Cyclic Voltammetry of MTC 400 nanocomposite

References

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Methodology

- Using CHFS as the originality of this research delivering advantages over traditional synthetic methodologies (Fig. 2).

- Desired concentrations of aqueous solutions of NH_3 and MXene were prepared as a precursor feed and ran through pumps of the CHFS reactor at 350 °C, 400 °C and 450 °C to obtain MXene/TiO_2/C (MTC) nanocomposites (Fig. 3).

Fig. 2 : Advantages of CHFS

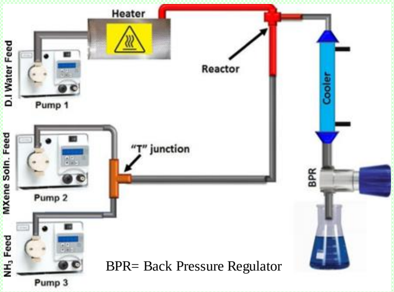

Fig. 3 : CHFS of MTC nanocomposites [4]

Research Findings

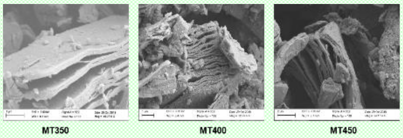

Fig. 4 : SEM Image of as-synthesised MTC nanocomposites

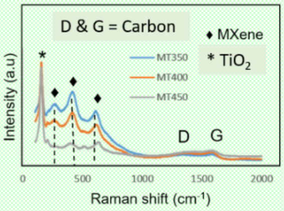

Fig. 6: Raman spectra of MTC samples synthesised at different reaction temperatures.

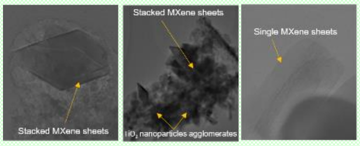

Fig. 5 : TEM Image of as-synthesised MTC nanocomposites

- CHFS allowed tunability of synthetic conditions resulting in control of sample composition and consequently end properties.

Conclusions

- One-step, controlled and tuned synthetic approach for formation of MXene/TiO_2/carbon (MTC) nanocomposites.

- Observable TiO_2 nanoparticles (Fig.4) randomly distributed across MXene sheets which helps prevents re-aggregation of 2D layers, improves surface area and access to electrolyte ions.

- Improved capacitive and rate performance supported by the presence of the additive (Fig. 7c).

- Limitation: Material not reaching expected value and optimisation work currently under investigation.

Acknowledgements

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