# Dowthwaite MScR Scholarship 2023/24 entry

DEPARTMENT OF PHYSICS

Principal Supervisor: Dr Michael Hunt

Other Supervisors: Prof Marek Szablewski

Project Title/Theme: Sustainable Energy Storage: Opening up the voltage window for aqueous supercapacitors.

Project Description

The urgent need to address climate change in a world ever hungrier for energy has led to increased emphasis on 'green' energy resources. However, renewable energy generation does not always align with peak power demand (e.g., solar generation occurs in daylight, whereas consumption is often maximal in the evenings) and there are many technologies (such as transport) where portable energy sources are required. Current battery technologies have the disadvantages of limited lifetime, poor recyclability and rely on raw materials extracted unsustainably. This project aims to develop the performance of a promising energy storage technology – supercapacitors – with emphasis on ensuring sustainability in both raw materials and processes.

Supercapacitors [1] are electrochemical energy storage devices related to batteries where charge is stored at electrode surfaces, rather than in the bulk. Hence, charging and discharging can be achieved far more rapidly than in batteries. Moreover, the absence of changes to the electrode bulk reduces degradation and supercapacitors can sustain >100,000 charge/discharge cycles – orders of magnitude more than batteries. However, supercapacitors store significantly less energy per unit mass than batteries, partly due to the limited voltage range over which they can operate. Commercially available supercapacitors partially address this problem by using organic electrolytes, which give the largest operating voltage 'window' but are expensive, toxic and flammable.

Aqueous (water-based) electrolytes are much more environmentally friendly and sustainable compared with organic electrolytes but have an even smaller potential range (limited by water decomposition at 1.23 V). Several strategies are being investigated to mitigate this limitation [2,3]. This project will expand upon them, developing two strategies to optimise the voltage window of sustainable electrolytes: (1) functionalisation of electrode surfaces; (2) formulation of electrolytes which kinetically limit water decomposition. To achieve this, model supercapacitor electrode materials will be produced and characterised with multiple techniques including Analytical Electron Microscopy, Raman spectroscopy and surface area analysis. Electrodes and novel electrolytes will be used in model supercapacitors, the performance of which will be evaluated by techniques such as cyclic voltammetry,

galvanostatic charging/discharging, and impedance spectroscopy. We hope to therefore develop a route for sustainable and recyclable energy storage.

[1] *Supercapacitors: Materials, Systems and Applications,* Beguin and Frackowiak (eds.), Wiley-VCH, Germany (2013).

[2] *Molecular crowding agents engineered to make bioinspired electrolytes for high-voltage aqueous supercapacitors,* Peng *et al.,* eScience 1 (2021) 83.

[3] *Strategies for enhancing the performance of carbon/carbon supercapacitors in aqueous electrolytes,* Fic *et al.,* Electrochmica Acta 128 (2014) 210.

How to apply
You must apply through the University's applicant portal

You will need to:

- State 'CMP and Sustainable Energy Storage: Opening up the voltage window for aqueous supercapacitors.in the 'Field of Study' section.
- On the funding tab select 'yes' you are applying for a scholarship, select 'Other' write DOW233 in the name of the scholarship, and select 1st October 2023 as the start date
- attach a covering letter and CV
- attach degree transcripts and certificates and, if English is not your first language, a copy of your English language qualifications.
- provide 2 referee contact details (specifically email addresses) who we will contact directly.

Contact
For enquiries please contact Dr Michael Hunt m.r.c.hunt@durham.ac.uk