



Project Title - Sustainable Particle Surfactants for Next-Generation Microemulsion Flow Batteries

Host University - Auckland University of Technology

Industrial Partner - Dot Ingredients Ltd

Allegro Energy Pty Ltd

Academic Supervisor(s)

Dr. Jack Chen

AUT

School of Science

jack.chen@aut.ac.nz

Industrial Supervisor(s)

Victor V. Yim

Head of Product, Dot Ingredients

victor.yim@dotingredients.com

Project Description

The global transition to renewable energy urgently requires storage technologies that are safe, efficient, and sustainable. Among emerging solutions, microemulsion flow batteries (MeFBs) offer a compelling platform for large-scale energy storage – combining the tunability of liquid electrolytes with the scalability of flow-cell architectures. However, their widespread adoption is limited by a reliance on petrochemical feedstocks and limited control over interfacial composition and structure, particularly in the formulation of high-performance electrolytes.

This Applied Doctorate project will pioneer a new class of bio-derived surfactants – Celluspheres™ – for integration into Allegro Energy’s proprietary MeFB electrolyte formulations, bridging green chemistry, materials science, and industrial innovation. Developed at Auckland University of Technology (AUT) and commercialised by Dot Ingredients Ltd, Celluspheres represents a transformative surfactant platform based on Janus cellulose nanoparticles. These nanoparticles possess distinct hydrophilic and lipophilic faces, enabling superior interfacial activity and emulsion stability through a Pickering mechanism. Derived from sustainably sourced timber off-cuts, Celluspheres delivers both environmental sustainability and exceptional performance, directly aligning with New Zealand’s circular economy and emissions-reduction goals.

The doctoral research will focus on optimising Cellusphere formulations for improved electrochemical stability, energy efficiency, and environmental compatibility within Allegro's MeFB technology. The project will advance through three integrated milestones:

1. Initial Evaluation (Months 1–6): The student will synthesise and characterise Cellusphere nanoparticles with tunable particle size and Janus balance (hydrophilic–lipophilic ratio). In-house testing at AUT will assess emulsion behaviour under high-salinity, battery-relevant conditions. The first iteration of Cellusphere samples will be transferred to Allegro Energy Pty Ltd (Australia) for baseline compatibility and sustainability assessment.
2. Performance Optimisation (Months 7–18): Based on Allegro's evaluation data, the student will engineer second-generation Cellusphere surfactants featuring anionic and cationic variants to optimise charge transfer and emulsion stability in electrolyte matrices. Comparative studies will quantify surfactant efficiency, enabling a reduction in surfactant loading while maintaining performance – achieving both cost and sustainability gains.
3. Customisation and Scale-Up (Months 19–36): The student will design and produce multifunctional Cellusphere derivatives tailored to Allegro's performance targets, followed by process-intensification studies to enable pilot-scale synthesis (target 10 ton per year capacity). These activities will position Dot Ingredients as a regional supplier of sustainable surfactants for advanced energy applications, while establishing a robust NZ-Australia innovation pipeline.

The candidate will be co-supervised by AUT and Dot Ingredients, with an extended placement at Allegro Energy to facilitate formulation testing and technology translation. The project's interdisciplinary nature will equip the student with advanced skills spanning colloid chemistry, electrochemical materials, and commercial scale-up – precisely the capabilities needed for Aotearoa's green-energy workforce.

By merging AUT's academic excellence, Dot Ingredients' sustainable-materials innovation, and Allegro Energy's industrial implementation, this project will deliver a breakthrough in sustainable battery chemistry, directly supporting the theme "Aotearoa's Path to Energy Innovation." The outcomes promise to reduce dependence on petrochemical surfactants, strengthen local manufacturing supply chains, and demonstrate how New Zealand-developed green technologies can underpin the world's transition toward a low-carbon future.

Student Time Split

University base for student (university, campus, department):

AUT, City Campus, School of Science, Department of Chemistry

Industry base for student (company, site, address):

Dot Ingredients, WN Building, 19 Mount St, Auckland 1010, NZ

Expected Time Split Between University and Industry Partner (in months):

Approximately 16 months AUT, 16 months Dot Ingredients, 4 months Allegro Energy Pty Ltd

Rationale for Time Split:

The student will divide their time between AUT University, Dot Ingredients Ltd (Auckland), and Allegro Energy Pty Ltd (Newcastle, Australia) to ensure seamless translation from laboratory research to industrial deployment.

During the first 16 months, the candidate will be primarily based at AUT, synthesising and characterising Celluspheres variants, studying interfacial properties, and conducting preliminary electrochemical compatibility tests. Close proximity to Dot Ingredients' pilot laboratory will enable iterative feedback on process scalability and quality control.

The next 2 months will be spent embedded within Allegro Energy's research facilities, where the student will integrate Celluspheres into real battery formulations, conduct performance benchmarking, and gain hands-on experience in energy-storage system engineering. This placement will provide critical insight into industrial R&D workflows, data reporting, and commercial product-development cycles.

For the final 18 months, the student will spend the majority of their time at Dot Ingredients with 2 months planned at Allegro Energy, refining formulations and scaling up production under joint supervision. This distributed structure maximises a continuous innovation feedback loop across the NZ-Australia partnership.

The proposed time-split ensures the student receives comprehensive training in synthesis, formulation science, and technology translation

Application

To apply for this project please first read the guidance document and then complete the application form on the Applied Doctorates Scheme website.