Faraday Institution: Major Project Renewal; Inclusion of New Scope Items

Call Type: Invitation for Proposals

Closing date: 11:00 hrs on 16 December 2022

Funding available: The budget allocation for each research scope item is based upon one PDRA and associated costs. Successful applicants will be expected to fully integrate with the overarching major project to which the scope item belongs.

Please read the full call document for guidance before submitting your proposal.

Expected Key Dates:

Activity	**Date***
Interactive Briefing Session	16 November 14:00 – 15:00
Applications Open	17:00 hrs 4 November 2022
Deadline for Applications	11:00 hrs (UK time), 16 December 2022
Review Panel	20-31 January 2023
Notification of Success	9-12 February 2023
Grant Start Date	1 October 2023

*These dates may change.

Additional information: Grants will be funded by the Faraday Institution based on 80% of Full Economic Cost (FEC). Terms of grant awards are based on Faraday Institution terms, which apply principles of active management although certain standard EPSRC conditions are also applied as indicated in this document. Project duration should be no more than 24 months, exceptions for shorter duration are detailed against relevant scope items.

Contacts:

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Contents

Summary

This funding call seeks to identify researchers, based at UK universities and qualifying research organisations, able and willing to contribute to the furtherment of at least one of the following four major research projects funded by the Faraday Institution: NEXGENNA, Nextrode, CATMAT and FutureCat. In doing so it aims to enhance the skills and innovation brought to the projects through participation, from an increased pool of UK talent whilst building upon its investment to date.

Through the process of reviewing the major projects against a renewed and re-evaluated set of aims and objectives, relevant to global drivers in 2022, a number of gaps and new opportunities were identified to accelerate the delivery of the major projects.

The scope of each call item, detailed in this document, is built upon one of these opportunities and designed to contribute to the overarching aims and objectives of the parent project to which they belong and as such are well defined. The particular problems to be addressed are clearly articulated from the current project team's point of view. However, applicants are invited to respond on the basis of their own expertise and track-record in addressing the challenge presented and in meeting the scope and objectives of the call.

Background

The Faraday Institution is the UK's independent institute for electrochemical energy storage research, skills development, market analysis, and early-stage commercialisation. It brings together academics and industry partners on research projects to reduce battery cost, weight, and volume; to improve performance and reliability; and to develop whole-life strategies from mining to recycling to second use. It is envisaged that outputs from this research will have a significant influence on technology for electric vehicles as well as having cross sector benefits for the energy sector and consumer goods.

Since April 2022, the Faraday Institution major project renewal process has been underway. Through this process the current Faraday Institution major projects (Degradation, ReLiB, MSM, SOLBAT, NEXGENNA, LiSTAR, Nextrode, SafeBatt, CATMAT, and FutureCat), were realigned to the latest context and landscape for research in electrochemical storage. As part of this process, and to consolidate progress to date, the core of the projects to be taken forwards were identified, along with new research areas that needed to be incorporated for the project to remain current and to meet its renewed and rescoped aims and objectives. These new areas of growth form the basis of this open call.

The renewal process is being undertaken in a phased approach where the 10 major projects were divided into two groups. Group 1 included: Degradation, MSM, ReLiB, SOLBAT, SafeBatt and LiSTAR; the expression of interest process for which was completed earlier this year. Group 2, the basis of this call, includes NEXGENNA, CATMAT, FutreCat and Nextrode.

More detailed project backgrounds can be found for each Group 2 project at the following links:

- CATMAT: https://catmatproject.com/
- FutureCat: https://futurecat.ac.uk/
- NEXGENNA: https://www.nexgenna.org/
- Nextrode: https://nextrode.web.ox.ac.uk/

Scope of the Call

Below is a list of scope headings for each major project against which applications should be made. It is expected that one project proposal should be made per scope item. Investigators may apply for multiple scope items. More detailed scope and objectives for each topic are provided in Appendix A.

1. CATMAT

- **Open call item 1.1: Green synthesis of cathodes**

2. FutureCat

- **Open call item 2.1: Developing new electrolytes for high voltage performance of next generation cathode materials**
- **Open call item 2.2: Quantifying cathode structure through X-ray diffraction computed tomography**
- **Open call item 2.3: Cathode particle coating through powder atomic layer deposition processing**

3. NEXGENNA

- **Open call item 3.1: The synthesis of sustainable high-performance hard carbons for negative electrodes**
- **Open call item 3.2: Routes to scale for sustainable high-performance sodium-ion batteries**

4. Nextrode

- **Open call item 4.1: New approaches to no solvent processing**
- **Open call item 4.2: Real time process control opportunities in Li-ion battery electrode fabrication**

Funding Available

It is expected that funding for each proposal will normally cover: 1 PDRA per area of scope, principal applicant costs, consumables and indirect costs. The finances template, found on the application portal, is designed to guide you through what is needed to be submitted and already accounts for mandatory costs e.g., PDRA training budgets.

Funding Exclusions:

There are no provisions within this call for equipment. The Faraday Institution has supported the development of the community through the procurement of key items of equipment on the basis of open access to the whole community; these should be sought. Please indicate in the application form any pieces of specialised equipment you may need access to so that we may facilitate introductions upon successful award.

How to apply

Applications should be submitted via the Faraday FlexiGrant portal by 11:00 am on Friday 16 December 2022. A link to the portal will be available from 4 November at https://www.faraday.ac.uk/research-opportunity/. The application system is designed to guide you through what will be expected for submission at each step; a list of items is detailed below. The form will specify whether the information to be submitted is optional or mandatory. The application form will contain fields for following:

- Who is involved in the project
- Description of research activities
- Financial breakdown
- A deliverables list with timeline
- Two-page CVs for the principal applicant and named PDRAs (mandatory)
- Institutional letters of support (mandatory)

Application Guidance

Some guidance is built within the application system. Below are some specific details:

High-Performance Computing (HPC) Costs

Applicants requiring access to high performance computing resources, via the Faraday Institution's dedicated computing cluster *Michael*, or otherwise, are expected to indicate within their Justification of Resources the total number of core hours requested for their proposal.

Eligibility Criteria and Conditions of Applying

To be eligible for funding, the individuals and research organisation involved in the proposal must:

1. Meet the Co-investigator eligibility criteria for EPSRC funding. Please refer to EPSRC eligibility criteria for details.
2. Facilitate the work of the Faraday Institution by allowing participating postdoctoral research associate staff the freedom to work solely on the work of the Institution.
3. Accept and comply with specific terms and conditions that will accompany the grant offer letter, as well as adhere to general Faraday Institution terms, conditions and management principles as defined in the following document: Faraday Institution T&Cs of fEC Grants.
4. Provide access to facilities funded by the Faraday Institution for the entire Faraday Institution community.
5. Work with others in the innovation chain, specifically across innovation and scale up activities.
6. Be prepared to work with the Faraday Institution HQ and to be directed by the overarching governance structure.
7. Agree to sign up to the relevant project collaboration agreement starting from 1st October 2023. Please note, only successful applicants will be sent the appropriate collaboration agreement to review and accept at the time of review process outcome notification.
8. Agree to fully integrate and actively participate in the existing team and arrangements. Including: Faraday Institution hosted project meetings; consortium meetings; attendance at regular project meetings.
9. Secure institutional acceptance of the terms and conditions of the Faraday Institution within the application. These include conditions specifically relating to the management of the outputs from these research projects, such as intellectual property. Applicants will be expected to obtain their institution's agreement to such terms and conditions as part of the funding process.

The Faraday Institution reserves the right to reject proposals deemed to not meet the eligibility criteria of the call.

The Review Process

Assessment and Award Process

The outline process from submission of application to decision for inclusion in the major projects is as follows:

1. Applications, once screened for eligibility by the Faraday Institution, will be subject to an independent peer review for Research Excellence and fit to scope by subject-matter experts and ranked according to the criteria described below.

2. Using the recommendations from the review panel and in consultation with the Principal Investigator, the Faraday Institution will select successful applicants in line with its research portfolio criteria.

3. All applicants will be notified of the outcome of the review process. The successful applicants will receive a notification that they have been successful in their application and that their project will be incorporated within the major project. No formal grant letter will be issued at this stage, the intention is that each successful applicant will be incorporated into the major project with a start date of 1 October 2023.

Peer Review Assessment Criteria

Proposals will be assessed against the following criteria:

1) **Fit to the scope of the call item as defined:** this is an assessment of how well the proposed activities fit the required need and the likelihood that they will deliver the desired outcome.
    a. Alignment of the proposal with the specific scope of the call and clarity of links to the overarching project.
2) **Approach, methodology and capability**
    a. Is the scientific approach appropriate to meet the challenge presented in the call? Is the research proposed of sufficiently high quality to add to the research excellence of the overall parent project?
    b. Is the research methodology proposed appropriate to address the challenge described in the call?
    c. Do the applicants have the necessary capability and expertise to undertake the research required and to deliver the relevant outcomes as part of the parent project on a two-year timescale?
3) **Value for money**
    a. Does the proposal represent value for money?
    b. Does the project appear adequately resourced for the work to be undertaken?

Role of Reviewers

The Faraday Institution will convene a panel to assess the research quality of the applications received. This review will be conducted by an independent panel composed of individuals from both industry and academia – internationally renowned experts in the areas of electrochemical energy storage, battery technology research and battery engineering. The role of the panel will be to review and provide recommendations to the Faraday Institution executive team for final funding approval. The Faraday Institution will convene and facilitate the panel review meeting but will not participate in the discussion or scoring of proposals.

Equality, Diversity and Inclusion

The Faraday Institution aspires to create a truly inclusive environment where all its researchers can thrive and feel a sense of belonging whilst empowering everyone to have a voice. We celebrate individuality and know that combining the skills and talents of a dynamic and diverse community brings great strength. The Equality, Diversity and Inclusion Working Group, headed up by The Faraday Institution's Chief Operating Officer, is looking at positive ways to ensure these values are lived out throughout our community.

The Faraday Institution is a member of WISE and committed to promoting gender balance in science, technology and engineering.

The long-term strength of the UK research base depends on harnessing all the available talent and the Research Councils have together developed the ambitious UK Research and Innovation Equality, Diversity and Inclusion Action Plan.

The Faraday Institution and EPSRC expect that equality and diversity is embedded at all levels and in all aspects of research practice. We are committed to supporting the research community in the diverse ways a research career can be built with our investments. This includes careerbreaks, support for people with caring responsibilities, flexible working and alternative working patterns. With this in mind, we welcome applications from academics who job-share, have a part-time contract, and/or need flexible working arrangements.

Ethical Information

Applicants should use the Ethical Issues section in their proposal to demonstrate to peer reviewers that they have fully considered any ethical issues concerning the material they intend to use, the nature and choice, current public perceptions and attitudes towards the subject matter or research area. The Faraday Institution will not fund a project if it believes that there are ethical concerns that have been overlooked or not appropriately accounted for. If the research will involve human participation, or the use of animals covered by the Animals (Scientific Procedures) Act 1986 it is recommended that applicants pay particular attention to the guidance highlighted below. The Faraday Institution reserves the right to reject applications prior to peer review if the Ethical Information sections are not completed correctly.

Other relevant guidance includes: EPSRC's policy on animal use in research

And the Responsible Innovation Framework.

Conflicts of Interest

The Faraday Institution is committed to maintain the highest standards of impartiality, transparency and fairness in all aspects of its work. From time to time a situation can arise where there is a conflict of interest. This is particularly the case where the Faraday Institution requires expert advice and those best placed to provide the required expertise may be actively involved in the field. These situations will be managed by adopting a clear policy for dealing with potential conflicts.

The Faraday Institution requires all individuals involved in such activities to agree to act according to our policy on conflicts of interest, which is available on the Faraday Institution website

Reviewers should declare any potential conflict of interest and panel members will not be present during any discussions of proposals in which they are conflicted.

Confidentiality & Privacy

The Faraday Institution Privacy Policy describes how we manage personal data.

The Faraday Institution assess all the grant applications through a review process proposal and such applications are sent to reviewers for comment. Applications are treated confidentially and only supplied to reviewers who have previously signed confidentiality agreements with the Faraday Institution.

Reviewing panel members are asked not to share or discuss reviewer comments/identities outside of the Faraday Institution management. Reviewers are asked for feedback forms. The content of applications, proposals and feedback forms are all kept confidential. If reviewers have any paperwork or have any additional notes, they are required to keep these secure and delete them as soon as the information is no longer required.

Whilst we ask within their submissions that applicants describe their proposed project in sufficient detail for reviewers to assess the application, potentially patentable results should not be included in a proposal until after a patent application has been filed. Under no circumstances should any applicant contact individual panel members. Reviewers are required to notify us immediately if any applicant contacts them directly. Under no circumstances should any Review Panel member contact bidding individuals.

Appendix A Open Call Scope Items – Detailed View

1. CATMAT

Overview, Aims and Objectives of the Project

The CATMAT project is focussed on understanding and mitigating the current limitations of nickel-rich cathodes (with low or no cobalt), lithium-rich oxygen-redox cathodes, and developing new high-energy density cathode chemistries. The project also aims to develop scalable synthesis techniques that will allow these new cathode materials to transition from the research lab to commercial applications.

Open call item 1.1: Green synthesis of cathodes

Scope:

Manufacturing of cathode active materials (CAM) incurs considerable energy costs and produces contaminated waste streams. To improve the sustainability and increase the margins for cathode active materials, new, lower cost and more efficient manufacturing and processing methods are required. Typical methods include co-precipitation methods, which produce contaminated wastewater, and a precursor material, which required subsequent filtering, drying, milling, firing, deagglomeration and removal of fines. All these steps require additional energy and transfer costs. We are looking for novel methods of synthesis of CAM which incorporate sustainability and green chemistry principals. Low energy processing methods, green chemistry methods, and methods of reducing waste streams from the process.

Objectives

- To investigate green synthesis routes for manufacture of cathode materials at a scale that can be transferred into electrode development and cell testing.
- The materials will be related to the outputs from other work-packages within CATMAT and should be designed around the 12 principles of green chemistry.
- Synthesis methods should minimise waste, avoid toxic by-products, and environmental impact.
- Synthesis methods that use renewable raw materials or feedstocks should be preferred where practical.

2. FutureCat

Overview, Aims and Objectives of the Project

FutureCat accelerates the development of next-generation cathodes for Li-ion batteries and is positioned to transfer the most promising technologies to industry. A key objective is delivering sustainable and economical routes to manufacturing industry-relevant cathode materials. Our research delivers impact through the development of next-generation cathodes to support high energy density batteries for improved range, high-power densities for fast charging, reducing cost through removal of expensive, non-abundant metals, and optimised morphologies/chemistries for extended lifetimes. Delivering improvements in cathodes which can be scaled-up by industry requires a holistic approach to materials discovery, characterisation and scale-up to deepen our understanding and push performance limits in a sustainable manner.

FutureCat Phase 2 consolidates our research around 3 key workstreams of increasing materials readiness level: 1) exploring/exploiting novel redox mechanisms through novel data-driven computational and synthetic approaches; 2) developing scalable routes to Ni-rich cathodes with tailored crystal chemistry and morphology to retain high capacity; and 3) materials manufacturing and scale-up of most promising near-market materials at kilogram-scale, working with industry to develop those routes that can transfer directly commercially, along with processing approaches that fully exploit materials performance of FutureCat materials. Our comprehensive approach has identified new cathodes we will optimise in Phase 2. We also target new $LiNiO_2$ generations including scalable designer morphologies (e.g. single crystal, concentration-gradient). We place a high value on collaboration and communication, ensuring seamless interactions and shared expertise across our consortium.

We seek expressions of interest from across the research community to join our consortium and contribute to this exciting programme of research.

Open call item 2.1: Developing new electrolytes for high voltage performance of next generation cathode materials

Scope

Higher nickel content and new cathode chemistries present challenges in terms of cycling stability and capacity fade. Often, these can be traced to deleterious reactions with the electrolyte. This work seeks a synthetic expert who can develop new candidate electrolyte systems with enhanced chemical and electrochemical stability, particularly at high voltage. Our initial focus is on Ni-rich cathode materials (first Generation I polycrystalline LNO followed by Generation II single crystal LNO), to provide tailored electrolytes suitable for cycling experiments at elevated potentials (>4.5 V). This work will develop our understanding of high voltage cycling and increase the stability window for high-Ni cathode materials, with an aim of improving electrochemical stability and extracting optimum performance from best-in-class FutureCat cathode materials. Novel electrolytes will be benchmarked against commercially available battery grade electrolytes to provide an understanding of the role of the electrolyte in enhancing performance properties. Such work will integrate with other activities within the project to understand the CEI formation and stability of the material within a half-cell configuration. Our initial suggested systems for study include ionic-liquid based electrolytes, but with direction of travel towards more sustainable and scalable alternatives (e.g. those based on deep eutectics).

Objectives

- Synthesise phase pure electrolytes for high voltage cycling of Ni-rich cathodes from within the project
- Establish design rules for a suitable electrolyte for high voltage cycling to assist with down-selection and new cathode materials discovery
- Work with project partners to develop an understanding of the (dis)charge mechanism and how the electrolytes influence the cathode performance properties

Open call item 2.2: Quantifying cathode structure through X-ray diffraction computed tomography

Scope

To enhance the lifetime of next generation lithium-ion cathode materials, morphological control, complex doping strategies and bespoke single crystal morphologies are some of the routes we have taken to improve cathode energy density and lifetime. X-ray diffraction computed tomography is an ideal method to aid in the analysis of such approaches, providing spatial resolution across the cathode layer to understand the different inter-particle and intraparticle processes and how the mitigation strategies are able to function over extended battery cycling. This work will apply advanced data analysis techniques such as non-negative matrix factorisation and machine learning to analyse data collected on a suite of FutureCat cathode materials. A significant amount of data already exists to support analysis technique development, and this will be built upon with additional measurements on Phase 2 FutureCat materials.

It is envisaged that this work will be carried out by a postdoctoral researcher based at the Diamond Light Source for 1 year.

Objectives

- Apply advanced analysis approaches to micro and nanobeam X-ray diffraction computed tomography data on FutureCat materials
- Working with consortium partners, identify and understand the role of dopants and gradient structures in improving long duration cycling performance of cathode materials

- Provide deep structural understanding, to inform and guide synthetic approaches to stabilise high energy density cathodes for enhanced performance

Open call item 2.3 Cathode particle coating through powder atomic layer deposition processing

Scope

Introducing highly controlled, conformal coatings on the cathode surface can significantly improve electrode longevity. Wet chemical routes such as sol-gel methods can be employed, but these present challenges in coating uniformity and control. Atomic layer deposition (ALD) is a well-established scalable technique which has been already applied to nickel-containing cathodes such as NMC611 and NMC532. Controlled coatings of Al_2O_3, for example, can introduce a barrier to particle surface corrosion as well as phase reconstructions. Up to now, there has been limited exploration of ALD coatings on LNO cathodes. This work will determine routes to particle ALD approaches, starting with our well-established FutureCat Generation I LNO cathode before progressing to Generation II single crystal LNO. Cycling over many hundreds of cycles will be required to fully examine the effect these coatings have on electrode longevity and will require operando examination, such as X-ray diffraction to monitor the cathode structural integrity.

Objectives

- Develop a standard protocol for optimising ultra-thin ALD coatings on LNO particle surfaces for Al_2O_3 and/or related passivated coatings that would be compatible with manufacturing at scale
- Produce (i) powdered coated cathodes for structural, morphological and mechanical testing and (ii) coated electrode coatings for the consortium for cell studies to correlate with capacity retention, Coulombic efficiency, impedance and structural integrity of (i) Gen I polycrystalline LNO and (ii) Gen II single crystal LNO
- Collaborate closely with consortium partners to apply additional characterisation techniques to fully examine cathode structure, morphology and electrochemical performance.

3. NEXGENNA

Overview, Aims and Objectives of the Project

In Phase II, NEXGENNA will surpass LFP by improving the energy storage, power, and lifetime of sodium-ion while maintaining sustainability, safety, and cost advantages. We will continue our highly integrated approach guided by our industrial partners to realise next-generation sodium-ion batteries.

The best positive electrodes

Assisted by computational screening, we will develop improved positive electrodes. Different approaches will target improvements in energy, power and/or sustainability.

The best negative electrodes

We will deliver inorganic and organic anode materials and hard-carbon composites with enhanced energy, power and/ or cycling stability. We will optimise electrode formulation in close collaboration with our electrolytes team and correlate SEI properties with electrochemical behaviour.

Understanding the interfaces

We believe we can win significant energy density and cycle-life gains by deploying new electrolytes and carefully studying the electrode interphase. To that end, we will continue to synthesise new electrolytes and employ solid-state NMR and other spectroscopic and microscopic techniques to probe electrolyte degradation, SEI formation and metal plating.

A “full-cell” approach to scale-up

Having established a promising pipeline, Phase II will build upon our materials discovery platform towards scale-up and commercialisation. Taking a "full cell" approach, we will assess our most promising emerging materials in pouch cells against both benchmarks and emerging NEXGENNA electrode materials.

Open call item 3.1: The synthesis of sustainable high-performance hard carbons for negative electrodes

Scope

This subtask builds on our understandings of hard-carbon electrodes and their composites. The work involves the synthesis of hard carbon from abundant precursors via sustainable approaches, the assessment of the environmental and economic viability of the developed carbons and the performance optimisation of cells coupling the hard carbons with NEXGENNA positives. The work also involves the characterisation of electrodes, interfaces, and cells using advanced techniques, which may include AFM, NMR, XPS, SAX, PDF, and Raman.

This work will help transition negative electrode materials from our labs to the pilot pouch cell line at St Andrews. A separate complementary subtask will target the scale-up of positive electrode materials.

Objectives

- Create tailored hard carbons (at 10s gramme scale) based upon the learnings from the first phase of the NEXGENNA project. We expect that these hard carbons will be biomass-derived and designed with different porosities, surface areas etc.
- Use promising candidate materials to produce hard-carbon composites compatible with inorganic and organic materials developed at NEXGENNA.
- Use alternative carbonisation approaches to reduce reaction times and temperatures, maximising process sustainability.
- Fully characterise the physical and electrochemical properties of the hard carbons, fostering collaborations within the project to complement gaps in capability.
- Probe the mechanism of sodium storage in these hard carbons using advanced characterisation techniques. The techniques might include NMR, SAXS and PDF.
- Integrate the most promising hard carbon negatives with NEXGENNA partners to test in full cells with the best positives emerging from NEXGENNA.
- Understand the evolution of the SEI for the best-performing cathode-electrolyte combinations.

Contribute to the demonstration of prototype pouch cells (of several ampere-hours).

Open call item 3.2: Routes to scale for sustainable high-performance sodium-ion batteries

Scope

This work draws together our materials development efforts to investigate the performance of emerging materials in full-cell configurations supporting the activities at the St Andrews scale-up facility.

This subtask encompasses the scale-up of positive electrode materials and cell design considerations. A complementary subtask will target the scale-up of negative electrode materials.

Objectives

- Work with the NEXGENNA team to identify materials for production at a scale suitable for electrode development (> 250g).
- Use low-cost synthetic methods to produce enough material for further processing.
- Characterise the material to ensure high quality and enable iterative improvement.

Work in partnership with the St Andrews pouch cell facility to:

- Investigate methods to develop high-quality electrodes for incorporation into full-cell devices. This goal may include the development of microstructures to optimise transport properties.

- Develop methods for mixing and coating, which we can use outside a dry room for translation to manufacturing lines.
- Develop novel formation methods using single-layer, full-cell pouch cells. Use the knowledge gained to maximise lifetime and capacity using novel NEXGENNA electrolytes.
- Develop methods and processes, which we can translate to the new manufacturing line at St. Andrews.
- Collaborate with NEXGENNA partners to study degradation and capacity fade.
- Maximise volumetric and gravimetric energy densities of our cells.

4. Nextrode

Aims and objectives of the project

All electrodes for mass market lithium-ion batteries are made by slurry casting. The process involves mixing electrochemically active materials, additives and binders to form a solvent suspension that is coated onto metallic foils and which then dries to produce electrodes typically 100 µm thick with randomly distributed pores and materials. Slurry casting has evolved to a highly productive process operating at up to 90 $m.min^{-1}$ of coated electrode. Recent research at the laboratory scale has demonstrated that new manufacturing methods can control better the arrangement of the constituent materials to produce “smart” electrodes with 30% more capacity and 50% lower degradation rates. Ideas of smart electrodes can be applied with variants of the slurry casting process, and more radical new approaches. Research concerns the development of these processes through application of process metrology, process simulation and data driven modelling, and novel experimentation, within the context of developing knowledge and technology at the commercial scale.

Our vision is to realise improvements in battery performance by smarter assembly of the different materials based on investigation, understanding and exploitation of the science of electrode manufacture. The anticipated benefits of such an approach will reduce trial and error, reduce scrap, increase flexibility and produce smarter and more sustainable products.

Open Call item 4.1: New approaches to no solvent processing

Scope

In the second phase of the Nextrode research programme, we have identified low and no solvent processing as a new cross-cutting theme. Our programme has significant research resource allocated to this work across a number of work-packages. However, given the possible advantageous commercial and performance benefits of low/no solvent processing, and the relative immaturity of the field, we are keen to explore if the research community has additional ideas to those already identified, which could be added to our programme.

Objectives

- To identify complementary research on the performance and sustainability benefits of low and no solvent processing of Li-ion battery (LIB) electrodes
- To integrate new ideas and research into the Nextrode programme and to accelerate the most promising ideas

Expressions of interest are invited for a two-year, single postdoctoral research assistant led research project in one or more of the areas A-C below. The work is envisaged to be predominantly experimentally led, although elements of modelling and simulation can be considered.

A. Dry powder mixing and flow

We are researching how to engineer the particulates used in LIB electrodes to improve their downstream performance (morphology and flow, surface tension, agglomeration, coatings, etc.) and how electrode properties can be controlled by changes in these particulate properties. The required and optimum properties for particulates used in dry processing are likely to differ significantly from those used in slurry casting. We are seeking new ideas and approaches to manipulating and assessing particulate properties to make them suitable for processing into competitive LIB electrodes.

Key objective: The development of dry mixing process design guidance, based on experimental understanding and complementary process/mechanical modelling for formulating dry mixed electrode formulations.

B. Low solvent slurry processing

We are undertaking research on high viscosity, low solvent content slurry formulation and deposition by extrusion for relatively thick LIB electrodes of up to 250 µm. Research ideas into complementary or alternative approaches to the formulation and deposition of high viscosity slurries into LIB electrodes are sought.

Key objective: The development of new approaches to low solvent processing and to explore the possible electrode performance and sustainability benefits conferred, and to consider implications for process scale-up.

C. No solvent, fully dry processing

We are undertaking research related to the shear processing of dry electrode mixtures and the formation of LIB electrodes that are stabilised mechanically by a low fraction of elongated polymeric fibres/fibrils. We are seeking alternative approaches to either understanding and exploiting the fibrilisation process, or alternative approaches to the deposition of electrodes without the use of liquid solvents or exposure to high temperatures for polymer debinding.

Key objective: The development of novel methods to dry deposit and form electrodes from fibrillated and granulated starting formulations with performance that matches current state-of-the-art.

Open call item 4.2: Real time process control opportunities in Li-ion battery electrode fabrication

In the second phase of the Nextrode research programme, process metrology and process modelling have emerged as new, cross-cutting themes. We will dedicate significant research resource to these themes across all work-packages, including research on sensor integration, novel metrology, physical modelling of key stages of manufacture, and data-driven modelling and data analytics across the manufacturing process and at different production scales. We have recognised that this focus on process measurements and modelling, and the linking of process parameters to performance, may provide a platform for real-time control of one or more of the key electrode manufacture processes. Real time control implementations are common in industrial polymer film production, the metallurgical sector, paper-making and other process industries but are under-utilised in electrode fabrication.

Expressions of interest are invited for a two-year, single postdoctoral research assistant led research project, as described below.

Scope

In terms of the Nextrode scope, we consider LIB electrode fabrication to cover the sequential steps of:

- Processing and preparation of the active, binder and conductivity enhancing particulates
- The formulation of slurries to be deposited into electrodes
- Deposition of the slurries onto the metallic current collector foil

- Drying of the slurry and the evolution of the electrode structure
- Calendering to reduce electrode porosity, and increase adhesion and mechanical integrity

Although each of the processes has been scaled to the gigafactory scale, they generally operate in open loop control where variables are set at predetermined optimum setting and are not generally altered in real time. We are seeking ideas and a proposed programme of work on how one or more of the stages might be brought under closed loop control where the process variables are altered in real time to control key properties, e.g., slurry rheological properties or electrode thickness and its distribution, to within target settings. Ultimately, control links between the steps can also be envisaged to bring the whole process under integrated control, as occurs in other process industries.

Objectives

- To identify and prioritise opportunities for real time closed loop process control in electrode fabrication.
- To undertake research on the related sensor, modelling, actuation, implementation and forecast benefits of real time control. This may include proof of concept experiments and design and simulation studies.