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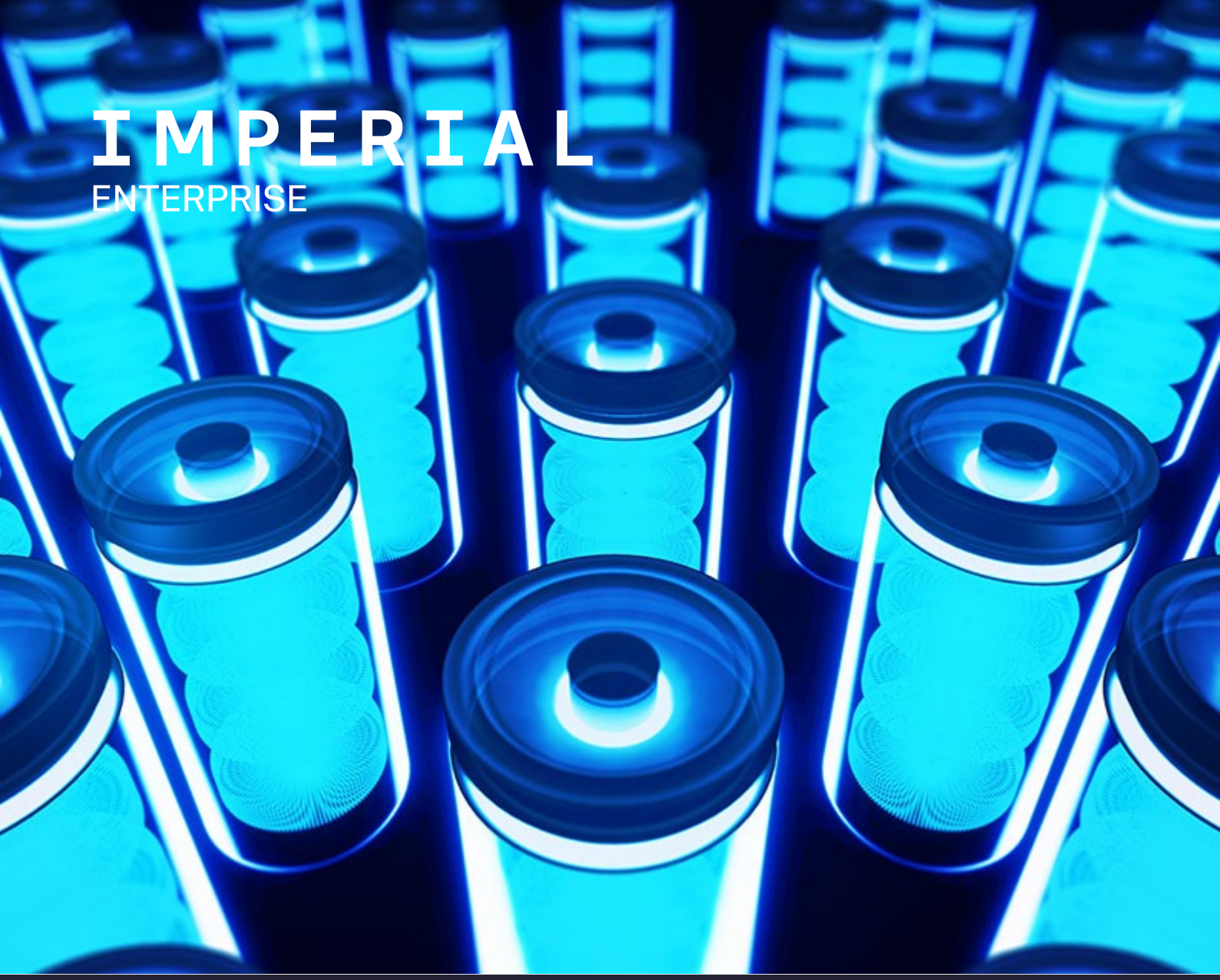

Materials recovery from end-of-life Sodium-ion batteries (SIBs)

A recycling process that recovers all the valuable materials from end-of-life SIBs. Cathode materials (aluminium, phosphorus, sodium, sulphur and vanadium) are selectively recovered and regenerated as high-quality precursors.

Dr Valeska Gonzalez

Commercialisation Executive

Faculty of Engineering

v.gonzalez-montilla@imperial.ac.uk

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Inventor information
Professor Magda Titirici
Xiaochu Wei

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Proposed Use

This innovative technology offers a sustainable solution for recycling spent SIB cathode materials into valuable products. The process enables the efficient separation of aluminium, phosphorus, and sodium species, yielding value-added by-products such as aluminium phosphate ($AlPO_4$). Vanadium can be selectively recovered either as battery-grade vanadium pentoxide (V_2O_5) or as intermediate precursors suitable for the synthesis of sodium vanadium phosphate (NVP) cathode materials.

Problem addressed

With the global SIB market projected to rise from USD 1.47 billion in 2024 to USD 6.25 billion by 2032 (compound annual growth rate of ~19 %), end-of-life waste is expected to become a major challenge. This invention presents the first complete process to recover all valuable materials from spent SIBs. It supports low-cost, low-emission recycling, helping to secure a sustainable battery supply chain.

Technology Overview

This invention utilises two closed-loop routes to recover materials from SLB black mass, each producing distinct vanadium precipitates. Route 1 predominantly yields V_2O_5, which can be used directly in NVP cathode synthesis or as a general-purpose vanadium precursor for various applications. Route 2 produces mixed sodium–vanadium compounds that can serve directly as precursors for NVP cathode synthesis, eliminating the need for further purification. Meanwhile, waste materials such as aluminium, phosphorus, sodium, and sulphur are precipitated in useful form and removed from the system.

Inventor information

Professor Magda Titirici, Chair in Sustainable Energy Materials, Department of Chemical Engineering - Faculty of Engineering.

Xiaochu Wei, Research Associate Department of Chemical Engineering - Faculty of Engineering.

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Benefits

- A simple process to recover all the valuable materials and impurities from spent SIBs.
- All cathode materials recovered in useful forms.
- Vanadium can be precipitated either by adjusting pH and temperature alone or with the aid of conventional salts, without requiring ionic liquids.
- Purified wastewater can be re-utilized in the process until all materials are recovered.
- Recycling process can be conducted at temperatures ranging from room temperature to around 100 °C.