Advanced Nuclear Skills Innovation Campus

GAMECHANGERS
DELIVERING NUCLEAR INNOVATION

Department for Business, Energy & Industrial Strategy

Electrochemical technology in nuclear material processing

C-Tech Innovation Ltd

Project Duration: 4 months

BEIS ANSIC funding awarded: £64,600

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This ANSIC project has accelerated the development of the ELENDES process for destruction of organic materials using an electrochemically generated silver (II) oxidant. The work will enable waste minimisation and advanced fuel cycle processing routes. Material recovery from simulated active waste streams has been demonstrated using C-Tech Innovation's 3D electrode technology. Silver recovered from the waste stream completes the loop of material recycling for the ELENDES process, demonstrating the wider process feasibility. The knowledge sharing between C-Tech Innovation Ltd and NNL on the applicability of electrochemistry to recovery and separation processes in the nuclear industry is expected to lead to the development of electrochemical applications that support advanced fuel cycle processes and additionally in Health and Nuclear Medicine, Space Propulsion, and radioactive waste minimisation.

Figure 1: Silver that has been recovered from waste solution before being recycled back into the process

Background

Electrochemistry is a powerful tool used widely in other industries for the oxidation or reduction of a range of materials. Electrochemistry offers significant advantages as it allows the processing, recovery or destruction of materials, in aqueous solutions, at low temperature.

The use of electrochemistry allows simplification of waste stream processing and the potential for recovery / separation of materials that are complex or costly by chemical means. Additionally, the efficient use of energy, low temperature processes and the use of electrically powered processes is a significant step towards the ambitions of net zero processing.

Bringing this technology, and the capability to develop and scale electrochemical processes, to the nuclear industry has been the focus for C-Tech Innovation. C-Tech Innovation have extensive background in electrochemical engineering from laboratory to production scale and have been working with NNL on the application of selected electrochemical technologies.

Project Aims

The ANSIC pilot was an opportunity for C-Tech Innovation to expand the utilisation of electrochemistry in the recovery and reprocessing of materials.

The project aimed to accelerate the development of the ELENDES process for organic destruction using an electrochemically generated silver (II) oxidant and to widen the understanding within both C-Tech Innovation and NNL of where electrochemistry can enhance the separation / recovery of nuclear materials.

To enable the widening use of electrochemistry in nuclear separations and recovery, the project increased awareness within NNL staff of the capabilities of electrochemical technologies and informed C-Tech Innovation of the challenges faced in the nuclear industry to identify the most promising applications.

Project Steps

The ANSIC project had two key elements, the first was based on experimental work at C-Tech Innovation to identify the critical design parameters in the operation and scale up of the ELENDES process when working with highly stable immiscible solvents.

The second area of work was focused on the identification of wider opportunities for electrochemically enhanced separation / recovery of valuable elements from the nuclear fuel cycle. For this, C-Tech Innovation provided background information to NNL technical staff on the electrochemical processing options for the elements of interest. NNL then highlighted opportunities with commercial or strategic promise, which could be followed up with proof-of-concept studies using C-Tech Innovation designed equipment.

Project Achievements

- C-Tech Innovation have significantly increased the understanding of the process requirements for the efficient destruction of immiscible organics in the ELENDES process, which will allow designs to be improved and reduce the risk on further scale up.
- Increased understanding within C-Tech Innovation and NNL of the capabilities of electrochemical technologies and of the specific applications where they might be productively applied to separation or recycling of valuable elements within the nuclear industry. The most promising applications are being prioritised for continued development.
- Recovery of silver from simulated waste solutions in an industrial electrochemical reactor, which is an important step in demonstrating the wider process feasibility of electrochemical processes which use electrochemically generated highly oxidising silver (II) for organic oxidation or oxide dissolution.

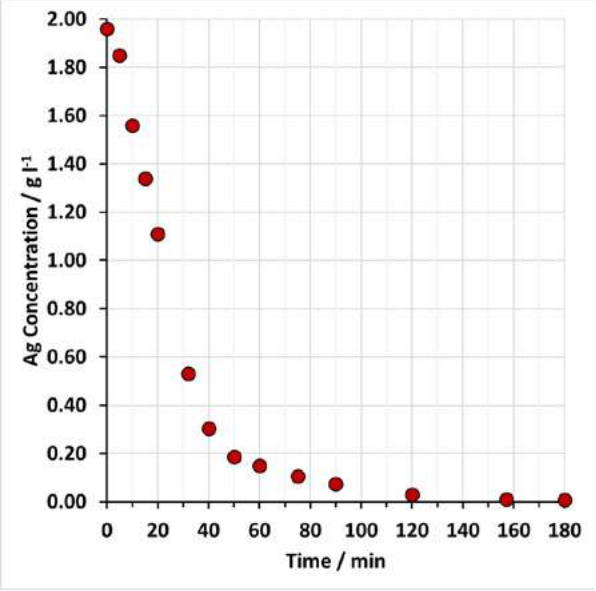

Figure 2: Fast and efficient reduction of dissolved silver from a simulated waste solution of 2 g/l Ag in 2.5M nitric acid silver down to ppm levels using a C-Flow 3D electrochemical cell. This enables reuse of the silver and minimises waste arising.

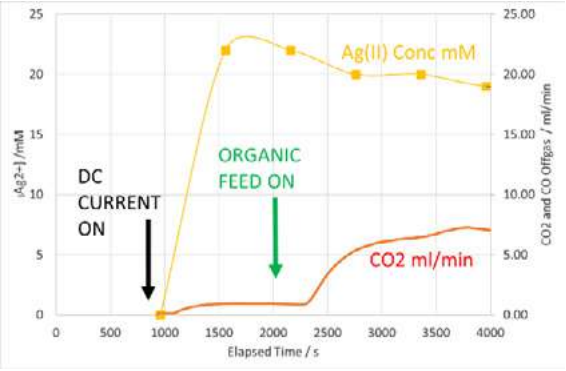

Figure 3: Data from the ELENDES process of electrochemical oxidation to carbon dioxide of organic waste streams. The concentration of highly oxidising silver(II) quickly builds up after the current is applied and oxidation to carbon dioxide is observed shortly after the organic feed is commenced.

Next Steps

Development of the ELENDES process for electrochemical oxidation of waste organics such as solvents will continue with NNL. The initial target being deployment as an integrated glovebox system for handling the solvents from the Advanced Fuel Cycle Programme but wider applications for organic destruction and for oxide dissolution are envisaged.

Concepts to use electrochemistry to enhance separations in the areas of health / nuclear medicine, reprocessing of spent fuel and high activity residues identified within this project will be further developed with NNL. These opportunities will be matched against identified priorities and proposals will be developed for grant funding to take them further.

Impact

- The project has given C-Tech the knowledge to improve its ELENDES process through redesign of process and validation of a silver recycle route within the process. The eventual deployment of this process will enable solvent wastes to be treated in a glovebox and new fuel reprocessing routes to be developed
- The project has assisted in the technical development of NNL staff through detailed discussion of the technology and results obtained from running of rigs during technical exchanges and visits to the active Laboratory in Preston by experts from C-Tech Innovation
- Increased mutual understanding between C-Tech Innovation and NNL of the applicability of electrochemistry to recovery and separation processes in the nuclear industry. It is expected that this will lead to the development of new projects which could lead to reduction in the cost of operating existing processes or applying electrochemical techniques to recovery and separations

C-Tech INNOVATION

www.ctechinnovation.com
info@ctechinnovation.com
0151 347 2900
Capenhurst Technology Park, Capenhurst, Chester CH1 6EH

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Twitter @GC_Innovators
email: apply@gamechangers.technology