SPIRE-10-2017

OCEAN

Full Title: Oxalic acid from CO2 using Electrochemistry At demonstratioN scale

Aim:

The OCEAN project aims to develop an integrated process for the production of high-value C2 chemicals from carbon dioxide using electrochemistry.

This will be achieved by:

1) improving and optimizing a TRL5 technology that can convert carbon dioxide to formate, to TRL6. OCEAN will bring this technology just one-step away from commercialization, by demonstrating this technology at the site of an industrial electricity provider, converting 250 g of CO2 per hour at 1.5 kA/m2. The energy efficiency will be improved by coupling the cathodic reaction to the oxidation of glucose at the anode, using a novel technology to match the kinetics of the reactions at both electrodes. The obtained formate can be converted to oxalate.

2) Developing new electrochemical methodologies to further convert formate and oxalate to formic acid and oxalic acid, respectively. Novel salt-splitting will be investigated using bipolar membranes. Again, this allows for direct coupling with an electrosynthesis step at the anode and/or cathode.

3) Developing new electrochemical methodologies by converting oxalic acid to glycolic acid and other high-value C2-products, these will be benchmarked with conventional hydrogenation.

4) Integrating the TRL6 and new (TRL4-5) electrochemical technologies in an industrial process, aimed at the production of high-value C2 products and polymers thereof by developing the process steps needed to produce oxalate, C2 products and polymers.

5) Demonstrating the economic feasibility by performing a market analysis and making a business case and exploitation strategy. Overall, OCEAN aims at addressing the critical elements that are currently hindering new electrochemical processes by targeting high value products that have the corresponding production margin to introduce this technology on the market, lower the power costs by combining oxidation and reduction, and a trans-disciplinary approach that is needed for the introduction of these advanced technologies.

Concept:
The objectives and main approach of OCEAN are: 1. Demonstration of the industrial feasibility: 3 leading SME’s from several countries in Europe will work together to develop a demonstration reactor, the Demo Cell, to proof the industrial feasibility of the electrochemical conversion of carbon dioxide to formate a. They will collaborate to optimize electrode design (GKL), optimize the process and technology and automate it (AVT) and manufacture the cell (HYS) b. Demonstration will be done at the site of the industrial partner (RWE), using real CO2 streams. 2. New electrochemical methodologies: To increase energy efficiency of the Demo Cell and of the electrochemical salt splitting, new electrochemical technology will be developed: the reduction of CO2 will be coupled to an anodic reaction: glucose to glucaric acid. This will avoid the production of oxygen gas at the anode, and make the overall process much more energy efficient. To match the kinetics of the reactions at the anode and cathode, the technology of GENS, an SME with a promising technology in this area will be demonstrated OCEAN. 3. New electrochemical methodologies: The conversion of carboxylates to carboxylic acids will be advanced: the conventional salt splitting to produce the carboxylic acid and the hydroxide (see section State-of-the-art and ambition) generally produces hydrogen and oxygen, which is unavoidable. IIT, a research institute working on a.o. process intensification will address this issue by performing salt-splitting using bipolar membranes. This water is splitted at these membranes, the electrodes themselves can be

used to couple an anodic or cathodic reaction to the salt-splitting. 4. Integration into existing industrial operations: In OCEAN, electrochemistry will be integrated into industrial process, by also investigating further downstream process steps of the reduction product of CO2 to create high value products: oxalic acid, ethylene glycol, glycolic acid and polymers. R&D of these steps will be a strong collaboration between SMEs and research institutes a. AVT will further optimize the process to convert formate to oxalate using catalytic calcination, and HYS will engineer and manufacture a new reactor design for this reaction b. In this part, the steps to high-value products will be investigated: i. ERIC will investigate the hydrogenation of oxalic acid to ethylene glycol, both electrocatalytic and chemocatalytic in order to compare. ii. The UVA will investigate 2 pathways to produce glycolic acid: 1) from formate using hydroformulation, which could be an alternative to the catalytic calcination of formate to make C2 products, and 2) by the hydrogenation of oxalic acid. The latter will be done in collaboration with ERIC. iii. The UVA will investigate existing and new applications of oxalic acid and glycolic acid, focussing on polymers 5. Proof the economic feasibility: Using the relevant info from all OCEAN partners, AVT and RWE will develop a strong business case which will take into account next to CAPEX and OPEX info also site-specific info such as scale (feedstock availability), feedstock concentration/purity, energy cost, etc. (objective 2) For several process steps, the electrochemical process steps will be compared to conventional conversions: eg. the electrochemical acidification will be compared with chemical acidification, and the electrochemical reduction of oxalic acid will be investigated both electrocatalytic and chemocatalytic. Not only will this provide input for the Business Case economics, but it also potentially allows transferring chemocatalytic concepts into electrocatalytic reactions. 6. Proof the impact on the environment: a Life Cycle Analysis will be performed by IIT to investigate the reduction in energy use and greenhouse gas emissions and the resource efficiency. Overall, OCEAN will foster strong collaboration between the 4 SME's to develop an electrochemical Demo Cell at TRL6, demonstrated at site of industrial partner. Novel electrochemical technology and process steps will be integrated into an industrial process, by strong collaboration between SME's, research institutes, and an industrial partner to develop a business case and exploitation strategy.

Start date:
01/10/2017

End date:
31/07/2022