InnoBuyer

FAST TRACK TO INNOVATION PROCUREMENT

RESHAPE

GERMAN AEROSPACE CENTER (DLR)

reSHAPE

PITCH

reSHAPE aims to develop innovative functional materials for urea-water electrolysis, focusing on anion exchange membrane (AEM) and nickel-based oxygen-evolution catalyst that are **re**engineered for electrolysis of high concentration urea-water solutions. This co-creation will be a stepping stone for **s**imultaneous **h**ydrogen and **a**mmonia **p**roduction via urea **e**lectrolysis and their various applications within energy, agriculture and transportation sectors.

ORGANISATION DESCRIPTION

The German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt e.V., DLR) is the national centre for aerospace, energy and transportation research of Germany, founded in 1969 as a public institution. It is headquartered in Cologne with 35 locations throughout Germany. The DLR is engaged in a wide range of research and development projects in national and international partnerships. DLR also acts as the German space agency and is responsible for planning and implementing the German space programme on behalf of the German federal government. As a project management agency, DLR coordinates and answers the technical and organisational implementation of projects funded by a number of German federal ministries. As of 2020, the German Aerospace Center had a national budget of €1.261 billion. The Institute of Engineering Thermodynamics at DLR conducts research into the field of efficient energy storage systems that conserve natural resources, and next generation energy conversion technologies. With booming, worldwide interest in hydrogen production, DLR is the sought for partner in research, development and implementation strategies of electrolysis systems. Our expertise lies in testing facilities activities aiming to explain the underlying electrochemical mechanisms of electrolysis cells, optimisation and upscaling.

CHALLENGE DESCRIPTION

Water electrolysis is a clear pathway for green hydrogen production, but soon, it could prove to be the same for ammonia production. Currently, ammonia is mainly produced from natural gas as a raw material and steam methane reforming (SMR). The production of nitrogen fertilisers is energy-intensive and the process produces about 36 million tonnes of CO_2 if all EU capacity is utilised (about 10% of the world's total). In 2022, DECHEMA and Fertilizers Europe published a report of technology options for CO_2 emission reduction of hydrogen feedstock in ammonia production creating a pathway for the European fertiliser industry decarbonisation for 2030. Electrolysis is pointed out to play a major role in green

Funded by the European Union

This project has received funding from the European Union's Horizon Europe research and innovation programme under the Grant Agreement 101071212. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.

ammonia production. Moreover, as the feasibility of the proposed urea-water electrolysis draws attention, more possible technology applications emerge.

Hydrogen production, especially for proton exchange membrane water electrolysis PEMWEL needs water of high purity as well as precious metal catalysts (platinum group metals). The anion exchange membrane water electrolysis AEMWEL, points in the right direction, as **with this technology Nickel catalysts, or similar, can be used for the oxygen evolving reactions.** Moreover, using **urea-water solutions, has the potential to improve the current density** as urea is oxidised in addition to the water molecules. The urea electrolysis may use wastewater, e.g., urine, diesel additive fluid or processed urea solutions. **Besides the pure hydrogen production** at the cathode and urea oxidation at the anode, **it is possible to hydrolyse urea at the anode catalysts and generate ammonia simultaneously.** Ammonia has several applications in the chemical industry such as fertilisers, deNOx catalysts to name some.

This call for a co-developed solution should focus on catalyst and AEM development. The catalysts that have a high selectivity for urea hydrolysis (instead of urea oxidation) making a co-production of ammonia and hydrogen possible need to be synthesised. The ammonia oxidation that can also take place at the anode should be suppressed, meaning a high selectivity on the urea to ammonia reaction is foreseen without further reactions of the produced ammonia. This would lead to a simultaneous production of two energy carriers. The catalysts itself or the activation of these due to an innovative cell design could solve this problem. Moreover, the available membrane technologies are not matching for the use in high concentration water-urea solutions.

CHALLENGE MAIN OBJECTIVES

To develop new functional materials for electrolysis of high concentration urea-water solutions for simultaneous hydrogen and ammonia production, whilst inhibiting CO2 reduction reaction. **The focus is to develop two main components for the electrolysis cell suitable for this application.**

- Anion exchange membrane for high urea concentrations (8 M urea) solution and low base pH (9 – 10 pH).
- Non-platinum-group-metal (non-PGM) oxygen-evolution catalysts (possibly with Nickel).
  The co-developed solution will be optimised on an electrolyser testbench with a cell active area of 4 cm2 and finally, if the results are promising, a small-scale urea-water electrolyser will be showcased.

SOLUTION FUNCTIONAL REQUIREMENTS

Funded by the European Union

This project has received funding from the European Union's Horizon Europe research and innovation programme under the Grant Agreement 101071212. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.

The solution should provide anion exchange membrane with reduced overpotential compared to commercial membranes by tuning the membrane for urea electrolysis without KOH operation. High enough mechanical stability and low gas permeability. The basic parameters should be on par with commercial membranes for anion exchange membrane alkaline water electrolysis e.g., Fumasep50 from Fumatech FAAA-3-50. Simultaneously, the solution should provide a urea oxidation catalyst that inhibits the CO2 reduction process and promotes urea hydrolysis (implementing Ni (OH)2 as the active electrocatalyst). All materials produced should be tuned for low temperature AEM electrolysis (50-70oC) with the use of urea in high concentrations (up to 9 M urea solution).

Compulsory functional requirements

- An Anion exchange membrane of minimum size: 3 x 3 cm, at least 10 samples. Non-permeable to ensure gas purity. Sufficient mechanical stability for cell compression. Thickness ca. 100 micrometres or lower. Stable up to 70oC and in high urea concentration (9 M).
- Nickel based catalyst nanopowder, minimum 2 grams, that displays superior activation overpotential and stability in later specified urea-water solution compared to reference pure Ni nanopowder 5-20 um. No PGMs are to be used (unless specifically agreed on, then PGM loading is to be 0.05 mg/cm2 max).

Electrolysis single cell benchmark indicators (to be tested at DLR):

- Current density of 100 mA/cm² at 2 V.
- Pure urea electrolyte without KOH.

Desirable functional requirements

Nice to have:

- Functional in low concentrations of urea in water e.g. 0.3 M urea, as well in up to 9 M.
- Development of both the membrane and an ion exchange ionomer that ensures better conductive properties for electrode production.
- Solution should be scalable to 16x16 cm for both the membrane (limited by membrane casting possibilities) and the electrode (which can be air brush coated at DLR).
- Current density of 300 mA/cm² at 2 V.
- PGM metal loading of 0 mg/cm².

PILOT SCOPE

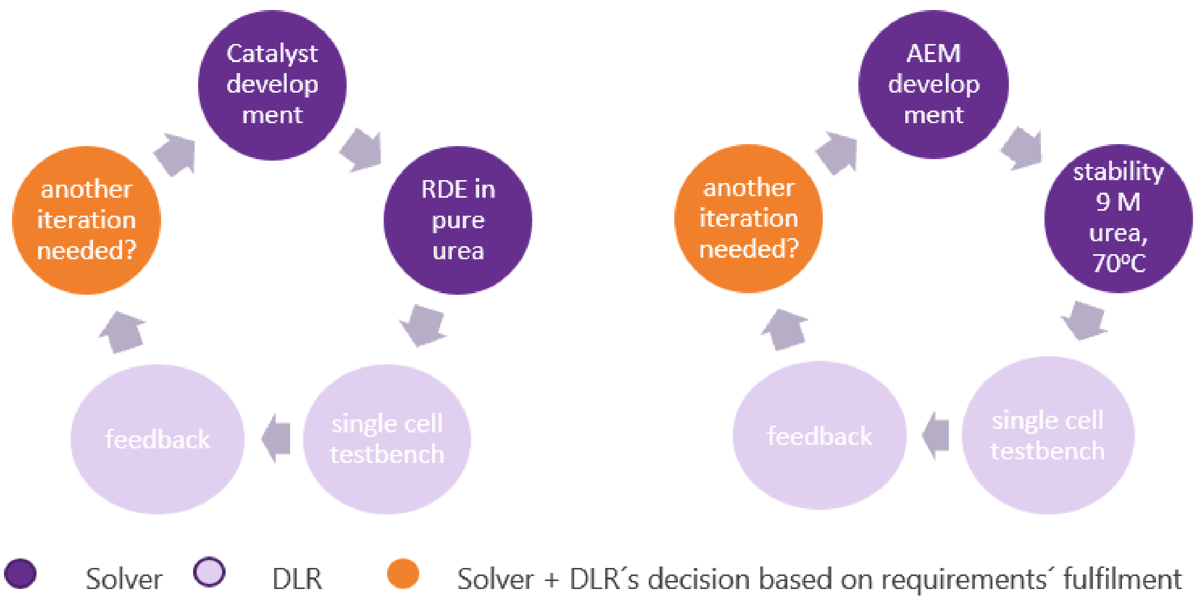
The materials provided by Solver will be screened and investigated, and further developed at DLR throughout the co-creation process. This will give an insight into the development direction over the process duration. Catalyst RDE tests are to be performed by the solver (not by DLR). Finally, if the performance is acceptable, the long-term durability and

Funded by the European Union

This project has received funding from the European Union's Horizon Europe research and innovation programme under the Grant Agreement 101071212. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.

degradation tests will be carried out in a single cell test electrolyser. An ideal outcome is to present a working, small scale electrolyser using the functional materials created in the challenge. The co-creator will gain the unique possibility of supplying their urea-water electrolysis functional materials for projects that DLR will be involved in in the future. A simultaneous co-development process summary can be visualised as follows:

TABLE 1 PROPOSED CO-DEVELOPMENT CYCLE



Type and number of targeted end-users

End-user type	Role	Number
Energy companies	urea-water electrolysis has potential to be energetically beneficial to water electrolysis. Moreover it subs Iridium use with Nickel reducing the technology cost.	Green energy end users. In 2020, the EU spent €11.2 billion on green energy products IMPORT to satisfy the consumer needs!
Fertiliser industry	CO2 emission reduction when used as support system for Haber-Bosch ammonia production technology	Manure and synthetic fertilizers emit the equivalent of 2.6 gigatons of carbon per year worldwide affecting the whole of the population.

Funded by the European Union

This project has received funding from the European Union's Horizon Europe research and innovation programme under the Grant Agreement 101071212. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.

Diesel plants and private users	NOx emission reduction	Diesel engine end users (ca. 120 million users only in the EU)

Language

English

Other aspects

Previous expertise in membrane science and catalyst development needs to be in the know-how of the solver. The solver needs to have their own development labs, catalyst synthesis abilities, the catalyst screening equipment e.g. rotating disc electrode and membrane production capabilities (nice-to-have membrane area 16 x 16 cm).

PILOT SET-UP CONDITIONS

Ethical, legal or regulatory

- Prior to any knowledge exchange, an NDA signed by both parties has to be in place.
- Technical scope proposition and time plan agreed by both parties.

Technological

The Solver will have the possibility to send their functional materials for testing at DLR Stuttgart – department for electrochemical engineering. Within the low temperature electrolysis research group, we operate and electrochemically characterise materials at a cell or stack level. Our main objective is performance and durability optimisation on an electrolyser level. By specialising in the upscaling science, we aim to form a bridge between the material development science and the industrial implementation.

Within this co-creation process, we will support the solver by electrochemically characterising their developed functional materials (meeting the initial KPIs) in a single cell setup with the active surface area of 4 cm2. The feedback will be given based on the cell activity, performance, stability and reaction kinetic speed (polarisation curves, EIS, standard activation and operation protocols will be employed). With this feedback, further iterations of the functional materials can be done within the time scope of the challenge.

Other

Short term visits at DLR Stuttgart are possible but will not be sponsored by DLR.

EXPECTED IMPACTS AND KPIs

- 5-10x performance improvement by implementation of tailor-made functional materials.

Funded by the European Union

This project has received funding from the European Union's Horizon Europe research and innovation programme under the Grant Agreement 101071212. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.

- 100% Platinum group metals (PGM) loading reduction (at least on the anode) from 1 mg/cm^2 to 0 mg/cm^2.
- Diesel exhaust line denoxification – improving the NOx emissions especially in the cities.

BUSINESS OPPORTUNITY

DLR is a project management agency focused on bringing the research and industry worlds together. We are looking for innovative functional materials tuned for the electrochemically induced urea to ammonia and hydrogen production in order to enter new markets and acquire R&D projects in this new topic. Should the co-development of this challenge be successful, we will acquire the functional materials for all ongoing and future urea electrolysis related projects.

Market size

As the AEM technology is being developed to tackle the existing technological and performance gap of urea electrolysis, the solution would be readily available for scaling it outside of DLR. The project results can be implemented in the industry (e.g. fertiliser, automotive) within 1-2 years for the small and medium enterprises (SMEs) and 3-5 years for the original equipment manufacturers (OEMs). This technology transformation will be vital for both the industry as well as the citizens, whose quality of life in regard to cleaner air will improve.

Adoption plans

We can wish for using the solution in upcoming European projects. That would include upscaling by electrolyser conceptualisation and operation in the near future – 2-3 years after solution is found. Another step would be to build electrolyser plants allowing for more upscale simultaneous urea and ammonia production.

Funded by the European Union

This project has received funding from the European Union's Horizon Europe research and innovation programme under the Grant Agreement 101071212. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EISMEA. Neither the European Union nor the granting authority can be held responsible for them.