

Scale-up, procurement, construction, assembly and integration of the electrochemical demonstration unit

Interview with Erik Verbeek (Coraltech B.V.)



Erik Verbeek

The EU-funded WaterProof demonstrates a unique electrochemical Carbon Capture and Utilisation (CCU) route in which captured carbon dioxide (CO_2) from waste and wastewater treatment is converted into formate and then into formic acid. Coraltech from the Netherlands contributes mainly to the scale-up, including procurement, construction, assembly and integration of the demonstration unit. A specific focus is the electrochemical acidification unit, where potassium formate is converted into formic acid and potassium hydroxide (KOH).

The WaterProof project aims to demonstrate a unique Carbon Capture and Utilisation (CCU) technology that turns captured carbon dioxide (CO₂) into formic acid. What is Coraltech's practical role in building the demonstration unit for this process?

Coraltech's practical role is to design, build, and integrate the demonstration unit for the WaterProof project. Coraltech provides its mechanical and electrical engineering, fabrication, and manufacturing expertise to translate the CCU process concept into a fully

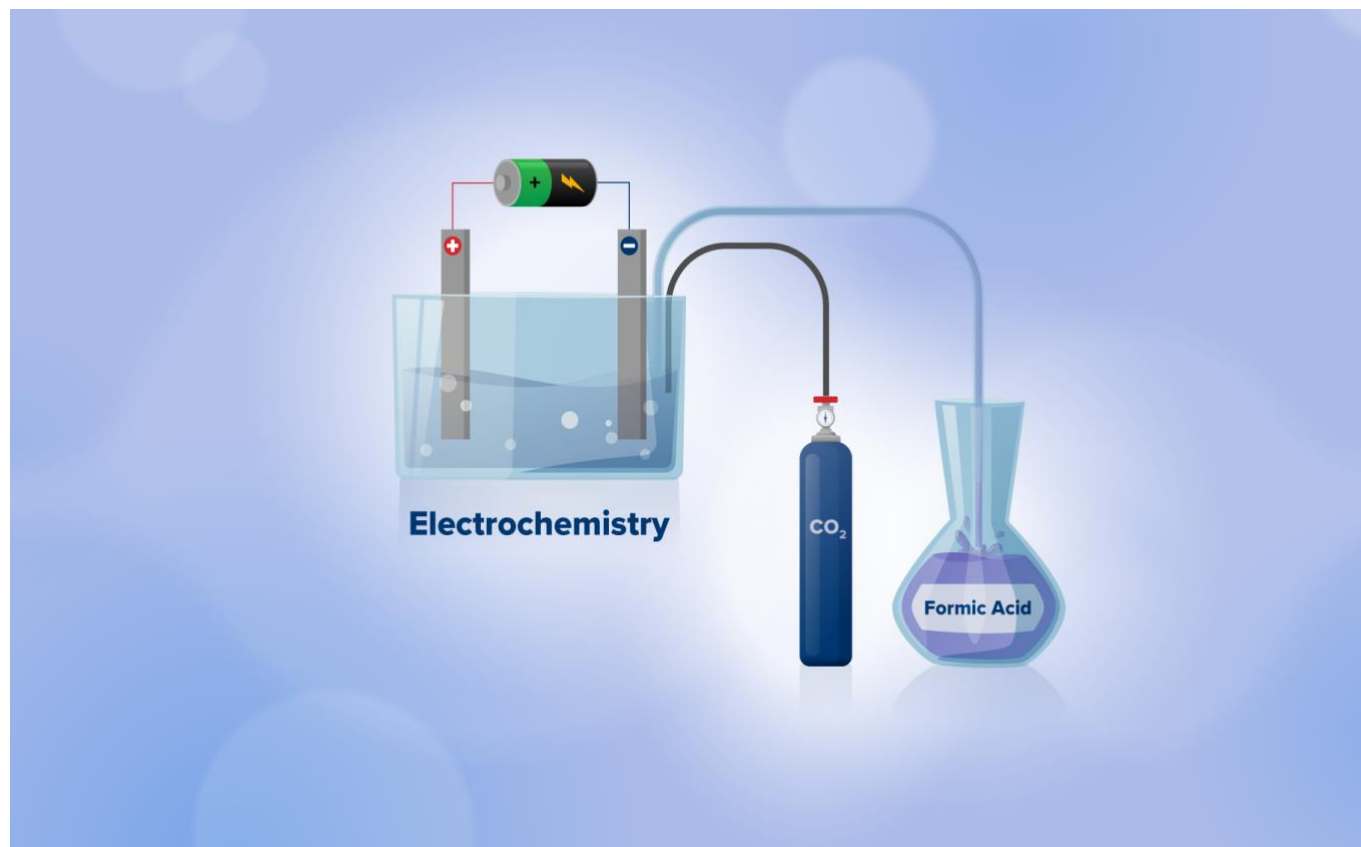
functional pilot-scale system. This includes the detailed engineering, fabrication and/or procurement of the required equipment and components, as well as their integration into a complete and operational demonstration unit.

In WaterProof, the electrochemical acidification unit converts potassium formate into formic acid and potassium hydroxide (KOH). Why is this step important for the overall CO₂-to-formic-acid process, and what makes the unit unique to build?

Coatema's *Click&Coat* technology offers maximum modularity and flexibility, allowing for

the rapid development and scale-up of special coatings for WaterProof electrodes. This

Electrochemical Processes (Source: Coatema)



revolutionary concept provides an endless number of process variants, enabling the configuration of the line to meet specific process requirements. *Click&Coat*'s flexibility is evident in its interchangeable coating heads and downstream components that can be easily assembled to create customized inline processes. With over 30 different process modules available, *Click&Coat* offers a wide range of configurations that can be tailored to meet the most demanding performance and quality standards. This technology not only streamlines the electrode coating process but also enhances efficiency,

throughput, and the development of coating and lamination technology.

Coatema's *Click&Coat* technology significantly contributes to the rapid development and scale-up of special coatings for the WaterProof electrodes. This technology enables the design and development of an appropriate roll-to-roll line, crucial for upscaling the production of gas diffusion electrodes (GDL) in projects like WaterProof. By upgrading the *Click&Coat* pilot line, Coatema enhances the efficiency and precision of coating processes, facilitating the production of innovative solutions for improving the carbon cycle of waste water.

Could you elaborate on any recent breakthroughs or innovations in electrochemical CO₂-conversion processes that have been achieved with the assistance of Coatema's electrode coating?

What makes the unit unique to build is the combination of electrochemical, mechanical, and electrical engineering requirements at demonstration scale. The unit must provide controlled separation and conversion, while handling corrosive chemicals, electrical current, and precise operating conditions. Coraltech's role

is to translate Avantium's process technology into a robust, safe, and operational demonstration unit, including the mechanical and electrical design, fabrication, procurement, and integration of the required components.

The demonstration unit combines electrochemical equipment, piping, instrumentation, control systems and safety features in a containerised pilot plant. What are the main engineering challenges in making this type of integrated system safe and reliable for operation at an industrial site?

The main engineering challenge is to integrate many different systems into one compact, safe and reliable industrial installation. This includes the electrochemical equipment, piping, instrumentation, electrical systems, control systems and safety functions, all of which must

work together under demanding operating conditions.

A particular challenge for Coraltech was the choice of materials. Whereas we normally design and install piping and vessels mainly in stainless steel, for this project approximately 90% of the piping and vessels were made from plastic. This

required careful material selection and engineering to ensure chemical compatibility, mechanical integrity, temperature resistance and safe operation.

The containerised design also required careful attention to layout, accessibility, ventilation, electrical safety, pressure control and emergency shutdown systems. The challenge is not only to make each individual component work, but to ensure that the complete integrated system is

robust, safe and reliable for operation at an industrial site.

An additional challenge was the project timeline. Coraltech joined the consortium at a later stage, which meant that we had a significantly shorter timeframe to complete the engineering, procurement, fabrication, integration and testing of our part of the demonstration unit. This required close coordination with the other partners, fast decision-making.

Many Carbon Capture and Utilisation (CCU) and Power-to-X technologies face challenges when moving from laboratory tests to integrated pilot plants on bigger scale. What lessons from Coraltech's work in WaterProof could be useful for other projects that aim to scale up electrochemical CO₂ conversion?

One of the key lessons from Coraltech's work on WaterProof is that scaling up an electrochemical process is not simply a matter of building a smaller version of a full-scale industrial plant. A pilot plant has a different purpose: it should provide a safe and reliable platform to demonstrate the technology, learn from its operation, identify improvements and generate the data needed for further scale-up.

The design therefore needs to be fit for purpose, with the right balance between safety, reliability, flexibility, cost and speed of construction. Over-engineering a pilot plant to full-scale industrial standards in every aspect can add unnecessary complexity, cost and lead time, while not necessarily improving the value of the demonstration.

Another important lesson is that integration needs to be considered from the beginning.

Electrochemical equipment, piping, materials, instrumentation, control systems and safety systems must be designed as one integrated system. In WaterProof, for example, the extensive use of plastic for piping and vessels required a different engineering approach from the stainless-steel systems Coraltech normally builds.

Finally, successful scale-up requires close cooperation between the technology developer and the engineering and construction partners. Clear interfaces, early design decisions and practical communication are essential, particularly when the project timeline is tight. For future electrochemical CO₂ conversion projects, we believe that a pragmatic, fit-for-purpose pilot design can accelerate learning and reduce the risk and cost of the subsequent scale-up.

WaterProof links CO₂ utilisation with industrial symbiosis by using emissions from waste-related sources as a raw material for products such as formic acid, cleaning products, leather tanning chemicals and Acidic Deep Eutectic Solvents (ADES) for metal recovery. What would be needed to transfer this kind of modular CCU concept to other industrial sites, sectors or CO₂ sources?

I think the main requirement is flexibility. Every industrial site is different in terms of the available CO₂ source, gas composition, utilities, available space, operating conditions and the products that can be made from the captured CO₂. A modular CCU concept therefore cannot simply be copied from one site to another; it needs to be adapted to the specific conditions and requirements of each location.

From a practical engineering perspective, standardising the main building blocks could nevertheless make this type of technology easier to replicate. Modular equipment, flexible piping and control concepts, and clearly defined interfaces could allow the system to be adapted without having to redesign everything from scratch.

It is also important to look at the complete value chain. The availability and quality of the CO₂, the

energy and other utilities required, the local infrastructure, the potential end products and their market value all need to make sense together. In some cases, a technically feasible solution may not yet be the most practical or economical one.

From Coraltech's experience in WaterProof, we see modularity as a promising approach, but we would not claim that there is one standard solution for every industrial site. The real opportunity is to develop flexible building blocks and a practical engineering approach that can be adapted to different CO₂ sources, industries and applications as the technology matures.