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CYCLIZE LAUNCHES P2M2X TO ADVANCE INDUSTRIAL CO₂ UTILIZATION THROUGH NOVEL PLASMA-MEMBRANE TECHNOLOGY

Stuttgart, Germany – Cyclize GmbH, a deep-tech company specializing in plasma-based carbon conversion technologies, announces the launch of the research and development project **P2M2X**, a strategic initiative aimed at enabling the industrial utilization of carbon dioxide (CO₂) as a sustainable carbon feedstock. The project focuses on the development of a novel plasma-membrane reactor that integrates CO₂ splitting and product gas separation within a single, highly efficient system. Coordinated by Cyclize and conducted in collaboration with the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB and the Chair of Electrical Energy Storage Systems at the Institute for Photovoltaics (*ipv-EES*), University of Stuttgart, the project will run from March 2026 until February 2029.

The project is funded under the Energy Research Program by the **Federal Ministry for Research, Technology and Space (BMFTR)** and is managed by the **Project Management Jülich (PtJ)**. The project will run for 36 months, from March 2026 to February 2029. A total of 1.5 million euros in funding has been approved for P2M2X. The budget for Cyclize totals 142,783.81 EUR, of which 99,948.67 EUR are earmarked as funding for Cyclize.

Industrial Context and Strategic Relevance

The increasing pressure on the chemical industry to transition toward climate neutrality has intensified the search for viable alternatives to fossil carbon sources. While CO₂ is abundantly available and represents a promising feedstock, its chemical stability has historically limited its economic utilization. Existing conversion technologies—particularly in the field of non-thermal plasma—have demonstrated technical feasibility but continue to face critical barriers in efficiency, scalability, and downstream separation of reaction products. One of the most persistent challenges lies in the effective separation of oxygen from the product gas mixture, a prerequisite for achieving high conversion rates and preventing recombination reactions that reduce process efficiency. P2M2X directly addresses this challenge through a fundamentally new approach that combines plasma-based CO₂ splitting with membrane-based oxygen separation in a tightly integrated reactor design.

Technological Innovation and Process Design

At the core of the project is the development of a plasma-membrane reactor that utilizes a **glow-to-arc discharge (GAD) plasma** in combination with a mixed ionic-electronic conducting hollow fiber membrane. This configuration represents a significant departure from existing plasma reactor concepts, which typically rely on microwave or dielectric barrier discharges and treat reaction and separation as distinct process steps. By contrast, the P2M2X approach integrates both functionalities within a single unit, enabling continuous removal of oxygen directly from the reaction zone. This not only enhances conversion efficiency but also shifts the thermodynamic equilibrium, allowing higher yields of carbon monoxide (CO), a key building block in the chemical industry. The use of GAD plasma further enables improved control over plasma conditions, particularly temperature distribution, which is essential for maintaining membrane performance within its operational window and ensuring stable long-term operation.

The technological innovation of P2M2X is underpinned by three key advancements: first, the stabilization and control of plasma behavior through magnetically induced plasma rotation, which enhances gas-plasma interaction and improves reaction uniformity; second, operation at or near atmospheric pressure, significantly reducing system complexity and facilitating industrial scalability compared to low-pressure plasma systems; and third, the integration of thermal management strategies that utilize process heat to drive oxygen separation through the membrane, thereby increasing overall energy efficiency. Together, these elements constitute a highly integrated process intensification concept that has the potential to overcome longstanding limitations in plasma-based CO₂ conversion technologies.

To demonstrate industrial relevance, the project has defined clear and ambitious technical targets, including a CO₂ conversion rate exceeding 30 percent, an energy efficiency above 40 percent, and an oxygen extraction efficiency greater than 90 percent. Achieving these benchmarks would represent a significant breakthrough in the field and position plasma-based CO₂ conversion as a competitive alternative to conventional fossil-based processes. Moreover, the modular design of the reactor concept allows for flexible deployment across a wide range of CO₂ sources, from concentrated industrial emissions to emerging direct air capture (DAC) systems, thereby broadening its potential application scope.

Integration into Cyclize's Platform and Market Impact

P2M2X is strategically aligned with Cyclize's broader technology platform, which focuses on the conversion of mixed waste streams and CO₂ into synthesis gas (syngas) using proprietary plasma processes. By enabling the efficient production of CO from CO₂, the project extends the company's capabilities in carbon circularity and provides a complementary pathway for integrating CO₂ into existing value chains. The generated CO can be combined with hydrogen to produce syngas, a versatile intermediate used in the production of fuels, chemicals, and materials such as methanol, polymers, and synthetic hydrocarbons. This integration supports the transition from a linear, fossil-based economy to a circular

carbon economy in which waste streams and emissions are continuously reintegrated as valuable resources.

The consortium behind P2M2X brings together complementary expertise across multiple disciplines. Cyclize contributes its experience in plasma reactor development, system integration, and commercialization of industrial-scale solutions. Fraunhofer IGB adds decades of expertise in membrane technology, particularly in the development and characterization of high-temperature ceramic membranes for gas separation. The *ipv-EES* at the University of Stuttgart provides deep knowledge in plasma physics, power electronics, and process engineering, building on prior research in plasma-based CO₂ conversion. The close collaboration between these partners, all located within the Stuttgart research ecosystem and organized in the CHEMampere Research Focus, enables agile development cycles and efficient knowledge transfer, increasing the likelihood of both scientific and commercial success.

Beyond its technological objectives, P2M2X contributes to broader environmental and economic goals by supporting the defossilization of the chemical industry and reducing greenhouse gas emissions. The electrified nature of the process allows direct coupling with renewable energy sources, enabling flexible operation in response to fluctuating energy supply and supporting the integration of renewable electricity into industrial processes. At the same time, the ability to utilize CO₂ as a feedstock reduces dependence on fossil resources and enhances supply chain resilience, particularly in regions facing increasing regulatory and economic pressure to decarbonize.

The project is expected to generate substantial scientific output, including multiple peer-reviewed publications and potential intellectual property filings, reflecting the novelty of the approach and its relevance to ongoing research in plasma catalysis and process intensification. In parallel, Cyclize intends to translate the project results into commercial applications, integrating the developed reactor concept into its product portfolio and offering it as part of scalable industrial solutions for carbon conversion. This dual focus on scientific excellence and industrial implementation underscores the project's role as a bridge between fundamental research and market-ready technology.

Project Partner

Cyclize GmbH
www.cyclize.de

Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB
<https://www.igb.fraunhofer.de/en>

University of Stuttgart, Institute for Photovoltaics, Electrical Storage Systems (*ipv-EES*)
<https://www.ipv.uni-stuttgart.de/en/>

About Cyclize

Cyclize, a spin-off from the University of Stuttgart, has developed a technology to defossilize the chemical industry using mixed plastic waste and CO₂ as raw materials to produce synthesis gas (a gas mixture of carbon monoxide and hydrogen). This synthesis gas is a fundamental building block for advanced chemicals and is used in making plastics, methanol, hydrogen, and e-fuels. Until now, synthesis gas has been obtained through the linear use of fossil resources such as natural gas. The innovative plasma-based process replaces fossil resources with waste materials, enabling a circular carbon economy and avoiding hundreds of megatons of CO₂ annually by 2050.

Founder Team

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