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Turning CO2 from urban waste into useful consumer products

EU-funded researchers are turning carbon emissions from urban waste into everyday household products – from cleaning liquids to leather.

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Europe's cities emit huge amounts of greenhouse gases into the atmosphere. Two essential urban services – waste incineration and wastewater treatment – are among the biggest contributors to municipal CO2 emissions in the EU.

These systems are vital for public health and urban life, yet they produce emissions that are difficult to eliminate entirely. But what if that CO2 did not have to go to waste?

For an international group of researchers, urban carbon pollution presents an opportunity. Working together in the EU-funded WaterProof initiative, they are developing a way to capture CO2 from these processes and convert it into formic acid: a simple, highly versatile chemical used across many industries.

This could allow emissions from waste incinerators and wastewater to be turned into the cleaning products under our sink, or even the leather on our shoes.

Turning a problem into a resource

Efforts to tackle climate change focus largely on renewable energy, electrification and improved efficiency. But some sources remain stubbornly hard to eliminate.

"Some emissions are difficult to stop," said Annelie Jongerius, an electrochemist and programme manager at Dutch chemical company Avantium, which coordinates the research.

One option is to capture the CO2 and store it underground. But the WaterProof team is exploring a more circular alternative: keeping carbon in use rather than locking it away.

“It would be nicer if we could use it,” Jongerius said. “At the same time, we need alternatives to fossil feedstocks for producing chemicals.”

That challenge is particularly visible at facilities like those operated by Dutch waste management company HVC, which runs two major waste incinerators in the Netherlands.

“We have to take in whatever waste society produces,” said Jan Peter Born, HVC’s waste-to-energy innovation manager. “We have no means of regulating CO2 emissions, apart from encouraging people to buy less and recycle more.”

HVC already captures some CO2 and sells it to greenhouse farmers, who use it to increase the yields of crops such as tomatoes and cucumbers. But this is only a partial solution.

“Most of the CO2 administered to the plants is released again through the greenhouse roof,” Born explained. “From our legal perspective, it’s a delayed emission. It is the farmer who achieves the emission reduction as he avoids gas-firing to produce CO2.”

The WaterProof researchers aim to go a step further by turning captured carbon into useful products that keep it out of the atmosphere for longer.

From CO2 to cleaning products

At the heart of the WaterProof innovation is an electrochemical process that converts captured CO2 into formic acid using renewable electricity.

“It’s one of the simplest conversions you can make,” said Jongerius.

An electrical current drives the reaction in a specialised cell, reducing CO2 into formic acid. Because the system runs on renewable electricity and uses waste-derived carbon, it reduces reliance on fossil-based raw materials.

The process may also offer additional benefits. In an electrochemical cell, two reactions take place at the same time, one at each electrode. While the WaterProof team focuses on converting CO2 into formic acid, they have also explored pairing this with a second reaction that produces hydrogen peroxide and related compounds.

These substances can help break down stubborn pollutants in wastewater, including residues from pharmaceuticals and pesticides. However, this part of the process is still at an early stage and is not being implemented in the current demonstration system.

The team is testing their CO2-derived formic acid in eco-friendly cleaning products such as toilet and surface cleaners.

“It performs exactly the same as conventionally produced formic acid,” Jongerius said. “It’s the same molecule.”

Beyond cleaning, the project is exploring the use of CO2-derived formic acid in leather tanning. While the acid can be used for all types of leather, the team is currently working with Icelandic company Nordic Fish Leather to bring eco-friendly fish leather – a more sustainable alternative to traditional cattle-based leather – to market.

Scaling up for real-world impact

While the chemistry is promising, scaling up is the next challenge.

Building on earlier EU-funded research, the team is now working on a large-scale pilot unit in which multiple electrochemical cells are stacked together, increasing the volume of CO_2 that can be processed. If successful, it will pave the way for commercial-scale plants.

The modular design allows the system to be adapted to different sites, from wastewater plants to incinerators. The aim is to demonstrate the WaterProof process in the summer of 2026, showing that a fossil fuel-free production chain can operate under real-world conditions.

Such systems could eventually be integrated into urban infrastructure, turning cities into hubs for circular chemical production rather than sources of emissions.

Recovering valuable materials from waste

The potential of the work being carried out goes beyond carbon reuse. The researchers are also exploring how formic acid can be used to recover valuable materials from waste streams.

By combining it with other compounds, they are developing deep eutectic solvents – low-toxicity liquids capable of dissolving and binding to metals in waste so that the metals can be extracted.

Many valuable materials end up in incinerator ash and wastewater sludge, including copper, lithium, cobalt, and even small amounts of gold – all critical for modern technologies and the green transition.

HVC already uses mechanical processes to recover metals, separating heavier particles from ash in a process similar to gold panning. But this produces mixed metal streams that are less valuable. The new solvents could allow more precise separation.

“These eutectic solvents can be tailored to target specific metals,” Born said. “That means you could recover individual materials rather than mixtures, which increases their value.”

However, economic realities remain a barrier. Gold is the only recovered metal that commands a decent price, Born explained. For many others, including rare earths, the market price is still too low to justify the cost.

This raises broader questions about policy and priorities, particularly as demand for critical materials continues to grow: how much societies are willing to subsidise recovery from waste, and whether strategic value should win out over purely market-driven decisions.

Closing the loop

This kind of “waste-to-resource” thinking is gaining traction across Europe. New EU rules planned for 2026 aim to make recycled materials more widely available – and more widely used.

If successful, they could help turn circular ideas like those behind WaterProof into everyday reality, supporting Europe’s ambition to lead the world in circular production by 2030.

By linking carbon capture, chemical production, water treatment and material recovery, the researchers are bringing together multiple elements of that vision in a single system.

For Jongerius, the concept is both practical and symbolic.

“If you take CO_2 from wastewater, turn it into a product, and then use that product to clean your toilet so it flows back into the wastewater system, you create a complete loop,” she said. “It is the ultimate example of the circular economy.”

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More info

- WaterProof (CORDIS)
- WaterProof project website
- Circular Economy