

CARBON DIOXIDE

They say two heads are better than one. On this basis, three heads are presumably even more desirable. And this seems to bode well for the coming together of a trio of companies, at the end of October 2020, to announce the worldwide premiere of a plastics bottle for the cosmetics industry derived from industrial carbon emissions.

This is quite a breakthrough and, for one of the three companies, the culmination of 15 years' experience with the process. Carbon recycling company LanzaTech, founded in New Zealand but based in Illinois, USA, is a global leader in gas fermentation, making sustainable fuels and chemicals through the biological conversion of waste carbon emissions. These include industrial off-gases, synthesis gas generated from any biomass resource, and reformed biogas.

Chief executive Jennifer Holmgren explains that the company has accrued experience in areas including fermentation scale-up, reactor design, machine learning and synthetic biology.

"Our company has commercialised its recycling process and demonstrated the production of more than 100 different chemicals," she says. "Our pipeline of projects around the world aims to provide novel circular solutions to mitigate carbon by producing consumer goods that would otherwise come from fresh fossil resources."

Another of the partner companies, energy giant Total, has been developing "plastics for the future" for many years, claims vice-president of business development for polymers David Vandewiele. The past decade, he explains, has seen the company develop a robust position in polymers and in transforming ethanol into PE.

"We also carefully followed the LanzaTech project," he says. "So, when we joined with the company to work on the proof-of-concept in our lab with them, it came as evidence [of our real interest]. Then, when L'Oréal asked for biopolymer and joined in, we had a concrete application to work on."

With a portfolio of 36 brands, beauty company L'Oréal has more than 4,000 people dedicated to research and innovation, so it is no surprise that the circular economy is high on the company's list of priorities.

"The circular economy is the spearhead of our packaging strategy, and L'Oréal participates in the development of recycling processes that complement existing mechanical recycling capabilities," says packaging and development director Jacques Playe. "For example, L'Oréal has created the Carbios consortium in partnership with Nestlé to develop enzymatic recycling. Each time, we seek the best partners to develop innovative solutions, and LanzaTech and Total seemed to us to be the partners of choice on this project."

Let the genie out of the bottle

Transforming carbon emissions into a plastics bottle might once have been considered pie-in-the-sky, but not any more. **Dominique Huret** interviews the stakeholders behind an innovative partnership that is unlocking new feedstocks



*Above: Carbon dioxide for this project is captured from the steel-mill waste stream of China's Shougang Group
Right: An essential part of the process is the bioreactor containing the brew of microbes*

Charting the path of the process

The inspiration for the LanzaTech process came from naturally-occurring acetogens, an ancient family of gas-fermenting organisms found near undersea hydrothermal vents. The vents provide these organisms with all the nutrients they need for their entire lifecycle – all in the form of gases. The vent gases have much in common with emissions from steel manufacturing and other industrial and landfill sources, namely content that includes carbon dioxide and carbon monoxide, as well as hydrogen, hydrogen sulphide and methane.

"It took us quite some research, all the way to a specific microorganism library in Germany, to find a strain of the right biocatalyst,"



explains Holmgren. “The clostridium, an organism categorised as WHO-risk 1 – as safe as baker’s yeast – can survive and thrive in industrial waste gases. Now, our company is engineering its own version of the microbial family.”

The second essential part of the process is the bioreactor containing the brew of microbes, which converts the deadly gas into ethanol and other products. “We have evaluated that one tonne of carbon dioxide allows for the production of 660 litres of ethanol,” says Holmgren. “At present, and for this project, the carbon dioxide is captured from the steel-mill waste stream of Shougang Group, a leading Chinese iron and steel producer located three hours from Beijing.”

“With several partners, we built our first commercial recycling plant in 2018, next to the steel mill. Today, our second one is under construction, also in China. As 50 per cent of all world steel is produced in the country, this makes perfect sense.”

What emerges from the recycling process is ethanol, and that’s when Total’s role takes shape.

The company’s Vandewiele explains: “At Total, we have developed with IFP Axens an innovative dehydration process to first convert this ethanol into ethylene and purify it, and then proceed with polymerisation into PE. And all of this creates the same technical characteristics as its fossil counterpart. With the pilot project, we have been creating the first ‘bricks’ of industrial ethanol. Now, the project has to scale up.”

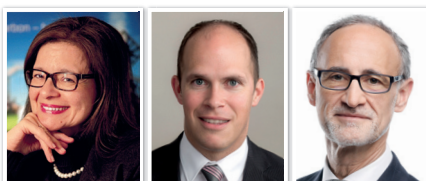
L’Oréal insists that it is “too early” to ask who the converter of the bottles will be, because the project is not yet in the industrialisation phase. Now that the pilot has been concluded, the beauty company has turned its attention to this next phase, with the objective of making the technology available to its strategic packaging suppliers.

“Our objective is to industrialise this technology by 2024,” states L’Oréal’s Playe. “In part, it is this innovation that will enable us to



Above left: L’Oréal boasts the first cosmetic plastics bottle made from industrial carbon emissions

Above: LanzaTech specialises in the biological conversion of waste carbon emissions



Above (left to right): Jennifer Holmgren, chief executive of LanzaTech, David Vandewiele, vice president of business development for polymers at Total, and Jacques Playe, packaging and development director at L’Oréal

achieve our ambitious objectives for 2030.”

LanzaTech and Shougang Group are one step ahead, because they already have an operational ethanol recycling unit with a capacity of 60 million litres a year. The second Chinese factory will be ready soon and will recycle fumes from ferro-alloy emissions, while the first European project is running with ArcelorMittal in Gent, Belgium.

This €150 million (\$181m) project is similar to the LanzaTech Chinese unit, in that it collects gases from the blast furnace of a steel mill. Funds came from various sources, including the EU’s Horizon 2020 programme, and the bioethanol forecast for this plant is expected

to reach 80m litres a year. The project is due to start production in 2022.

For Total, a huge task lies ahead. A first plant has to be built, and site evaluations across Europe are already taking place, in addition to feasibility studies. They say that ‘where there is a will, there is a way’, and Total’s senior vice-president of polymers, Valerie Goff, has announced a plan for the mass industrialisation of shampoo and conditioner bottles by 2024-’25. L’Oréal has set its sights on the same timeline.

Price linked to supply and demand

“One can reasonably expect there will be an extra cost in producing this biopolymer, at least in the first years,” admits Total’s Vandewiele. “We have to build a plant from scratch and guarantee volume for economies of scale. All brand-owners are welcome to join in, as this breakthrough innovation will pave the way for additional opportunities in the capture and re-use of industrial carbons.”

Technology continues to unlock new feedstocks that potentially help keep fresh fossil resources in the ground. This is enabling industries that are traditionally seen as polluters to create new value by driving environmental benefits and reducing pollution.

Consumer brands are now rethinking their supply chains with waste carbon seen as a viable and sustainable feedstock – we think of this as the New Carbon Economy,” says LanzaTech’s Holmgren. “We are running out of time to bend the curve of our rising emissions, and we need all sustainable solutions to create a circular bio-economy. The combined leadership of countries and companies will help create this movement and accelerate the transition we need to safeguard our planet.”

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