Natural gas

More than 90 percent of available natural gas is burned to generate electricity, a process that releases CO_2. Javier Pérez-Ramírez is looking to produce high-grade chemicals from methane, a component of natural gas, without producing CO_2.

Fuelling sustainable chemistry

A group of researchers led by Javier Pérez-Ramírez is developing catalysts that could help make plastic manufacturing greener and less dependent on oil.

TEXT Martina Märki

In the Middle Ages, alchemists strove to transform base metals into gold – a goal that still eludes us to this day. Yet much of modern chemistry actually does something similar, producing a plethora of refined products from a limited number of the cheapest available materials. According to estimates, 90 percent of the chemical reactions this involves rely on the use of catalysts.

Catalysts are substances that initiate or speed up chemical reactions. "They play a key role in our efforts to optimise the use of available resources," says Javier Pérez-Ramírez, a professor of catalysis engineering. He and his team are busy developing new catalytic technologies to foster "greener" chemistry that will make manufacturing more eco-friendly and lead to more sustainable products. "The goal is to make efficient use of raw materials while consuming less energy and creating less waste."

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FOCUS

Turning a waste product into biodegradable plastic

Pérez-Ramírez points to the plastic cups of water on the table: "That's a perfect example." Most plastics are made from crude oil. At the same time, plastic waste is a huge environmental issue because many plastics are not biodegradable. One alternative that already exists is an eco-friendly, biodegradable plastic made from polylactic acid (PLA). Working with a number of other ETH researchers, Pérez-Ramírez's group has succeeded in developing a new method of producing lactic acid. As well as being more efficient and cost effective, their process is also less polluting than conventional manufacturing techniques, reducing CO_2 emissions by up to 30 percent.

The new method for making PLA uses glycerol, a waste by-product of first-generation biofuel production. Glycerol previously had a very low reuse value, but PLA production now offers an environmentally friendly application. One of the keys to minimising the environmental impact is the catalyst used in the reaction, which the researchers have optimised by various different means. This is based on a zeolite, a microporous mineral with a structure that has proved to be ideal for certain chemical reactions. "With the new methods we've developed, we can do things like investigating how the pores of a catalytic material are connected," says Pérez-Ramírez, adding: "The combination of precisely tailored, rational design and a little help from nanotechnology has enabled us to raise the bar of catalyst quality."

A new use for natural gas

His team is also creating catalysts to facilitate new applications for natural-gas components such as methane. "Natural gas is currently used to supply energy, but it could also potentially be a useful raw material for chemistry, like oil is now," argues Pérez-Ramírez: "Perhaps in the future we won't just be producing plastics from methane, but also vitamins or even pharmaceutical products."

In recent years fracking has opened up access to large reservoirs of gas, so methane is now available in abundance. One major challenge, however, is that methane is chemically very stable, which makes it difficult to transform into useful chemicals. Currently, the most common method of using methane is to convert it into synthetic gas by means of steam reforming. "That uses a lot of energy and produces CO_2, neither of which is a sensible goal," says Pérez-Ramírez. Other attempts to produce chemical products from methane have generally been thwarted by the expensive and time-consuming nature of the catalytic methods involved, or due to their poor selectivity – in other words, the targeted product represents only a small fraction of the reaction end products.

Pérez-Ramírez and his group have come up with a new approach, creating a catalyst that offers very high efficiency. They use hydrogen chloride and hydrogen bromide to convert methane. Both of these are chemical waste products that this new process can recycle. However, halogen chemistry is complicated by the fact that the compounds are highly toxic and very corrosive. "Only a handful of laboratories worldwide can work with halogens in the same way we do," says Pérez-Ramírez. The conversion process yields products that can be used to create useful raw materials for chemistry. To develop the catalytic process, the group has worked with different phosphates and metal oxides; their catalyst presents a selectivity of over 90 percent. The researchers are now hoping to establish a spin-off company to commercialise their groundbreaking technique. ○

Bioplastic can be produced in an even more eco-friendly way.

Javier Pérez-Ramírez

Javier Pérez-Ramírez has been a professor of catalysis engineering at ETH Zurich's Institute for Chemical and Bioengineering since 2010. He studied chemical engineering at the University of Alicante and earned his PhD at TU Delft in the Netherlands in 2002. After spending a few years working in industry, he returned to academia in 2005 as research professor at ICIQ in Tarragona, Spain.

Advanced Catalysis Engineering Group:
→ www.perez-ramirez.ethz.ch

Turning a waste product into biodegradable plastic:
→ www.ethz.ch/news-bioplastic

Photos: Bo Cheng; Giulia Marthaler