

Chemicals from wood waste

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Vitamins, medication, solvents, crop protection products and polymers—in future, it will be possible to manufacture many of these from wood waste. The processes will also be at least as cost-effective, environmentally friendly and safe as current oil-based processes. This has been demonstrated by an international team of researchers headed by ETH scientists.

The present-day chemical industry is based on oil: many chemical products - from plastics through to detergents and solvents to medication and crop protection products - have their origins in oil and its constituents. Since oil reserves are finite, scientists have been looking for ways to manufacture these products from sustainable materials.

An international research team has now demonstrated just such an alternative [manufacturing method](#) for a major basic chemical product: succinic [acid](#) (see box). The team led by Konrad Hungerbühler, Professor of Safety and Environmental Protection Technology in Chemistry at ETH Zurich, also included scientists from EPFL and the Chalmers University of Technology in Gothenburg.

As the researchers demonstrated in a comprehensive ecological assessment, succinic acid can be manufactured in a cost-effective, environmentally friendly and safe manner - using bacteria. The researchers identified wood or cellulose waste from the forestry and paper industries as their source material of choice.

More cost-effective or more sustainable

The scientists used simulation procedures to compare different manufacturing processes and bacteria, which were optimised in the laboratories at EPFL for manufacture of succinic acid by biotechnological means. Their findings showed that depending on the bacteria and processes used, biotechnological manufacture using wood waste is either significantly cheaper or considerably more eco-friendly than conventional methods based on oil. The researchers considered the total energy required for manufacture, including grey energy (which also covers the indirect energy required to manufacture primary products, infrastructure and waste management), as a measure of the environmental impact.

The scientists calculated that for a specific biotechnological manufacturing method, succinic acid can be manufactured 20% more cheaply with a comparable environmental impact. Using a second method with different bacteria, the environmental impact can be reduced by 28% - with comparable costs to traditional oil-based methods.

Innovation for the paper industry

In order to manufacture succinic acid using bacteria, glucose (grape sugar) is required as the raw material. This can be extracted from sugar beet or sugar cane, and wood is also an option. "Cellulose, found in wood, can be converted to glucose by adding acid," explains Merten Morales, PhD student in Hungerbühler's group and lead author of the study.

The scientists compared the method of manufacture of succinic acid from sugar beet with the process for manufacture from wood waste. In terms of cost effectiveness, environmental impact and safety, the differences are negligible. "If it is possible to use [wood waste](#) - in other

words, waste from the forestry industry - that is what we should do," says Morales. "Then there is no competition with the food supply chain."

This new method would also interest the paper industry: an alkaline solution containing cellulose is also formed as waste in this sector, but it is not currently recycled. It would be an ideal source of glucose. "The European paper industry could once again hope to compete with strong competition overseas if it succeeded in recycling waste products and selling them with added value," says Morales. However, construction of a biotechnological production plant is a long-term investment and as such a matter of consideration for the chemical engineer. Before a company proceeded along this route, it would need to know whether it would be worthwhile. "We have now been able to answer this question in the affirmative thanks to our work."

Succinic acid

Succinic acid is added to fuel and lubricants to protect motors from corrosion. It goes under the name of E 363 in the food industry, where it is used as an acidifier and flavour enhancer, and to introduce air into food products. However, succinic acid is used predominantly as a starting point to create a huge range of chemical compounds: among other things, it is used to manufacture vitamins, medication, solvents, crop protection products, polymers and aromatic substances for perfumes.

More information: Merten Morales et al, Sustainability Assessment of Succinic Acid Production Technologies from Biomass using Metabolic Engineering, *Energy Environ. Sci.* (2016). [DOI: 10.1039/C6EE00634E](https://doi.org/10.1039/C6EE00634E)

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