

Purple bacteria 'batteries' turn sewage into clean energy

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You've flushed something valuable down the toilet today.

Organic compounds in household sewage and industrial wastewater are a rich potential source of energy, bioplastics and even proteins for animal feed—but with no efficient extraction method, treatment plants discard them as contaminants. Now researchers have found an environmentally-friendly and cost-effective solution.

Published in *Frontiers in Energy Research*, their study is the first to show that purple phototrophic bacteria—which can store energy from light—when supplied with an electric current can recover near to 100% of [carbon](#) from any type of [organic waste](#), while generating hydrogen gas for electricity production.

"One of the most important problems of current wastewater [treatment plants](#) is high carbon emissions," says co-author Dr. Daniel Puyol of King Juan Carlos University, Spain. "Our light-based biorefinery process could provide a means to harvest green energy from wastewater, with

zero carbon footprint."

Purple photosynthetic bacteria

When it comes to photosynthesis, green hogs the limelight. But as chlorophyll retreats from autumn foliage, it leaves behind its yellow, orange and red cousins. In fact, photosynthetic pigments come in all sorts of colors—and all sorts of organisms.

Cue purple phototrophic bacteria. They capture energy from sunlight using a variety of pigments, which turn them shades of orange, red or brown—as well as purple. But it is the versatility of their metabolism, not their color, which makes them so interesting to scientists.

"Purple phototrophic bacteria make an ideal tool for resource recovery from organic waste, thanks to their highly diverse metabolism," explains Puyol.

The bacteria can use organic molecules and nitrogen gas—instead of CO₂ and H₂O—to provide carbon, electrons and nitrogen for photosynthesis. This means that they grow faster than alternative phototrophic bacteria and algae, and can generate [hydrogen gas](#), proteins or a type of biodegradable polyester as byproducts of metabolism.

Tuning metabolic output with electricity

Which metabolic product predominates depends on the bacteria's environmental conditions—like light intensity, temperature, and the types of organics and nutrients available.

"Our group manipulates these conditions to tune the metabolism of [purple bacteria](#) to different applications, depending on the organic waste source and market requirements," says co-author Professor Abraham Esteve-Núñez of University of Alcalá, Spain.

"But what is unique about our approach is the use

of an external electric current to optimize the productive output of purple bacteria."

This concept, known as a "bioelectrochemical system", works because the diverse metabolic pathways in purple bacteria are connected by a common currency: electrons. For example, a supply of electrons is required for capturing light energy, while turning nitrogen into ammonia releases excess electrons, which must be dissipated. By optimizing electron flow within the bacteria, an electric current—provided via positive and negative electrodes, as in a battery—can delimit these processes and maximize the rate of synthesis.

Maximum biofuel, minimum carbon footprint

In their latest study, the group analyzed the optimum conditions for maximizing [hydrogen production](#) by a mixture of purple phototrophic bacteria species. They also tested the effect of a negative current—that is, electrons supplied by metal electrodes in the growth medium—on the metabolic behavior of the bacteria.

Their first key finding was that the nutrient blend that fed the highest rate of hydrogen production also minimized the production of CO₂.

"This demonstrates that purple bacteria can be used to recover valuable biofuel from organics typically found in wastewater—malic acid and sodium glutamate—with a low [carbon footprint](#)," reports Esteve-Núñez.

Even more striking were the results using electrodes, which demonstrated for the first time that purple bacteria are capable of using electrons from a negative electrode or "cathode" to capture CO₂ via photosynthesis.

"Recordings from our bioelectrochemical system showed a clear interaction between the purple bacteria and the electrodes: negative polarization of the electrode caused a detectable consumption of electrons, associated with a reduction in carbon dioxide production.

"This indicates that the purple bacteria were using

electrons from the cathode to capture more carbon from organic compounds via photosynthesis, so less is released as CO₂."

Towards bioelectrochemical systems for hydrogen production

According to the authors, this was the first reported use of mixed cultures of purple bacteria in a bioelectrochemical system—and the first demonstration of any phototroph shifting metabolism due to interaction with a cathode.

Capturing excess CO₂ produced by purple bacteria could be useful not only for reducing carbon emissions, but also for refining biogas from organic waste for use as fuel.

However, Puyol admits that the group's true goal lies further ahead.

"One of the original aims of the study was to increase biohydrogen production by donating electrons from the cathode to purple bacteria metabolism. However, it seems that the PPB [bacteria](#) prefer to use these [electrons](#) for fixing CO₂ instead of creating H₂.

"We recently obtained funding to pursue this aim with further research, and will work on this for the following years. Stay tuned for more metabolic tuning."

More information: *Frontiers in Energy Research*, DOI: [10.3389/fenrg.2018.00107](https://doi.org/10.3389/fenrg.2018.00107) , <https://www.frontiersin.org/articles/10.3389/fenrg.2018.00107/full>

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