Chemical looping turns environmental waste into fuel

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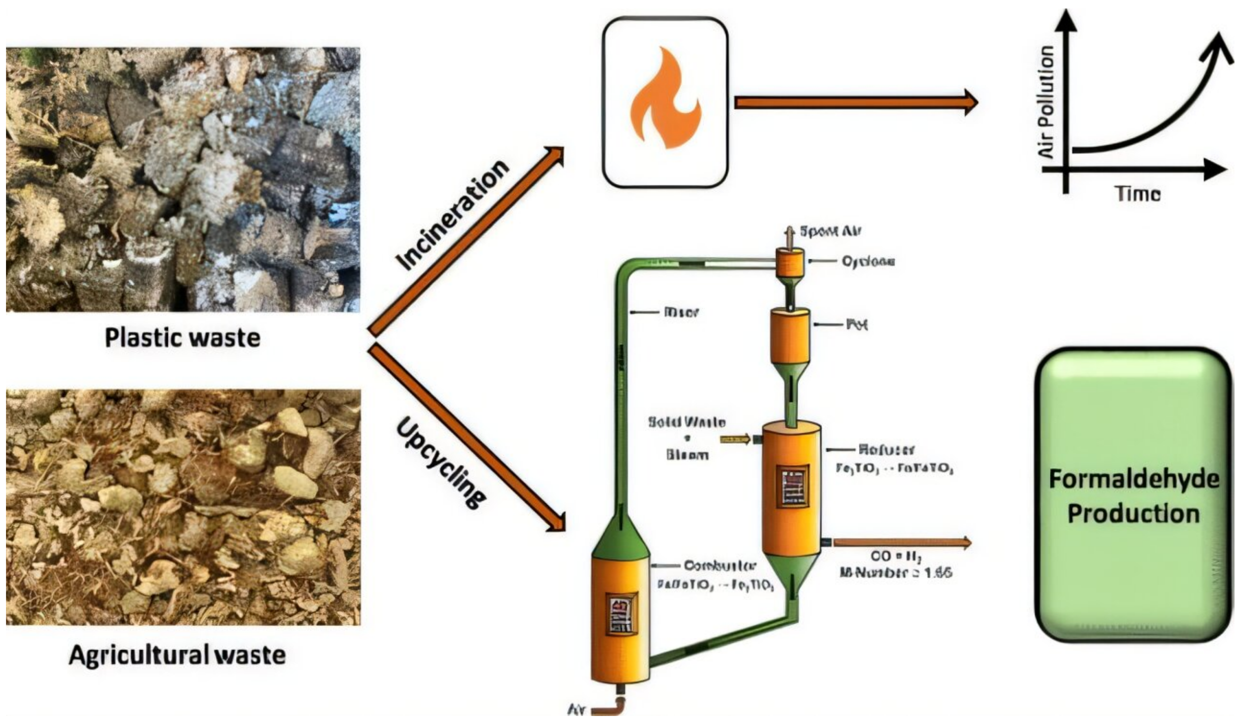

Credit: *Energy & Fuels* (2024). DOI: 10.1021/acs.energyfuels.4c02643

Turning environmental waste into useful chemical resources could solve many of the inevitable challenges of our growing amounts of discarded plastics, paper and food waste, according to new research.

In a significant breakthrough, researchers from The Ohio State

University have developed a technology to transform materials like plastics and agricultural waste into syngas, a substance most often used to create chemicals and fuels like formaldehyde and methanol.

The work appears in *Energy & Fuels*.

Using simulations to test how well the system could break down waste, scientists found that their approach, called chemical looping, could produce high-quality syngas in a more efficient manner than other similar chemical techniques. Altogether, this refined process saves energy and is safer for the environment, said Ishani Karki Kudva, lead author of the study and a doctoral student in chemical and biomolecular engineering at Ohio State.

"We use syngas for important chemicals that are required in our day-to-day life," said Kudva. "So improving its purity means that we can utilize it in a variety of new ways."

Today, most commercial processes create syngas that is about 80 to 85% pure, but Kudva's team achieved a purity of around 90% in a process that takes only a few minutes.

This study builds on decades of previous research at Ohio State, led by Liang-Shih Fan, a distinguished university professor in chemical and biomolecular engineering who advised the study. This previous research used chemical looping technology to turn fossil fuels, sewer gas and coal into hydrogen, syngas and other useful products.

In the new study, the system consists of two reactors: a moving bed reducer where waste is broken down using oxygen provided by metal oxide material, and a fluidized bed combustor that replenishes the lost oxygen so that the material can be regenerated. The study showed that with this waste-to-fuel system, the reactors could run up to 45% more efficiently and still produce about 10% cleaner syngas than other methods.

According to a report by the Environmental Protection Agency, 35.7 million tons of plastics were generated in the U.S. in 2018, of which about 12.2% is municipal solid waste, such as plastic containers, bags, appliances, furniture, agricultural residue, paper and food.

Unfortunately, since plastics are resistant to decomposition, they can persist in nature for long periods and can be difficult to completely break down and recycle. Conventional waste management, such as landfilling and incineration, also poses risks to the environment.

Now, the researchers are presenting an alternative solution to help curb pollution. For example, by measuring how much carbon dioxide their system would pump out compared to conventional processes, findings revealed it could reduce carbon emissions by up to 45%.

Their project's design is just one of many in the chemical sector being driven by the urgent need for more sustainable technologies, said Shekhar Shinde, co-author of the study and a doctoral student in chemical and biomolecular engineering at Ohio State.

In this study's case, their work could help drastically reduce society's dependence on fossil fuels.

"There has been a drastic shift in terms of what was done before and what people are trying to do now in terms of decarbonizing research," he said.

While earlier technologies could only filter biomass waste and plastics separately, this team's technology also has the potential to handle multiple types of materials at once by continuously blending the conditions needed to convert them, noted the study.

Once the team's simulations yield more data, they eventually hope to test the system's market capabilities by conducting experiments over a longer time frame with other unique components.

"Expanding the process to include the municipal solid waste that we get from recycling centers is our next priority," Kudva said. "The work in the lab is still going on with respect to commercializing this technology and decarbonizing the industry."

Other Ohio State co-authors include Rushikesh K. Joshi, Tanay A. Jawdekar, Sudeshna Gun, Sonu Kumar, Ashin A Sunny, Darien Kulchytsky and Zhuo Cheng.

More information: Ishani Karki Kudva et al, Low Carbon Formaldehyde Generation from Chemical Looping Gasification of Heterogeneous Solid Waste, *Energy & Fuels* (2024). DOI: 10.1021/acs.energyfuels.4c02643

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