Chemical plastics recycling is ready to go: Researchers show that it's all about the stirring

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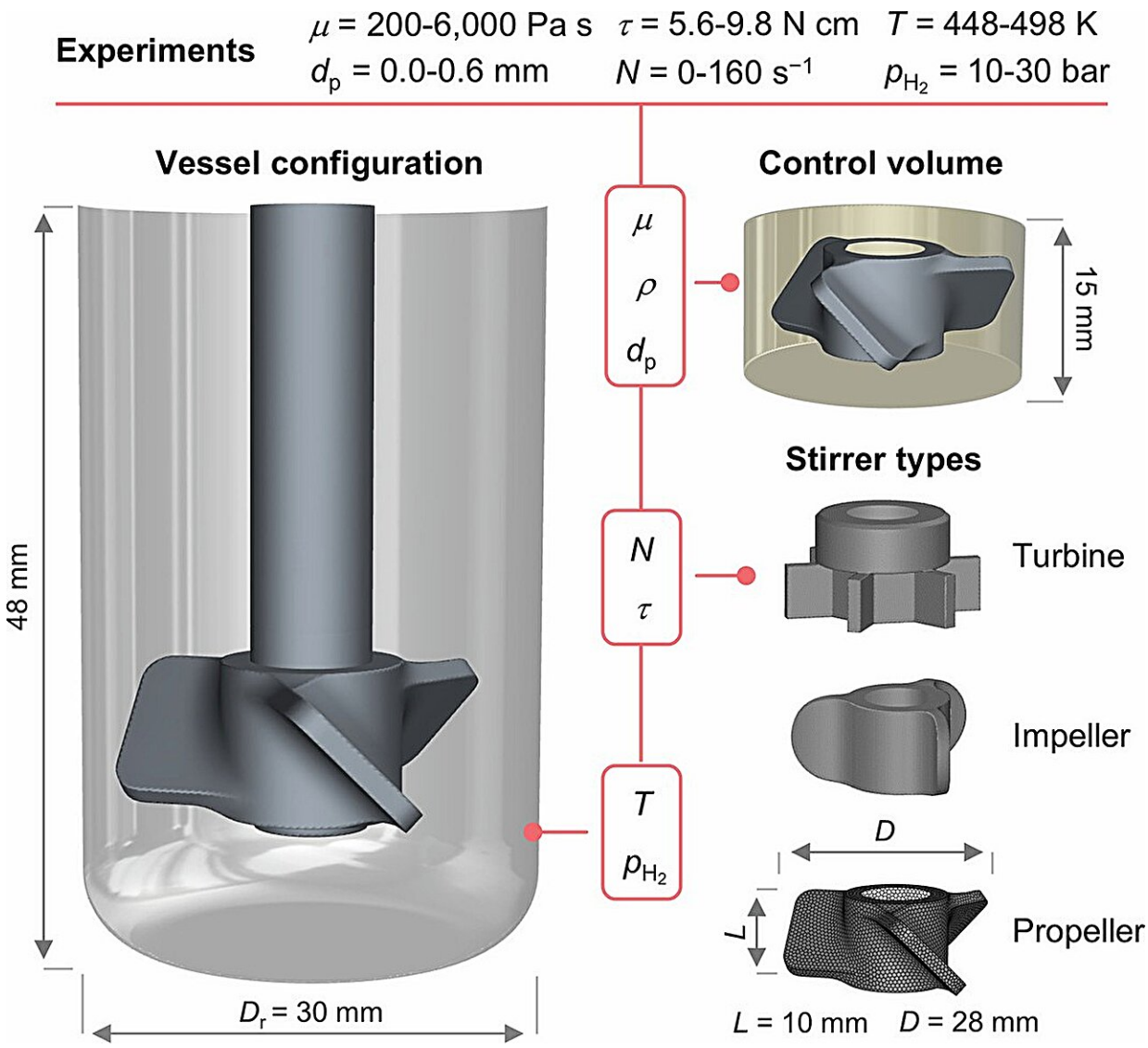

Geometry and reaction variables. Credit: *Nature Chemical Engineering* (2024). DOI: 10.1038/s44286-024-00108-3

Hundreds of millions of tons of plastic waste are generated worldwide every year. Scientists are working tirelessly on new methods to recycle a large proportion of this waste into high-quality products and thus enable a genuine circular economy. However, current recycling practices fall short of this goal.

Most plastic waste is recycled mechanically: shredded and then melted down. Although this process does result in new plastic products, their quality deteriorates with each recycling step.

An alternative to this is chemical recycling, which avoids loss of quality. This method involves breaking down long-chain plastic molecules (polymers) into their fundamental building blocks (monomers), which can be reassembled into new, high-quality plastics, creating a truly sustainable cycle.

Fuels from plastic waste

As the approach of chemical recycling develops, the initial focus is on breaking down these long polymer chains into shorter-chain molecules that can be used as liquid fuels, say, or lubricants.

This gives plastic waste a second life as petrol, jet fuel or engine oil. Scientists at ETH Zurich have now laid down important foundations for developing this process. These enable the global scientific community to engage in more targeted and effective recycling development work.

Researchers in a group led by Javier Pérez-Ramírez, professor of

catalysis engineering, investigated how to break down polyethylene and polypropylene with hydrogen. Here, too, the first step is to melt the plastic in a steel tank. Gaseous hydrogen is then introduced into the molten plastic. The work has been published in *Nature Chemical Engineering*.

A crucial step involves adding a powdered catalyst containing metals such as ruthenium. By carefully selecting a suitable catalyst, researchers can increase the efficiency of the chemical reaction, promoting the formation of molecules with specific chain lengths while minimizing byproducts such as methane or propane.

Rotational speed and geometry are key

"The molten plastic is a thousand times thicker than honey. The key is how you stir it in the tank to ensure the catalyst powder and hydrogen get mixed right through," explains Antonio José Martín, a scientist in Pérez-Ramírez's group.

Through experiments and computer simulations, the research team demonstrated that the plastic is best stirred using an impeller with blades parallel to the axis. Compared to a propeller with angled blades or a turbine-shaped stirrer, this results in more even mixing and fewer flow vortices. The stirring speed is equally crucial. It must be neither too slow nor too fast; the ideal speed is close to 1,000 revolutions per minute.

The researchers successfully developed a mathematical formula to describe the entire chemical recycling process with all its parameters. "It's every chemical engineer's dream to have a formula like this at hand for their process," Pérez-Ramírez says. All scientists in the research field can now precisely calculate the effect of the stirrer's geometry and speed.

With this formula, future experiments can focus on directly comparing different catalysts with the influence of mixing under control. In addition, the principles developed here are central for scaling up the technology from the laboratory to large recycling plants.

"But for now, our focus remains on researching better catalysts for the chemical recycling of plastics," Martín says.

More information: Shibashish D. Jaydev et al, Assessment of transport phenomena in catalyst effectiveness for chemical polyolefin recycling, *Nature Chemical Engineering* (2024). DOI: 10.1038/s44286-024-00108-3

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