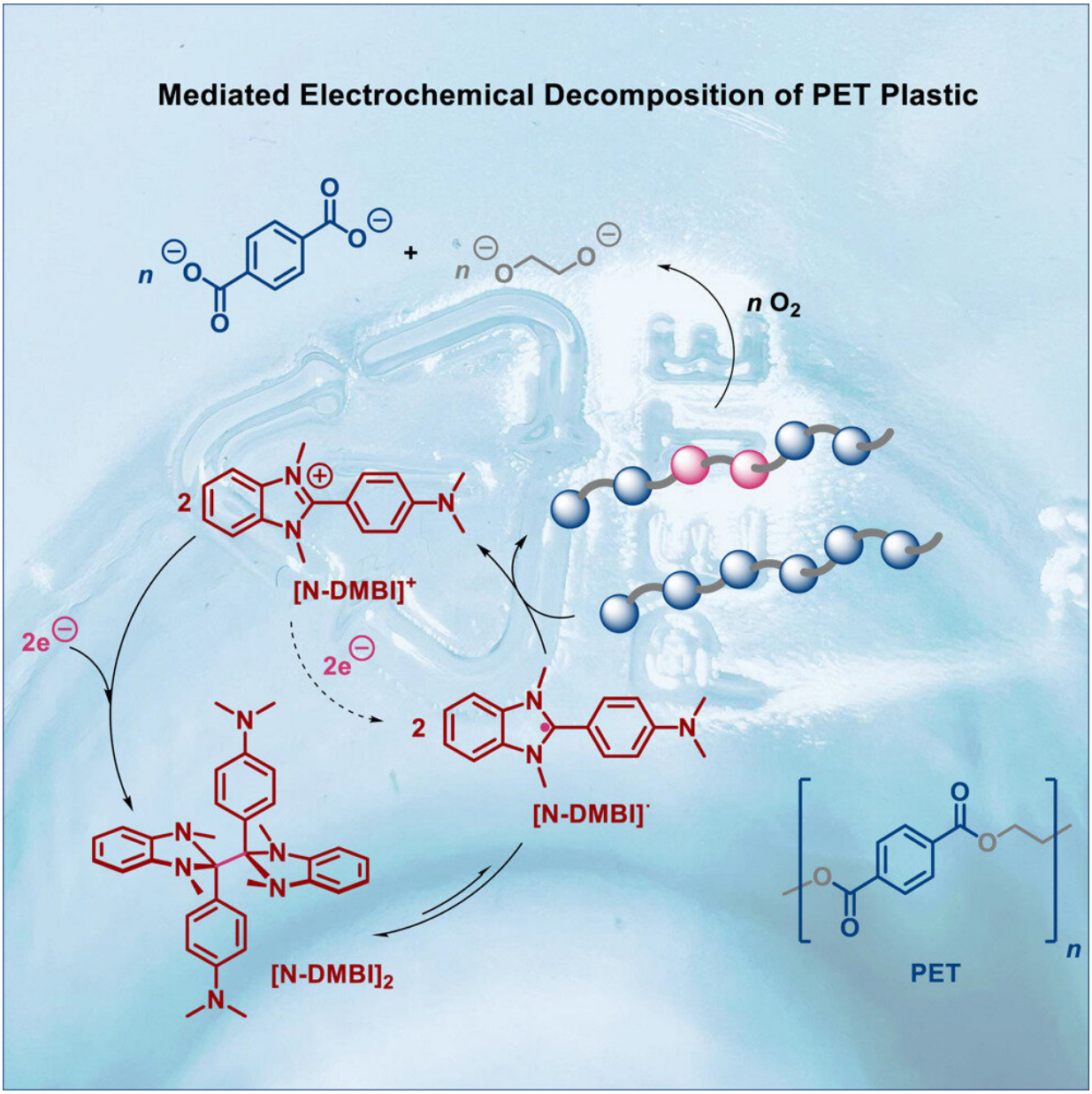
The future of recycling could one day mean dissolving plastic with electricity

July 5 2023, by Daniel Strain



Graphical abstract. Credit: *Chem Catalysis* (2023). DOI: 10.1016/j.checat.2023.100675

Chemists at CU Boulder have developed a new way to recycle a common type of plastic found in soda bottles and other packaging. The team's method relies on electricity and some nifty chemical reactions, and it's simple enough that you can watch the plastic break apart in front of your eyes.

The researchers described their new approach to chemical recycling in the journal *Chem Catalysis*.

The study tackles the mounting problem of plastic trash around the world. According to the Environmental Protection Agency, the United States alone produced nearly 36 million tons of plastic products in 2018. A majority of the waste winds up in landfills, said study co-author Oana Luca.

"We pat ourselves on the back when we toss something into the recycling bin, but most of that recyclable plastic never winds up being recycled," said Luca, assistant professor in the Department of Chemistry. "We wanted to find out how we could recover molecular materials, the building blocks of plastics, so that we can use them again."

In the new research, she and her colleagues got one step closer to doing just that.

The group focused on a type of plastic called polyethylene terephthalate (PET), which consumers encounter every day in water bottles, blister packs and even some polyester fabrics. In small-scale lab experiments, the researchers mixed bits of that plastic with a special kind of molecule

then applied a small electric voltage. Within minutes, the PET began to disintegrate.

The team has a lot more work to do before its recycling tool can take a realistic bite out of the world's plastic trash problem. But it was still fun to watch the waste, which can stick around in garbage piles for centuries, disappear in a matter of hours or days, said study lead author Phuc Pham.

"It was awesome to actually observe the reaction progress in real time," said Pham, a doctoral student in chemistry. "The solution first turns a deep pink color, then becomes clear as the polymer breaks apart."

One person's trash

Luca said it's a whole new way of thinking about the possibilities of trash. Recycling bins, she noted, may look like a good solution to the world's plastics problem. But most municipalities around the world have struggled to collect and sort the small mountain of rubbish that people produce every day. The result: Less than one-third of all PET plastic in the U.S. comes close to being recycled (other types of plastic lag even farther behind). Even then, methods like melting plastic waste or dissolving it in acid can alter the material properties in the process.

"You end up changing the materials mechanically," Luca said. "Using current methods of recycling, if you melt a plastic bottle, you can produce, for example, one of those disposable plastic bags that we now have to pay money for at the grocery store."

She and her team, in contrast, want to find a way to use the basic ingredients from old plastic bottles to make new plastic bottles. It's like smashing your Lego castle so that you can retrieve the blocks to create a whole new building.

Another's treasure

To achieve that feat, the group turned to a process called electrolysis—or using electricity to break apart molecules. Chemists, for example, have long known that they can apply a voltage to beakers filled with water and salts to split those water molecules into hydrogen and oxygen gas.

But PET plastic is a lot harder to divide than water. In the new study, Pham ground up plastic bottles then mixed the powder into a solution. Next, he and his colleagues added an extra ingredient, a molecule known as [N-DMBI]+ salt, to the solution. Pham explained that in the presence of electricity, this molecule forms a "reactive mediator" that can donate its extra electron to the PET, causing the grains of plastic to come undone. Think of it like the chemistry equivalent of delivering a karate chop to a wooden board.

The researchers are still trying to understand how exactly these reactions take place, but they were able to break down the PET into its basic building blocks—which the group could then recover and, potentially, use to make something new.

Deploying only tabletop equipment in their lab, the researchers reported that they could break down about 40 milligrams (a small pinch) of PET over several hours.

"Although this is a great start, we believe that lots of work needs to be done to optimize the process as well as scale it up so it can eventually be applied on an industrial scale," Pham said.

Luca, at least, has some big-picture ideas for the technology.

"If I were to have my way as a mad scientist, I would use these electrochemical methods to break down many different kinds of plastic

at once," Luca said. "That way, you could, for example, go to these massive garbage patches in the ocean, pull all of that waste into a reactor and get a lot of useful molecules back."

More information: Phuc H. Pham et al, Electricity-driven recycling of ester plastics using one-electron electro-organocatalysis, *Chem Catalysis* (2023). DOI: 10.1016/j.checat.2023.100675

Provided by University of Colorado at Boulder