Car parts, ski boots and boxes: How broken or used plastic is being given new life

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Derived from fossil fuels, plastic is a vital part of modern life but a lack of recycling and proper disposal has tainted its production, use and consumption. Credit: Marc Newberry / Unsplash

Since the early 1950s, humans have produced more than 8.3 billion tonnes of plastic—the weight of around a billion elephants. About 60%

of that plastic has ended up in a landfill or in the natural environment, according to the UN Environment Programme, but that pattern may start to change as repair and recycling technology gathers pace.

"Worldwide, the challenge (for a circular economy) remains to establish innovative processes for recycling plastic waste," said Costas Charitidis, a professor at the National Technical University of Athens, Greece.

The material, derived from fossil fuels, is a vital part of modern life—used in everything from food packaging through to components in computers—but a lack of recycling and proper disposal has tainted its production, use and consumption. As part of its circular economy plastics strategy, the European Union has committed to reducing plastic waste and has banned the export of non-sorted plastic waste to foreign countries.

But to reduce plastic waste, governments and companies will need new technologies to cope with the rather complex task of recycling or repairing different types of plastic.

Broadly speaking, plastics are synthetic and semi-synthetic materials made up of polymers, which are long chains of repeating molecules, and there are thousands of different types of plastic. Each of these types has different compositions and characteristics—and there is no single method to recycle or reuse them.

"While certain commonly used plastics are widely recycled, plastics with more specialised uses often aren't," said Prof. Charitidis, who is scientific coordinator of a project called Repair3D, which aims to find innovative uses for recycled thermoplastics and carbon fibres valorised from carbon-fibre reinforced polymers (CFRPs).

In the project's first stage, researchers identified different plastic and

CPRFs waste streams from industries such as the automotive and rigid packing industry. From there, they worked to recycle these materials into pellets or filaments so that they could be made into other products through additive manufacturing.

3D printing

Additive manufacturing, also known as 3D printing, is a technology that builds 3D objects by adding layer-upon-layer of material, most commonly plastic. The blueprint for the component is contained in a computer file that can be shared or uploaded. Increasingly, manufacturers are turning to this production method because it enables them to create complex and custom objects quickly and sometimes remotely.

'3D printing is at the heart of Repair3D," said Prof. Charitidis. The next step in the project is to imbue the recycled plastics with carbon fibres and various nanoparticles to give them additional functionalities.

The project is working with several large industry partners in, for example, the automotive and sports sectors, to 3D print items ranging from car parts through to ski boots, as well as wearable electronics.

By adding different nanoparticles, it is possible to make printed objects self-sensing, self-repairing and recycling options, says Dr. Tanja Kosanovic Milickovic, a chemist at the National Technical University of Athens who is part of the project. To create self-repairing plastics, for example, researchers add magnetic nanoparticles which, when exposed to a magnetic field, can create localised heat, melting and rebonding the broken polymers.

However, in addition to using recycled plastic to create new products, the resultant goods must themselves be recyclable, says Dr. Milickovic.

"There is a balance between the properties of the products and recycling."

Each year about 400,000 tonnes of returnable transport plastic, which is the hard plastic used in pallets or plastic boxes, is damaged. Credit: Markus Winkler / Unsplash

By the end of the project, the team aims to have products that can be recycled and reused multiple times before they are finally disassembled and their nanoparticles removed.

However, recycling is only part of the answer for reducing waste, says Jon García Armendáriz, a business developer at Spanish company Plastic

Repair System (PRS). PRS focuses on repairing plastic products, such as pallets and boxes, rather than letting them go to landfills or for recycling.

The company was initially established in 2011 to repair municipal solid waste containers, but it soon became apparent that there were many other applications for their technology.

Each year about 400,000 tonnes of returnable transport plastic, which is the hard plastic used in pallets or plastic boxes, is damaged. "Historically, people have been throwing away old items and buying new ones," said Armendáriz.

To repair the plastic, PRS technicians prepare the broken part of the object, inject new plastic, and reshape the repaired section.

This option is significantly cheaper than buying a new product and greener than recycling the entire object, says Armendáriz.

Their current process is hard work, though, because each item is custom repaired. "This is one of the problems we have: we are working manually," he said. "We need people because each pallet that is broken is different, no two are exactly the same."

The team is currently working to automate the process for Euro containers or KLT boxes. These ubiquitous industrial stacking containers were originally used by the German automotive industry, but soon spread to other industries like shipping and manufacturing. This automation will allow PRS to repair more boxes quickly. Currently, it repairs about 10,000 plastic items a month, says Armendáriz, and the company estimates that its work helped avoid 7,114 tonnes of CO_2 emissions in 2019.

Headquartered in Spain, the company has three workshops in their home

country and one in Mexico. It also has 13 other workshops in partnership with big pallet users, near their premises, to cut down on transportation costs. Its expansion plans will see PRS spreading to the rest of Europe by 2030.

There will increasingly be demand for plastic repair and recycling as companies and local governments work to move their operations in line with the European Union's new regulations—both to curb plastic waste and to keep it within the bloc's borders.

And this is where further research into new methods and technologies is crucial. "Today recycling (of CFRPs) is very expensive," said Repair3D's Prof. Charitidis. "So we have a huge challenge to make recycling more cost effective."

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