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Recycling tyres and plastics with an ancient heating method

Thermal decomposition is helping to green two major EU manufacturing industries.

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For thousands of years, humans have converted wood into charcoal through a technique called pyrolysis. Now, Jean-Michel Douarre wants to use this age-old method for a modern purpose: turning old car tyres into new ones.

Douarre, the head of research into sustainable materials at French tyre maker Michelin, hopes pyrolysis will put his industry on a greener footing.

Clean carbon

Tyres, which are made of rubber and petrochemicals, contain a lot of carbon. And producing tyres currently involves fossil-fuel burning that releases greenhouse gases into the atmosphere.

Pyrolysis is the high-temperature breakdown of materials without oxygen and, unlike incineration, uses thermal decomposition to convert them for reuse.

Scientists have learnt how to harness this technique to make fuels, chemicals and materials from carbon-rich waste as well as from renewable biomass. And it fits perfectly into the EU's goal of a circular economy involving more recycling and less waste.

'In Europe, most end-of-life tyres are collected, which is a good thing, but almost none of them are used to make raw materials for new tyres,' Douarre said.

He leads a research project that used EU funding to show pyrolysis can turn old tyres into a clean version of carbon black, a major tyre ingredient.

This carbon-rich substance makes up 20% to 30% of an average tyre and is usually derived from fossil fuels including oil. Carbon black gives the tyres their colour, prevents damage from ultraviolet light and helps make them durable.

Called BlackCycle, the four-year project run by Douarre is due to wrap up in June 2024.

Pyrolysis generates three products: a liquid, solid and gas. By adjusting the pyrolysis chamber's conditions – such as temperature and speed of heating – it's possible to control the amount and chemical composition of these products.

The BlackCycle team has found that it can tweak the process to generate large quantities of oil from the pyrolysis of old tyres. The researchers used this oil, which is chemically similar to the fossil-fuel kind, to produce a high-quality type of carbon black.

'We produced several tonnes of carbon black,' Douarre said.

Rolling on

The researchers have since used this carbon black to make a bus tyre, which was tested for use on roads.

The prototype was found to have rolling resistance, levels of durability and other characteristics comparable with current tyres.

But it's not just carbon black being produced.

'What we want to do in the recycling process is use everything that we produce,' Douarre said.

For instance, the gas created by the pyrolysis of the tyres is used as fuel to power the whole process, while any oil that isn't converted into carbon black can be used to make resins.

The hope is that, in the future, these too can be used in new tyres.

Valuable waste

Europe generates around 3.5 million tonnes of used car tyres a year, according to the European Tyre and Rubber Manufacturers' Association.

At least 90% of these end-of-life tyres are reused in some way. About 40% are incinerated for energy production and around half are recycled.

Most recycled tyre waste – 70% – is ground down to produce rubber granules and powder, with much of this becoming artificial sports pitches and playground flooring.

The rest is incorporated into cement or used for civil engineering projects. For instance, whole tyres can be used to build coastal erosion barriers while shredded tyres are used in foundations for roads and railways.

Nonetheless, researchers and tyre manufacturers are keen to produce higher-value products from tyre waste.

Michelin, the world's biggest manufacturer of tyres, wants to replace all raw materials in its products with sustainable substances by 2050, according to Douarre.

'Recycling tyres is one of the ways to do this,' he said.

Tyres are a major source of microplastics pollution worldwide. The Pew Charitable Trusts said in a 2020 report that tyre particles were responsible for almost four-fifths of microplastics in oceans.

Plastics push

Pyrolysis is also being increasingly deployed to recycle plastics.

Recycling plastics through pyrolysis is usually done at temperatures of around 400°C, so-called low-temperature pyrolysis. The resulting pyrolysis oils are then further processed to produce hydrocarbons.

Cranking up the pyrolysis temperature to more than 700°C increases the production of gases from the technique, according to Rebeca Yuste, a circular-economy expert at Spain-based petrochemicals company Repsol.

This makes it possible to break down hard-to-recycle plastics and turn them into propane and ethene.

These gases, known as olefins, are the chemical building blocks of plastics and are usually produced from petrochemicals. Olefins from old plastics could be used to make new ones, greening another major manufacturing sector.

Yuste leads an EU-funded project to demonstrate that this process can work at an industrial scale. Called Plastics2Olefins, the project is due to run for five years through May 2027.

It aims to design and develop a full-sized industrial demonstration plant for recycling plastics at a Repsol chemical plant in the Spanish municipality of Puertollano between Madrid and Seville.

The team has already built a smaller pilot plant.

The researchers will improve the technology at this site before scaling it up to the larger demonstration plant, which is expected to start operating in 2028.

‘We are going to multiply the capacity by 100,’ said Yuste.

Slashing emissions

While in theory pyrolysis will work with any kind of plastic waste, in practice things aren’t that simple.

‘If we use very low-quality plastic waste or plastics that have contaminants, the quality of the final products is going to be worse,’ said Yuste.

Poor-quality or highly contaminated plastic will also reduce the proportion of pyrolysis gas produced compared with oils and solids, making the process less cost-effective.

‘In the pilot plant, we are going to test different qualities of plastic waste to see what is the worst quality of plastic waste that we can feed into the process,’ said Yuste.

If achieved on an industrial scale, the high-temperature pyrolysis technique could result in 70% fewer greenhouse gas emissions than current plastic-recycling methods, according to Repsol.

The reasons: it would be possible to run the process using 100% renewable electricity and high-temperature pyrolysis is a much more efficient and less energy-intensive way to produce olefins than the low-temperature method.

Once up and running, the plant will be used to produce polyethylene and polypropylene, which are two of the most widely used plastics in the world and are found in products including bin bags, food packaging, disposable cups and bottle caps.

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- Plastics2Olefins
- EU circular economy research and innovation