From useless plastic waste to valuable oil

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Researchers and business people have developed a new technology that can make oil from plastic waste that cannot be recycled. This oil can be used to make new plastic and other oil-based products. The technology

was recently used in a new commercial facility in West Zealand, Denmark.

Do you ever wonder how much (or how little) of the plastic waste (packaging, containers, and milk cartons) you put in your recycling bin is actually recycled? The garbage truck transports it to a waste management facility for sorting and recycling. The 'good' plastic is recycled, and the rest—which is either too dirty, mixed, or damaged for recycling—is incinerated.

In Denmark alone, around 370,000 tons of plastic waste is incinerated every year. According to the Danish Ministry of the Environment, plastic waste incineration makes up a significant portion of Denmark's fossil-fuel carbon emissions. In other words, there is a huge green potential in developing new methods for recycling even more plastic waste than we do now.

If we can also reduce the amount of non-renewable plastic waste, we can reduce the need for the non-renewable raw materials needed for plastic production—oil and natural gas.

A group of DTU researchers have therefore investigated new possibilities for recycling our plastic waste in collaboration with Roskilde University and a number of industry partners. Their research project, RePlastic, has shown that valuable oil can be produced from otherwise useless plastic waste through pyrolysis.

"I'm surprised at the great potential of pyrolysis technology for the most impure and mixed plastic fractions. This process can handle the plastic we have no other uses for. This enables us to bring end-of-life plastic back into the cycle and make it useful again," says Anders Egede Daugaard, Associate Professor at DTU Chemical Engineering and head of the RePlastic project.

Plastic is not just plastic

To fully understand Anders Egede Daugaard's enthusiasm, you need to understand the challenges of recycling and sorting plastic waste into different categories and fractions. The current number of different plastic types with different properties is incredibly high—just take a look at your own plastic waste, where you will find hard, soft, ductile, colored, and transparent plastics.

Plastic waste is generally divided into two categories: industrial and household. Industrial plastic waste is usually more uniform as it often consists of only one type of plastic, where both the additives and manufacturing process are known. Household waste, on the other hand, is more often a mixture of different types and grades of plastic. The plastic is then sorted into different fractions depending on properties and quality.

Because the chemical additives vary according to the properties of each plastic product, our plastic waste needs to be sorted before it can be recycled in a mechanical process that granulates, heats, and remolds it into new plastic products. You cannot make new quality plastic from mixed plastic types because the melting points and additives differ and are often completely unknown.

In the RePlastic project, Associate Professor at DTU Anders Egede Daugaard and his team have assessed the potential of several plastic materials from the least valuable plastic fractions in our plastic waste. These fractions are where the majority of our household plastic waste ends up, along with industrial plastic waste that has already been recycled six or seven times and is therefore too worn out to be mechanically recycled again.

Pyrolysis creates new possibilities

The RePlastic project focused on using pyrolysis for chemical recycling. During the process, plastic waste is heated to high temperatures in a nitrogen-filled furnace, triggering a splitting of the chemical components of the plastic materials. Because there is no oxygen in the furnace, the plastic does not burn, but gasification occurs. The gas is then condensed into so-called pyrolysis oil, which can be used as an additive in fuel or new plastic products.

In the laboratories at DTU Chemical Engineering, researchers have been studying which plastic fractions can potentially be used for pyrolysis and how pure the plastic needs to be. The assessment of the purity required for the pyrolysis oil and its applications has been a key focal point for the project partners, as it is crucial to whether or not the technology can be commercialized.

The initial conclusion was that obtaining usable pyrolysis oil required a very clean system. This meant that the plastic waste had to be thoroughly sorted and cleaned before going in the pyrolysis furnace and that the resulting pyrolysis oil subsequently had to be distilled and purified.

However, the RePlastic project shows that this is not actually necessary. The pyrolysis technology can handle the impurities in our mixed and dirty plastic waste.

From test reactor to industrial facility

When RePlastic launched in January 2020, the goal was to form the basis for a technological solution that could be commercialized within a few years for the benefit of the green transition. The aim was to attract investors for the primary project partner, Waste Plastic Upcycling

(WPU), which specializes in converting plastic waste into different types of oil that the industry can use in the production of new products.

Things have been moving really fast since then because the technology is scalable, and there is a demand for new technologies that can handle the different fractions of our plastic waste. Already during the research project, WPU has found investors, built an industrial pyrolysis facility, and hired employees.

"We're experiencing a lot of interest in robust and financially attractive technologies such as WPU's, both nationally and internationally. The fact that plastic waste doesn't have to be treated before the pyrolysis process with us makes a big difference, both financially and in relation to the assessment of potential environmental impacts and resource consumption," says Niels Bagge, CEO of WPU.

Because the pyrolysis technology minimizes the resource-intensive sorting and purification, the is a great potential for making the process more sustainable. However, exactly what role pyrolysis technology will play in our waste system in the future depends on many factors.

"Pyrolysis technology definitely has potential in terms of recycling some of the more difficult plastic waste. In the future, we need to make sure to take into account both the choice of materials in products, the management and processing of waste in the waste system, and reusing it for new raw materials for industries. Using pyrolysis for mixed plastic fractions can play an important role in the plastic cycle," says former DTU Professor Thomas Fruergaard Astrup, who assessed the sustainability of plastic recycling and pyrolysis technology in the RePlastic project.

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