Project NEOREC develops innovative process to recycle complex plastic waste and make materials of interest to industry

Santiago Llopis, Chemical Recycling Researcher at AIMPLAS

One of the greatest challenges facing humankind is the need to reduce the amount of waste generated and turn waste into recycled materials. This challenge is especially relevant when it comes to plastic materials and plastic waste.

Plastic is a crucial material and, as such, it is important to continue working towards reducing plastic waste, introducing it to the market as a resource and preventing it from being discarded.

Recycling plastics significantly reduces the environmental impact, as it allows waste to be recovered and reduces the need to produce new materials and extract so much oil.

Project NEOREC aims to develop recycling processes suitable for complex waste that will make it possible to create materials and substances of interest to industry.

The project focuses on chemical recycling technologies. Chemical recycling is a type of recycling in which chains are broken or waste is cracked to make useful materials and substances for the plastics and chemical industries. Chemical recycling complements mechanical recycling and physical recycling (dissolving and precipitation) and is better for the environment than energy recovery.

This project applies different technologies to a range of polymers such as polyethylene terephthalate (PET). PET is a thermoplastic created by repeating units of terephthalic acid (TPA) and ethylene glycol (EG) linked by an ester bond. PET is therefore classified as a polyester, and many of its physical and chemical properties derive from this bond.

To carry out project NEOREC, the team worked with PET waste, but used an innovative process known as partial depolymerization. The goal of this process is to break the chain in a controlled manner by ensuring that the polymer stays at a lower molecular weight than the initial polymer, eliminating degradation and then re-polymerizing it. This process aims to reduce the environmental and economic impact of the more traditional method.

In this study, PET was partially depolymerized using an excess of EG in the absence of a catalyst. The variables adjusted in this study were time and temperature.

An example of one of the different characterizations carried out on the products is gel permeation chromatography (GPC). This technique can be used to determine the average molecular weight of the oligomers formed, as shown in Figure 1:

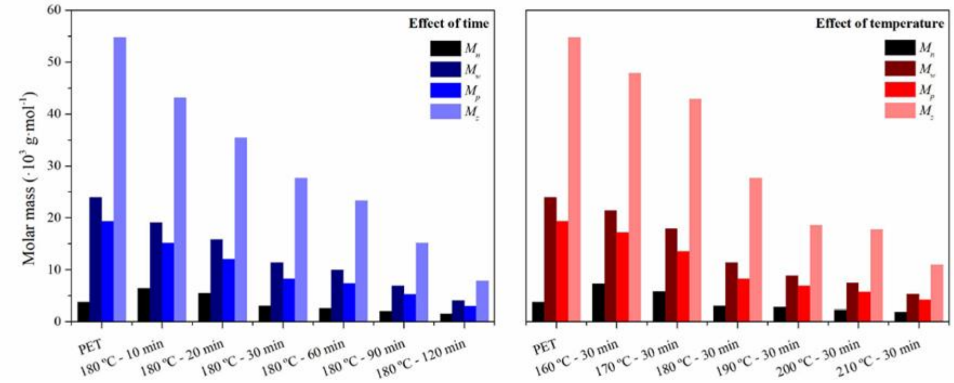

Figure 1: GPC of partial depolymerization of virgin PET as a function of time and temperature.

As shown, both time and temperature are factors that contribute to the formation of oligomers. In other words, there is a direct relationship between temperature or time and molecular weight; as the exposure time increases, the molecular weight decreases. The same happens with temperature.

This same process was applied to actual waste, in this case bottles retrieved from the sea. As shown in Figure 2, this type of waste has a high degradation level and its reprocessability is limited, which means it cannot be mechanically recycled. Therefore, chemical recycling makes more sense.

Figure 2: PET bottle from the sea.

Three experiments were performed on this waste, as shown in the table below:

Reaction	Time (min)	Output	Molecular weight (g·mol^{-1})	Molecular weight (g·mol^{-1}) of the reactions with virgin PET
1	10	>97	14260	19104
2	30	>97	9778	10798
3	60	>97	6997	9939

Given that the molecular weight of the PET waste found in the sea was 24383 g·mol^{-1} and that of the virgin PET was 23917 g·mol^{-1}, the marine waste biodegraded more under the same conditions. This is because the waste had already started to degrade in its previous environmental conditions, and the chains were therefore easier to break.

In conclusion, it is clear that the partial depolymerization of PET waste has enormous potential as a chemical recycling technique due to the mild experimental conditions, low reaction times, experimental ease and low energy consumption.

Project NEOREC was financed by the Valencian Ministry of Sustainable Economy, Productive Sectors, Trade and Labour through IMPIVA grants and co-financed with EU ERDF funds as part of the Valencian Community ERDF Operational Programme for the 2017-2027 period, under file number IMDEEA/2021/96. These grants are intended for technology centres in the Valencian Community to develop non-economic R&D projects carried out in collaboration with companies for the 2021 financial year.