# (Thermo)chemical recycling of bio-based and nanocomposite polymers in the circular economy

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**Abstract**

The two major challenges of humanity today are the fight against the pandemic and the protection of the environment. Concerning the latter, one of the great concerns is the successful management of plastic wastes and particularly plastic packaging. In 2020, from the collected post-consumer plastic packaging (17.8 million tonnes), 42% was recycled 39.5% was used for energy recovery and 18.5 % was landfilled. Most of the waste was recycled mechanically, and only very limited volumes (less than 0.1 million tonnes) were treated by chemical recycling processes. To achieve the circular economy for plastics, zero landfilling is needed. Therefore, the amount of polymers recycled should be greatly increased.

In addition to conventional polymers, alternative materials were sought having similar properties though more environmentally friendly. This need gave birth to the production of biodegradable or bio-based polymers used in the production of biodegradable or bio-based plastics. In 2019, the global production of bioplastics, was 2.11 million tons. Compared to the total production of plastics, i.e. 368 million tons in the same year, it can be postulated that the current production of bio-based plastics is still rather small, almost 1%. Recently, these bio-plastics are reaching the recycling systems together with conventional plastics. However, there is still a question on how could they affect the standard recycling techniques used in non-biodegradable polymers?

The purpose of the study is to investigate the current state of knowledge regarding the chemical recycling of waste plastics together with bio-based plastics and nanocomposites. Chemical recycling is used for processing various types of waste plastics, including municipal solid waste, waste packaging and WEEE. The established technologies of chemical recycling of plastics, i.e. chemolysis, pyrolysis, gasification vary in their ability to ensure the circularity of plastics. Pyrolysis and gasification produce by-products and non-reusable residues that need to be disposed of. Both technologies mostly produce intermediates that need further processing to become chemical products, fuels, or energy, and therefore do not result in circular closed-loop systems for plastics. Both technologies can treat heterogeneous streams of plastic waste, including mixed and contaminated post-consumer plastic waste, and could therefore be complementary to mechanical recycling in dealing with waste streams that otherwise would be landfilled or incinerated. Chemolysis (such as hydrolysis, glycolysis, etc.) is reported to produce monomers of a virgin-grade quality. Usually by-products or residues of chemolysis are not produced. All these issues will be discussed and experimental data will be presented from our lab obtained during the last years. Additionally, in this work the impact of the presence of bio-degradable or biobased plastics, such as PLA on the recycling of PET, is reviewed. Finally, the potential effect of the existence of nano-additives on the materials recovered after the chemical recycling of conventional polymers will be addressed.

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