

# Valorization of a post-consumer poly(lactic acid) residue by mechanical recycling

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Keywords: poly(lactic acid), mechanical recycling, plastic waste

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## Introduction

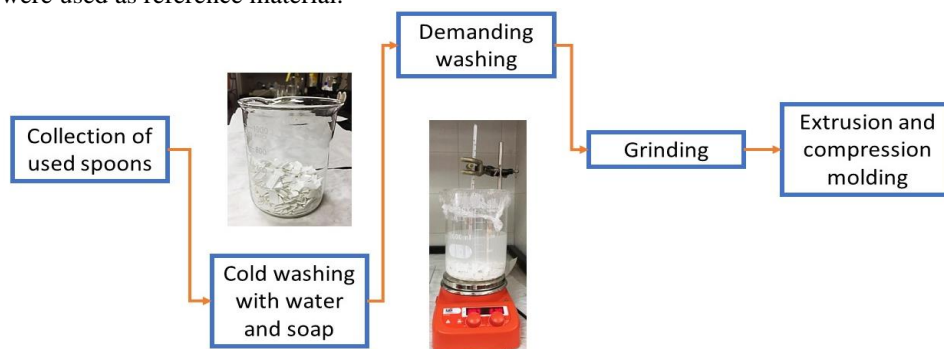
The negative environmental consequences derived from the accumulation of plastic wastes has been one of the topics that has raised most interest in the society in recent years. Several alternatives have been posed to reduce the pollution and the consumption of non-renewable raw materials generated by the massive use of fossil-fuel based plastics, among which is the introduction of bioplastics. One of the most established bioplastics in the market is poly(lactic acid) (PLA), which is an aliphatic polyester produced from renewable resources, biocompatible and with good optical properties (Castro-Aguirre et al., 2016).

Regarding the end-of-life scenarios, PLA has been traditionally considered a biodegradable plastic. However, it must be taken into account that PLA grades used in demanding applications, such as food packaging, are not compostable in home conditions, and some PLA grades are hardly compostable even in industrial conditions. The low degradation rate of these PLA grades could result in the accumulation of wastes, ultimately leading to an environmental problem. In order to address this issue, the valorization of PLA wastes using methods such as chemical or mechanical recycling has become an interesting subject (Beltrán et al., 2018).

Among the valorization methods, mechanical recycling could play a prominent role, since it allows to reduce the use of arable lands, the emissions and the consumption of energy and water associated to the production of virgin PLA (Beltrán et al., 2019). The main drawback of mechanical recycling is that there is a significant degradation of the polymer, which results in a decrease in some important properties (Beltrán et al., 2018). Although there are some studies regarding the mechanical recycling of PLA subjected to accelerated ageing in laboratory conditions, there is little information about the properties and structure of recycled materials obtained from post-consumer PLA waste. Consequently, the main aim of this work is to study the mechanical recycling of a post-consumer PLA waste, concretely, a material used in cutlery applications.

## Material and methods

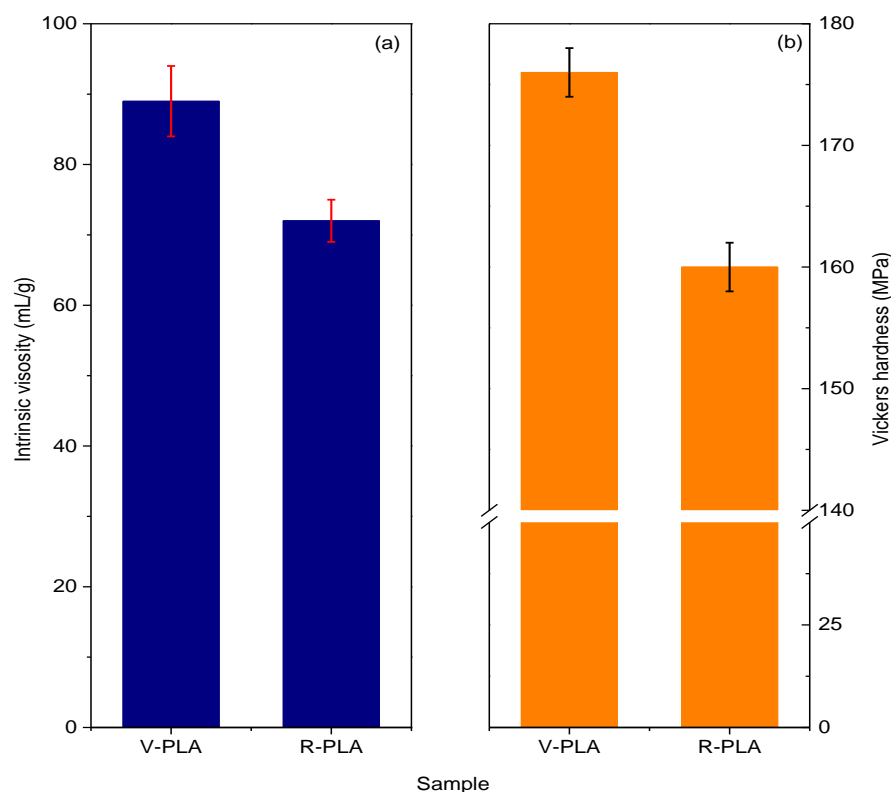
The studied post-consumer PLA waste was obtained from spoons used in an ice cream shop in Madrid. Figure 1 shows a scheme of the process followed to obtain the recycled post-consumer plastic. Firstly, the collected spoons were washed with water and soap to remove the superficial dirtiness. After that, the material was subjected to a demanding washing at 85 °C in a NaOH (1.0 %wt.) and a surfactant (0.3 %wt.) during 15 minutes, which is similar to the process used in other food contact materials (Beltrán et al., 2018). The washed material was then grinded and finally processed by melt extrusion and compression molding. The resulting films, labeled as R-PLA, were characterized by means of intrinsic viscosity (IV), Fourier-transform infrared spectroscopy, microhardness measurements, differential scanning calorimetry and thermogravimetric analysis. It is worth to note that non-used spoons, labeled as V-PLA, were used as reference material.



**Figure 1.** Obtainment of the mechanically recycled post-consumer PLA.

## Results and discussion

Intrinsic viscosity of both V-PLA and R-PLA are shown on figure 2a. It can be seen that the IV of mechanically recycled PLA is 20% lower than that of the non-used spoons, due to the degradation that takes place during the service life and recycling. Previous studies indicate that the washing and melt reprocessing step could lead to chain scission reactions that negatively affect the average molecular weight, and hence the IV, of PLA (Beltrán et al., 2018, Beltrán et al., 2019),



**Figure 2.** Intrinsic viscosity (a) and Vickers hardness (b) of PLA before and after mechanical recycling.

The decrease on the intrinsic viscosity resulted in a reduction on some properties of the post-consumer PLA. For instance, it can be seen on figure 2b the Vickers hardness decreased 10% in the recycled material. Such decrease is related to the degradation of the polymer, since it is known that strength and rigidity depend on the molecular weight. These results suggest that special attention should be paid to the degradation of post-consumer PLA during its service life and mechanical recycling, along with the resulting reduction on the properties of the recycled material. The possibility of using different cost-effective methods for improving the properties of recycled post-consumer PLA becomes important to increase the recyclability of the plastic.

## Acknowledgements

Authors received funding from European Union's Horizon 2020 research and innovation program under grant agreement No. 860407 BIO-PLASTICS EUROPE, as well as from MINECO-Spain (project CTM2017-88989-P) and Universidad Politécnica de Madrid (project UPM RP 160543006).

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