Upcycling of Polymeric Waste Streams *via* the Remelting-Restabilization approach and Solid-State Polymerization

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ABSTRACT

Plastics waste pollution is a severe environmental, social and economic problem, that needs to be efficiently addressed in a global-scale. One solution lies in the methods of *Recycling* and *Upcycling*. *Recycling* commonly refers to the actions followed for converting waste materials into reusable products. *Upcycling* however, includes the process of transformation of by-products and waste materials, into upgraded, value-added products, while minimizing the environmental impact of disposal and serving the circular economy purposes[1]. In the early steps of Upcycling, it is important to estimate if the degradation degree of a polymeric waste stream (PWS) is such, that its properties need to be upgraded (e.g. PET), or simply maintained (e.g. PP) before its second life cycle[2]. In this framework[3], the PWS examined are: post-consumer PP from Electric and Electrical Equipment waste (WEEE) and a PET waste stream from Textiles. The standard procedures include an initial homogenization step, followed by standardized characterization methods for estimating the degradation degree, the thermal and mechanical properties of each PWS. Upcycling is then conducted *via* state-of-the-art technologies, such as remelting-restabilization for additives blends incorporation and Solid-State polymerization. Regarding the PP[4], the degradation assessment is conducted by multiple extrusion cycles under intense temperature and shearing conditions. The thermal, rheological and mechanical properties throughout all five cycles of reprocessing are evaluated *via* TGA, DSC, MFR, Parallel Plate Rheology, Tensile and Impact testing. The material is then compounded with selected antioxidant additives in different concentrations. The thermomechanical degradation rate of the re-stabilized material is assessed by repeating the reprocessing and comparing the re-examined properties with those of the non-stabilized grade. Thus, the optimum additives' formulation for effective upcycling is determined. The upcycling of PET is conducted in two steps[5]. First, the material is shredded, compacted and compounded to uniform pellets. During these pretreatment stages, the Intrinsic Viscosity (IV) appears decreased, considerably lower than the targeted value. The pellets are then, subjected to SSP in a fixed bed reactor at 220°C and IV increases by more than 45%. These results are verified by GPC, as average molecular weight values are also increased by more than 70%, proving the SSP's effectiveness.

KEYWORDS: Plastics recycling, Polypropylene, Polyethylene Terephthalate, Remelting-Restabilization, Solid State Polymerization

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