MECHANICAL RECYCLING OF HDPE-BASED PACKAGING: INTERPLAY BETWEEN CROSS CONTAMINATION, AGING AND REPROCESSING

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Developing efficient mechanical recycling strategies for polyolefins remains a significant challenge due to several factors. Firstly, the thermo-mechanical degradation that occurs during reprocessing, along with various forms of degradation experienced throughout their service life, leads to substantial alterations in the microstructure of polyolefins. This, in turn, causes a gradual decline in their performance. Additionally, limitations in sorting technologies often result in minor cross-contamination within recycled polyolefins. These factors contribute to the production of recyclates with a heterogeneous and complex morphology, which greatly influences their final properties and frequently restricts their potential applications. Our work aims at addressing these issues, evaluating the combined effect of cross-contamination and of the degradation undergone by the polymers during service life and reprocessing for high-density polyethylene (HDPE) containing low amounts of polypropylene (PP) and polyethylene terephthalate (PET) as contaminants.
Starting from the typical composition of HDPE bottles, HDPE-based materials with cross-contaminations were formulated and exposed to photo-oxidative or thermo-oxidative aging treatments. The resulting systems were reprocessed and analysed to evaluate potential functional and microstructural modifications caused by the combined effects of cross-contamination and degradation, as well as their impact on the final mechanical properties of polymeric materials. Firstly, it was demonstrated that the presence of cross-contaminations significantly reduces the formation of oxygen-containing functional groups resulting from photo- and thermo-oxidative treatments, particularly in photo-oxidized materials. Furthermore, the addition of PP and PET led to the formation of immiscible blends, with their final microstructure being highly influenced by the impact of the specific aging treatment on the viscosity of the HDPE matrix phase. In particular, the photo-oxidised sample of HDPE with PP and PET showed significant morphological alterations, driven by both aging and reprocessing, leading to a more refined morphology compared to the non-aged counterpart. Finally, tensile characterization results highlighted the critical role of cross-contamination in causing severe embrittlement of HDPE, particularly in thermo-oxidized materials; in contrast, under photo-oxidative aging, PP and PET presence has a negligible impact on HDPE ductility, which is already significantly compromised by degradation.

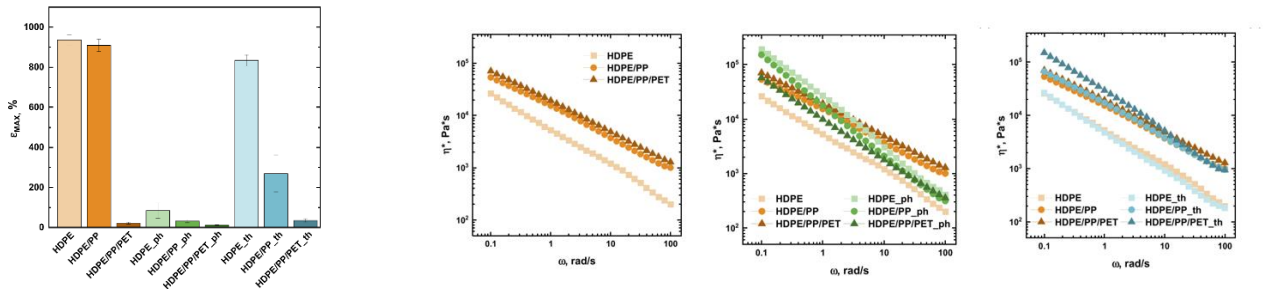

Fig. 1 Mechanical and rheological characterization of aged samples.