sciforum-137425: The interplay between cross-contamination, aging and reprocessing in the mechanical recycling of HDPE-based packaging

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Developing efficient mechanical recycling strategies for polyolefins is challenging due to several factors. Firstly, thermo-mechanical degradation during reprocessing and other degradation throughout their service life alters the microstructure of polyolefins, causing a gradual decline in performance. Also, minor cross-contamination in recycled polyolefins is often due to limitations in sorting technologies. These factors lead to recyclates with a complex morphology which restricts their applications. Our work aims to address these issues 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, cross-contaminated HDPE-based materials were exposed to photo- and thermo-oxidative ageing treatments. These systems were then reprocessed and analysed to evaluate modifications caused by cross-contamination and degradation, and their impact on the polymers' mechanical properties. Firstly, it was demonstrated that cross-contamination significantly reduces the formation of oxygen-containing functional groups from photo- and thermo-oxidation, particularly in photo-oxidised materials. Furthermore, the addition of polypropylene (PP) and polyethylene terephthalate (PET) led to immiscible blends, with the microstructure being influenced by the specific ageing treatment on the HDPE matrix phase. Notably, the photo-oxidised HDPE sample containing PP and PET exhibited significant morphological alterations driven by ageing and reprocessing, resulting in a more refined morphology compared to the non-aged counterpart. Finally, tensile characterisation results emphasised the critical role of cross-contamination in severely embrittling HDPE, particularly in thermo-oxidised materials. In contrast, the presence of PP and PET has a negligible impact on the ductility of HDPE under photo-oxidative ageing, which is already significantly compromised by degradation.