RING-CHAIN EQUILIBRIUM FOR POLYESTER RECYCLING

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Given the chemical recycling complexity and the impossibility of removing colours and contaminants with mechanical recycling, this work reports an innovative technology for polyesters recycling by ring-chain equilibrium and ring-opening polymerisation (ROP).

Cyclodepolymerisation reactions are commercially used to produce virgin cyclic oligomers (e.g. Lactide) from small chains oligomers to be then polymerised by ROP. In this work, the use of cyclodepolymerisation enhanced by distillation (DA-CDP) is exploited for the recycling of polyester polymers. An additional value of the proposed approach is its ability to directly recycle PET waste bottles without sorting the scrap by colours. The light contaminants are removed by catalyzed reactive distillation during the first process step. At the same time, PET is partly depolymerised to produce cyclic oligomers and simultaneously increase the molecular weight of the linear chains. In a second step, the product collected after the reactive distillation is purified to eliminate the residual heavy contaminants and the solvent. The purified polymer/oligomer mixture is then (i) used directly as lower grade material after separation (for fibers or sheets) or (ii) re-polymerised by ring-opening polymerisation to high molecular weight polymer without need of further addition of catalyst. In the latter case, high molecular weight polymer (MW higher than that typical of bottle grade) is achieved in less than 15 minutes: therefore, the last step can be effectively performed by reactive extrusion. Notably, fibre-grade PET can be recycled into bottle-grade PET thanks to the final increase of molecular weight: then, up-cycling is actually achieved. Preliminary cost evaluation shows that the proposed technology compares favorably with recycling processes available on the market in terms of CAPEX and OPEX. Due to its simplicity and small number of steps, the investment cost and the energy consumption are quite reduced with respect a traditional chemical depolymerisation recycling.

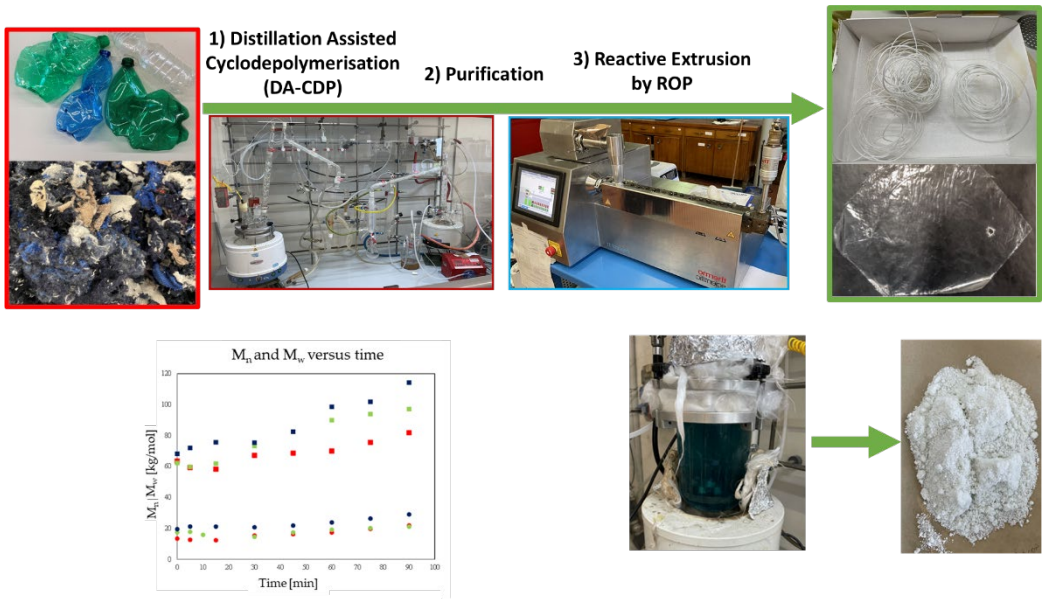

Figure 1 – Novel process of PET recycling: main steps