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Thermo-mechanical degradation of plasticized poly(lactide) after multiple reprocessing to simulate recycling: multi-scale analysis and underlying mechanisms

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Abstract

The thermo-mechanical recycling of poly(lactide) (PLA) by reprocessing was recently considered as a new end-of-life scenario for this biosourced and biodegradable polymer. With this regard, the degradation mechanisms of plasticized PLA (pPLA) engendered by multiple reprocessing were little investigated to date, and hence, the relevancy of its reprocessing was not assessed. They were identified in this paper by a multiscale approach in the case of a lab-developed grade of pPLA obtained by the reactive extrusion of PLA with acrylated poly(ethylene glycol) (acryl-PEG) as reactive plasticizer. pPLA structure consisted of a semi-crystalline PLA matrix in which grafted poly(acryl-PEG) micro-inclusions were dispersed. Up to 5 successive processing cycles including extrusion and compression-molding, the tensile and impact properties drastically dropped indicating an embrittlement of pPLA. Structural analyses revealed that reprocessing caused these mechanisms: chain scission of PLA, crystallization of PLA, damaging of the inclusions, decrease of the size of poly(acryl-PEG) phases within the inclusions, and cracking of PLA. At the same time, the amount of grafted poly(acryl-PEG) was not influenced by the reprocessing. Inclusion damaging and matrix