Mechanical recycling of biopolyesters: Influence of multiple extrusion cycles on degradation and properties

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The use of bioplastics is increasing, and biodegradable polyesters such as polylactic acid (PLA) and polyhydroxy alcanoates (PHAs) in particular are considered to have a large growth potential. Even though these materials are compostable, and biodegradation is a feature for some applications such as mulch films in the agricultural sector or to reduce waste pollution in case of accidental spreading to the environment, the majority of these biopolyesters are used for packaging [1]. After only a short period of use, packaging ends up in waste again very quickly. In terms of energy consumption and general value retention, recycling could be the better approach for EoL of biopolyesters than incineration or composting (**Figure 1**).
Biopolyesters characteristically have ester bonds that are relatively easy to split, and several mechanisms contribute to their degradation. What is a feature in composting, is more of an obstacle in mechanical recycling: thermal, oxidative, and hydrolytic chain scissions are detrimental to the retention of high material properties, especially after multiple recycling.
We exposed biopolyesters to exactly this scenario: a multiple recycling process, represented by five successive extrusions of PLA and PHA. After each cycle, the extent of degradation and its influence on the optical appearance, rheological and mechanical properties was evaluated. Depending on the process conditions, a degradation in chain length was observed, progressing after each extrusion cycle. Nevertheless, good mechanical properties could be preserved, which in turn suggests that these bioplastics should also be mechanically recycled in the interests of sustainability, and ultimate EoL solutions can only be an option for special application cases.

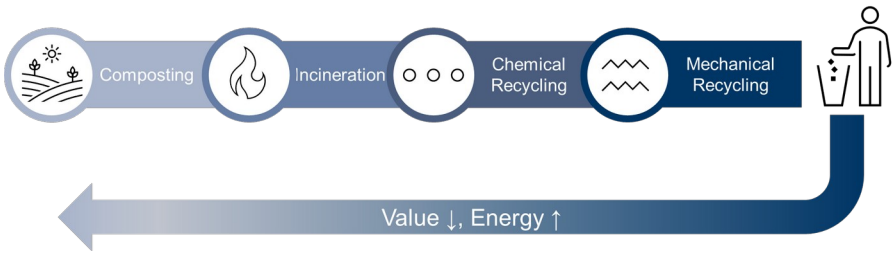

Figure 1: EoL scenarios for plastics according to "value" and energy loss.

Keywords: biopolyesters, PLA, PHA, mechanical recycling, multiple extrusion, characterisation

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References

[1] European Bioplastics e.V. (2025, April 1), https://www.european-bioplastics.org/