Effect of Functional Nanofillers on the Thermo-Rheological Properties of PLA-Based Nanocomposites

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Developing biodegradable polymer composites with enhanced performance is a key challenge in advancing sustainable materials. In this study, nanocomposites based on Ecovio®, a commercial blend of polylactide and poly(butylene adipate-co-terephthalate), were prepared using a range of functional nanofillers. These nanofillers encompassed modified montmorillonite clays and polymeric brushes derived from poly(butyl acrylate) and poly(butyl methacrylate).

Thermal analysis showed typical two-step degradation (PLA, then PBAT), with (3-aminopropyl)triethoxysilane-functionalized clays reducing thermal stability and poly(butyl acrylate) functionalised clays improving it. Thermomechanical and FTIR analyses confirmed that (3-aminopropyl)triethoxysilane functionalised clay promoted degradation during processing, while poly(butyl acrylate) functionalised clays mitigated these effects. At the same time, differential scanning calorimetry analysis revealed no significant effects of the fillers on the glass transition, melting, or crystallisation temperatures [1, 2]. These observations are consistent with the established behaviour of polylactide-based systems, which are known to be sensitive to nucleating agents and blend morphology [3].

The composites' rheological behaviour was evaluated through dynamic shear experiments. Advanced data interpretation techniques, including Cole–Cole and van Gurp–Palmen plots, have led to the discernment of alterations in viscoelastic properties and interfacial interactions. This, in turn, has furnished insights into the structure–property relationships of the modified systems [4, 5].

While the thermal characteristics remained largely unaffected by nanofiller incorporation, subtle shifts in crystallisation behaviour and notable changes in viscoelastic properties point to underlying modifications at the filler–matrix interface. These findings provide a foundation for optimising the performance of biodegradable composites in environmentally conscious applications.

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References

[1] Chatiras, N.; Georgiopoulos, P.; Christopoulos, A.; Kontou, E. *Effect of poly(lactic acid) matrix on the mechanical and thermal behavior of biodegradable composites*. *Polymer Composites* **2019**, 40, 4340–4350.

[2] Hamad, K.; Kaseem, M.; Ayyoob, M.; Joo, J.; Deri, F. Sustainable approach of the synthesis and applications of biodegradable polymers. *Progress in Polymer Science* **2018**, 85, 83–113.

[3] Farah, S.; Anderson, D.G.; Langer, R Physical and mechanical properties of PLA, and their functions in widespread applications—A comprehensive review. *Advanced Drug Delivery Reviews* **2016**, 107, 367–392.

[4] Kostenko, M.; Stetsyshyn, Y.; Harhay, K.; Melnyk, Y.; Donchak, V.; Gubriy, Z.; Kracalik, M. Impact of the functionalized clay nanofillers on the properties of the recycled polyethylene terephthalate nanocomposites. *Journal of Applied Polymer Science* 2024, 141, e55543.

[5] Kracalik, M.; Laske, S.; Witschnigg, A.; Holzer, C. *Evaluation of the molecular structure of polymer blends by means of van Gurp–Palmen and Cole–Cole plots*. *Rheologica Acta* **2011**, 50, 937–946.