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Advances in biodegradable polymers for sustainable packaging

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Growing global concerns regarding plastic pollution have driven rapid advancements in biodegradable polymer research, particularly for sustainable packaging applications. Biodegradable biopolymers such as polylactic acid (PLA), polyhydroxyalkanoates (PHA), and starch-based composites have emerged as viable alternatives to conventional plastics due to their reduced environmental impact and favourable mechanical properties. This study examines the structural, thermal, and degradation behaviours of these materials under simulated environmental conditions, highlighting their potential to replace petroleum-derived packaging. Experimental analyses demonstrate that PLA provides excellent tensile strength and transparency, making it suitable for food packaging. However, its slow degradation rate in natural environments presents challenges. PHA, in contrast, offers superior biodegradability, even in marine ecosystems, although its high production cost limits widespread application. Starch-based biopolymers, while cost-effective and fully biodegradable, require reinforcement to improve moisture resistance and mechanical stability. Various biofillers, such as cellulose nanofibres and lignin particles, were incorporated to enhance the performance of these materials. The results indicate that hybrid composites significantly improve barrier properties and durability while maintaining biodegradability. Life cycle assessment (LCA) studies further confirm that biopolymer-based packaging reduces carbon emissions by 40–60% compared with traditional plastics. Overall, this research provides a comprehensive evaluation of biodegradable biopolymers and offers insights into their industrial adoption, challenges in processing, and future innovations required to advance sustainable packaging solutions.

Biography

Elena Morales is an Associate Professor of Materials Science at the University of Barcelona with over 15 years of research experience in biopolymers, eco-friendly composites, and sustainable packaging technologies. She has led multiple EU-funded projects on circular materials and has authored more than 60 scientific publications. Her work focuses on bridging green chemistry with industrial applications, promoting the development of biodegradable alternatives that support global sustainability goals. Dr. Morales is widely recognized for her contributions to polymer innovation and environmental materials science.

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