Development of sustainable biomanufacturing process for packaging applications

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Abstract

This study addresses the need for sustainable alternatives to conventional plastic coatings in packaging by developing a biodegradable coating system based on polylactic acid (PLA) and polyhydroxyalkanoate (PHA). A novel spray coating technique, followed by hot pressing, was employed to apply PLA/PHA blends onto kraft pulp paper, aiming to enhance its mechanical strength, barrier properties, and water resistance while maintaining compostability. The coating behavior was strongly influenced by the PLA to PHA ratio. PLA formed a dense surface layer that effectively sealed pores, while PHA penetrated more deeply into the fibrous matrix, filling internal voids. These complementary roles contributed differently to the overall performance. In particular, the 50:50 PLA/PHA blend showed the most balanced results, achieving the lowest oxygen transmission rate and improved tensile strength. The thermogravimetric analysis further confirmed enhanced thermal stability in all coated samples compared to uncoated paper, with the degradation temperature profile shifting depending on the polymer composition. However, coatings with excessive PHA content showed surface irregularities and reduced barrier performance due to poor film formation. Overall, this work demonstrates that compositional tuning of PLA and PHA enables multifunctional coatings with improved mechanical, thermal, and barrier properties. The proposed spray-based method offers a scalable, eco-friendly solution for high-performance biodegradable packaging.