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DEVELOPMENT OF PHB/CHITOSAN BIOHYBRID FIBROUS MATERIALS FOR ECO-FRIENDLY BIOCONTROL APPLICATIONS

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Introduction: Modern agriculture faces the challenge of balancing crop productivity with environmental sustainability. Eco-friendly alternatives to chemical pesticides are urgently needed. Bacillus subtilis is an effective biocontrol agent, but its application is limited by low stability under field conditions. Poly(3-hydroxybutyrate) (PHB) combined with chitosans can enhance encapsulation, bacterial viability, and controlled release. This study compares two PHB-based approaches: (i) dip-coating with chitosan solutions [1], and (ii) simultaneous electrospinning/electrospraying of COS/B. subtilis [2]. Experimental part: PHB (Mw 330,000 g/mol) was obtained from Biomer (Germany). COS (3,000–5,000 g/mol) was purchased from Kitto Life Co. (Korea). Low- (50,000–190,000 g/mol) and high-molecular-weight chitosan (~600,000 g/mol) were supplied by Sigma-Aldrich (USA). B. subtilis and phytopathogenic fungi were obtained from Biodinamika Ltd. (Bulgaria). PHB fibers (14% w/v) were fabricated and functionalized either by dip-coating with chitosans (COS, low- or high-MW) or simultaneous electrospraying of COS/B. subtilis. Morphological, structural, and surface analyses were performed by SEM, ATR-FTIR, and water contact angle measurements. Mechanical properties were evaluated, and microbiological assays assessed bacterial viability after incorporation and 90-day storage, as well as antifungal activity against Alternaria and Fusarium. Results: PHB/COS mats prepared by electrospinning/electrospraying showed uniform bacterial distribution, enhanced hydrophilicity, and sustained bacterial proliferation. Embedded

B. subtilis inhibited Alternaria and Fusarium growth. Chitosan-coated mats improved tensile strength and maintained long-term spore viability, strongly suppressing Alternaria. Discussion: Both methods preserved fibrous PHB while improving mechanical strength and wettability. Chitosan molecular weight influenced viscosity and film formation in dip-coating, whereas COS electrospraying yielded thin, uniform layers. Both approaches ensured bacterial viability and antifungal activity, but electrospinning/electrospraying proved more scalable and efficient. Conclusion: PHB/chitosan-based fibrous biohybrids represent an efficient, sustainable platform for encapsulation and delivery of Bacillus subtilis. Both dip-coating and simultaneous electrospinning/electrospraying approaches ensured long-term bacterial viability and effective antifungal activity, highlighting the potential of natural polymer-based carriers as next-generation eco-friendly formulations for sustainable agriculture.

Keywords: *electrospinning, encapsulation, biohybrids, Bacillus subtilis, plant protection.*

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