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QUANTITATIVE ANALYSIS OF NANOMECHANICAL PROPERTIES OF POLYHYDROXYALKANOATE POLYMER FILMS

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Introduction

Polyhydroxyalkanoates (PHAs) are biopolymers synthesized by bacteria under specific growth conditions and have gained attention due to their biocompatibility, biodegradability, and applicability in biomedical and industrial fields [1.2]. The mechanical properties of these polymers, particularly at the nanoscale, influence their usability in applications like tissue engineering and coatings. This study investigates the nanomechanical properties of three PHA polymers using Atomic Force Microscopy (AFM): poly(3-hydroxybutyrate) [(P3HB)], poly(3-hydroxybutyrate-co-valerate) [(P3HBV)], and poly(3-hydroxybutyrate-co-4-hydroxybutyrate) [(P3HB4HB)]. Furthermore, different thicknesses of P3HBV films (10 µm, 30 µm, and 60 µm) were examined to determine their impact on nanomechanical behavior.

Methodology

PHA polymers were synthesized using Cupriavidus necator B-10646 under controlled conditions. The films were fabricated using the solution-casting method, with thickness variations achieved by adjusting polymer concentrations. AFM-based force-distance curves were used to measure nanomechanical properties, including Young's modulus, adhesion force, and stiffness. The Derjaguin–Muller–Toporov (DMT) model was applied to determine mechanical characteristics, while additional characterization techniques such as X-ray diffraction (XRD) and scanning electron microscopy (SEM) were utilized to analyze crystallinity and surface morphology.

Conclusion

The study provides valuable insights into the relationship between polymer composition, thickness, and nanomechanical properties. These findings highlight the importance of tailoring polymer films for specific applications, particularly in biomedical engineering and coatings. By integrating computational modeling with experimental data, this research advances the understanding of PHA-based materials and their functional optimization.

References:

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