



INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI  
SHORT ABSTRACT OF THESIS

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Programme of Study : **Ph.D.**

Thesis Title : **Preparation, characterization, and biodegradation studies of novel active poly (3-hydroxybutyrate) nanocomposite films and their application in packaging fresh produce**

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**SHORT ABSTRACT**

The rising environmental concerns associated with non-biodegradable petrochemical-based food packaging underscore the critical need for sustainable alternatives. Poly (3-hydroxybutyrate) (PHB), a natural polyester of microbial origin has excellent potential for food packaging applications owing to its renewability, high crystallinity, biocompatibility, biodegradability, and physical attributes comparable to conventional plastics. Nonetheless, PHB has certain shortcomings, including low elongation at break, moderate gas barrier properties, and negligible antimicrobial and antioxidant activities for its direct application in food packaging. Observing these facts, our work focused on overcoming the limitations of PHB by combinational loading of essential oil and nanofiller, evaluating the suitability of developed PHB-based nanocomposite films for storing fresh produce and assessing the biodegradability of these films in natural environmental conditions viz. soil and river water. Firstly, five different chemical synthesis routes (precipitation, sonication-precipitation, microwave combustion, conventional combustion, and solvothermal processes) were screened to customize the properties of MgO nanoparticles (NPs) for their reinforcement in PHB. Wherein, the microwave combustion route yielded MgO NPs with higher specific surface area ( $67.32 \text{ m}^2/\text{g}$ ), smaller particle size (5-35 nm), and outstanding antimicrobial and antioxidant activities compared to

other routes. In the next step, PHB-based films were prepared by incorporating varying concentrations (1-10 wt%) of essential oils, namely grapeseed oil (GS), bergamot oil (BG), and ginger oil (GG), through the solution casting route and extensively characterized. The tensile strength and elongation at break of pristine PHB films are  $20.48 \pm 0.51$  MPa and  $0.51 \pm 0.04$  %, respectively. Meanwhile, the water vapor and oxygen permeability of pristine PHB films are  $1.29 \text{ g}\cdot\text{mm}\cdot\text{m}^{-2}\cdot\text{day}^{-1}\cdot\text{atm}^{-1}$  and  $6.03 \times 10^{-9} \text{ g}\cdot\text{m}^{-1}\cdot\text{s}^{-1}$ , respectively. Notably, the best improvement (30-fold) in elongation at break of PHB is achieved with 5 wt% loading of GS (PHB/5GS) but at the cost of reduction in tensile strength (1.3-fold) and thermal stability. To overcome the limitations of PHB/5GS films, MgO NPs obtained via the microwave combustion route were introduced as reinforcing agent at varying loading rates (0.1-1 wt%), and the PHB/5GS/MgO nanocomposite films were fabricated by sonication-assisted solution casting route. Interestingly, the PHB-based films loaded with 5 wt% GS and 0.7 wt% MgO NPs (PHB/5GS/0.7MgO) demonstrated higher tensile strength (by 1.4-fold) and elongation at break (by 30-fold), along with 79 and 90 % reduction in water vapor and oxygen transmission, respectively compared to pristine PHB films. In addition, these films showed good UV-blocking properties,  $65.25 \pm 0.98$  % antioxidant activity, and completely inhibited the growth of *Staphylococcus aureus* and *Escherichia coli*. Furthermore, the PHB/5GS/0.7MgO films proved beneficial effects in terms of extending the shelf-life of white button mushrooms up to 6 days and cherry tomatoes up to 21 days at ambient room conditions maintaining their physicochemical as well as organoleptic properties. Additionally, the PHB/5GS/0.7MgO films showed 100 % weight loss in soil in 25 days and 20 % weight loss in river water in 120 days.