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# BIOTOUGH HBV

## – Functional Masterbatch for Additive Manufacturing




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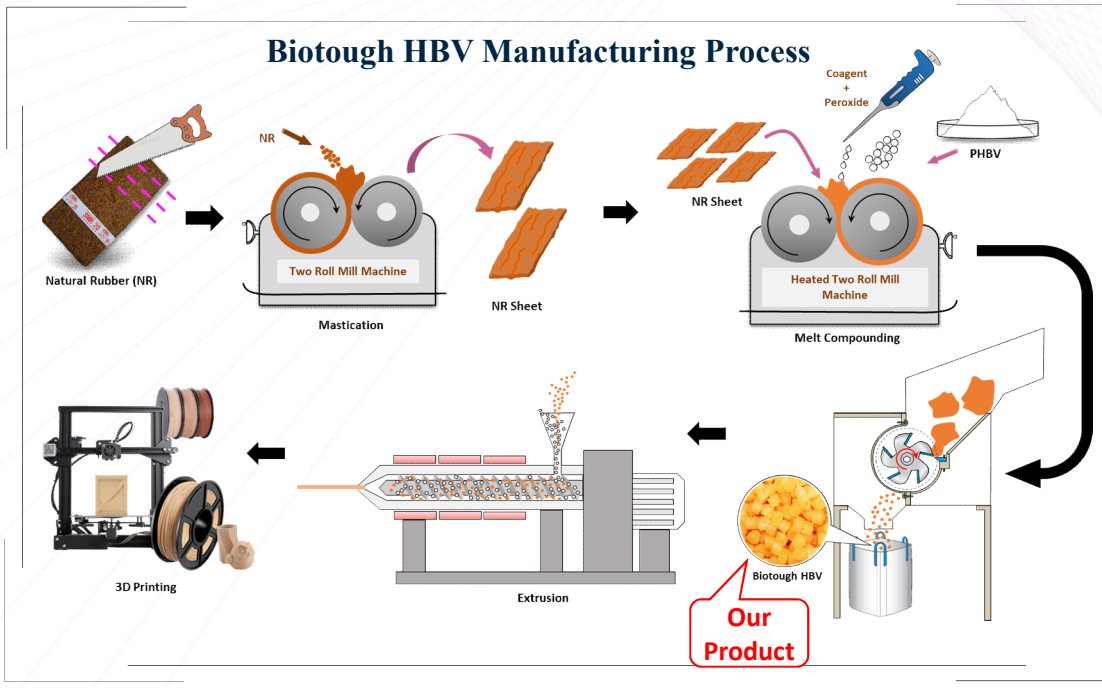
## Introduction

Poly(hydroxybutyrate-co-valerate) (PHBV) is the ideal replacement for petroleum-based plastic, owing to its biocompatible, non-toxicity, and production naturally by bacteria. However, PHBV has high brittleness due to high crystallinity, becoming a major challenge for PHBV commercial production and limiting its use in moulded products. To overcome the brittleness of PHBV, incorporating toughening agents such as natural rubber (NR) could be a good idea due to it being ductile, elastic, affordable, and abundant in Malaysia. This motivates the development of novel and better dispersing methods for NR in the PHBV matrix. The use of Biotough HBV helps to improve product consistency and process stability through better dispersion. In mass production, using masterbatch for more uniform dispersion can result in fewer rejected parts due to inconsistent properties that might negatively impact product quality. Masterbatch allows for less complicated addition at the extruder. The premise underlying this strategy is to achieve well-dispersed NR, improve crystallization temperature, and lower processing temperature while retaining the effective dispersion obtained in Biotough HBV. The renewability and biodegradability of Biotough HBV bring a positive impact towards additive manufacturing development as it improved material properties while keeping PHBV's "green" status in order to align with the Sustainable Development Goals 8th, 9th, 12th, and 13th.

## Problem Statement

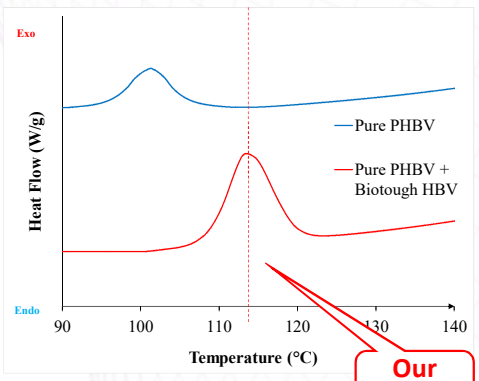
Most additive currently used to toughen additives are non-degradable, generating environmental problems. NR created an excellent opportunity to increase toughness while minimising the effect of non-degradable materials used in PHBV. Basically, NR has a very high molecular weight that can be reduced by masticating. Lower molecular weight NR should result in a smaller particle diameter in the blend and ultimately result in a material with improved toughness. The pre-dispersion masterbatch method was used to improve the dispersion of the NR within the PHBV matrix, producing the new “Biotough HBV” functional masterbatch.

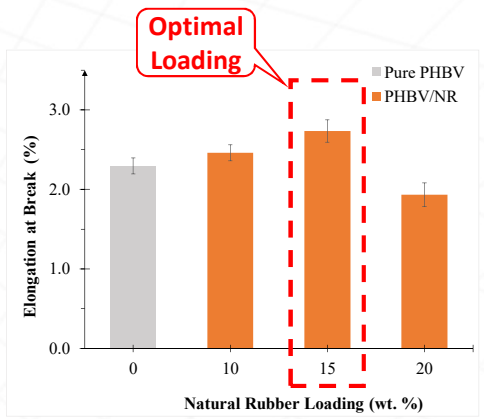
## Biotough HBV Manufacturing Process




## Biotough HBV Functional Masterbatch comes with the following features :

- Higher Crystallization Temperature
- Enhanced Tensile Elongation




## NOVELTY

- First attempt to use Malaysia Natural Rubber for masterbatch additive application.
- Pioneer work on the use of Biotough HBV as bio-based toughening agent masterbatch for biodegradable copolymer
- Novel approach – combination of high concentration and pre-dispersion NR

## KEY PUBLICATIONS

1. K C Lim, N A S A Halim, S N S Mahamud, A F Osman, M H M Pisal and A Masa. Mechanical Properties of Poly-(Hydroxybutyrate-co-Valerate)/ Natural Rubber/ Cellulose Nanocrystal (PHBV/NR/CNC) Nanocomposites Prepared by Using Two-Roll Mill Method. AIP Conference Proceedings (International Symposium On Advanced Material & Processing 2022) (Submitted)
2. K C Lim, N A S A Halim, S N S Mahamud, A F Osman, M H M Pisal and S S M Saleh. Effect of Blend Ratio and Cellulose Nanofiber Loading on the Mechanical Properties of Poly(3-hydroxybutyrate-co-3-hydroxyvalerate) Natural Rubber/ Cellulose Nanofiber (PHBV/NR/CNF) Nanocomposites. AIP Conference Proceedings (World Integrated Chemical and Material Engineering Technology Conference 2023) (Submitted)

## ACKNOWLEDGEMENT

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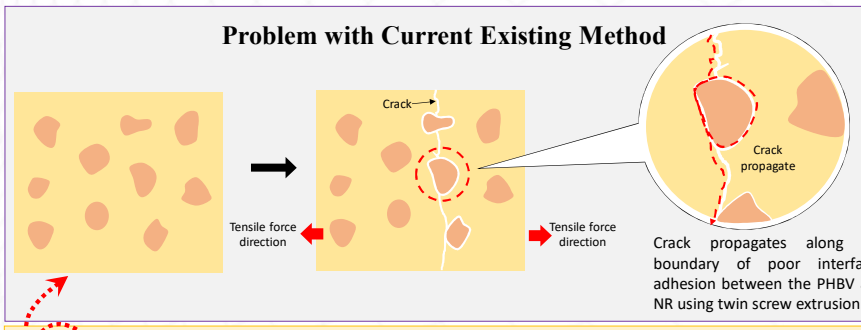
## ADVANTAGES

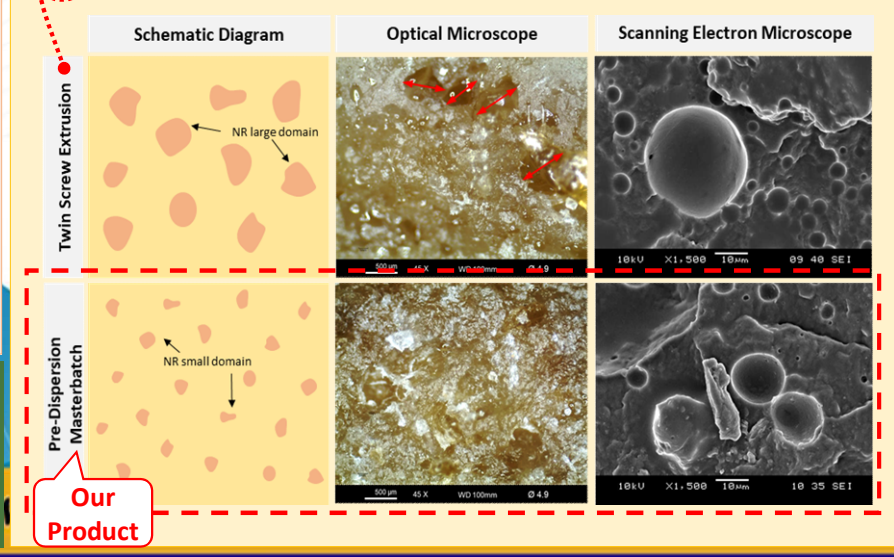
- Raw materials used are sustainable materials from renewable resource. PHBV produced by bacteria while NR produced naturally from plant
- Unlike other chemical + petroleum based masterbatch, Biotough HBV is biodegradable and non toxic (reducing landfill waste and leachate to the environment).
- Using non-toxic melt blending method (hazard-free) to prepare masterbatch compare to solvent casting and shorter processing time. PHBV bio-based copolymer is thermoplastic material which can be recycled, minimizing the plastic waste during production.
- Easier incorporation of additives - less complicated addition through pellet-to-pellet blending or addition at the extruder.
- Improved product consistency and process stability
- Increased toughening agent stability and shelf-life. Solid masterbatches are solvent-free. Therefore, they tend to have longer shelf life as the solvent will not evaporate over time.
- THE USE OF NATURAL RUBBER HELPS TO PROMOTE AND COMMERCIALIZE OUR LOCAL PRODUCT!!! CONTRIBUTE TO MALAYSIA ECONOMIC GROWTH !!!

8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION

## Problem with Current Existing Method




## Dispersion of NR in PHBV

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