

Optimization of Treatment and Ratio of Ground Coffee Waste (GCW) as Filler in Polylactic Acid (PLA) Bio-Composite

Nur Alia Fateha Mohd Shamsudin^a, Wan Nor Raihan Wan Jaafar^{a*}

Structured Abstract

Background: Plastics are widely used due to their excellent physical and chemical properties; however, their excessive production and improper disposal have led to severe environmental issues. In response, industries are increasingly seeking sustainable alternatives to petroleum-based plastics. PLA a biodegradable polymer derived from renewable resources has emerged as a promising alternative due to its lower density, biodegradability, and compatibility with natural fillers. However, improving its mechanical performance remains necessary for broader applications. GCW offers a sustainable and cost-effective filler material for PLA. GCW's availability, affordability, and functional properties make it a suitable natural filler that can improve PLA's mechanical and chemical properties while supporting circular economy initiatives. This study aimed to optimize the treatment and percentage of GCW as a sustainable filler in PLA bio-composites, with the primary objective to enhance mechanical and chemical properties of the composites. There are two types of composites produced, the first one is untreated composites and the second one is treated composites.

Methods: GCW was treated through a boiling process for 1 hour before its incorporation into the PLA matrix at 10%, 20% and 30% filler percentages for both composites. The mechanical properties of the resulting bio-composites, particularly impact strength, were rigorously assessed. FTIR spectroscopy was employed to analyse the chemical interactions and structural changes occurring between the treated GCW and the PLA matrix, confirming the effectiveness of the treatment in altering the filler's surface and promoting good blending.

Results: Results demonstrated that the boiling treatment has improved the impact strength of the PLA bio-composites compared to their untreated counterparts. FTIR analysis further supported these findings by confirming the effective alteration of the GCW's surface and its successful integration within the PLA matrix. Among the different filler loadings tested, the 20% treated GCW composite exhibited the highest impact strength, suggesting this ratio as the optimum filler content. Beyond 20%, a slight reduction in mechanical performance was observed.

Conclusion: Overall, this study provides evidence of optimizing the treatment and percentage of GCW as a sustainable filler in PLA bio-composites which can enhance mechanical and chemical properties of the composites, offering a sustainable approach for value-added utilization of coffee waste.

Keywords: Polylactic Acid (PLA) Bio-Composites, Ground Coffee Waste (GCW), Sustainable filler, Impact Strength, FTIR Spectroscopy

*Correspondence: raihanjaafar@uitm.edu.my

^a School of Industrial Technology, Eco-Technology Programme, Faculty of Applied Sciences, Universiti Teknologi MARA, Shah Alam, Malaysia