

The properties of banana peel powder filled polycaprolactone composites

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ABSTRACT

In recent years there has been an increase interest in biodegradable polymers. They are widely used in packaging, agriculture, medicine and other areas. This work investigates the conversion of banana peel waste as filler in biopolymer which can be alternative materials to synthetic plastics. Polycaprolactone (PCL) based polymers composites were filled with banana peel powder (BPP). BPP/PCL composites were prepared by dissolving PCL pellets and incorporate BPP in 5, 10 and 15 wt% loading. Water absorption and TGA were conducted on the composites samples to recognized its properties. Percentage of water uptake increased with increment of BPP loading. The TGA results showed that the composites were thermally stable with the addition of BPP. Thus BPP/PCL composite is suitable for the lessening of banana peel waste and developing value-added biocomposites materials.

1.0 INTRODUCTION

To meet society's growing demand, the materials industry is encouraged to develop sustainable, eco-friendly materials based on natural resources. The disadvantages of synthetic fibres include their higher density, non-biodegradability, non-renewability, and high energy consumption during production. Environmental awareness and social concern, a high depletion of petroleum resources, new environmental regulations, and the concept of sustainability have all sparked interest in eco-friendly materials research (Rabiatal & Ummu, 2021).

Among potential alternatives, the creation of bio-composites from agricultural waste is presently receiving attention. Due to their availability, agricultural wastes are good prospective alternative waste materials to substitute plastic items. Aside from their availability and renewability, agricultural wastes are beneficial to the economy, ecology, and technology because of their low density, low industrial energy requirement, low CO₂ emissions, and high biodegradability (Getu & Sahu, 2014). This natural waste can be utilised to create natural bio-based composites.

The banana is a delectable fruit that is grown all over the world and consumed on a daily basis by people. Banana is one of the most widely produced crops in practically every tropical country. The yellow or green peels are often discarded, and the fruit is consumed. As a result, it is one of the most abundant and inexpensive agricultural crops. These peel wastes are high in minerals and biomolecules with a variety of functional groups. Banana peel has been investigated as a viable filler for environmentally friendly composites. Banana peels were used as starting material in this study as an example of agricultural waste being used and converted from trash into valuable products.

Polycaprolactone (PCL) has a relatively low glass transition temperature ($T_g \sim -60^\circ\text{C}$), quite low melting point (60°C) and high elongation to break (679–948%) (Guarino et al., 2017). The well-known

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biocompatible and biodegradable polymer, PCL a hydrophobic semi-crystalline polyester. The current study looks at the inclusion of banana peel powder as an agrowaste material in PCL composites. Water absorption and TGA were investigated in order to better understand the characteristics of the composites.

2.0 EXPERIMENT PROCEDURE

PCL used as matrix was supplied by Sigma-Aldrich. Banana was purchased from a local food supermarket. Banana peel (BP) was collected, washed and dried in an oven at 180 °C for overnight and crushed into powders by using a blender. Next the banana peel powder (BPP) was sieved and the size of 36µm was chosen to be incorporated with PCL in this research. The PCL pellets were mixed with chloroform to dissolve it. BPP loading was 5, 10 and 15 wt% with neat PCL samples were run along with. The mixture then was poured into a petri dish and the BPP/PCL composites were obtained.

The samples undergo water absorption test, for 3 weeks following ASTM D570. Prior to the immersion, all samples were conditioned in an oven at 50°C for 24 hours. The BPP/PCL composites film were cut into 2cm x 2cm sample size and weighed prior to immersion in water. The samples were weighed again after 24 hours for 21 days to obtain the weight of water absorbed. The test was conducted in room temperature. The increase in weight was reported as percentage of water absorbed. The calculation is as follows:

$$\text{Water absorption percentage} = (W_1 - W_0)/W_0 \times 100\% \quad (1)$$

where W_0 represent the weight before immersion and W_1 represents the weight of immersed sample.

The TGA instrument was used to determine the sample's thermal stability such as the temperature and the amount of weight changes of BPP/PCL composites. The analysis was performed by thermogravimetric analysis (TA Instruments). Samples were scanned and heated up to 600 °C under nitrogen atmosphere.

3.0 RESULTS AND DISCUSSION

The absorption of water by a material is assessed in the water absorption test. Various materials absorb different quantities of water, and the presence of absorbed water may change polymers in a variety of ways, including physical appearance, dimensions, and characteristics. The results of water absorption of BPP/PCL composites at different loading are shown in Figure 1. The water absorption was conducted for 21 days at room temperature. The results acquired were in percentages of water absorbed into the samples.

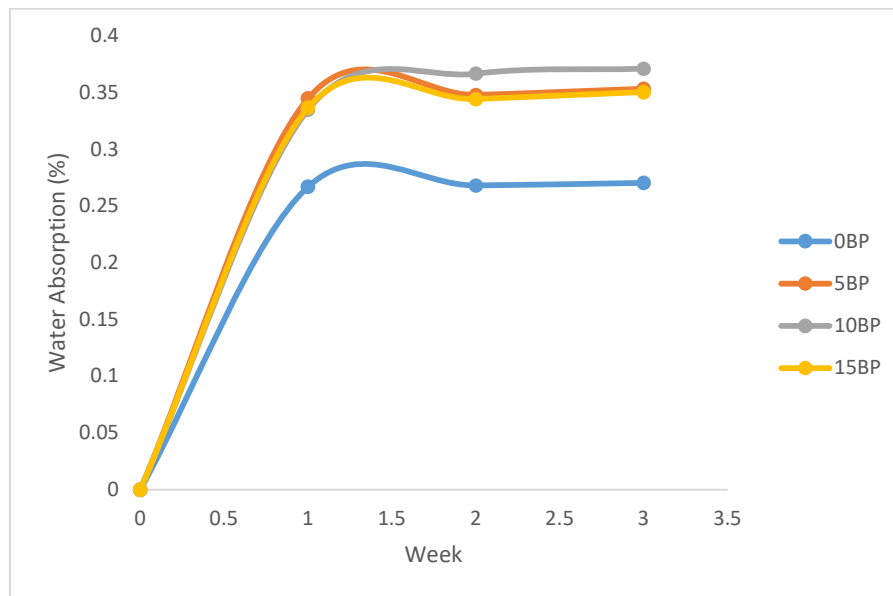


Figure 1: Water absorption of BPP/PCL composites.

The samples were immersed in water for 3 weeks until the material reached saturated condition. From the graph shown in Figure 1, it can be seen that the water absorption was very high for the first week of immersion of all samples. After the first week, the water absorption increased slowly until the second week. By this time, all the samples were almost saturated. Immersion continued until the third week, with small increment of water absorbed for all samples.

The water absorption shown increment for all BPP/PCL composites samples compared to pure PCL samples. Samples at all filler loading shown similar trend of water absorption for the 21 days duration. This is due to the incorporation of banana powder filler that encourage more water uptake in the samples. The variation of water uptake was found to differ slightly for all loading of BPP/PCL composites. The water absorbance increased drastically in the first week due to difference in the concentration gradient of water and the composites. However, for the second and third week, the water uptake was slower due to the saturated phase of water in the composites.

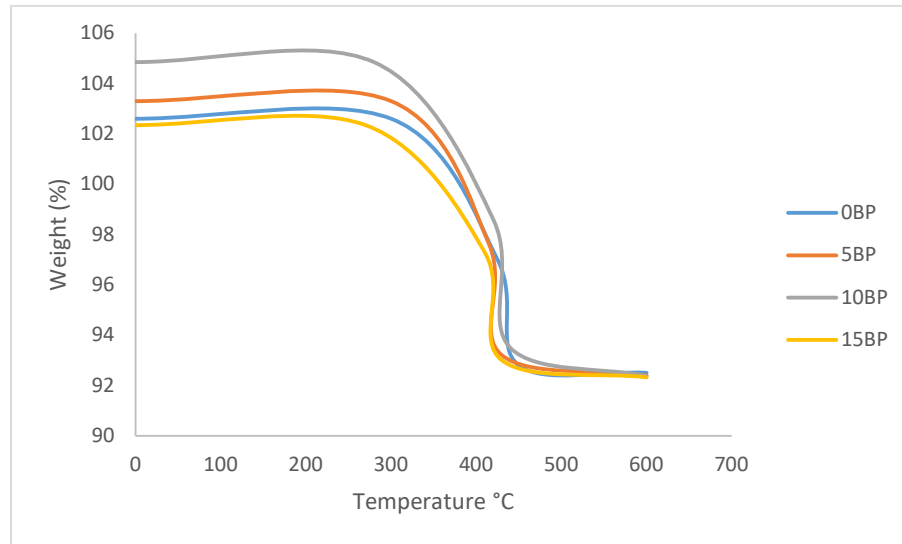


Figure 2: TGA thermogram curves of pure PCL and BPP/PCL composites.

Thermogravimetry offers information on changes in mass of materials caused by temperature changes in a controlled way. The thermal stability of various composites was assessed to determine the influence of banana peel powder on the thermal degradation of the BPP/PCL composites. The thermal stability of the composites was compared with the thermal stability of the neat PCL matrix under nitrogen. Figure 2 shows the TGA thermograms for the neat PCL and BPP/PCL composites.

From the figure, the incorporation of BPP in the PCL matrix increased the initial degradation temperature of the composites with increasing BPP proportion. For 5BP and 10BP the initial degradation increase compared to neat PCL, indicating that BP improved the thermal stability of the composites. The weight loss occurred because of breaking of chemical compound into smaller mater caused by high temperature. It can be seen from the figure that the delayed in weight loss for thermal degradation of BPP/PCL composites indicates better thermal stability of the composites.

4.0 CONCLUSION

Based on the research conducted and the results obtained, the following conclusion are drawn:

- The water absorption percentage increase with the increment of filler loading in BPP/PCL composites.
- The thermogravimetric analysis results demonstrated that increasing BPP content improved the thermal stability of BPP/PCL composites
- Fabrication of BPP/PCL composites were simple and did not involve extreme condition hence suitable for further study to shed more light on the properties of the composites.

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REFERENCES

- Rabiatul Manisah Mohamed, Ummu Aiman Suhaimi (2021). The Properties of Coconut Coir Fiber Reinforced Epoxy Composites, International Journal of Synergy in Engineering and Technology, Vol. 2 (1) pp 103-108
- Alhayat Getu, Omprakash Sahu, (2014). Green Composite Material from Agricultural Waste, International Journal of Agricultural Research and Review, Vol. 2(5) pp 056-062
- V. Guarino, G. Gentile, L. Sorrentino, L. Amrosio, (2017). Polycaprolactone: Synthesis, Properties, and Applications, Encyclopedia of Polymer Science and Technology, 1-36, doi:10.1002/0471440264.pst658