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Mini-Review

# Important Criteria for Preparation of 3D Printer Filaments from Polymer Biocomposites

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**Abstract:**

Nowadays, there are many types of 3D printer filaments have been produced to fulfill the demand of small-scale fabrication industry. The use of polymer biocomposites as 3D printer filaments is one of the ways to reduce the dependence on the synthetic thermoplastics that are expensive and non-biodegradable. This is due to the utilization of natural fibers as fillers that can decrease the percentage of synthetic thermoplastics usage. Nevertheless, there are some criteria must be considered to ensure the quality of the 3D printed products fabricated from the biocomposites is good as existing filaments. This paper has briefly explained some important criteria that recently identified before preparing 3D printer filaments from polymer biocomposites.

**Keywords:** Polymer, natural fiber, biocomposite, 3D printer, filament

## Introduction

Polymer biocomposites are materials produced from natural fibers (such as kenaf, jute, hemp, rice husk, etc.) that absolutely acted as fillers [1]. The polymer matrices of the biocomposites are usually synthetic thermoplastics or bioplastics. The composites have attracted the attention of the researchers and industry players due to the production cost could be reduced by utilizing natural fibers that are inexpensive [2]. Moreover, the usage of biocomposites in the fabrication of daily use products probably could protect the environment from pollution because they have biodegradable and recyclable properties as well [3]. Therefore, 3D printer filaments prepared from polymer biocomposites can lessen the fabrication cost of the products and they are also environmentally friendly materials.

## 1. Temperature

The processing temperature in preparation of the filament from polymer biocomposite is the first important criterion because of the higher processing temperature could decompose the natural fibers [4]. The recommended maximum processing temperature for preparation of the filaments is 180°C, however it depends on the character of natural fibers. The decomposition of natural fiber in the biocomposites could be observed when the original color of natural fiber changed to darker or black color after the first-time extrusion. Thus, the usage of polymer matrices with high processing temperature such as ABS, HIPS, PC, PETG, Nylon, TPU, etc. should be avoided.

## 2. Composition

The optimum composition between polymer matrix and natural fiber is the second important criterion due to the more natural fiber incorporated to the polymer matrix, the less melt flow index (MFI) value obtained [5]. This can give discontinuous filament after the second-time extrusion and it is hard for winding to the spool. The suggested maximum natural fibers percentage in preparation of the biocomposite filaments is 30 wt.%, nonetheless it relies on the particle size of natural fibers. Hence, the optimum composition between polymer matrix and natural fiber in the biocomposite must be determined to facilitate preparation of the 3D printer filament.

## 3. Compatibility

The good compatibility between polymer matrix and natural fiber is also the important criterion because it can provide the biocomposite filament with high flexibility compared to the incompatible ones which is naturally brittle and easy to break. This is due to the synthetic thermoplastic matrices normally possessed non-polar character compared with natural fibers that have polar property. Thus, the different polarity between polymer matrix and natural fiber offers incompatible filament with high brittleness characteristic. The good compatibility could be achieved by treating the natural fibers or compatibilizing the biocomposites with other chemicals or substances [6-8].

## 4. Difficulty

The difficulty to print the products is one of the important criteria that should be considered. This is because of the presence of natural fibers in the biocomposite filaments can cause a clogged print nozzle. It is frequently occurred if natural fibers with big particle size (>400 µm) used. Hence, the small particle size must be utilized in order to prevent the clogged nozzle problem which can cause the difficulty to print. This can make the filaments smooth and easy to print. Moreover, the biocomposites also have moderate volumetric shrinkage [9], therefore it is likewise should be counted before 3D printing the products.

## 5. Safety

The safety in term of food safety is the important criterion as well especially for the products that be in contact with the foods. The polymer matrices such as ABS, PC and PS are not advised to be used in preparation of the biocomposite filaments for such products. This is because they commonly could release bisphenol A, toxic fumes, styrene, etc. at high temperature. Hence, the bioplastic matrices such as PBS, PCL, PHB, PLA, etc. are suggested, nevertheless the price of the prepared filaments will increase due to the price of the bioplastics is quite high compared to the typical synthetic thermoplastics [10].

## Conclusion:

Five important criteria have been identified and explained briefly for preparation of 3D printer filaments from polymer biocomposites. The moderate processing temperature could prevent the natural fibers from decomposition. The optimum composition between polymer matrix and natural fiber could provide continuous filament which is easy for winding. The good compatibility between polymer matrix and natural fiber could increase flexibility of the filament. The difficulty to print the products could be reduced by using natural fibers with small particle size. The food safety could be achieved by utilizing bioplastics as matrices for biocomposite filaments. In conclusion, the polymer biocomposites could be used to prepare 3D printer filaments with some criteria that must be considered in order to obtain good quality products.

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