

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

Shamsuri AA*

Laboratory of Biocomposite Technology, Institute of Tropical Forestry and Forest Products, Universiti Putra Malaysia, UPM Serdang, Selangor, Malaysia.

*Corresponding Author:

Ahmad Adlie Shamsuri,
Laboratory of Biocomposite Technology, Institute of Tropical Forestry and Forest Products,
Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia.
Email: adlie@upm.edu.my

Received: December 02, 2019

Accepted: December 31, 2019

Published: January 02, 2020

Copyright: ©2020 Ahmad Adlie Shamsuri. This is an Open Access article published and distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution and reproduction in any medium, provided the original author and source are credited.

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.

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.

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.

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].

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 (>400µm) 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.

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 biocom-

posites could be used to prepare 3D printer filaments with some criteria that must be considered in order to obtain good quality products.

References

- [1]. Shamsuri AA, Sumadin ZA. Influence of hydrophobic and hydrophilic mineral fillers on processing, tensile and impact properties of LDPE/KCF. biocomposites. *Composites Communications*. 2018 Sep 1;9:65-9.
- [2]. Shamsuri AA. Compression moulding technique for manufacturing biocomposite products. *Int. j. appl.* 2015 Jun;5(3).
- [3]. Shamsuri AA, Zolkepli M, Naqiuddin M, Ariff M, Hanim A, Sudari AK, Abu Zarin M. A preliminary investigation on processing, mechanical and thermal properties of polyethylene/kenaf biocomposites with dolomite added as secondary filler. *J. Compos.* 2015;2015.
- [4]. Pandey JK, Nagarajan V, Mohanty AK, Misra M. Commercial potential and competitiveness of natural fiber composites. In *Biocomposites 2015 Jan 1* (pp. 1-15). Woodhead Publishing.
- [5]. Urreaga JM, González-Sánchez C, Martínez-Aguirre A, Fonseca-Valero C, Acosta J, De la Orden MU. Sustainable eco-composites obtained from agricultural and urban waste plastic blends and residual cellulose fibers. *J. Clean. Prod.* 2015 Dec 1;108:377-84.
- [6]. Shamsuri AA, Sudari AK, Zainudin ES, Ghazali M. Effect of alkaline treatment on physico-mechanical properties of black rice husk ash filled polypropylene biocomposites. *Materials Testing*. 2015 Apr 1;57(4):370-6.
- [7]. Shamsuri A, Azid M, Ariff A, Sudari A. Influence of surface treatment on tensile properties of low-density polyethylene/cellulose woven biocomposites: a preliminary study. *Polymers*. 2014 Sep;6(9):2345-56.
- [8]. Sudari AK, Shamsuri AA, Zainudin ES, Tahir PM. Exploration on compatibilizing effect of nonionic, anionic, and cationic surfactants on mechanical, morphological, and chemical properties of high-density polyethylene/low-density polyethylene/cellulose biocomposites. *J. Thermoplast. Compos. Mater.* 2017 Jun;30(6):855-84.
- [9]. Santos JD, Fajardo JI, Cuji AR, García JA, Garzón LE, López LM. Experimental evaluation and simulation of volumetric shrinkage and warpage on polymeric composite reinforced with short natural fibers. *Frontiers of Mechanical Engineering*. 2015 Sep 1;10(3):287-93.
- [10]. Albuquerque PBS, Malafaia CB. Perspectives on the production, structural characteristics and potential applications of bioplastics derived from polyhydroxyalkanoates. *Int J Biol Macromol.* 2018 Feb;107(Pt A):615-625.

Submit your manuscript at

<https://www.enlivenarchive.org/online-submission.php>

New initiative of Enliven Archive

Apart from providing HTML, PDF versions; we also provide video version and deposit the videos in about 15 freely accessible social network sites that promote videos which in turn will aid in rapid circulation of articles published with us.