Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 184 (2017) 478 – 485

Procedia Engineering

www.elsevier.com/locate/procedia

Advances in Material & Processing Technologies Conference

Optimization of Hot Press Parameters on Tensile Strength for Unidirectional Long Kenaf Fiber Reinforced Polylactic-Acid Composite

I. Tharazi [a,b,*], A.B. Sulong[a], N. Muhamad[a], C. H. C. Haron[a], D. Tholibon[a,c], N. F. Ismail[a], M. K. F. M. Radzi[a], Z. Razak[a]

[a]*Department of Mechanical and Material Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia.*

[b]*Faculty of Mechanical Engineering, Universiti Teknologi MARA Shah Alam, 40450 Shah Alam, Selangor, Malaysia.*

[c]*Department of Petrochemical Engineering, Politeknik Tun Syed Nasir Syed Ismail, 25350 Semambu, Kuantan, Pahang, Malaysia.*

Abstract

Processing conditions are one of the factors that significantly influences the properties and characteristics of the polymer matrix composites products. Therefore, the suitable processing parameters must be selected in order to yield the optimum properties of the composite products. In this work, Box-Behnken Design (BBD) was selected as experimental design approach. Biodegradable composites from unidirectional long kenaf fibre reinforced polylactic-acid were fabricated by hot pressing method. Response surface methodology (RSM) and analysis of variance (ANOVA) were used to optimize as well as determine the significance of the factors affecting the tensile strength. Three factors studied were pressure, temperature and heating time at three different levels. The experimental results showed that all three factors are the significant processing parameters affecting the strength of composite. The combination of hot pressing parameters for optimum tensile strength was 200^{o}C temperature, 3MPa pressure, and heating time at 8 minutes. Confirmation runs test yield error less than 7% verified the validity of the model.

Peer review under responsibility of the organizing committee of the Advances in Materials & Processing Technologies Conference

Keywords: Biodegradable Polymer; Long Kenaf Fibers; RSM; BBD; Tensile Strength.

Peer review under responsibility of the organizing committee of the Advances in Materials & Processing Technologies Conference
doi:10.1016/j.proeng.2017.04.150

1. Introduction

Nowadays, there has been increasing demand for polymer matrix composite in the field of automotive, aerospace, and building constructions. This is due to composite benefits that are stronger, stiffer, and lighter. Fibers typically used for polymer matrix composites are from petrochemical based such as carbon fiber and glass fiber. On the other hand, the types of polymer used are polypropylene and epoxy. However, with environmental concerns and the need for sustainability, the application of fibre based composites is shifted towards natural fibres reinforced biocomposite materials which can decompose naturally. These types of eco-friendly materials find their way in several structural and non-structural applications where they are not subjected to high loads. Kenaf or scientifically named as Hibiscus Cannabinus L. was a plant originated from Africa and has been around 4000 years ago. It became a popular plant fibre crop because of its nature of being easily grown under wide range of weather and harvesting takes a short period time for about 3 to 4 months [1]. Polylactic-acid (PLA) is a biodegradable aliphatic polyester and has been regarded as the most promising biodegradable plastics to substitute the petrochemical based polymers such as polyethylene, polypropylene, polyester and etc [2]. For instance, PLA offers excellent properties such as high strength and stiffness and it is now being used in several applications, such as consumers packaging, degradable plastic bags, as well as in automotive applications [3].

Extensive research literatures have covered the studies of green composites or biocomposites reinforced with natural fibres [4][5][6][7][8]. Issues such as poor wettability, insufficient adhesion between fibre and polymer, void formation, and improper processing method have been addressed. These issues are among the factors affecting the mechanical properties of the composites. In addition, Mukherjee and Kao [2] stated that the mechanical properties of the fibre composites depend on the fibre matrix adhesion which may also be directly related to the processing condition. Ku et. al [9] revealed that the processing conditions are one of the factors that significantly influences the properties and characteristics of the polymer matrix composites products. Therefore, suitable processing parameters must be carefully selected in order to yield the optimum composite products. Traditional approach to experimental work is to vary one factor at a time, holding all other factors fixed. This method does not produce satisfactory results in a wide range of experimental settings as well as time consuming. Therefore, an efficient procedure called as statistical design of experiments (DOE) technique is introduced so that the obtained data can be analyzed to yield valid results and conclusions. RSM is one of DOE techniques, which has been widely used in for optimization operating conditions parameters in systems. Kumar and Balachandar [10] studied the effect of hot press forming mould pressure, temperature and holding time on flexural strength of Glass/PP composites through RSM using BBD analysis and found the optimum temperature is 220◦C with low holding time. In another study, Kandar and Akil [11] looked at the effect of moulding temperature, pressure, and time on the impact strength of woven flax fibre reinforced PLA composites with BBD. They found an increase in impact strength with increasing moulding temperature but at minimum moulding pressure and time. In the work of Kiran et. al [12], processing temperature has the most significant effect on mechanical properties measured by using Taguchi. Hence an attempt is made to analyze the effect of hot press process parameters on tensile strength of unidirectional long kenaf fiber/PLA composites.

For this purpose, an inexpensive-an-easy-to-operate experimental strategy based on Box-Behnken design is adopted to study the effect of various process parameters. The present study aims at studying the influence of process parameters and determining the optimum hot press processing parameters on tensile strength of the green composites.

2. Experimental Method

2.1. Materials

Continuous long fibre of kenaf from bast undergone water-retting process was supplied locally by Innovative Pultrusion Sdn. Bhd. Long kenaf fiber (LKF) bundles were combed manually and aligned in a single direction as in Fig.1(a) before being cut to the same length as that of hot press mould (length of 175 mm). Based on previous experiment, the composites' optimum fibre content was set to 50%wt. PLA pellets and microfine powders in size of 20μm from Shenzun Esun China Ltd as in Fig.1(b) and Fig.1(c) were also supplied by Innovative Pultrusion Sdn.