Effects of extrusion temperature on the rheological, dynamic mechanical and tensile properties of kenaf fiber/HDPE composites

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1. Introduction

The interest in using natural fibers in polymer matrix composite (PMC) has increased in recent years. This is due to the lightweight, non-toxic, low cost and biodegradable properties of natural fibers. The use of natural fibers, derived from renewable resources, as reinforcing agent in both thermoplastic matrix composites provides positive environmental benefits with respect to disposability and raw material utilization [1].

Kenaf fiber has potential as reinforcement filler in PMC. The purpose of producing PMC is to create a new material that has better properties compared to their individual material. Kenaf fiber can generally be classified into two types. The first type is the outermost layer known as bast while the second type is the inner part, known as core. The core is very soft, hollow and suitable for application as organic filler in plastic, while bast fiber has hard properties and is suitable for blending with plastic, textile industry and also fiberglass technology applications. Kenaf fiber is also used as reinforcement for plastic and synthetic product, cosmetic product, organic filler and medicine. Besides that kenaf fiber is also environmentally friendly.

The performance of a composite material varies with the fiber–matrix bond strength and to some extent, depends on the choice of suitable processing techniques. There are various methods of processing natural fiber–polymer matrix composites. Methods such as extrusion, compression and injection molding are used to introduce fibers into the thermoplastic matrix. Twin-screw extruder system, with a feeding and a mixing zone, consists of screws with a multiplex shape. In this system, the fillers are very well blended with the matrix polymer because the mixtures pass through a number of mixing blocks [2]. Potente et al. [3] studied the impact of speed, melt throughput, continuous-phase viscosity, screw configuration, and disperse-phase content on the melting behavior and morphology development in the melting zone of a twin-screw extruder of polypropylene/polyamide-6 composite. Their result showed a finely dispersed morphology at the start of the melting section and the screw can feed and mix the melted mixture simultaneously. The use of unmodified and modified sugarcane bagasse cellulose/HDPE composite with zirconium oxychloride formed by compounding 10% by weight of fiber using extrusion and compresion molding showed that the modified composites present better tensile strength compared to unmodified composites [4]. Rheological measurement conducted in various steady state and dynamic environments is a widely used technique for determining the sensitivity of a material during processing [5]. From the findings conducted on multi-wall carbon nanotube (MWCNT)/poly(ether ether ketone) (PEEK) composites containing...
upward shift with HPT for pure HDPE, 8.5 and 17.5 wt% fiber loadings compared to the LPT. Moreover, increasing the fiber loading showed an upward shift of Han plot from pure HDPE to the highest fiber content of 17.5 wt%.

DMA showed that the storage and loss moduli of composites increased with increasing fiber loading and 17.5 wt% fiber composite showed the highest value of storage and loss moduli at HPT. However, composite with the highest fiber loading (17.5 wt%) compounded at LPT showed the lowest storage and loss moduli curves. The incorporation of the kenaf fiber at HPT reduced the magnitude of tan $\delta_{\text{max}}$ values with the increasing fiber loading except for the low loading fiber of 3.4 wt%. Storage and loss moduli as a function of temperature appeared to be more sensitive to the fiber loading at LPT while this was not observed in the storage and loss moduli as a function of angular frequency.

By increasing the compounding temperature, the tensile modulus presented an increasing pattern compared to the ones processed at LPT. The tensile modulus also increased with increasing fiber loading when processed at HPT. However, the tensile strength of the composites decreased with increasing content of the fiber at both LPT and HPT. Nevertheless, composites processed at HPT showed better tensile strength compared to the ones at LPT. The tensile strains of the composites decreased with the increasing amount of fiber loading while composites processed at LPT presented a higher tensile strain compared to those at HPT. From the above, it can be concluded that the composites compounded at HPT provides best performance of rheological, thermo-mechanical, and tensile properties in comparison with composites compounded at LPT.

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References


