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The Effects of Kenaf Fiber Loading Reinforced Polypropylene and Nanoclay

Nur Kamarliah Kamardin, Yakub Md Taib, Anizah Kalam*

Faculty of Mechanical Engineering, Universiti Teknologi MARA (UiTM), 40450 Shah Alam, Selangor, Malaysia.

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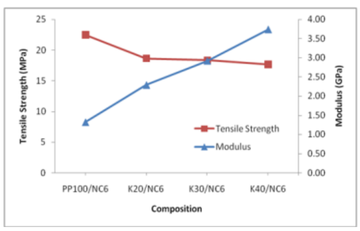
*Corresponding author
anizahkalam@salam.uitm.edu.my

Graphical abstract



Abstract

The mechanical properties of hybrid composites which consists of polypropylene (PP), nanoclay (NC) and kenaf fiber (K) have been investigated. The size of kenaf fiber used was limited to 250-160µm with constant 6phr of NC. In this research, the K, PP and NC were blended in a twin screw extruder and then injection molded with the fiber weight fraction varying between 20-40wt%. The hybrid composited denoted as KPPNC specimens were tested using tensile and izod test according to ASTM D638 and ASTM D256. The consolidation of kenaf fiber into polymer matrix reduced the tensile and impact properties of the composites. The fractured surfaces of impact KPPNC composites were observed using the scanning electron microscopic technique.

Keywords: Kenaf loading, polypropylene, impact test, tensile test, SEM

1.0 INTRODUCTION

Most naturally occurring materials derive their superior properties from a combination of two or more components. By combining natural fibers and resin a bulk material is produced with a strength and stiffness close to the fibers. Hybrid composites are possible to achieve some resistance to crack propagation and an ability to absorb energy during deformation. Natural fibers such as oil palm empty fruit bunch, kenaf, sisal, rice husk are lignocelluloses fibers. This natural fiber used as a filler due to low cost, on abrasive, sustainable, easy to obtain, can be replant and abundance [1, 2]. The right combination between lignocelluloses and the polymer matrix is still in investigation. Addition of nano-filler into polymer matrix into polymer matrix increase the strength as well as the modulus of the composites.[3,4] However the combination between the non-polar polypropylene and highly polar lignocelluloses fibers can result in difficulties in the dispersion of fibers along with weak fiber-matrix adhesion. The objective of this study is to determine the effect of different fiber loading (20wt%, 30wt% and 40wt %) on the mechanical properties and its fracture morphology.

2.0 EXPERIMENTAL

2.1 Materials and Methods

Polypropylene impact copolymer Titanpro SM340 was supplied by Titan Petchem (M) Sdn Bhd to be used as the matrix. Its melt flow index was 4g/10mins at 230˚C. Kenaf powder supplied by Symphony Advanced Sdn Bhd, Malaysia, was sieved using the Fritsh Vibratory Sieve Shaker Machine with a size of 250-160µm. Nanoclay was purchased from Sigma Aldrich Inc., USA. The K, PP and NC were mixed as according to the set formulation of kenaf powder weight fraction of 20%, 30% and 40% respectively by using Prism twin screw extruder. The compounds were cooled at room temperature before being ground with crusher to become granule form. These KPPN pallets were then injected by using Jinhwa Glotech VDC II-140 Injection Molding. The specimen thickness is 4mm. All materials were dried at 80˚C in an oven prior to compounding and injection molding. Specimens were designated according to their composition; for example (K20/PP80) NC6 was referred as specimen with 20wt% of kenaf powder, 80wt% of PP and 6phr of NC.

2.2 Mechanical Testing

The various formulations of KPPN samples were machined cut into the respective test specimens. Specimens for tensile test were in the form of Dumbbell-shaped with geometry defined in ASTM D638. Tensile tests were conducted on computer-controlled Instron 100 kN Model 3382 equipped with extensometer at constant crosshead speed at 5 mm per minute. The Izod impact tests specimen configuration followed the set standard procedures in which the energy is normalized to the area behind the notch. Izod tests were conducted as ASTM D256 on Microcontroller Based Izod Impact Tester (LT-160) with hammer weight of 0.453 kg.

2.3 Material Characterization

Scanning Electron Microscope (SEM) was carried out to determine the surface morphology in order to evaluate dispersion and interfacial bonding of fiber in the matrix on the impact fracture surfaces.

3.0 RESULTS AND DISCUSSION

3.1 Tensile Strength & Tensile Modulus

Figure 1 shows the tensile properties of KPPNC composites. The pure PP100/NC result highest tensile strength is 22.5MPa. The tensile strength further decrease as the fiber loading increased about 17% similar observation had been reported by H.D Rozman et all [5] for oil palm frond reinforced high density polypropylene composites. The capability to transfer stress from the polymer composites are low due to irregular shape of filler which contributes to low aspect ratio. The other reason is poor adhesion between matrix and filler causes from untreated surfaces and agglomeration between the fibers at higher fiber loading. [6]. It does believe that with the addition of fibers in a polymer matrix gives rise to defects at the interface, therefore contributes to strength reduction [7, 8, 9, 10].

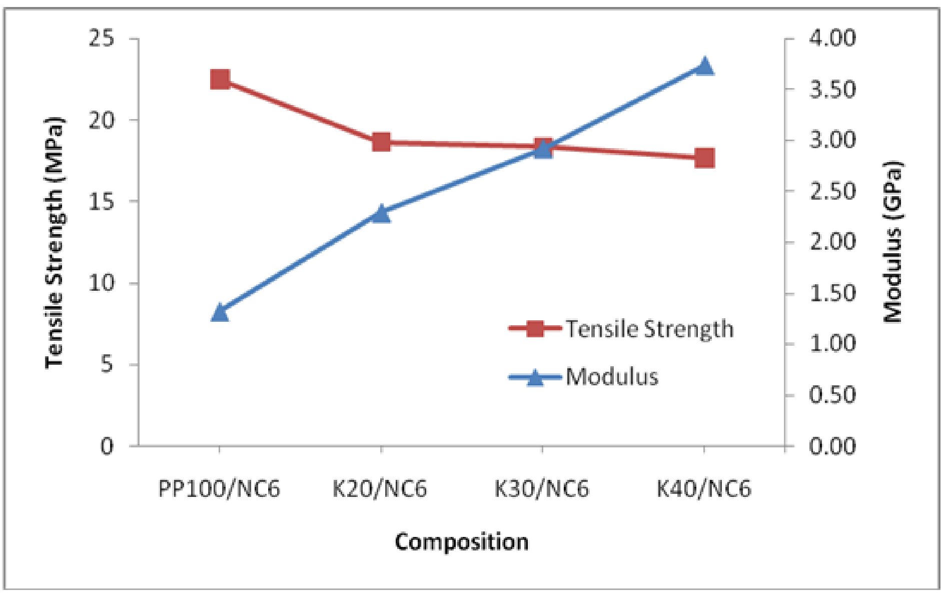


Figure 1 Tensile Strength and Modulus

The tensile modulus showed improvements as the kenaf loading increased. The fiber itself is lignocelluloses materials, addition of these fiber to the polymer matrix lowered the matrix mobility therefore contributes to the overall stiffness of the composites. Increasing the volume fraction will increase the stiffness and lowered the strain. [10, 11, 12]. A study on 125-150µm wood floor/PLA/talc [14] for the wood flour content 10-40wt % showed the tensile modulus keep increasing with increasing wood floor loading. This reason believe its related to the higher filler stiffness that the matrix not allow their free mobility, thus avoids deformation therefore increase the elasticity modulus as the loading increases.

3.2 Izod Test

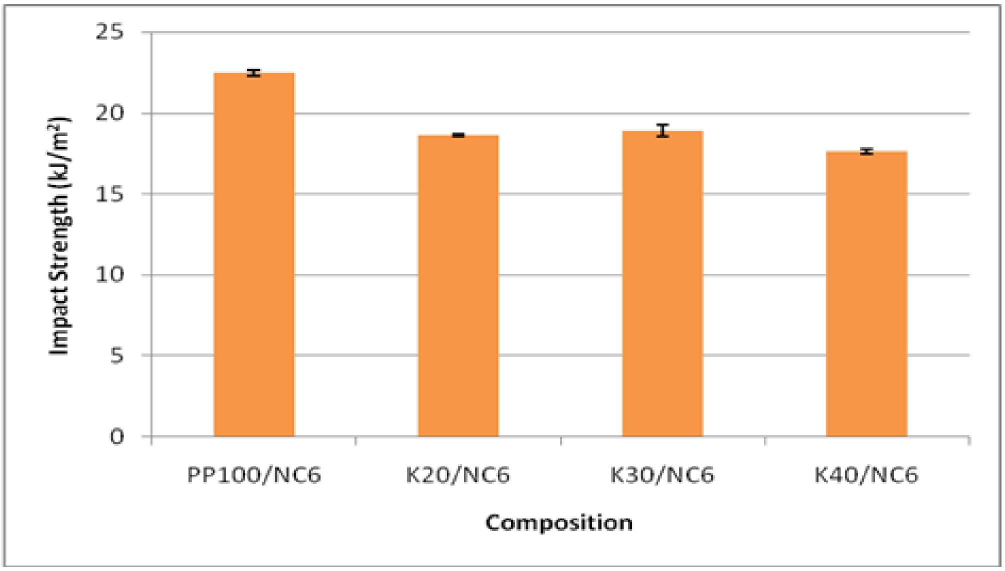


Figure 2 Impact Strength of Hybrid Composites

The effects of kenaf loading on the impact strength of hybrid composites are reported in Figure 2. As the kenaf loading increases, the impact strength slightly decreased about 17% to 21% compared without addition of kenaf that also agreed by other researcher. According to Anand R.Sanadi et all [13] for kenaf fiber-PP composites, with the addition of fiber, it requires less energy to originate the crack because of the fiber creates region of stress concentration. Besides, untreated of fiber contribute highly to fracture propagation because of poor interfacial bonding between fiber and matrix. The extensive fiber pulls out and low interfacial bonding as observed from the SEM micrograph (Figure 4), show a proof for the poor impact properties of the composites.

3.3 Morphology Observation

Impact fracture surface of hybrid composites for 20wt% and 40wt% of kenaf are shown in Figure 3 and 4 below at the same magnification (100times). Morphology of the lower percent of fiber shows fiber act as bridges and resist to the propagation of the crack (Figure 3). However, highest percentage of kenaf shows many holes left after the fiber were pulled out from matrix (Figure 4). The failures occur at the weak fiber and matrix interface. The interfacial bonding between the fibers and matrix was very low due to weak interfacial adhesion. Delaminating of fiber also occurs because of higher polymer mobility which contributes to fiber pull-out. [5]

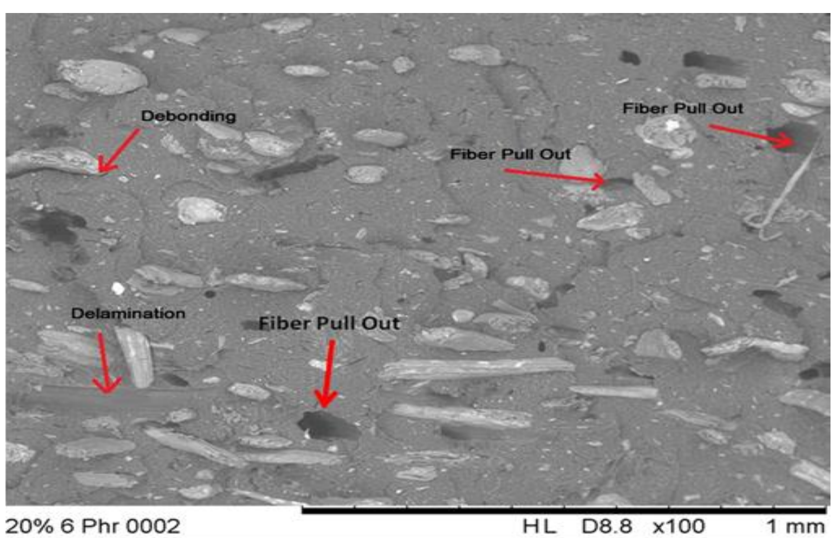


Figure 3 Impact SEM morphology of 20wt% kenaf fiber

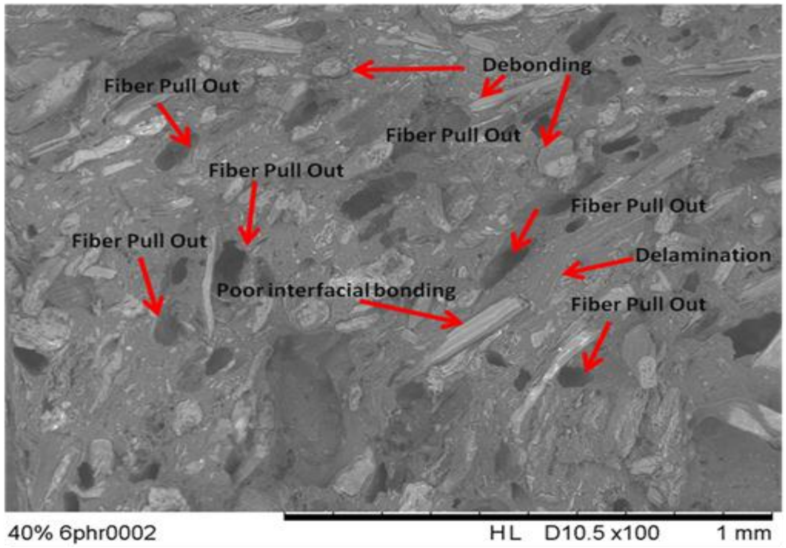


Figure 4 Impact SEM morphology of 40wt% kenaf fiber

4.0 CONCLUSION

The mechanical and impact properties of kenaf reinforced PP composites have been investigated. Increased kenaf loading of fiber with constant content of nanoclay displayed increased tensile modulus but it decreased the impact and tensile strength of the materials. Treated fiber and addition of coupling agent will be carried out in future works.

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