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Mechanical properties of polypropylene/kenaf composites filled montmorillonite

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Abstract. The effect of montmorillonite as additive on the mechanical properties of polypropylene/kenaf composites has been investigated. The polypropylene/kenaf composites filled montmorillonite were prepared by using a mixer and hot press at temperature 180°C. Polypropylene was filled with kenaf at various loading at 0, 10, 20 and 30% and 5 % of montmorillonite. Tensile test for the composites was carried out according to ASTM D638 using Instron Tensile Model 5569. From the tensile results, it shows that the tensile strength, Young's modulus and elongation at break were increased with increasing of filler loading. The presence of montmorillonite also increased the tensile properties of the composites. The increasing of tensile properties with the addition of kenaf and montmorillonite within the polypropylene matrix, leading to an efficient stress transfer from matrix to filler and additives. The incorporation of additive of montmorillonite in appropriate amount in the fabrication of polypropylene and kenaf will increase the mechanical properties of this composite.

1. Introduction

The composite materials are the combining of two materials which will give better properties and best characteristic of each component. The main advantages of the materials will give higher strength and low density [1]. Usually the composite materials are combining with two materials that have different type of properties. To understand the composite materials, we can classify in three ways that is early composites, making composites and modern example [2]. The first modern composite material was fiberglass.

Polypropylene/kenaf composite is one of the famous composite materials. By using thermoplastic with fiber, it will give an advantage for the properties for both type of resources and provide the opportunity to produce advance composite materials and build a new perspective for composite materials.

For the researcher, it will give them the opportunity to design a new type of composite materials based on cost, recycle and environment perspective [3]. The additive can be added to ensure the composites have high strength or more high properties. Additive is a substance added in small quantities typically to improve or preserve the composite materials [4]. The montmorillonite was added as new additive to kenaf-polypropylene composites to increase the mechanical and chemical properties.

Polypropylene is one of the versatile polymers out there. Polypropylene serve both duty that is plastic and as a fiber. Polypropylene is a type of thermoplastic polymer resin. It is a part of both the average household and is in commercial and industrial applications. The chemical designation is C_3H6 [5]. One of the benefits of using this type of plastic is that it can be useful in numerous applications including as a structural plastic or as a fiber-type plastic [6].

Kenaf is comparatively commercially available and economically cheap amongst other natural fiber reinforcing material. Customarily kenaf denoted as industrial kenaf due to its great interest for the production of industrial raw materials. Kenaf fiber belongs to species of Hibiscus cannabinus [7]. Kenaf is a hardy, strong and tough plant with a fibrous stalk, resistant to insect damage and requires relatively fewer amount of or no pesticides.

Kenaf fiber is potentially outstanding reinforcing filler in thermoplastic composites. From the result of 50% polypropylene/kenaf composite with compare to 40% of glass fiber/polypropylene, it shows that kenaf fiber can be used as alternative in inorganic/mineral based reinforcing as long as the right processing condition are use [8]. Nowadays, kenaf and polypropylene are used in many categories such as factory, house and building because they are easily to get and not polluted the environment. Combining kenaf fiber with other resources provides a strategy for producing advanced composite materials that take advantage of the properties of both types of resources. It allows the scientist to design materials based on end-use requirements within a framework of cost, availability, recyclability, energy use, and environmental considerations. The combination of kenaf fiber with polypropylene materials composites will result the tensile and flexural strength doubled with the addition of kenaf fiber as compared to polypropylene alone. The use of kenaf fiber has resulted in significant property advantages as compared to typical wood flour or wood based fibers for plastic/fiber composites. In fact, the outstanding specific moduli of the kenaf-fiber polypropylene composites compare well with that of glass fiber, talc, and mica reinforced molded polypropylene composites. The cost for kenaf fiber also low, it will effect significantly in cost saving. There also will result less weight [9].

Montmorillonite is a name one of the clay that discover in France. Montmorillonite name are given by Mauduyt in 1847. Montmorillonite exist in the bentonite as some of clay mineral [10]. Usually, montmorillonite in form of microscopic crystal known as clay because the montmorillonite is a very soft phyllosilicate group of materials. Montmorillonite is a member of smectite group [11].

2. Experimental

2.1. Raw material

2.1.1. Polypropylene. Virgin polypropylene is purchased from Barbara Trading which located at Salem Country, US, New Jersey in pellets form. Polypropylene is used in this experiment because of the outstanding physical, chemical, mechanical and thermal properties that not found in other thermoplastic. Polypropylene is used as a matrix and has high tensile strength, impact resistance, lightweight, high compressive strength and low moisture absorption. The properties of polypropylene show in table 1.

Table 1. Polypropylene characteristics.

Polypropylene	
Chemical name	Poly(1-methylethylene)
Chemical formula	$(C_3H_6)X$
Density	0.90 g/cm^3
Melting point	173 ˚C
Degradation point	286 ˚C

2.1.2. Kenaf. Kenaf is used in this experiment because it has many advantage compared to synthetic fiber. As compared to synthetic fibers, kenaf requires much less energy. Natural fibers are produced by solar energy while carbon fibers require a great deal of energy to be produced since its processing temperature can exceed 1200°C and 3000°C respectively.

2.1.3. Montmorillonite. Additive is a substance that added in a small amount to another substance to improve the characteristic of the substances. There are many type of additive. For example, montmorillonite clay that use on flax fabric reinforce poly lactic acid composites with amphiphilic additive. The tensile strength test result indicates that the individual nature of the additive determines the tensile strength of the bio-composite. The additive always is used to improve the mechanical properties of the composites. The montmorillonite will increase the mechanical and chemical properties of polypropylene/kenaf composites.

2.2 Mixing process

The mixing process of the composites was carried out by using the blade mixer at temperature 180˚C for speed 50 rpm. The formulations for polypropylene/kenaf composites with and without montmorillonite are listed in table 2 below.

Table 2. Formulation for polypropylene/kenaf composites.

Materials	Without montmorillonite	With montmorillonite
Polypropylene (%)	100,90,80,70	100,90,80,70
Kenaf (%)	0,10,20,30	0,10,20,30
Montmorillonite (%)	-	5

2.3 Compression molding

To produce the sheet sample, compression molding is done by using compression molding machine model Hydraulic Testing machine with temperature 180˚C and pressure 20 tons.

2.4 Mechanical testing

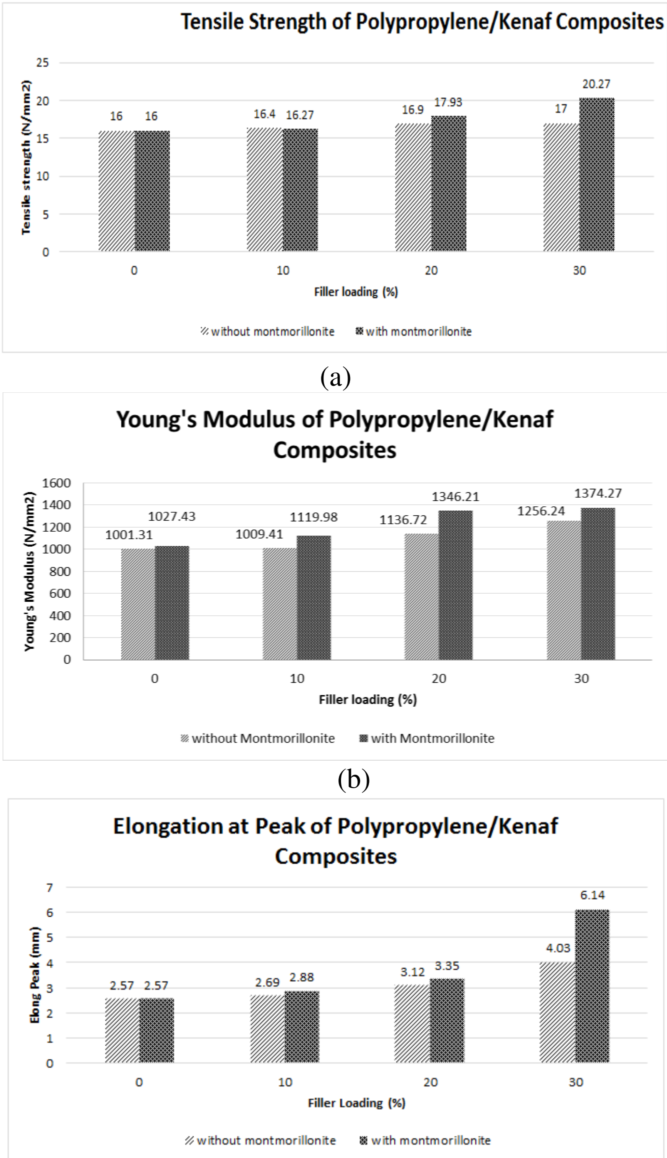
Tensile strength for the composite materials was carried out according to ASTM D 638 using Instron Tensile model 5569. The gauge length was set at 70mm and the cross head speed of testing at 10mm/min at temperature 25 °C to 28 °C.

3. Experimental results

Figure 1(a) shows the effect of filler loading on tensile strength of polypropylene/kenaf composites with and without montmorillonite. The tensile strength increase steadily with increasing of filler loading. The addition of montmorillonite as additive give significant improvement in tensile strength of the composites. It shows that the montmorillonite can be effectively functioned in increasing of mechanical properties of the composites.

Figure 1(b) shows the effect of filler loading on Young's modulus of polypropylene/kenaf composites with and without montmorillonite. Both composites show the similar trend of Young's modulus that increase with increasing of filler loading. The Young's modulus of composites with montmorillonite is higher compared to the composites without montmorillonite. It shows that the use of additive is significantly improves the fiber-matrix adhesion. For the composites without montmorillonite, the results are lower than that containing montmorillonite, which suggest that there is comparatively little stress transfer from matrix to filler for the composites without montmorillonite as additive.

The effect of filler loading on elongation at peak of polypropylene/kenaf composites with and without montmorillonite is shown in figure 1(c). The elongation at peak of both composites increase with increasing of filler loading. The result for elongation at peak of composites with montmorillonite is higher than the result of the composites without montmorillonite. There is some huge margin for the elongation peak at 30% filler loading. It shows that when adding enough and suitable mass of the materials to become composite materials it will have higher properties. It can prove that the most suitable mass or values of each material that can be used to make composite materials are at 30% filler loading.



(a)

(b)

(c)

Figure 1. The effect of filler loading on (1) tensile strength, (2) Young's modulus and (3) elongation at peak of polypropylene/kenaf composites with and without montmorillonite.

4. Conclusions

The use of kenaf fiber with the polypropylene give an outstanding result in mechanical properties. The price of kenaf is also less than plastic matrix so it will give many advantages and cost saving. From the results shown in the graph, the incorporation of montmorillonite as additive make an improvement in the properties of the composites. The increase in mechanical properties demonstrates that montmorillonite has effectively functioned as additives in polypropylene/kenaf composites. In such formulations of the composites, it gives the special attractive for manufacturing and automotive applications. This combination can contribute to the light-weight of the automotive parts.

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