Influence of weathering effect in natural environment on thermal properties hybrid kenaf blast/glass fibre and unsaturated polyester composite

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Abstract. Unprecedented growing on environmental concern has put research on completeive driven effort to quest for new material in various application, the effort toward producing thermally stable polymer is ever gaining considerable interest. Thus, this study proposed the integration of glass fiber with kenaf based polymer to improve thermal properties. Based on the TGA and DSC results, the composites show slow and steady initial weight loss until major weight loss at 360°C. Thus, with incorporation of glass fiber extend region of degradation until 260-360°C show no exothermic or endothermic changes, this reflected that the composites thermally stability have been improved.

1. Introduction
The researchers across the globe have begun to focus attention on increasing demand for environmentally friendly materials [1-7]. Besides ecological considerations natural fibers exhibit many advantageous properties which promote the replacement of synthetic fibers in polymer composites, offer high potential for an outstanding reinforcement in lightweight structures [8-16]. Natural fibers are derived from a renewable resource and do not require a large energy requirement to process and biodegradable[17-25]. These fibers also offer significant cost advantages and therefore the utilization of lightweight, lower cost natural fibers such as jute, flax, hemp, sisal, abaca, coir offer the potential to replace a large segment of the synthetic fibers in numerous applications [25-35]. In recent years this natural fiber composites have been used in many engineering applications due to natural properties that they offer such a variety of lightweight, reform, cheap and environmentally friendly[36-40]. Natural fiber composites are used in various industries such as automotive, sporting goods,
marine, electrical, construction and household appliance [41-51]. Kenaf, sisal, coir, banana, hemp, pulp, wood flour, palm oil, pineapple leaf and coir is the main natural fiber used as reinforcement [50-57]. Kenaf fiber provides the hardness and strength values are high [48, 58]. They also have a higher aspect ratio which makes them suitable for use as reinforcement in polymer composites is a perennial plant herb [58-61]. Kenaf is a plant heat-season annual lane. The attractive feature of kenaf fiber is inexpensive, lightweight, Reform, biodegradability and certain properties of high mechanical. Kenaf contains bast fiber containing 75% cellulose and 15% lignin and offers the advantage of being environmentally friendly and safe environment (Mansur & Aziz, 1983). Kenaf fibers have superior flexural strength and excellent tensile strength that makes the kenaf good candidate for many applications [48]. However, it has several drawbacks, including high moisture absorption, which have a negative impact on the mechanical properties [36-40].

2. Methods

Initially kenaf mat was cut to 20×20 cm dimensions (three layers), this followed by compressing them using compress machine at 90 0C. Two layers of fiber glass 20×20cm were also prepared. The first layer of fiber glass was put in the mold and hand lay up the resin (unsaturated polyester +hardener (2 %)) and with ratio of 30 wt %:70 wt % (fiber to resin) to it. Then prior putting to the mold and hand lay-up resin to bottom of the kenaf, then the kenaf was put inside the mold. Resin impregnated into kenaf/glass fiber mat via hand lay-up method. This processes is divided into two stages (1) for fabrication of layer of kenaf whereas in impregnated into 4 layer to make kenaf (UP) composite (2) fabrication of hybrid kenaf/glass (UP) composite impregnated resin into 3 layers of kenaf and 2 layers of glass fiber after that compressed for 10 min without heating at 5 MPa and allowed it to cure at room temperature for 24 hrs. This followed by separating it from mold using hack saw. The prepared composite was measured and cut to 2.5 × 20 cm about 8 samples were obtained. The was followed by preparing the sample for test. We compared the composite in room temperature and composite after exposure to weathering by two weeks for three months.

3. Results and Discussion

Thermogravimetric analysis was carried out to observe distinct process of weight loss occurring on natural fibers and their composites at different temperature. Figures 1 &2 show the thermogravimetric analysis curves of pure kenaf composited and hybrid kenaf/glass fiber composites, respectively, before and after exposed to weathering. From figure 1, pure kenaf composites exposed and unexposed to weathering displayed three stages of weight loss. The first stage occurs at temperature range from 50-110 0C due to release of moisture which was absorbed by natural fiber. At the second stage, the major degradation occurred with temperature range at about 200-300 0C, which was related to degradation of hemi cellulose and cellulose of natural fiber. The third stage of weight loss occurred at temperature range at about 460-600 0C, which was related to degradation of lignin (Campos A, et al., 2011). All this values mentioned prior lines will increased in hubris kenaf/glass fiber composites due to high thermal stability of glass fiber existed in the composites, which will act as a shield in the composite for burning process (Yao et al., 2008).
By increasing the weathering period, TGA curves are shifted to lower temperatures, showing a decrease in the thermal stability for both unsaturated polyester and its composites. The decrease in thermal stability in polymer matrix could be due the reduction of molecular weight of unsaturated polyester. For the composites, TGA transition were shifted to slightly lower temperatures after increasing the exposure period. This could be the result of unsaturated polyester chain scission along with degradation of both fiber and fiber matrix interfacial bonding (M. D. H. Beg and K. L. Pickering, 2008).

It can be noticed in figure 4.9 that the slop of TGA curves for all the composites after exposure to weathering is almost similar. This can be due to degradation process and moisture absorption have reached to the saturation stage after the first month of exposure to weathering. Deative thermogravimetric is used to determine the weight loss and identify the decomposition of the composites at different temperature. Figures 3 and 4 show the derivative thermogravimetric curves of pure kenaf composites and hybrid kenaf/glass fiber composites, respectively, before and after to weathering.
Table 4 shows the three stages of weight loss during the weight loss process with prolonged temperatures. All the values presented in the table increase in the hybrid kenaf/glass fiber composites because of existing of glass fiber in the composites which has high thermal stability. This glass fiber will act like a protector to the composites against burning process (Yao et al., 2008)

Table 1. Weight loss stages of the composites.

| Stage 1 | 50-110 °C | Evaporation of moisture in the fiber | (P. Methacanon et al., 2010) |
|---------|-----------|-----------------------------------|-----------------------------|
| 400 °C  | Thermal decomposition of hemicellulose and glycosidic links of cellulose | (Araújo et al., 2008) |
| 350-400 °C | Characteristic of low molecular weight components such as hemicelluloses | (Lee et al., 2006) |
| 320-400 °C | Pyrolysis of hemicelluloses | (Suwardana et al., 2011) |
| Stage 2 | 300-400 °C | Thermal decomposition of hemicellulose | (P. Methacanon et al., 2010) |
| 460 °C  | Thermal decomposition of α-cellulose | (Manfredi et al., 2006) |
DSC curves of pure kenaf composites and hybrid kenaf/glass fiber composites are shown in Figure 5 and 6, respectively, before and after exposed to weathering. Pure kenaf composites and unexposed to weathering display one broad endothermic peak between 50-100 °C due to release of moisture absorbed by natural fiber (Ray et al., 2002). The region between 100-200 °C shows no exothermic or endothermic changes reflected that the composites are thermally stable. It was reported that natural fibers lignin degrade at temperature around 200 °C while the other constituents such as hemicellulose and cellulose degrade at higher temperature (Aziz, S.H. & Ansell, M.P. 2004). All these values increased in the hybrid kenaf/glass fiber composites due to existing of glass fiber which will act as a mask to its composites. Figure 3 indicates that the glass transition temperature (Tg) of the weathered UP also decreased with increasing the weathering time. This can be probably due to photo-oxidation of polymer itself. According to Abu-Sharkh and Hamid (2004), exposure of polymers to ultraviolet rays during natural weathering will result in chain scission of polymer. As a result of chain scission the properties of polymer such a molecular weight, chain symmetry, flexibility, mechanical strength and intermolecular forces have deteriorated (Zhu et al., 2006). Thus resulting in decrease of Tg of the weathered composites in comparison with the composites which have been reinforced by glass fiber. As seen in Figure 4 which is the glass transition temperature, Tg was increased with addition of glass fiber. Wang et al. (2005) reported that glass fiber plays a significant role in the thermal stability of natural fiber composites wherein the temperature causes a direct thermal expansion or contraction. Glass fiber has high content of inorganic silica. During pyrolysis process organic components such as cellulose and hemicelluloses decomposed and gasified leaving silica which can play a role as a heat shield (Yao, et al., 2008).

![DSC curve of pure kenaf composite before and after exposed to weathering.](image-url)
Figure 6. DSC curves of kenaf/glass fiber hybrid composite before and after exposed to weathering.

4. Conclusion
The study demonstrate the study on the effect of weathering on thermal properties of kenaf hybrid we compared both pure kenaf and hybrid kenaf-glass fiber before and after exposure, the composite shows slow and steady initial weight loss until major weight Loss is detected at approximately temperature $390^\circ$C. While as the weathering increase, the weight Loss started as low as $290^\circ$C. it was equally found that, the weakness in the molecular interfacial bond cause by moisture absorption. The glass transition temperature also is affected by weather for both composites, pure kenaf composites shows lower value of glass transition temperature compared with kenaf /glass fiber hybrid composites . This is due to photo-oxidation of weathered UP during natural weathering will results in chain scission of polymer . As a consequence the properties of polymer including chain symmetry ,flexibility and intermolecular forces have deteriorated. Thus study has revealed the effect of the weather to pure kenaf thermal properties and improve could be achieved with the integration of GF.

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