The weathering effect in natural environment on kenaf blast and unsaturated polyester composite

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Abstract. A Kenaf composite was prepared by using hand lay-up process. The effect of weather on mechanical, morphology and thermal properties of kenaf composite were studied. Tensile strength of kenaf composite was found to be 60MPa. Unfortunately, tensile strength of the composite starts to decrease after the first weathering month through to the weathering periods with constant reduction of tensile, at the end of the weathering period, almost 85% of the composite mechanical behaviour is lost. From the mechanical properties result obtained it clearly seen that natural fiber and their composites are not able to stand environmental condition because they have poor wettability, incompatibility with some polymeric matrices and high moisture absorption. Due to the high moisture absorption properties, there are formations of void in interfacial adhesion between fiber and matrix which can reduce the mechanical properties of composite such as flexural strength or flexural modulus this clearly supported by SEM results. Fortunately some modification can do towards improving the mechanical properties and it is good enough to achieve the high performance of the composite with proper system formulation during the modification process and the result of reinforced kenaf fiber will be presented in our next publication.

1. Introduction
Considerable interest has been shown research community to work with kenaf and Kenaffiber is unique and potentially reliable natural material that occupied the mind scientist engineered and the development of high-performance engineering products made from natural resources is increasing worldwide, due to renewable and environmental issues[1]. Among the many different types of natural resources, kenaf plants have been extensively exploited over the past few years[2]. Kenaffiber is extracted from bastfiber of kenaf plants and properties of kenaffiber composite are comparable to conventional fiber composites, moreover, kenaffiber
composite can be produced using conventional fiber composite manufacturing and kenaf fiber composite have a bright future due to its renewability and eco-friendly. Hence this work is presenting reinforcing of glass fiber with kenaf fiber [3]. The quest to develop high-performance materials made from natural obtained from resources is increasing worldwide, especially the material with integrity to be used in much application[1,4].

The greatest challenge in working with natural fiber reinforced plastic composites is their large variation in properties and characteristics with respect to different condition [5]. Bio composite’s properties are influenced by a number of variables, including the fiber type, environmental conditions (where the plant fibers are sourced), processing methods, and any modification of the fiber. Recently there has been a surge of interest in the industrial applications of composites containing biofibers reinforced with biopolymers [6]. In the other hand, there is a growing trend to use bio fibers as fillers and/or reinforces in plastics composites[7]. This is due their flexibility during processing, highly specific stiffness, and low cost (on a volumetric basis) makes them attractive to manufacturers[8]. This century has witnessed ever-increasing demands for the utilization of plastics as important raw materials, more than 80% of which are thermoplastics[9-15]. However, using kenaf constitute some disadvantage which occur during the addition of natural fibers, including kenaf into a polymer matrix, is the lack of good interfacial adhesion between the two components, which results in poor properties in the final product[3].

Another problem is affected by humidity aging is widely recognized as one of the main causes of long-term failure of an organic matrix exposed to the atmosphere; or in contact with an aqueous media[15,16]. There are several recognized modes of humidity aging, namely plasticization of the matrix; differential swelling related to concentration gradients, linked the degradation of the macromolecular [17-25].Kenaf fibers, as reinforcement, have recently attracted the attention of researchers because of their advantages over other established materials[26].

Moreover, They are environmentally friendly, fully biodegradable, abundantly available, renewable and cheap and have low density[27-33]. Plant fibers are light weight compared to glass, carbon and aramid fibers. The biodegradability of plant fibers can contribute to a healthy ecosystem while their low cost and high performance fulfills the economic interest of industry[35,36]. When natural fiber-reinforced plastics are subjected, at the end of their life cycle, to combustion process or landfill, the released amount of CO$_2$ of the fibers is neutral with respect to the assimilated amount during their growth[37]. The abrasive nature of fiber is much lower which leads to advantages in regard to technical process and recycling process of the composite materials in general [37-40]. Natural fiber-reinforced plastics, by using biodegradable polymers as matrices, are the most environmental friendly materials, which can be composed at the end of their life cycle [41].

Natural fiber composites are used in place of glass mostly in non-structural applications [42]. A number of automotive components previously made with glass fiber composites are now being manufactured using environmentally friendly composites [43].Glass fibers (GF) are the most common reinforcement for polymeric matrix composites [44]. Their principal advantages are the relationship between their high tensile strength, high chemical resistance, and insulating properties [45]. The disadvantages are low tensile modulus, relatively high specific gravity, sensitivity to abrasion during handling, low fatigue resistance, and high hardness and the compositional difference and low manufacturing cost make it more attractive materials[46].The best way to increase the material efficiency without sacrificing environmental safety is to employ natured fiber reinforced composite materials[47-49]. Producing the material with the focus on improvement aspects is very important in various
applications [50]. The goals are to increase the performance of the materials and also to find the solution to reduce the cost hence able to reduce the production cost [50-54]. The latest incorporation natural material develops plastic based material has resulted in higher material properties and more possibilities use in many different applications [55-60]. However the use glass fiber becomes at higher cost than long natural fiber reinforced polymer, additional costs incurred by using glass include the added compounding and using specialized equipment to process [50, 61].

2. Methods
Kenaffiber was obtained from Rahamatullah Sdn. Bhd, Malaysia. All the kenaf mats in this study were used without any surface treatment. A standard unsaturated polyesters resin was supplied by CastmeschTechnologies Sdn. Bhd. MEKP (solution in dimethyl phthalate) used was from Kaumjung AkzoNobel peroxide Ltd by trade name Butanox M60. Initially kenaf mat was cut to 20x20 cm dimensions (four layers), this followed by compressing them using compress machine at 90°C for ten minute. This process was done to remove air between the kenaffibers and to uniform thickness. The first layer of kenaffiber was put in the mold and hand lay up the resin (unsaturated polyester + hardener (2 %)) and with ratio of 30:70 wt% (fiber to resin) to it. Resin impregnated into kenaf fiber mat via hand lay-up method. Where in impregnated into 3 layers to make pure kenaf is the top composite after that compressed the composites for 10min without heating at 5MPa and allowed it to cure at room temperature for 24hrs. This followed by separating it from mold using hack saw. The prepared composite was measured and cut to 2.5 x 20 cm about 8 samples were obtained. The was followed by preparing the sample for test and the first test was tensile and in this case, the sample need to measure with the gauge length of 140mm to be ready for tensile test (the speed 2 mm/min). To get the properties such as ultimate tensile, strength, yield strength, break elongation and modulus of elasticity and also do scanning electron microscopic test to observed degradation process that will happen in natural fiber and matrix. We compared the composite in room temperature and composite after exposure to weathering by two weeks for three months If a figure has parts these should be labelled as (a), (b), (c) etc on the actual figure. Parts should not have separate captions.

3. Results and Discussion
The preparation of kenaf fiber was completed successfully and kenaf fiber composite showed very tensile properties. This is due to the improvement in adhesion between fibers to polyester matrix. The composites with the kenaf exhibited higher tensile and module and strength compared to other material. The strength is decrease when they are exposed to weather. As expected, the results of the tensile tests, in terms of tensile strength, tensile modulus breaking elongation show similar trend. Fives samples (pure kenaf composite fiber hybrid composite with different exposure were tested (before exposure, 1 month of exposure, 2 months of exposure, 3 month of exposure in an interval of 2 weeks) were tested.
The degradation process due to the weathering is usually affecting the mechanical properties of the composite. Figure 1, show the tensile strength of the pure kenaf composites. Unexposed pure kenaf composite show approximately 60.8 MPa strength and is very important to note that, decrement trend of tensile strength of kenaf composite. From the results, it can be seen that the kenaf composite has significant decrement for before exposure compared to the after exposure, due to natural plant fibers are susceptible to biodegradation thus their composites face high risk of degradation when subjected to outdoor application. When natural fiber composite exposed to moisture, water penetrates and attached onto hydrophilic groups of fiber establishing intermolecular hydrogen bonding with fibers and reduced interfacial adhesion of fiber to matrix this lead to poor transfer stress from matrix to fiber will result to lower tensile strength of pure kenaf composite.

Figure 2. Effect of different weathering period on the elongation at break of pure kenaf composite.
From the results of break at elongation in figure 2, it can clearly be seen that natural fiber and their composites are not able to stand environmental condition due to the high moisture absorption properties, there are formations of void in the composites which can reduce the mechanical properties of composite such as flexural strength or flexural modulus. Similar trend also shown by many researchers. Break at elongation modulus of the weathered specimen were lower than those not weathered specimen. This is common for lignocellulose polymer composites because exposure to photo-oxidation and thermo-oxidation reaction during natural weathering results in a more brittle composite and brittleness of polymer matrix due to chain scission.

![Figure 3. tensile modulus of the composite with weathering periods.](image)

From the figure 3 the tensile modulus shows the same trend with tensile strength. Incorporation of fiber before weathering has better the tensile modulus of kenaf fiber composite to 3000 MPa compared to after weathering kenaf composite 2000 MPa. When expose to environment, it can be seen that the tensile modulus decrease for kenaf composite. Kenaf fiber provide stiffness to the composite but when expose for a longer time to environment, fiber-matrix debonding will occur in pure kenaf composite due to the weathering effect. Besides moisture absorption, both polymer matrix and kenaf fiber in pure kenaf composite will experience solar degradation during natural weathering. Photo degradation upon ultraviolet (UV) exposure is expected to be the major cause of changes to surface appearance and chemistry of the composite.

Morphological study of the pure kenaf composite were performed by SEM for the determination of the mode or cause of failure and to fully reveal the mechanical behavior that was seen in the above section. The effect of weather on properties of the composite and pure kenaf can be evaluated by comparing the morphologies of the pure kenaf composite with different weathering periods. All the possible effects on composite properties must be considered which indicates such behaviour. The micrographs with 500X magnification were obtained and shown in Figure 4.
Figure 4. Micrograph of the kenaf composite by SEM at 500X magnification (a) kenaf composite, (b) kenaf composite after one month of exposure (c) kenaf composite after two months exposure (d) kenaf composite after three month of exposure.

As shown in Figure 4, the kenaf composite show very good and smooth morphology compared to other three samples, as the weathering periods increased the void in the kenaf increased compared to pure kenaf before exposure. Based on the micrographs, weathering cause the kenaf degrade due to absorption of moisture, this equally revealed in the tensile behavior discussed in this above section. As the weathering periods increase the kenaf dislocation increase. Natural materials tend to show very low mechanical properties because they do not plastically deformed and in agreement with tensile, flexural results. Decrease of the mechanical properties of samples is due to the formation of void in within fiber molecular bond. Micrographs figure 4(c) and figure 4(d) show obvious picture where there are some voids in the fiber molecular chain. It can be seen from the micrographs that, the size of voids were increased with the increase in weahtering exposure. Consequently, it has caused the reduction in mechanical properties as discussed before. Micrograph shows some obvious cracked. This indicates weak interfacial interaction between natural fibre because there were micro spaces existing at the interfacial area between fibres within the same system due moisture.

4. Conclusion
The major challenge for natural fiber matrix its affinity to water, it has high absorption to moisture which have serious consequences to it properties. Al though, incorporating reinforcement in kenaf play an important role in improving the mechanical and thermal properties this is could be due to the maintaining of structural integrity and bonding of the fibre from the matrix, resulting from the prevention of shear stress at the interface. However, this gradually affected due to absorbed moisture with weathering. In in conclusion there is tensile and break elongation reduction due to long term
exposure to weather and the effect of weather on tensile properties of kenaf composites, the modulus is 10MPa compared with tensile strength 60MPa before weathering. As mentioned, mechanical behaviour of materials starts to decrease after the first weathering month through to the weathering periods with constant reduction in tensile strength.

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