Water Absorption Associated with Gamma Irradiation on Kevlar/Oil Palm EFB Hybrid Composites

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Abstract*: The objective of this work is to analyse the water absorption behaviour on the gamma irradiated Kevlar/Oil Palm EFB hybrid composites. The hybrid composites were fabricated through manual hand lay-up method. Different layering sequence of hybrid composites were fabricated which is Oil Palm EFB/Kevlar/ Oil Palm EFB (OP/K/OP) and Kevlar/Oil Palm EFB/Kevlar (K/OP/K). Various Gamma radiation doses; 25 kGy, 50 kGy and 150 kGy were exposed to the composites. The results showed that for both layering pattern, the water absorption for non-irradiated hybrid composites absorbed more water than irradiated hybrid composites. Water uptake for non-irradiated K/OP/K is 51% and with radiation is 21% at 50 kGy. Hybrid OP/K/OP that is not irradiated absorbed less water which is 27% as compared to the same hybrid but with radiation only 17%of water being absorbed at 50 kGy. The results showed that irradiated hybrid composites absorb less water compared to non-irradiated hybrid composites. This suggest that crosslinking took place due to the radiation. This implies that with radiation of certain dose could improves the properties of water absorption for Kevlar/ Oil Palm EFB hybrid composites.

***Index Terms*: Gamma irradiation,hybrid composites, water absorption**

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I. INTRODUCTION

Natural fibres are now becoming in great demand for producing composites. The advantages of natural fibres are low cost, low density, biodegradable, low energy consumption [1, 2, 3, 4]. Among the natural fibres used in composites are jute, oil palm Empty Fruit Bunch (EFB), flax, hemp and many more. Desirable mechanical properties may not be achieved with the reinforcement of single type natural fibre. Hence, hybridization with more than one fibre is one of the methods to enhance its mechanical properties [5, 6].

Hybrid composites are composites consisting minimum of two fibres as the reinforcement in a single matrix [1]. The fibre of the reinforcement can be made up from natural-natural fibre, synthetic-synthetic fibre or natural-synthetic fibre. Due to the environmental issues, combination of natural-natural fibres and natural-synthetic fibres [7, 8, 9, 10, 11] have open for more research work in this area.

In this present study, natural fibre used was oil palm EFB in order to utilize the abundance of waste from the palm oil plantation industry in Malaysia. Besides, the oil palm EFB has the potential as the reinforcing fiber in polymer composites for energy absorption applications [12]. Table 1 tabulated the hybrid composites of oil palm EFB with other fibers.

Table 1:Hybrid composites of oil palm fibre

Authors	Types of Fibres in Oil Palm Composites	References
Tshai et al.	Oil palm EFB – chopped glass strand	[13]
Jawaid et al.	Jute – oil palm	[14]
Zainudin et al.	Coir – oil palm	[15]
Karina et al. Hariharan & Khalil	Oil palm – glass	[16] [17]

In enhancing the strength of hybrid composites, several approaches were used such as hybridizing the reinforcement [7, 8, 18], chemical treatment [19] such as using sodium hydroxide [NaOH], fibre pretension [20], irradiation method such as gamma irradiation and electron beam [EB] [21] and many more. However, gamma irradiation is sometimes preferred compared to other methods such as it is continuous operation, less

atmospheric pollution [22], catalyst is not required to initiate the reaction [23]. Gamma irradiation is the process where the specimens are exposed to gamma radiation to enhance the fibre-matrix interfacial bonding [24]. By increasing the interfacial bonding strength hence this could lead to better mechanical properties. Different radiation doses were exposed to the hybrid composites and it is expressed in unit of kilo Gray [kGy].

Many studies related to water uptake in hybrid composites had been reported previously [3]. Studies were conducted on the water uptake oil palm empty fruit bunch/jute hybrid composites [1, 26], Yahaya et al. [27] studied on the behavior of water uptakefor Kenaf-Kevlar epoxy reinforced hybrid composites. Recently, water absorption behavior for gamma irradiated hybrid composites were carried out. Supreeth et al. [24] studied the gamma radiation effect on pineapple/jute hybrid reinforcement on the water absorption behavior. Zaman et al. [28] studied on the water uptake when jute fabrics-reinforced polypropylene composites were exposed to gamma radiation. The results showed that specimens irradiated with gamma attained lower water absorption compared to specimens not being irradiated. In this present work, water absorption behavior on the irradiated epoxy trilayer Kevlar/oil palm EFB/Kevlar (K/OP/K) and oil palm EFB/Kevlar/oil palm EFB (OP/K/OP) were studied.

II. METHODOLOGY

A. Materials

Oil palm EFB mat used in this study were procuredfrom HK Kitaran Sdn. Bhd. Malaysia. The synthetic fibre Kevlar, which was used to produce hybrid composites, was purchased from ZKK Sdn. Bhd together with the epoxy resin typed Zeepoxy HL002TA and hardener typed Zeepoxy HL002TB.

B. Preparation of Composites

The woven Kevlar and oil palm EFB fibre mat were used in the preparation of the hybrid composites. In preparing the composites, hand lay-up method was applied [29]. Two different sandwich-structured combinations of hybrid composites were prepared. The first combination was fabricated with oil palm EFB in the middle while Kevlar woven fabric as the outer layer at both top and bottom and the second combination was vice versa with the Kevlar woven fabric as the core. After the cutting process of specimens according to the ASTM standard, they were exposed to gamma radiation at the radiation facility with various doses; 0 kGy, 25 kGy, 50 kGy and 150 kGy. The radiation facility located at Malaysian Nuclear Agency, Bangi as shown in Figure 1.

Fig. 1: Radiation Processing Plant Facility. (Courtesy of Malaysian Nuclear Agency)

C. Water Absorption Test

The composites with dimension 76 mm x 25 mm were prepared. Six specimens from each types of composites were taken. The average value was calculated. The samples were oven dried for 24 hours before being immersed in the water bath. The initial value of the weight specimens were recorded. The immersion of samples in the distilled water was controlled in a room temperature. Weight of samples before and after removing from water at different intervals were recorded. The test continued until a constant weight of specimens were obtained.

The following equation (1) was applied to calculate the percentage of water absorption [3],

$$\text{Water absorption, WA (\%)} = (w_f - w_i)/w_i \times 100 \quad (1)$$

Where wf is the final weight and wi is the weight before the immersing the specimens in the water bath.

III. RESULTS AND DISCUSSIONS

Figure 2 and Figure 3 show the water absorption behavior trend for oil palm EFB/Kevlar hybrid composites with different layering pattern. The water absorption depends on the fibre properties and the degree of matrix-fiber adhesion [24]. It is clear from Figure 2 and Figure 3, that water absorption increased with the immersion time regardless of the specimens being irradiated or not irradiated. The results showed rapid water uptake for first several hours before saturation. The trend observed is similar with the study done on the water absorption behavior for oil palm EFB/jute fiber [1].

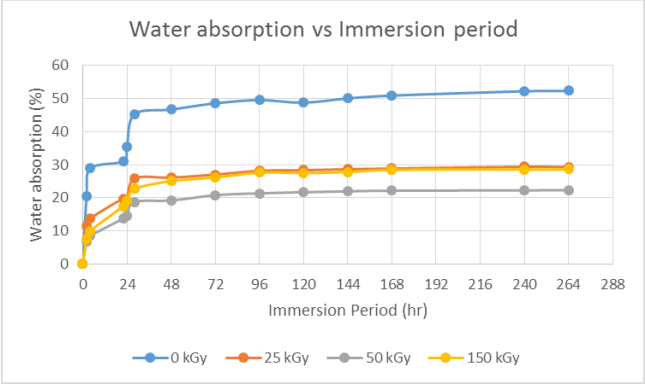

Fig. 2: Water absorption behavior for K/OP/K pattern

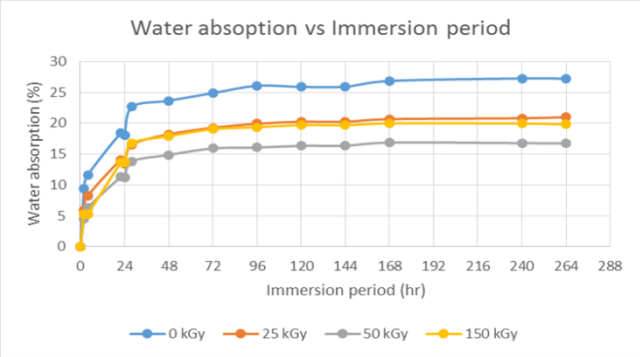

Fig 3: water absoprtion behavior for op/k/op pattern

The hydrophilic characteristics of the cellulosic materials is the cause of the rapid uptake. Voids and micro cracks were found within the composites as the cellulosic structure holds the water molecules in their inter-fibrillar spaces [1, 25]. The water molecules that fills in the voids and cracks is due to capillary action [11]. This phenomena resulted in the interfacial de-bonding at the interface [1]. Water absorption behavior depends on the hydroxyl group (OH) that presents in the cellulose and lignin structure of oil palm EFB [1].

When the specimens were irradiated, the water absorption capacity decreased. The trend observed agreed with the work done when Pineapple Leaf Fiber/Jute hybrid composites [24] and jute fabrics-reinforced polypropylene composites [28] were irradiated with gamma radiation with certain dose. Without radiation the water uptake for layering pattern when oil palm EFB in the centre is 51% as shown in Figure 3 while layering pattern when Kevlar fabric in the centre is 27%. However, both layering pattern showed a decreased of 21% for layering when oil palm EFB as the core and 17% when Kevlar as the core material in the water uptake capacity at 50 kGy. As the radiation further increased until 150 kGy, the water capacity increased higher than water capacity at 50 kGy. This may be due to chain scission at 150 kGy. These results can be seen in Figure 3 and Figure 4.

Natural fibres such as oil palm EFB contain hydroxyl group (-OH) in their chemical composition which is the cause of water absorption. However, water uptake capacity were reduced for samples irradiated with gamma radiation. Gamma radiation decreased the hydroxyl groups in the oil palm EFB fibre by removing the moisture [22] and increased the crystalline region through crosslinking phenomena which resulted in the decrease of the amorphous regions [24]. Through gamma radiation the strength between Kevlar and matrix was improved by slightly changing the crystallinity of Kevlar fibres [30]. Since there is cross linking phenomena hence this situation leads to better fibre matrix adhesion as compared to non-irradiated specimens. The optimum dose to reduce the water uptake capacity is at 50 kGy for both layering pattern.

IV. CONCLUSION

The effects of gamma radiation upon oil palm EFB/Kevlar hybrid composites have been studied through water absorption behavior. Hybrid composites treated with gamma radiation showed less water uptake compared to non-radiated specimens. The optimal radiation dose was at 50 kGy. However at 150 kGy, the water uptake capacity increased more than at 50 kGy. The results indicated that using gamma radiation, the adhesion of fibre-matrix was effectively improved. Higher moisture resistance is developed after the specimens were exposed to the gamma radiation. From the experimental results, gamma radiation is an effective approach to reduce the water capacity of the oil palm EFB/Kevlar hybrid composites.

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