Charpy Impact Property of Sugar Palm Fibre Reinforced Epoxy Composite

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Abstract: The sugar palm fibre reinforced epoxy composite use cheap fibre material, renewable and has low density. Charpy impact test was carried out to investigate the mechanical properties of composite. To maintain a low cost of the composite product, the composite was produced without compatibilizer. The impact strength of composite was measured with variation in length of the fibre embedded in epoxy matrix. The length of the fibre were 3, 6, 9 cm. The result shows that the impact strength was higher than the pure epoxy. As the length of the fibre increases, the impact strength was increases. The scanning electron micrograph shows insufficient compatibility between particle and polyester matrix. This compatibility was attributed to the strength of the sugar palm fibre reinforced epoxy composite. The mechanism of the composite failure was dominated by fibre breaking for composite with the highest impact strength.

Keywords: Epoxy, Sugar palm fibre, Natural fibre composite, Hand lay-up, Impact strength

1. Introduction

Natural fibre for reinforcement of polymer composite exhibited an adequate strength, low density and environmental friendly [1]. Despite the cost of the extraction of this fibre, natural fibre is cheaper than the other reinforcement. Epoxy is widely used as engineering material. However, conventional epoxy system shows poor fracture toughness, poor resistance to crack growth and low impact strength [2]. Addition of the suitable filler in pure epoxy could improve the impact strength of the epoxy in form of composite.

The total impact energy can be divided into elastic and plastic deformation, in wood flour/ polyurethane composite, most energy was consumed by propagation of the crack, the increases of the cross linking energy leads to increase of energy for crack initiation in composite [3]. The increase of impact strength was observed for PALF composite because the fibre forces the crack to grow around the fibre and bridging the crack trough fibre pull-out [4]. The addition of coir composite was also increased the impact strength at fibre content above 30%wt. The addition of compatibilizer on Coir/PP composite decreased the impact strength of the composite because high interfacial strength of fibre and matrix decreased the failure mechanism of pull-out and debonding [5]. High energy impact was showed by Hemp/UP composite. The grater energy absorption in the bio-composite containing treated fibre. When the cracks moves forward, the chain motions change due to their flexibility and create a barrier for crack growth [6]. Egg shell improves the toughness of epoxy matrix in egg shell/epoxy composite. Significant improvement of impact strength of 16.7 KJ/m^2 compare with 9.7 KJ/m^2 of the neat resin [2].

Fibre fineness contributed to the strength of the composite because it leads to better fibre embedment during compression, fibre fineness also increased the contact surface between fibre and polymeric matrix and increases the number of actually embedded fibres that lead to a reducing concentration of peak stresses at the end of the fibres and therefore higher mechanical properties of composite properties. Slightly weaker interface strength should result in a higher degradation of impact energy, supporting fibre pull-out. In reverse, good adhesion result in abrupt fibre fracture with a minor energy degradation. There is not an additional energy-consumption mechanism. The same reasons also cause the decreasing of impact energy of sisal/PP composite. The addition of fibre increases the probabilities of fibre agglomeration and stress concentration. High stress concentration of fibre ends could cause crack initiation and possible fibre failure [7].

In this paper, the 13 % weight fraction of sugar palm fibre (SP) was loading into the epoxy matrix. The SP fibre with variation in length of 3, 6 and 9 cm was embedded into the epoxy matrix. The impact strength of the composite was tested using charpy impact test. The failure mechanism of the composite was observed using SEM micrograph.

2. Materials and Methods

2.1 *Materials*

Sugar palm (SP) fibre being used in this study was originally from Lampung province, Indonesia. Sugar palm fibre was extracted by brushing it from the stalk, cleaning and drying [1]. The fibre use in this study has diameter in the range of 0.25-0.35 mm. Cleaned SP fibre was immersed in the NaOH aqueous solution 5% by weight for 2 hours, washed with distilled water and then drying. Alkali untreated sugar palm fibre was dried for 36 hours at room temperature. Alkali treated SP fibre was dried further inside the furnace at 80 °C for 15 minutes. SP fibre was cut into 3, 6 and 9 cm in length. The fibre was used to reinforce polymer matrix. The polymer matrix was epoxy resin.

2.2 *Preparation of the Composite*

A slightly modification of hand lay-up technique with the help of vacuum pump was used to minimise the void in fabrication of the composite. The loading of the SP fiber was 13% for all composite samples. The variation of length was 3, 6 and 9 cm. The epoxy and hardener was pump separately into the glass container using vacuum pump and mixed manually using metal bar. During this process the pressure inside the glass container was kept constant at 20 Psi. Then using the vacuum pump, the mixture of epoxy and hardener was pumped into the mould with the fibre inside and at the same time, the vacuum pump removed the air out from the mould. After epoxy resin filled the mould, the flow of epoxy resin was stopped. Composite was heating inside the furnace for curing at 80°C for 15 minutes. Then cured composite was cut to make the specimen for charpy impact test.

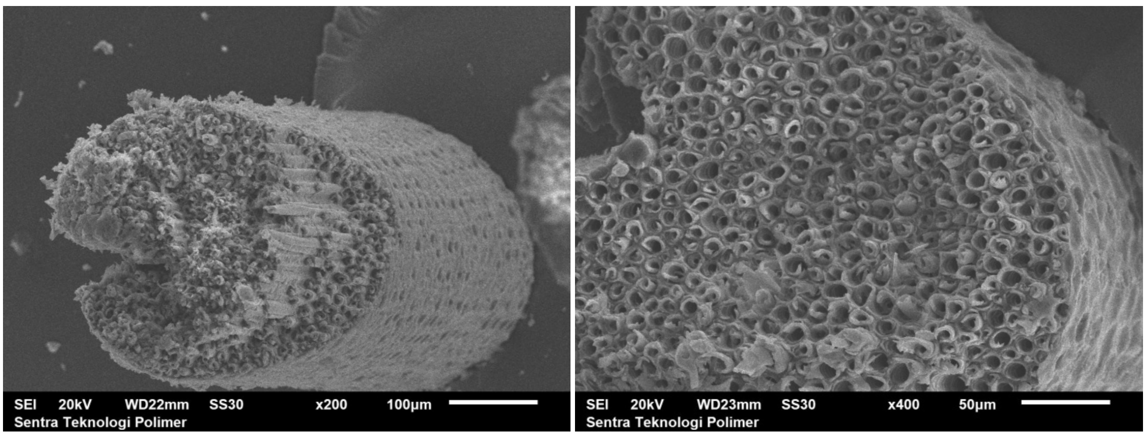
2.3 *Charpy Impact Test and SEM*

Charpy impact test was carried out to investigate the resistance of SP fiber/epoxy composite under impact loading. The test were carried out using the resil impactor CEAST according to ISO 179-1-2010 standard. The tests were carried out at room temperature. Scanning micrograph of the composite was taken on the cross section of the fracture composite under impact loading. The SEM equipment was JEOL JSM/6510LA.

3. Result and Discussion

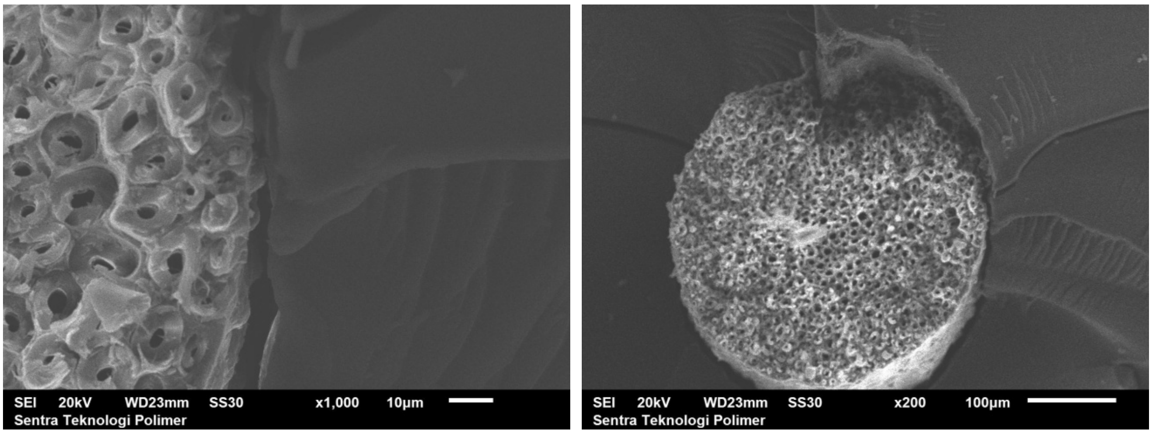
3.1 *Morphology of CS Particle*

The diameter of the SP fibre was around 250-350 μm. Morphology of SP fibre is shown in figure 1. The cross section of the fibre consisted of micro fibril. There was a gap at the interface of SP fibre and epoxy matrix as shown in Fig. 2. The gap was indicated insufficient adhesion between SP fibre and epoxy matrix. The composite impact strength was higher than pure epoxy although from SEM micrograph observation, the interface bonding between SP fibre and epoxy matrix was low.



(a) (b)

Figure 1 Cross Section of Sugar Palm (SP) Fibre: (a) Morphology of SP Fibre, (b) Fibril of SP Fibre



(a) (b)

Figure 2 Sugar Palm (SP) Fibre Embedded in Epoxy Matrix: (a) Interface between SP Fibre and Epoxy Matrix (b) Compatibility between SP Fibre and Epoxy Matrix

3.2 *Mechanical Properties of Composite*

The result from charpy impact test of SP/Epoxy composites was shown an increase of energy absorption as compare to the neat epoxy matrix as shown in Fig.3. Addition of the SP fibre acted as a barrier for the propagation of crack. More energy was consumed to overcome the fibre before composite failure. SEM micrographs in figs. 4-6 on the cross section of the specimen after impact were shown some failure mechanism of composite such as fibre matrix debonding, fibre pull-out and fibre breaking.

In comparison of impact energy for a different length of the fibre being observed, impact energy increases with the fibre length as shown in Fig. 3. SEM observation shown the different dominant failure mechanism of composite with different fibre length embedded. Figure 4 is shown the impact fracture of the specimen with 3 cm fibre length. Pull-out was likely a dominant failure mechanism because fibre length was short. While figs 5-6 is shown less fibre pull out for composite with 6 and 9 cm fibre length. The longer the fibre length, less fibre pull-out was observed.

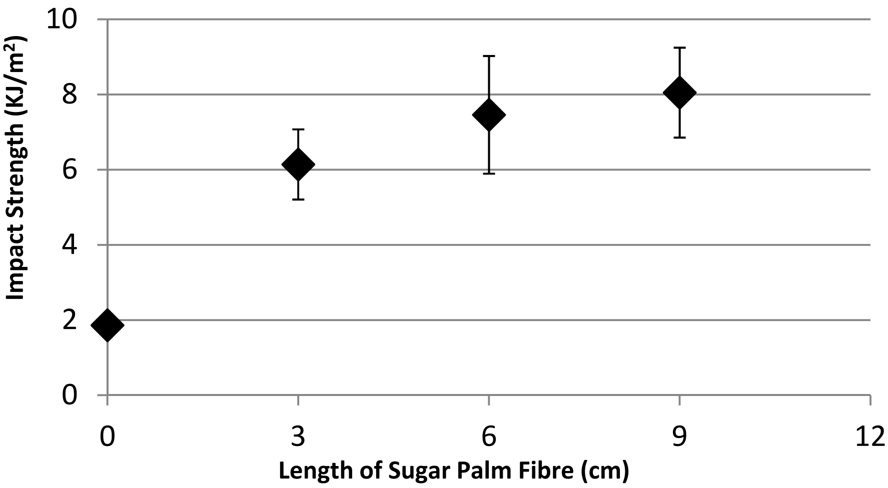


Figure 3 Impact Strength of Pure Epoxy and SP/Epoxy Composite as a Function of Fiber Length

For composite with 9 cm fibre length embedded, the fibre breaking was likely the dominant mechanism that results in higher energy absorption.

Other factor that affects the strength of the composite is the fibre distribution in the matrix. As can be seen in Figs. 4-6, the distribution of the fibre was not uniform across the matrix. This is also the reasons for high deviation standard of impact strength value in Fig.3.

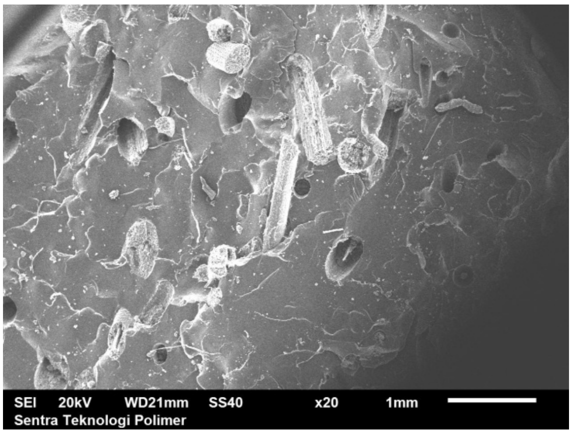


Figure 4 Fracture of SP/Epoxy Composite under Impact Loading: 3 cm Fibre Length

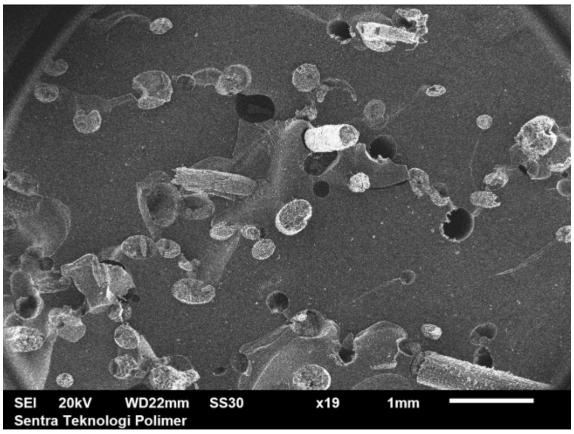


Figure 5 Fracture of SP/Epoxy Composite under Impact Loading: 6 cm Fibre Length

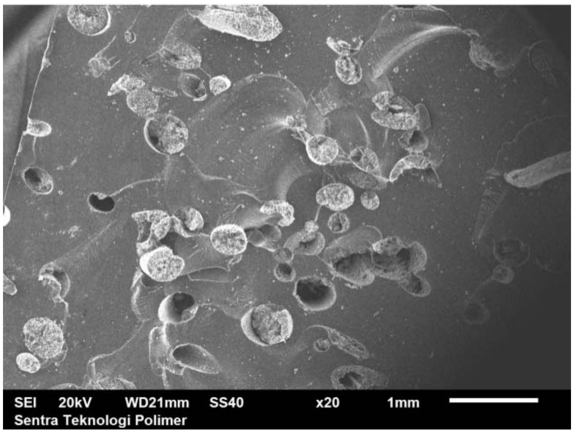


Figure 6 Fracture of SP/Epoxy Composite under Impact Loading: 9 cm Fibre Length

4. Conclusions

The sugar palm fibre reinforced epoxy matrix was prepared using a hand lay-up technique. The void was minimizing using the vacuum pump. Incorporation of SP fibre to the epoxy matrix was shown higher impact strength of SP/Epoxy composite compare with the neat epoxy matrix as much as 300%. The energy consumption before composite failure was increased by the various failure mechanism of composite.
As the fibre length increases, the impact energy was increased. From SEM micrograph, fibre breaking and fibre pull-out was observed as the dominant failure mechanism of epoxy/SP composite. Fibre distribution also contributed to impact strength of SP/Epoxy composite.
Sugar palm fibre was successfully increases the impact strength of epoxy and hence it has a potential to be

used as reinforcement in SP/Epoxy composite.

5. References

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