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THE EFFECT OF FILLER CONTENT AND PARTICLE SIZE ON THE IMPACT STRENGTH AND WATER ABSORPTION OF EPOXY/COCKLE-SHELL POWDER (ANADORA GRANOSA) COMPOSITE

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ABSTRACT

An environmental issues which has become major concern in composite field is the main reason to develop replacement of synthetic filler with natural filler. In this research, the effect of filler content and particle size of cockle-shell powder in epoxy on the impact strength and water absorption of the composite were studied. Epoxy resin was used as the matrix, and cockle-shell powder was used as filler with variation of filler content viz. 10, 20, 30, 40 and 50% (wt.) and the particle sizes were varied from 50, 110, to 170 mesh. The composite was prepared by using compression moulding, and was tested to obtain impact strength and water absorption. The results showed that the highest improvement of the impact strength was occured on the incorporation of 30% (wt.) and 170 mesh of cockle-shell powder. This was supported by the scanning electron microscopy (SEM) characterization result. It was also revealed that the water absorption was significantly increased as the particle size of the filler was increased.

Keywords: cockle-shell powder, epoxy resin, impact strength, water absorption.

INTRODUCTION

Composite is a material consisting of two or more materials which has better property from its constituent. One of trending composite study is polymer composite. Polymer composites have received increasing attention in several field of industry such as in plastic product, automotive, aviation, textile, etc. This is because polymer exhibits magnificent properties compared to metals or ceramics such as lighter, cheaper, rust-proof and lower processing temperature. Usually, polymer is used as blended material in order to create composite which exhibits better properties.

Epoxy resin is commonly used as composite matrices because of good adhesive properties (Singla and Chawla, 2010). Other advantages consist of temperature and weather resistant, it exhibits isolator properties and easy to process (Bray, *et al.* 2013). However epoxy resin is not considered as a tough polymer because of its brittleness and low impact strength (Chen, *et al.* 2013).

Epoxy resin is one of the most used thermoset polymer right now. However, epoxy resin still needs to be hardened in order to be used for application. A hardener is req uired to harden the epoxy resin. Organic compounds that can be used as hardener for epoxy resin are amines, amides, acid anhydrides, imidazoles, boron trifluoride complexes, phenols, mercaptans, and metal oxides (Augustsson, 2014).

On the other hand, in general the use of fillers in composites aim to reduce costs, provide color, strengthen or reinforce composite materials. As a filler, natural fibers have several advantages compared to inorganic fillers such as lower density, renewability, improvement in the mechanical properties, increase in range of applications, biodegradability, greater deformability, enhanced energy recovery and relatively lower cost. Many researches have been conducted to improve mechanical strength of epoxy resin. Some have utilized natural fillers such as, pineapple leaves (Payae and Lopattananori, 2009), sisal (Grisha, *et al. 2012)*, coconut shell (Chanal, 2012), bamboo [Bahrom and Radin, 2009), etc. In this paper, cockle-shell was used as filler to improve the impact strength of epoxy polymer.

Cockle-shell, in Indonesia, is one of the most valued sea commodities, but its usage is only limited for food consumptions. Its shell is rarely used and usually considered as waste. Because of cockle-shell is largely consumed in Indonesia, the shell waste is increasing and is not good for the environment.

Cockle-shell is relative hard compared to other natural materials and consists mostly of calcium oxide (CaO) and magnesium oxide (MgO), which is 66,7% and 22,28% respectively (Siregar, 2009). In other study, MgO has been used which was accompanying with titanium oxide as fillers in epoxy composite. Here, polystyrene has also been used to harden the composite. It was reported that magnesium oxide was capable of improving the impact strength of epoxy. The highest impact strength was at the composition of 15% MgO (Deya'a, 2011).

In this study, the effect of filler (cockle-shell powder)content and particle size on the impact strength and water absorption of epoxy/cockle-shell powder (anadora granosa) composite were observed.

MATERIALS AND METHODS

Materials

The epoxy resin, hardener and polystyrene that were used in this study were purchased from local chemical store. The cockle-shell was obtained from local seafood restaurant from various places. The cockle-shell was crushed using ball mill and then sieved to particle size of 50, 110 and 170 mesh. The chloroform used is technical grade and bought from local chemical store.

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METHODS

Composite preparation

The composite preparation consists of four steps. Each will be explained as follow:

Dissolving polystyrene in chloroform: The polystyrene was dissolved using chloroform with the ratio 1:4 (w/w). The polystyrene was stirred manually until homogeneous mixture was obtained.

Matrix preparation by mixing epoxy resin with hardener and polystyrene solution: The epoxy resin was mixed with hardener with the ratio 1:1 (w:w). The epoxy compound then mixed with polystyrene solution with the solution is 10% (w) to matrix compound.

Mixing matrix with cockle-shell powder filler: The matrix was mixed with cockle-shell powder with filler content of 10, 20, 30, 40 and 50% (wt.) from composite. One sample made with no filler (pure matrix) was used as control.

Compression molding: The composite was then poured on the impact testing mold which comply to ASTM D4812. The composite was compressed with Hydraulic Molding Test Press model GT-7014-A30C by Gotech Testing Machine Inc. The compression process was set to 10 minutes with ram pressure of 1600 kgf/cm^2 using room temperature. After the compression time has achieved, the composite was left overnight before removed from the mold.

Impact strength test

The prepared composite is subjected to impact testing using Izod&Charpy digital impact tester model GT-7045-MDL by Gotech Testing Machine Inc. with Izod method.

Water absorption test

The impact testing fragment was then used for water absorption test. The water absorption test was done by measuring the weight of sample before immersed in water (w_1) and then measure the weight of sample after immersed in water (w_2) periodically until a constant measurement was achieved. The percentage of water absorption (WA) was obtained by the formula:

$$\text{WA (\%)} = \frac{w_1 - w_2}{w_1} \times 100\% \qquad (1)$$

Scanning Electron Microscopy (SEM)

The fracture site of composite fragment after impact testing was characterized with scanning electron microscopy using Hitachi TM-3000.

RESULTS AND DISCUSSION

Impact strength

The effect of filler content and particle size on impact strength of composite can be seen in Figure-2. It is shown that incorporating cockle-shell powder as filler in epoxy increases its impact strength. Cockle-shell itself was known as a hard material, beside that, it is possible that the cockle-shell powder is capable of creating a good mechanical bonding with the matrix so incorporating it can increase the strength of composite. The cockle-shell powder can withstand the crack propagation and can serve as the load transfer medium in the composite.

One of the most dominant composition in cockle-shell is MgO. In their research, Deya'a, *et al.*. has proved that the addition of MgO in epoxy composite can increase the impact strength of the composite. The highest impact strength is reported at the composition of 15% MgO, they also reported that MgO is a rigid material and incorporation of rigid filler may enhance the impact properties of composites (Deya'a, 2011).

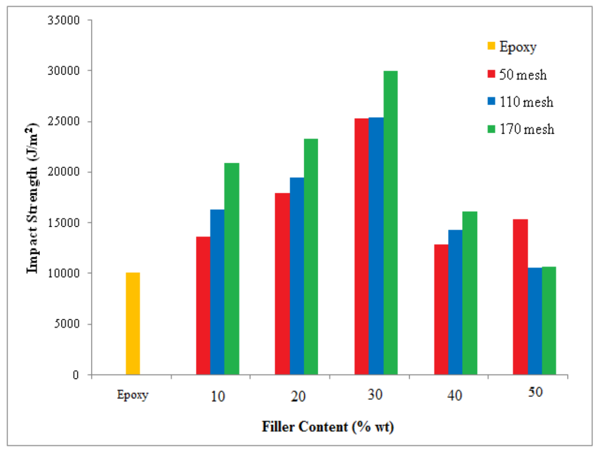

Figure-2. Effect of particle size and filler content on impact strength.

Figure-2 shows that increasing the composition of cockle-shell powder in composite can increase the impact strength of the composite until 30% (wt.) of filler loading. However, in the 40 and 50% (wt.) of filler loading, the decrease of impact strength have occurred. The decrease of impact strength is due to particle agglomeration of cockle-shell powder. The agglomeration will lower interfacial area thus load transfer will become limited resulting lower impact strength.

Figure-2 also shows that using finer fillers from 50 to 170 mesh also increases impact strength of the composite, although in 50% (wt.) of filler loading the impact strength dropped drastically even with the use of finer filler. The increase of the impact strength is because of the smaller particle size can increase the area of composite interface, so the mechanical bonding between matrix and filler will be stronger.

Water absorption

The effect of particle size of cockle-shell powder on water absorption properties of composite can be seen on Figure-3.

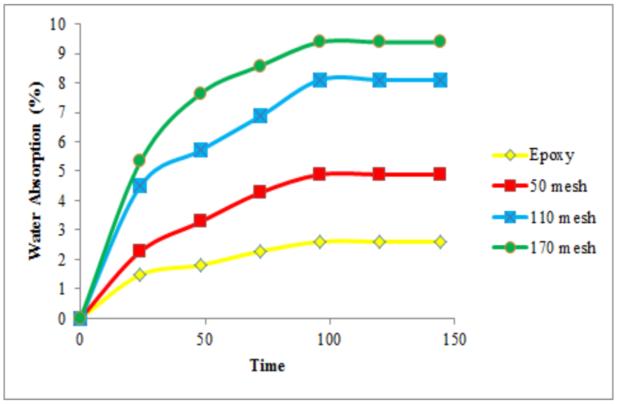

Figure-3. Effect of particle size on water absorption (Filler content 30% wt).

The trend of water absorption property shows monotonous. It is shown that as the filler content increased, the water absorption has increased for all particle sizes of cockle-shell powder. It is because cockle-shell powder consists mostly MgO and CaO, which is known to be a hygroscopic material (Apane, 2012).

On the longer soaking time, the water absorption of the composite is increased for all variation of the particle size It can be seen that in the 24 and 48 hour, the water absorption have increased drastically compared with the next interval hour, it is because in the early hour, there are still a lot of empty space inside composite, therefore a lot of water were absorbed easily into the composite, resulting the water absorption value increase drastically. But in the next interval hour, the water absorption increase slowly, and then become constant.

On the other hand, it shows that the finer the cockle-shell powder used, the more water will be absorbed and it is shown that the composite with 170 mesh has the highest value from the start until constant measurement is reached.

Scanning Electron Microscopy images

Scanning Electron Microscopy (SEM) images of fracture site of composite can be seen on Fig 4. It is shown that rougher surface is shown if cockle-shell powder is incorporated as filler. Figure-4a shows the smooth surface, while from Figure-4b filler has been incorporated in composites. However, Figure-4b shows that filler distribution is not good because some areas are not incorporated with filler. The area without filler could result in lower impact strength. Figure-4c shows less void and rough surface. This proves that the matrix shows more resistance against load given. This agrees with filler content of 30% (wt.) and particle size of 170 mesh exhibits the highest impact strength. Figure-4d shows the excess filler loading. It can be seen that agglomeration and poor filler distribution occur. It shows that filler content of 50% (wt.) with particle size of 170 mesh will possess inferior impact strength.

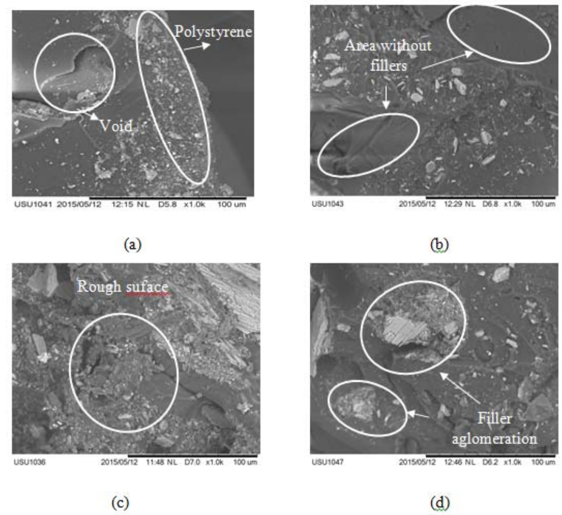

Figure-4. SEM Images of (a) Pure Epoxy (b) 30% (wt.) filler loading; 50 mesh (c) 30% (wt.) filler loading; 170 mesh (d) 50% (wt.) filler loading; 170 mesh.

CONCLUSIONS

It can be concluded that cockle-shell powder is capable in improving the impact strength of epoxy resin. The optimum filler composition was reached on 30% (wt.) of filler content. Using finer cockle-shell powder will increase the impact strength with the optimum result is at 170 mesh. This result is agreed by SEM images showing the best images occurred at 30% (wt.) of filler content and particle size of 170 mesh. Increasing filler content further was promoting the agglomeration and lower impact strength. However, using finer cockle-shell powder would give a drawback that higher water absorption would be expected.

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