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Mechanical Properties of Coconut Shell ParticlesReinforced Polyester Composite

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Abstract

The coconut shell particle reinforced polyester composite was produced using a simple technique called hand lay-up. Tensile and flexural testswere carried out to investigate the mechanical properties of the composite. To maintain a low cost, the composite was produced without compatibilizer. The result shows that the tensile and flexural strength increases with the particleloading. The elastic modulus and the strain at failure are high at a certain particle loading. The scanning electron micrograph shows adequate compatibility between particle and polyester matrix. This compatibility is attributed to the strength of the polyester/CS composite.

Keywords: *Composites, Polyester, Hand lay-up, Coconut Shell Particle, Natural Composite*

Composite reinforced by natural particle exhibited adequate strength with low cost, low density, renewable and environmental friendly. Some example of natural particlesthat have been used to reinforced composite werewood flour (Srekala, 2003), cordenka (Katsoulotos, 2008), Rice Hull (Tay, 2010) and micro crystalline celulosa (Alireza, 2010).

Particle is considered as reinforcement in composite beside reinforcementby the fibre. For well-bonded fibre and matrix, the applied stress is effectively transferred from matrix to the particle.The limitation of thermoset resin is a low resistance to crack growth. Natural particle can enhance the toughness of that resin and others mechanical property.

Size of the particle affects the mechanical properties of the composite. There is a critical size of particle that the magnitude of this critical size depends on the matrix, particle and the matrix/particle adhesion. The strength of composite increased as the size of the particle decreases because small particle has a large surface area. The strength of the composite particle mostly depend on the stress transfer from matrix to particle therefore the compatibility between matrix and particle is highly affected the strength (Shao-Yun Fu, 2008).

Compatibility is very important issue in composites. Man-made cellulose, Cordenka is partly replaced with jute in PP matrix. Addition of jute with compatibilizer enhances the tensile properties but do not give significant effect on the impact property. Less Pull out is suspected as a causes of low impact strength (Katsoulotos, 2008).

The strain at fracture for the rice hull reinforced PP composite shows the increase in tensile stress and strain at fracture. However the addition of copolymer decreases the elastic modulus of that composite (Tay, 2010).

The impact behavior of Wood Flour (WF) reinforced polyol from tung oil and polyurethane increases with the WF content(Srekala, 2003).

Composite reinforced with wood particle and *microcrystalline Cellulose* (MC) used *polypropylene-graft-maleic anhydride*(PP-g-MA)as *compatibilizer*. The result shows that the tensile strength, flexural and impact strength are higher than the pure PP and composite without MC (Alireza, 2010).

Hybrid bamboo and precipitated calciumcarbonate (PCC) fillers reinforced a recycled polypropylene/polyethylene composite. Compounding the PCCparticles with the plastic resin helped separate anddisperse them in the matrix. The tensile and flexural moduli of this composite were improved with the increase of PCC content (Birm June Kim, 2012).

In this paper, the natural particle from the agriculture waste i.e. coconut shell particle is used to reinforce polyester. To maintain the lower cost of these natural composite, the compatibilizer is not used. The composite is prepared using hand lay-up technique. The mechanical properties are analyzed by conducting the tensile and flexural tests.

MATERIALS AND METHODS

Materials

The matrix was unsaturated polyester resin, Yukalac 157 BQTN-EX. The specific gravity of cured polyester is 1.215 at 25°C and the viscosity number is 4.5-5.0 poise. The polymer matrix was received in liquid form (Anonim, 2008). The catalyst for the resin was Metil etil keton and peroksida (MEXPO). The

coconut husk was a waste of coconut industry. The particles were extracted from the coconut shell (CS) by skin of the shell and sieving the particle. The coconut shell usually consists of 26% cellulose, 29.4% lignin, pentose 27.7%, water 8% and ash 0.6% (DOE Fuel, 2008). The CS particles went through ASTM C136 sieving and result in particle size of 0.425-0.595 µm. The CS particle was immersed in the NaOH aqueous solution 5% by weight for 2 hours, washed with distilled water and then drying for 72 hours at room temperature.

Preparation of the Composite

The loadings of the CS fiber were 10%, 15%, 20%. The resin was manually mixed with the filler. Then the 1% catalyst was added into the mixture. The mixture was than poured into the glass mould which is already layer by the mirror glaze for releasing the composite after it dry. The load than introduce into the mould to give the pressure on the composite. After 8 hours, the composite was taking out from the mould and store in the furnace for curing at 60°C for 4 hours. Cured composite was then cut into tensile and bending specimen.

Tensile and Flexural Test

Tensile and flexural tests were conducted to evaluate the mechanical properties of the composites. The tensile and flexural tests were carried out using the Universal material tester machine series of WP 310. The tests were carried out at room temperature. The tensile test and flexural test were carried out according to ASTM D3039 and ASTM D790-92 standard, respectively. Scanning micrograph of the composite was carried out using SEM Philips XL-20.

ResUlt and discussion

Morphology of CS Particle

The particles from coconut shell are widely varied in size. The variation in size is due to the extraction method of CS particle. The diameter of the particle is around 50-500 µm. The extraction of the coconut shell by skinning other than grinding is chosen to maintain the strength of the CS particle. The skinning causes the particle to be twine and some of the particle is agglomerate as shown in Figure 1. The agglomeration of the particle tends to decrease the strength of the composite since the transfers of the load to the fiber become inadequate.

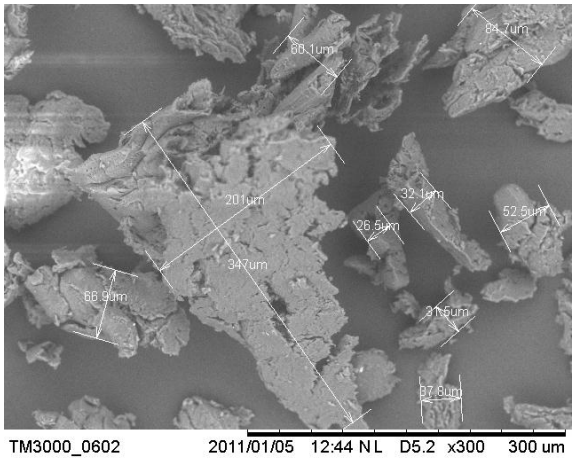

Fig.1 Morphology of CS Particle

Mechanical Properties of Composite

The elastic modulus of Polyester/CS composites is increases as shown in Fig.2. In the range of a given weight fraction of CS particle, the elastic modulus increases with the addition of CS particle until it reaches the optimum value at 15% fiber loading.

For both composites, the increasing of elastic modulus is due to a rise of the constraint of the matrix yielding by the filler. The elastic modulus is measured at relative low deformation. Hence other factors that affects the composite properties e.g. the interface adhesion, does not affect the elastic modulus.

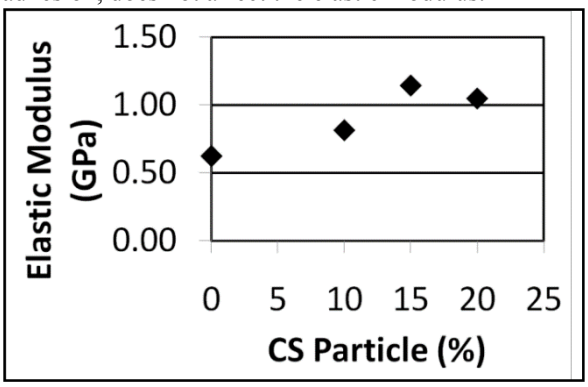

Fig.2 Elastic Modulus as a Function of CS Particle

In Fig.3, the tensile strength of Polyester/CS composite is increases gradually with the filler loading. In polyester/CS composite, the hard CS particle act as a barrier for matrix yielding and crack growth, result in higher composite tensile strength. However, the enhancement is not high enough since the filler size is quite large. The particle size up to a few microns gives an optimum reinforcement on polymer composite (Shao-Yun Fu, 2008). The other factor is the interfacial adhesion between matrix and particle, observation from SEM micrograph shows an adequate compatibility as shown in Figs. 6-9. It is indicates with minimum gap between matrix and the fillers.

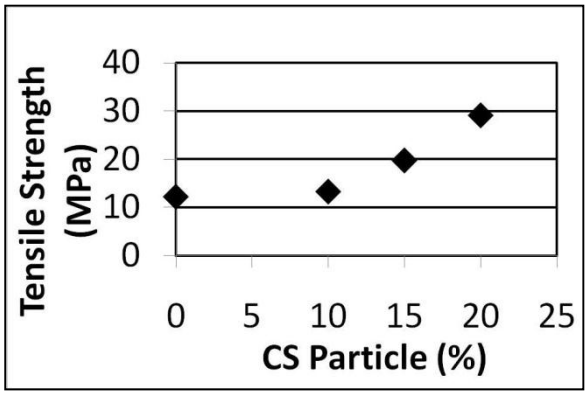

Fig.3 Tensile Strength as a Function of CS Particle

The strain at failure slightly increases only at high particle loading of 20% as shown in Fig.4. It seems that the CS particles less affected the failure strain.

The flexural strength increases significantly with the CS particle content as can be seen in Fig. 5. The flexural strength is higher than the tensile strength. Composite is not a homogeneous material although in some case, random composite is considered as one. Under tensile loading, all part of the specimen is at the same stress hence the specimen will fail at its weakest part. Under flexural loading, the maximum stress is controlled by the intact part of the specimen. Therefore if the intact part is the strongest part i.e. the load is sustained by the particle, then the flexural strength is high. It is well known that the flexural strength is sensitive to the surface defect.

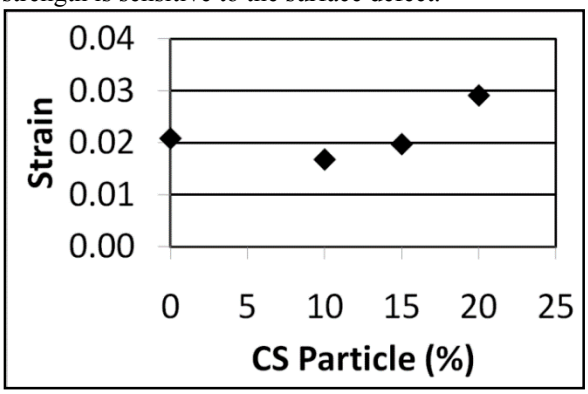

Fig.4 Strain at Failure as a Function of CS Particle

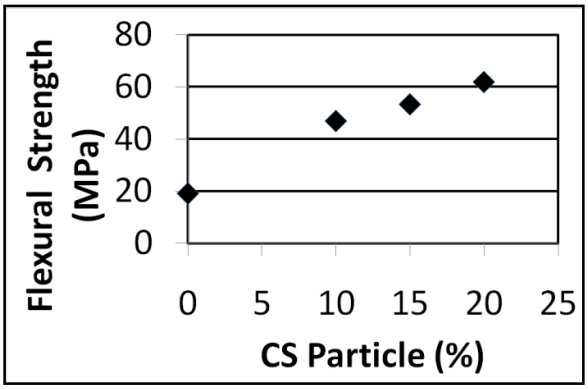

Fig.5 Flexural Strength as a Function of CS Particle

From the scanning electron micrograph in Figs. 6-8, as the particle content increases, there is more reinforcement to the composite by the particle. As a result, the tensile and flexural strength of composite are increases. Figure 9 shows the SEM image of fracture of tensile specimen. The fracture surface is similar with the flexural specimen.

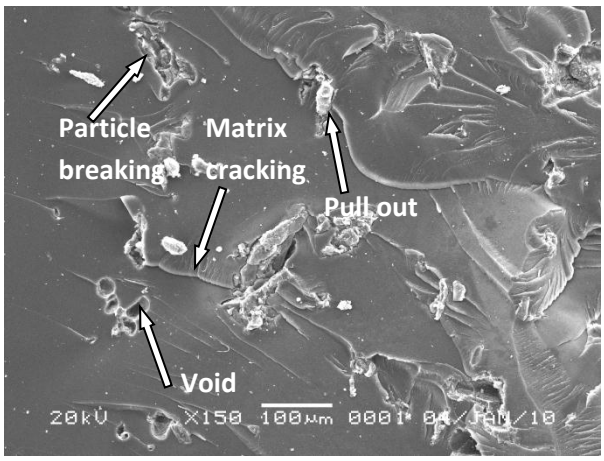

Fig.6 Fracture under Flexural Loading of Polyester/10%CS Particle Composite

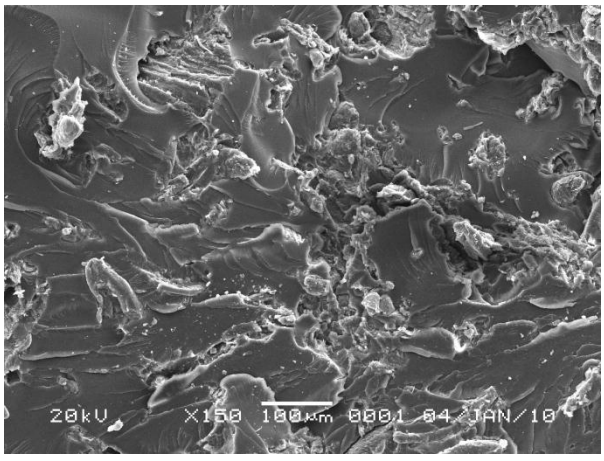

Fig.7 Fracture under Flexural Loading of Polyester/15%CS Particle Composite

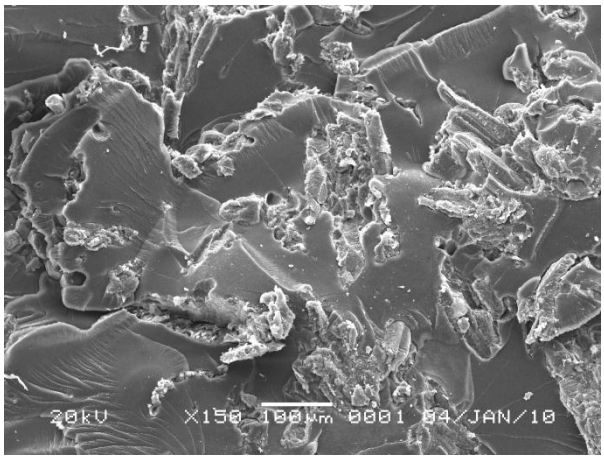

Fig.8 Fracture under Flexural Loading of Polyester/20%CS Particle Composite

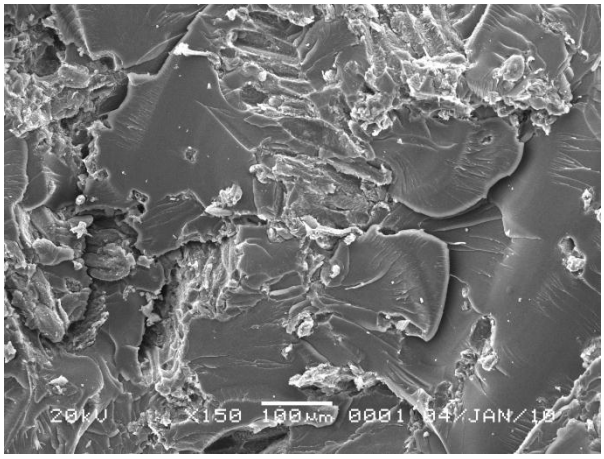

Figure 9 Fracture under Tensile Loading of Polyester/15%CS Particle Composite

CONLUSIONS

The coconut shell reinforced polyester matrix was prepared using hand lay-up technique. Incorporation of CS particle to the polyester matrix shows an increase in tensile strength and flexural strength of polyester/CScomposite. Elastic modulus and strain at failure increased at certain loading of particle. The strain at failure slightly increases at high loading.

The interface adhesion without compatibilizer was sufficiently to transfer stress. This was exhibited in increasing of mechanical properties as compare with the pure PP.

This composite has a potential use in the future as reinforcement because of its adequate strength.

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