Advances in Environmental Biology, 7(6): 1101-1104, 2013
ISSN 1995-0756

This is a refereed journal and all articles are professionally screened and reviewed **ORIGINAL ARTICLE**

Effect of Fiber Volume Fraction on Tensile Properties of Rice Husk Reinforced Polyester Composites

S.A. Syed Azuan

Universiti Kuala Lumpur Malaysia France Institute, 43650 Bandar Baru Bangi, Selangor, Malaysia

S.A Syed Azuan: Effect of Fiber volume fraction on Tensile Properties of Rice Husk Reinforced Polyester Composites

ABSTRACT

The effect of fiber volume fraction on the tensile properties of rice husk reinforced polyester composites was studied. Tensile properties was evaluated by using different volume fraction of rice husk fibers, (5%, 10%, 15% and 20%). Composites were produced by using a hand-layout technique. Untreated rice husks were mixed with unsaturated polyester and pour into the mould. Analysis of variance (ANOVA) was conducted at the end of the experiment by using one way ANOVA. The results showed the decreased tensile strength and tensile modulus when increasing the fiber volume fraction, which indicates that ineffective stress transfer between the fiber and matrix.

Key words: Tensile properties, Rice husk, Natural fiber composites

Introduction

The use of natural fiber as a reinforcement in polymer matrix composites has received increasing attention both by the academic sector and the industry. Natural fibers have many significant advantages over synthetic fibers. Currently, many types of natural fibers [1-5] have been investigated for use in plastics including flax, hemp, jute straw, wood, rice husk, wheat, barley, oats, rye, cane (sugar and bamboo), grass, reeds, kenaf, ramie, oil palm empty fruit bunch, sisal coir, water, hyacinth, pennywort, kapok, paper mulberry, banana fiber, and pineapple leaf fiber. They are environmentally friendly, fully biodegradable, abundantly available, renewable and cheap and have low density.

Mechanical properties of plant fibers are much lower when compared to those of the most widely used competing reinforcing glass fibers[6]. However, because of their low density, the specific properties (property-to-density ratio), strength, and stiffness of plant fibers are comparable to the values of glass fibers [7]. Unsaturated polyesters are extremely versatile in properties and applications and have been a popular thermoset used as the polymer matrix in composites [8].

They are widely produced industrially as they possess many advantages compared to other thermosetting resins including room temperature cure capability, good mechanical properties and transparency.

Rice husk is one of the biomass materials abundantly available in Malaysia. Rice husk can be obtained easily from the rice mill plants which are rendered as a waste and can be explored as a potential reinforcement. Rice husks makes up about 20% of the rice (paddy) weight. Nowadays almost 70% of the rice husks are not commercially used [9]. According international estimates the rice demand by 2020 will growth to 780 million tons.The uses for rice husk are continually growing. Today it is increasingly used as biomass to fuel and co-fuel power plants. Other uses are in horticulture (soil aeration), animal bedding, and composites (WPC decking, materials & furniture).

The first such as a project in Malaysia using rice husk bio-composite was made possible by the Techno Fund grant, awarded by the Ministry of Science, Technology and Innovation in late 2007 [10].

In this project, natural fibre materials are compounded in larger composition and extruded with a certain amount of thermoplastics, while additives are used for ease of processing and for promoting the bonding between the otherwise incompatible natural fibre and thermoplastic components. Research in rice husk normally used in ground size / powder / filler form rather than used it directly like other natural fibers[11,12].

Corresponding Author

Syed Azuan Syed Ahmad, Department of Mechanical and Manufacturing,Universiti Kuala Lumpur, Malaysia France Institute, Malaysia
E-mail: syedazuan@mfi.unikl.edu.my

Adv. Environ. Biol., 7(6): 1101-1104, 2013

Therefore, in this paper, the main objective is to investigate the uses of ungrounded rice husk by addresses it performance by analyzing the effect of volume fractions on the composite tensile properties.

Experimental Methods:

Rice husk is the outermost layer of protection encasing a rice grain as shown in Fig. 1. It is a yellowish colour and has a convex shape. It is slightly larger than a grain of rice, thus length up to 7 mm are possible. Typical dimensions are 4 mm - 6 mm and it is lightweight in density. Rice husk was obtained from the rice mill located at Simpang Empat, Perlis, Malaysia

.

Fig. 1: Rice husk

The rice husk subsequently washed by using water to remove the dirt and later dried in the sunlight until all the moisture is removed from the rice husk. No chemical treatment has been made to the rice husk in an attempt to simulate the original strength of the rice husk. Polyester resin is obtained from Luxchem polymer under the trade name of Polymal 820-1-WPT(P). It appears as clear yellow colour liquid with viscosity of 400 cps and specific gravity of 1.13.

The composites with rice husk loading 5%, 10%, 15% and 20% of volume fraction were fabricated using hand lay up method with size mould of 200 mm (length, *L*) × 150 mm (width, *W*) × 3 mm (thickness, *T*). Initially, polyester resin and hardener were mixed with ratio 200 : 2 to form a matrix. Then, fibers were spread into mould and covered with the matrix. The composites were compressed until thickness of 3 mm was achieved. The curing time was about 24 hours applied near room temperature (25-30°C). Finally, composites plates were cut into the tensile specimens based on ASTM standard D638 – Type 1 as shown in Fig. 2. Tensile tests were conducted by using Instron universal testing machine at Universiti Kebangsaan Malaysia. The tests were performed at the crosshead speed of 10 mm/min.

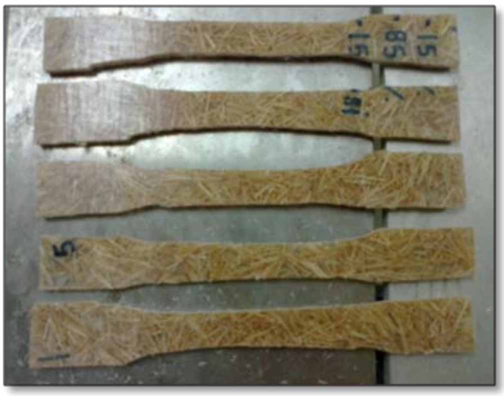

Fig. 2: Tensile specimen Each value obtained represented the average of five samples.

Result And Discussion

Fig. 4 and 5 showed the results of tensile strength and tensile modulus with the increase in percentage of rice husk volume fraction, respectively. Fig. 4 result showed that the tensile strength of pure polyester is much higher than reinforced composites. There is a decrease trend in the ultimate strength of the composite with the increase in the rice husk volume fraction. There was not much difference in tensile strength value from 5 vol% to 20 vol%. The highest tensile strength for rice husk reinforced polyester composites is obtained at 5 vol% with value of 10 MPa, in average. It was 75% reduction of tensile strength value compared to the pure polyester. The result from this current study is similar to the result obtained from by Ishak et al.,[11] which used ground rice husk /polyester composites. It has been observed that the increasing ground rice husk (sieved size of 120 -200 um) volume fraction resulted in 68% reduction tensile strength.

Fig. 5 indicated the tensile modulus for the rice husk reinforced polyester composites. It shows the decreasing trend when increasing the rice husk volume content. This maybe due to the fact that the load for fiber is low than the load for matrix itself.

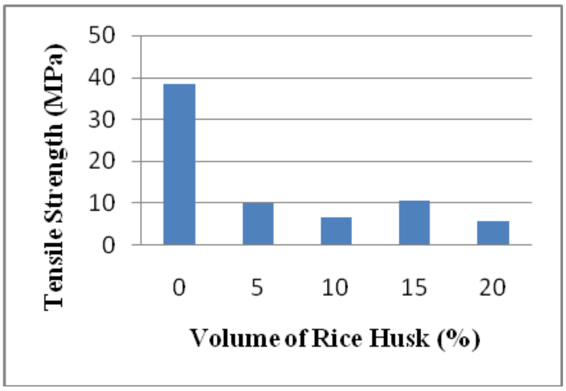

Fig. 4: Effect of rice husk volume fraction on tensile strength

From the two figures, the strength and modulus decreased as in increasing of rice husk volume fraction. The decrement is due to poor interfacial bonding between rice husk and matrix. The brittleness of the rice husk also contributed to low mechanical strength because higher fibers contain higher possibilities of the fibers to sustain load. The concave shape of the husk also contributed to the incomplete wettability or bonding between rice husk and polyester resin and also poor in their capability to support stress transmission in form of the matrix.

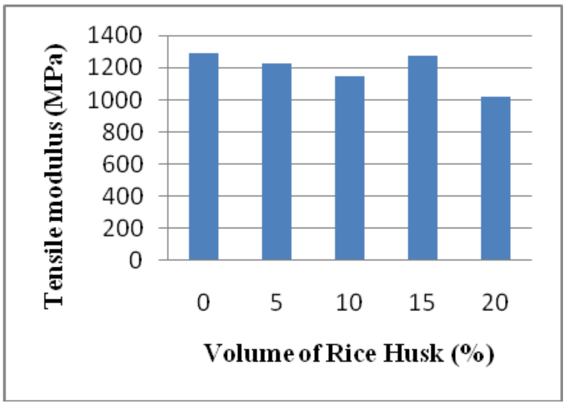

Fig. 5: Effect of rice husk volume fraction on tensile modulus

Rozman et al.,[12] investigated the effect of rice husk loading, percentage of rice husk hydroxyl and rice husk size on the mechanical properties of rice husk / polyurethane composites found that the increased of rice husk volume fraction also increased the tensile strength. It also mentioned that the size of rice husk also played a significant role in the properties, where smaller size of rice husk produced composites with higher strength. However, based on the reduced size of rice husk in the previous study[11] the result of tensile strength is similar to the originally size / ungrounded rice husk in this present study.

Statistical analysis has been carried out by one-way analysis of variance (ANOVA) and the results are shown in Tables 1 and 2 for the difference fiber volume fraction regarding tensile strength and modulus respectively.

ANOVA analysis shown in Table 1 decomposes the variance of tensile strength into two components: a between-group component (BG) and a within-group component (WG). The F-ratio, which in this case equals 313.7, is a ratio of the BG estimate to the WG estimate. Since the P-value of the F-test is less than 0.05, there is a statistically significant difference between the mean tensile strength from one fiber loading of composite to another at the 95.0% confidence level.

ANOVA analysis shown in Table 2 decomposes the variance of tensile modulus into two components: a between-group component (BG) and a within-group component (WG). The F-ratio, which in this case equals 1763.8, is a ratio of the BG estimate to the WG estimate. Since the P-value of the F-test is less than 0.05, there is a statistically significant difference between the mean tensile modulus from one level of composite to another at the 95.0% confidence level.

As indicated in Table 1 and 2 , because the significant value of fibre volume fraction (0.000) is less than the threshold value (0.05), it can be concluded that the increasing of fiber volume fraction has effect the tensile strength and tensile modulus by decreasing the strength and modulus value.

Table 1: ANOVA test for tensile strength of various fiber volume fraction

Source	SS	df	MS	F-Ratio	P-value
BG	3739.8	4	934.9	313.7	.000
WG	59.6	20	2.98		
Total	3799.4				

Table 2: ANOVA test for tensile modulus of various fiber volume fraction

Source	SS	df	MS	F-Ratio	P-value
BG	246230.0	4	61557.5	1763.8	.000
WG	698.0	20	34.90		
Total	246928.0	24			

Conclusion:

Tensile properties of rice husk reinforced polyester composites was investigated and presented. The results showed that tensile properties decreased as the rice husk volume increased. This is because as the fiber volume fraction increased, thereby increasing the interfacial area, the worsening interfacial bonding between fiber and matrix polymer decreased the tensile strength. The optimum percentage of rice husk in polyester resin to obtain the highest tensile properties was found at 5 vol% but there was no effect of addition more than 5 vol% to the tensile properties of composites. The role of the matrix in a fiber reinforced composite is to transfer stress between the fibers, to provide a barrier against an adverse environment and to protect the surface of the fibers from mechanical abrasion. For rice husk cases, polyester resin didn't play it role in transferring the stress due to the adhesion problem.

Beside that poor rice husk matrix interactions and rice husk dispersions are believed to be responsible for the poor ultimate strength properties. The square like shape of rice husk fiber indicated by their lowest aspect ratio , also made rice husk fiber to contribute less on stress dispersion than those higher aspect ratio.The fact that the strength of the composites specimens are not as strong as other natural fibers (jute, sisal, coir, hemp, flax) reinforced polyester composites[13] it doesn't mean to necessarily exclude the potential use of rice husk as reinforcement in composites. Therefore, more studies are needed to determine the beneficial and cost effective applications of rice husk in composites.

References

1. Amar, K.M., M. Manjusri and T.D. Lawrence, 2005. Natural Fibers, Biopolymers, and Bio-composites. CRC Press, Tailor & Francis.
2. Jain, S., R. Kumar and U.C. Jindal, 1992. Mechanical behavior of bamboo and bamboo composite. J Mater Sci., 27(4): 598-604.
3. Wambua, P., U. Ivens and I. Verpoest, 2003. Natural fibers: can they replace glass in fiber-reinforced plastics? Compos. Sci. Technol., 63: 1259-1264.
4. Geethamma, V.G., R. Joseph and S. Thomas, 1995. Short coir fibre-reinforced natural rubber composites: effects of fibre length, orientation and alkali treatment. J App Polym Sci, 55(5): 83-94.
5. Ahlblad, G., A. Kron and B. Stenberg, 1994. Effects of plasma treatment on mechanical properties of rubber/cellulose fibre composites. Polym Int, 33(10): 3-9.
6. Li, Y., Mai and Y-W. Lin, 2000. Sisal fibre and its composites: a review of recent developments. Compos Sci Technol, 60(20): 37-55.
7. Bledzki, A.K., and J. Gassan, 1999. Composites reinforced with cellulose based fibers. Prog. Polym. Sci., 24: 221-274.
8. Sharifah, H.A., P.A. Martin, T.C. Simon and R.P. Simon, 2005. Modified polyester resins for natural fiber composites. Compos. Sci. Technol, 65: 525-535.
9. Rice husk Technology. Retrieved Nov 2011, from http://www.poerner.at.
10. Ruhil, A., 2010. First-of-its-kind green furniture using rice husk set to enter market in 2010. Retrieved Nov 2011, from http://www.sirim.my/press.
11. Ishak, A., R.A.B. Dayang, N.M. Siti, and R. Anita, 2007. Direct Usage of Products of Poly(ethylene terephthalate) Glycolysis for Manufacturing of Rice Husk/Unsaturated Polyester Composite. Iranian Polymer Journal., 16(4): 223-239.
12. Rozman, H.D., L.G. Ang, G.S. Tay and A. Abu Bakar, 2003. The mechanical properties of rice husk–polyurethane composites. Polymer – Plastic Technology Engineering, 42(3): 1237-1247.
13. Ticoalu, A., T. Aravinthan and F. Cardona, 2011. Experimental investigation into gomuti fibres/polyester composites. Centre of Excellence in Engineered Fibre Composites, Faculty of Engineering and Surveying, University of Southern Queensland, Toowoomba, Queensland, Australia. Retrieved Nov 2011, from http://www.usq.edu.au/ceefc