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Recycle of Plastic Waste and Agricultural Waste

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ABSTRACT

Manufacturing of polymer composites using plastic waste is one of the solutions to solve the environmental pollution problems caused by non-biodegradable polymer. In this study, Rice husk fiber Reinforced Polyethylene composites (RhRP) have been fabricated with rice husk fiber and plastic waste (recycle low density polyethylene) by compression molding method. Effect of fiber volume fraction, pressure and temperature on the properties of the composite samples was studied. In addition, mechanical properties, thermal properties and durability of RhRP composites were measured. Moreover, chemical modification of rice husk fiber was done through acid and aqueous alkaline solution. The modified fiber samples exhibit the higher strength as well as the lower water absorption rate compared with the unmodified fiber composite samples. Therefore, the resistance to aging of the composites in aqueous environment improved significantly for the modified composite samples. Furthermore, Scanning Electron Microscope (SEM) was also used to characterize the surface feature and the interfacial adhesion between fiber and matrix polymer. The modified composite samples reveal better interfacial adhesion than the unmodified composite ones. Thermo Gravimetric Analysis (TG/DTA) was employed to determine thermal stability of the composite samples. The modified fiber samples have higher thermal stability than the unmodified composite ones.

Keywords: Rice Husk, Plastic Waste, Chemical Modification, Fabrication, Mechanical Properties

1. INTRODUCTION

In Myanmar, paddy is the most widely planted crops. Therefore, many million tones of rice husk would be available yearly. Usually, the husks are used for low-valued applications such as chicken litter, juice pressing aid and animal bedding. Then, the extra husks are burnt in open field which create growing problems of atmosphere (Luh, 1980). Similarly, plastic waste (recycle polyethylene) was obtained from public waste which can cause the disposal problems. Therefore, the environmental pollution problems can be prevented by fabrication of value-added rice husk fiber reinforced polyethylene composites. The objective of this work is to solve the environmental pollution problems caused by non-biodegradable polymer and agro waste.

2. MATERIALS AND METHODS

2.1. Raw Material

Rice husks were obtained from local paddy. The chemical compositions of rice husk are shown in **Table 1**. The recycle low density polyethylene (plastic waste) was collected from public waste with the density of 0.91-0.95 gcm^{-3} and the melting point of 110-120°C (Anonymous, 1992).

Table 1. Chemical compositions of rice husk

Components	Percent (w/w)
Cellulose	35
Hemicellulose	25
Lignin	20
Silica	16
Ash	1
Extractives	1

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2.2. Sample Preparation

Rice husk fiber Reinforced Polyethylene composites (RhRP) were fabricated by compression molding method. First, rice husk fiber and plastic waste (recycle low density polyethylene) powder were thoroughly mixed and placed in a mould. This mat was slowly transferred to hydraulic hot press. During fabrication, temperature and pressure were adjusted; finally, rice husk fiber polyethylene composite was obtained (Mar, 2002). Rice husk fiber was modified by aqueous alkaline solution and acetic acid. Rice husk fibers were immersed in 2% w/v NaOH solution for 24 h at ambient temperature and then washed with distilled water until all NaOH was eliminated. The fibers were dried at 60°C for 24 h. Similarly, rice husk fibers were soaked in 2% v/v glacial acetic acid for 24 h at ambient temperature. The fibers were washed with distilled water and dried at 60°C for 24 h (Gonzelez, 1998).

3. RESULTS AND DISCUSSION

3.1. Tensile Properties

Fiber to polymer ratio, pressure and temperature were varied during fabrication. Then, the tensile strength of the composites was tested.

The results were shown in **Fig. 1a-c**. In **Fig. 1a**, the strength of the composite samples gradually increased to maximum about 202.33 kg cm^{-2} at fiber to polymer ratio 3: 2.

In this case, fiber wetting, dispersion and PE penetration into some of the lumens of rice husk fiber are excellent (Thwe and Liao, 2003).

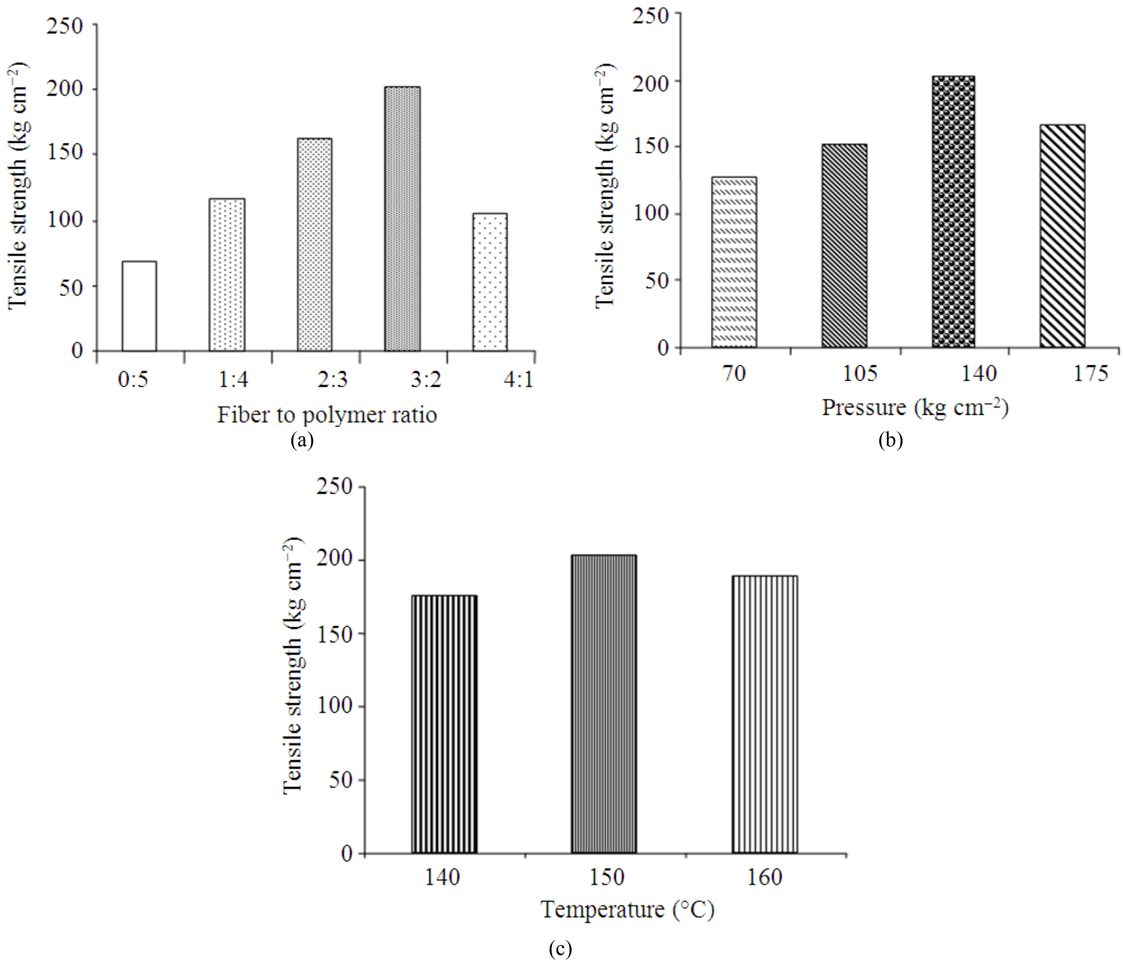


Fig. 1. Tensile strength of RhRP composites (a) at various fiber to polymer ratio: Temperature (150°C), pressure (140 kg cm^{-2}) and processing time (15 min) (b) at differenat pressure: Fiber: Polymer (3:2), temperature (150°C) and processing time (15 min) and (c) at different temperature: Fiber: Polymer (3:2), pressure (140 kg cm^{-2}) and processing time (15min)

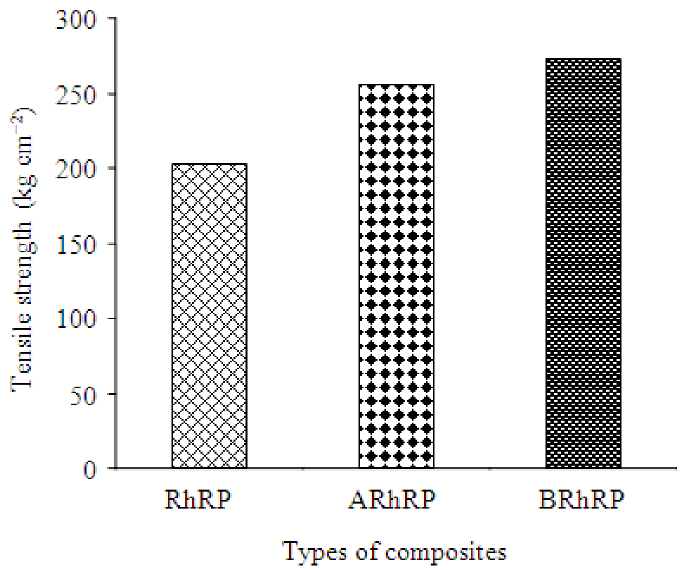
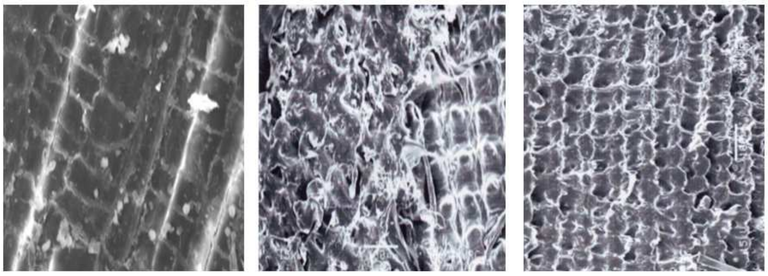
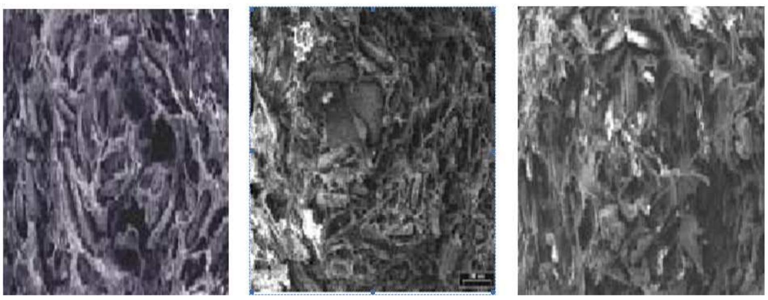


Fig. 2. Tensile strength of RhRP composites



(a) (b) (c)

Fig. 3. SEM micrograph of (a) unmodified fiber (b) acid modified fiber and (c) alkali modified fiber



(a) (b) (c)

Fig. 4. SEM micrograph of the fracture surface of (a) unmodified composite samples (b) acid modified composite samples and (c) alkali modified composite samples

When fiber to polymer ratio 4:1 was reached, the strength of the composite samples rapidly went down by approximately 104.57 kg cm^{-2}. There exists very little interaction between fiber and matrix interfaces in that volume fraction. In **Fig. 1b**, the strength of the composite samples went up until the pressure 140 kg cm^{-2} and then, dropped markedly.

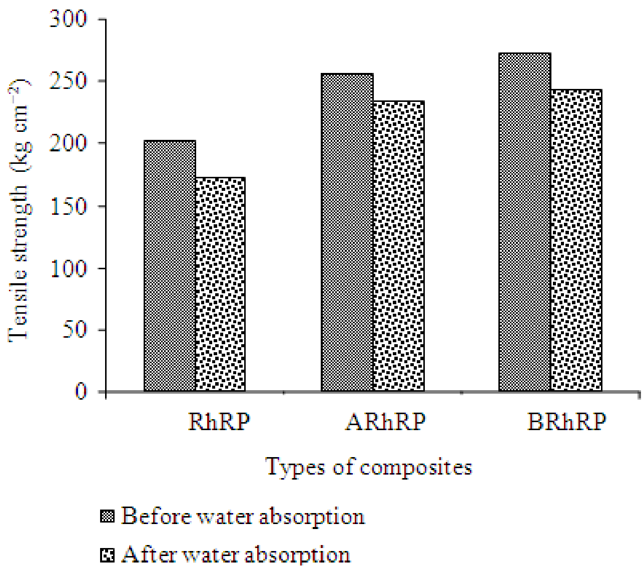


Fig. 5. Tensile strength of RhRP composites before and after aging

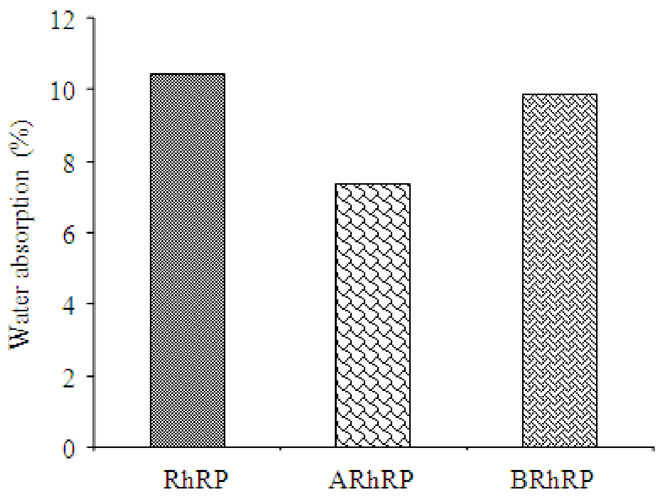


Fig. 6. Water absorption rates of RhRP composites

At that pressure, the fiber and matrix interface interaction is the most significant compatibility. Then, it is reduced to the exceeding of that pressure. **Figure 1c** can be found that the composite samples have achieved the highest tensile strength at temperature 150°C. At that temperature, the matrix polymer revealed a complete fusion in compression molding.

3.2. Effect of the Modified Fiber

Figure 2 indicates that the strength of the modified composite samples significantly increased. The strength of alkali (BRhRP) and acid (ARhRP) modified composite samples raised to 35 and 26% respectively, compared with the unmodified composite samples. After the fibers had been treated, their surface became more roughness as shown in **Fig. 3**. Therefore, the interfacial adhesion between fiber and matrix polymer interface interaction is stronger as shown in **Fig. 4**.

3.3. Effect of the Absorbed Water

After aging had been carried out, the strength of the samples was tested again.

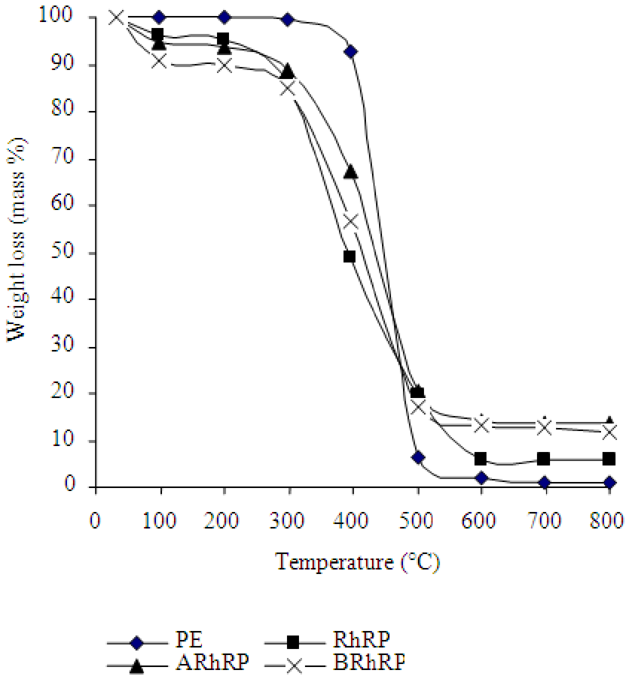


Fig. 7. TGA thermo gram of RhRP composites

In **Fig. 5**, the strength of the composite samples showed the negative effect. However, the strength of the modified composite samples has less decreased than that of the unmodified composite ones. The retention of the composites strength after aging depends on the interfacial adhesion between fiber and matrix polymer (Gonzelez, 1998). The absorbed water can cause the reduction of the mechanical properties of the composites as a consequence of the moisture sorption behavior and the organic nature of the natural fiber (Thwe and Liao, 2003). Furthermore, water diffusion through the matrix makes weakening the adhesion between fiber and polymer matrix.

3.4. Aging Properties

Aging resistance of all samples was carried out at ambient temperature for 60 days. The results are shown in **Fig. 6**. It can be clearly found that the acid modified composite samples have lower water absorption percent than alkali modified and unmodified composite ones. The fiber became more hydrophobic after modification due to the free Hydroxyal (-OH) groups available on cellulose compounds had linked together with acetyl groups from acetic acid and Na^+ groups from sodium hydroxide.

3.5. Thermal Properties

Thermo gravimetric analysis was carried out in order to understand the difference in thermal stability of various types of rice husk fiber composite samples and the results are shown in **Fig. 7**. All the TGA curves of the composite samples show two-step decomposition whereas the curve of PE shows only one, indicating their distinct individual thermal characteristics. The first stage of thermal decomposition occurred at the temperature between 100 and 350°C and the second stage occurred at the temperature between 350 and 450°C while PE was completely decomposed at 500°C. At 800°C, 13.5 and 11.8% of residue were observed for Acid modified Rice husk fiber Reinforced Polyethylene composite (ARhRP) and alkali modified Rice husk fiber Reinforced Polyethylene composite (BRhRP), respectively. Therefore, the modified fiber in RhRP composite samples has exceedingly affected on the thermal stability of the composite samples.

4. CONCLUSION

From the results, fiber to polymer ratio (3:2), pressure (140 kg cm^{-2}) and temperature (150°C) are found to be suitable for preparing rice husk fiber polyethylene composites. Moreover, the modified rice husk fiber composites has affected on the tensile strength of the composite samples. However, the absorbed water can cause the reduction of the mechanical properties of the composite samples. Alkali modified composite samples are more water uptake than the acid modified ones. In addition, the modification of fiber has also affected on the thermal stability of the composite samples. Similarly, the modification of fibers has also affected on the morphology of the fiber surfaces and the interfacial adhesion between fiber and matrix polymer. In RhRP composites, rice husk fiber as a reinforcing filler and plastic waste as a matrix polymer were used which can solve the environmental pollution problems and reduce the cost of the composite materials. It can be suggested that rice husk fiber reinforced polyethylene composites are recommended to be used as structural materials such as ceiling sheet, interior decoration and partitioning panels, light weight building materials and furniture for rural public their low-cost housing.

5. ACKNOWLEDGEMENT

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