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INVESTIGATION OF POLYMER MATRIX COMPOSITES REINFORCED WITH SAWDUST AND RICE BRAN

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Abstract: Due to the global demand for fibrous light-weight materials, research on composites reinforced with plant materials has increased. Natural fiber reinforced composites offer several advantages: light weight, competitive specific mechanical properties, easy processing, large volume availability, low cost, and low environmental footprint. Especially, using agricultural wastes such as rice bran saw dust etc. as fillers/fibres in composites provides the chance to improve material properties while improving their sustainability. In the present work, rice bran and saw dust were chosen as fillers for their differing morphology, aspect ratios, and difference of structure. As matrices, polyethylene (PE) and polypropylene (PP) were studied, either neat or modified with maleic anhydride grafted PP/PE as coupling agent or compatibilizer between hydrophobic matrices and hydrophilic bio-fillers. The bending modulus is improved due to filler addition. In presence of compatibilizer, the improved interfacial interaction leads to improved bending and tensile strength as well as toughness. Furthermore, the influence of the filler and compatibilizer on composite properties such as hardness, dynamic mechanical behaviour, thermal expansion, thermal degradation, melting and crystallisation behaviour are presented and mechanical properties has been enhanced through composites.

***Index Terms* - Sawdust, Rice bran, Composites, Interphase, Polymer.**

I. Introduction

The global demand for light-weight materials calls for the broad use of fiber-reinforced plastic materials. Developing composites using natural fibers provides the chance to improve materials while decreasing their ecological footprint. Even using agricultural and forestry wastes such as rice bran, and saw dust (SD) can lead to significantly improved material properties. Rice bran and saw dust, by-products of the rice milling and wood sawing processes respectively, are potential reinforcing fillers for thermoplastic matrix composites because of their lingo cellulosic characteristics. These fillers offer advantages of easy processing, large volume availability, annual renewability, low cost, light weight, competitive specific mechanical properties, and high sustainability. The morphology differs: Rice bran is made up of rectangular platelets and saw dust of short fiber bundles.

The most common thermoplastics used as matrices for bio-fillers are polyethylene (PE) and polypropylene (PP). When a polymer is used as a matrix for a bio-filler composite, the incompatibility between hydrophobic matrix and hydrophilic bio-filler is an important issue. Therefore, there have been many studies on improving interfacial interactions between the polymers and bio-fillers. According to previous studies, the best solution of the problem is using an appropriate coupling agent or compatibilizer such as maleic anhydride functionalized polymer, for example, maleic anhydride-grafted polypropylene (MAPP) for PP or maleic anhydride-grafted polyethylene (MAPE) for PE.

Biomaterials such as saw dust, bamboo powder, or grain bran used as fillers in polymer matrix composites are natural compounds, mainly containing cellulose, hemicellulose, and lignin. Their degradation takes place at a relatively low temperature, around 200°C. Therefore, bio-fillers will be subjected to thermal degradation during composite processing with the majority of common thermoplastic polymers. This leads to undesirable properties, such as odor and browning along with a reduction in mechanical properties of the bio-composite. Therefore, it is important to understand and predict the thermal decomposition processes of bio-filler in order to better design composite processes and estimate the influence of the thermal decomposition on composite properties.

In this work, the suitability of rice bran and saw dust as reinforcing agents for composites based on different polymer matrices was evaluated. The filler morphology is characterized. Mechanical tests of their composites were evaluated as a function of filler content and filler morphology. The effect of maleate polymer as compatibilizers on the mechanical properties of the composites as well as hardness of the composites was studied. Thermal studies of biomaterial-filled polymer composites included thermo mechanical analysis (TMA) and the thermal and mechanical dynamic behaviour according to the filler loading and the presence of compatibilizers. The crystallization is characterized by differential scanning calorimetry (DSC) analysis and the thermal degradation by thermo gravimetric analysis (TGA).

II. Experimental Materials and Methods

The polymer wastes are collected from house hold and corporational society. Rice bran obtained from a rice mill factory in Danang, Vietnam, was ground. Saw dust from Acacia auriculiformis tree was collected from a Wood processing factory in Danang, Vietnam. Rice bran and saw dust were screened and dried at 80°C for 24 h before preparing the composites. Where a wood block was used for comparison, its dimensions were the same as those of the composite samples in the tests. Test material details have been given for easily understanding the compositions of polymer composite such as sample 01 including the following details.

Polymer = 80% (by weight)

Saw dust = 10% (by weight)

Rice bran = 10% (by weight)

Fig. 2.1 Prepared samples of polymer composites

Fig. 2.1 Prepared polymer composite sheets

Table 1. The compositions of polymer composites

Sl No	Polymer (%)	Saw dust (%)	Rice Bran (%)
1	80	10	10
2	80	5	15
3	80	20	0
4	80	15	5
5	80	0	20

III. Results and discussion

3.1 Tensile test

The tensile testing was carried out to measure the force required to break the test material (plate of polymer composite) and find the extent to which the specimen stretches or elongates to the breaking point. Tensile tests produce a stress-strain diagram, which will be used to determine tensile modulus. In the tensile test, 5 test plates were used. They are tested by using a tensile testing machine, the test readings are noted and the readings are calculated as average readings, 2.603, 6.659, 6.922, 8.495 and 7.446. The readings were analyzed and the fourth reading is high and so, the fourth specimen is found to be better than other samples.

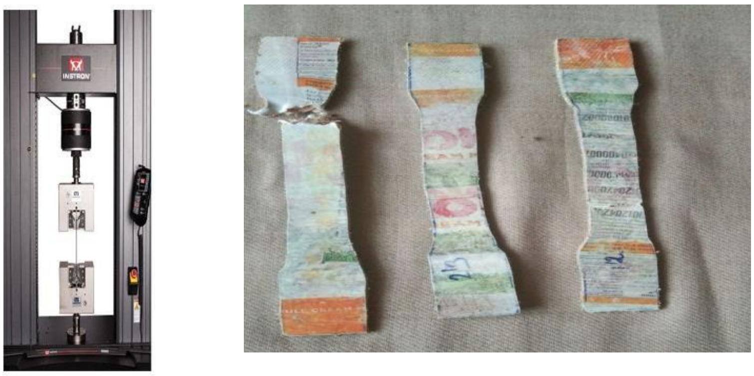

Fig. 3.1 Tensile test conducted experiments and tested samples

Table 3.1. The tensile test results with elongation and ultimate tensile strength

Polymer composite samples	Area (mm2)	Peak load (N)	% of Elongation	UTS N/mm2
Sample 01	45	175.59	5.32	3.294
	45	123.73	8.47	2.747
	45	51.11	1.59	1.138
			Average	2.063
Sample 02	45	314.19	8.89	6.985
	45	266.31	7.74	5.915
	45	317.80	8.45	7.06
			Average	6.654
Sample 03	45	252.47	7.47	5.611
	45	346.67	13.33	7.701
	45	335.32	14.37	7.45
			Average	6.922
Sample 04	45	368.18	7.57	8.191
	45	360.23	8.7	8.005
	45	417.97	10.75	9.29
			Average	8.495

3.2 Flexural test

Flexural testing is used to determine the flex or bending properties of a material. Sometimes referred to as a transverse beam test, it involves placing a sample between two points or supports and initiating a load using a third point or with two points. Maximum stress and strain are calculated on the incremental load applied. Results are shown in graphical format with tabular results including the flexural strength and yield the strength.

In the flexural test, 5 test plates were used. They are tested by using a flexural testing machine, the test readings are noted and the readings are calculated as average readings, 601.49, 704.014, 162.245, 588.073 and 593.594. The readings were analyzed and the second reading is high and so, the second specimen is found to be better than other samples.

Fig. 3.2 Experiments with flexural testing and tested samples

3.3 Impact test

The impact response of composite materials was of only minor interest prior to the introduction of carbon fiber in the mid-1960s. Before that time, the composites in use were primarily reinforced with glass fibers, which performed well under impact loads. This soon proved not to be true for carbon fibers, which are relatively brittle. But since their static strength and stiffness properties were very attractive, development of carbon fiber reinforcements for structural applications continued.

Table 3.2 The results of flexural testing with flexural strength and flexural modulus

Polymer composite samples	Area (mm2)	Peak load (N)	Flexural strength (MPa)	Flexural modulus GPa
Sample 01	39	20.699	16.718	679.23
	39	10.83	8.747	250.93
	39	16.93	13.676	873.87
			Average	**601.49**
Sample 02	39	15.19	12.27	534.10
	39	23.27	18.08	914.34
	39	17.27	13.95	663.58
			Average	**704.01**
Sample 03	39	20.611	16.647	41.296
	39	20.954	16.924	72.841
	39	22.426	18.113	372.765
			Average	**162.953**
Sample 04	39	23.014	18.588	154.053
	39	16.187	13.073	914.168
	39	15.961	12.892	696.34

			Average	**588.073**

Fig. 3.3 Experiments with impact testing and tested samples

Table 3.3. The results of impact testing with flexural strength and flexural modulus

Polymer composite samples	**Area (mm^2)**
Sample 01	0.8
	0.4
	1.15
Average	**0.783**
Sample 02	0.6
	0.75
	1
Average	**0.727**
Sample 03	1
	1.1
	0.75
Average	**0.95**
Sample 04	1.75
	1.25
	0.20
Average	**1.06**

In the impact test, 5 test plates were used. They are tested by using an impact testing machine, the test readings are noted and the readings are calculated as average readings, 0.783,0.783,0.95,1.06 and 1.06, The readings were analyzed and the second reading is high and so, the second specimen is found to be better than other samples. The performance of rice husk and saw dust fillers, in the polymer matrix of milk sachets were investigated. While comparing all the test specimens, it was found that the specimen with a composition of polymer 80%, saw dust 15%, and rice bran 5% is better than other specimens for tensile test. The specimen with a composition of polymer 80%, saw dust 5%, rice bran 15% is better than other specimens for flexural test. The specimen with a composition of polymer 80%, saw dust 15%, rice bran 5% is better than other specimens for impact test.

IV. Conclusion

From the test results it is concluded that the increase in weight % of saw dust & rice bran in the polymer matrix invariably increases the Tensile strength and impact strength , whereas decreases the flexural strength of the composites . The reason for the change of properties could be the cohesion between the saw dust and rice bran particles with the polymer matrix. The performance of rice husk and saw dust fillers, in the polymer matrix of milk sachets were investigated. While comparing all the test specimens, it was found that the specimen with a composition of polymer 80%, saw dust 15%, and rice bran 5% is better than other specimens for tensile test. The specimen with a composition of polymer 80%, saw dust 5%, rice bran 15% is better than other specimens for flexural test. The specimen with a composition of polymer 80%, saw dust 15%, rice bran 5% is better than other specimens for impact test.

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