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Unsaturated Polyester Resin and Rice Husk Composites

Mili S. Shah[1,*], Manthan Panchal[2], Ravi B. Patel[3], D.K. Bhoi[4]

Abstract

Plastic is a very useful and important part of human beings but it is quiet harmful to environment. The increasing demand for the eco-friendly material is growing interest towards the field of Composites. The Natural composites of Styrene Diluted Unsaturated Polyester resin are made. Various natural materials are used to make different composites. This study includes Rice Husk Composite of SDUPR. There are many methods to prepare composites. Methods such as Spray-Up, Pultrusion, Manual layup, Automated layup, Resin Transfer Molding etc. are used to make composites, in this study composites are made by manual layup method. Various sheets are prepared by different proportion of Rice Husk and SDUPR and curing agent is added to the mixture. In this study four different sheets are prepared having ratios 50:50, 55:45, 60:40 and 65:35. Tests like Flexural Test, Izod Impact test, Rockwell Hardness test and Biodegraiblity test are done. Hardness and degradation is varied as the ratio of Rice Husk and SDUPR varies. The comparison is shown among all the sheets prepared. It can be examined by comparing all four sheets that the mechanical properties are varied due to variation of Rice Husk and SDUPR ratios. By the results of all tests it is observed that as the ratio of Rice Husk increases the mechanical properties such as Flexibility, Hardness and Impact energy of product decreases and Biodegraiblity of product decreases.

Keywords: Biodegraiblity, composites, hardness, polyester resin, rice husk

INTRODUCTION

J.J. Berzelius first introduced the term polymer. He considered an example: Benzene is Polymer of Ethyene. It is a Natural or Synthetic Substance (very Large) which is made up of small molecules which are known as Monomers. Polymers are having very high molecular weight. Polymers are mainly divided into three parts: Thermoplastics, Thermosetting, and Elastomer. The Substances which becomes Plastic on heating and then harden on cooling. It becomes soft and Pliable from above by heat treatment are Thermoplastics, for example Acrylic, Polyester, Nylon, Polystyrene, Teflon. The Plastics which cannot be re–shaped means the plastics can only be shaped once are called Thermosetting Plastics, for example Melamine, Epoxy, Silicone, and Polyurethane. Elastomers are the Amorphous Polymers which are maintained their Glass transition. They have elasticity like Rubber. Their bonds are Feasible, for example Ethylene Propylene diene rubber, Fluoro elastomer, Nitrile Rubbers. There are three main Chain Polyester which can be classified as Aliphatic, Semi aromatic, Aromatic. There are two types of Polyester Resin: Orthopthalic and Isopthalic polyester Resin [1, 2].

When Multicomponent material is comprised with different phase's domains and from that at least one domain phase remains continue is called a Composite. In short Composites are made up of several elements. It is compulsory that phases should be non-gaseous. The phases may be solid or liquid (Figures 1 and 2).

*Author for Correspondence
Mili S. Shah
E-mail: milishah2408@gmail.com

[1]Research Scholar, Department of Chemistry, Silver Oak University, Ahmedabad, Gujarat, India
[2]Professor, Department of Chemistry, Silver Oak University, Ahmedabad, Gujarat, India
[3]Professor, Department of Chemistry, Shree P. M. Patel Institute of Post graduate Studies and Research in Science, Anand, Gujarat, India
[4]Professor, Department of Chemistry, J & J College of Science, Nadiad, Gujarat, India

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Figure 1. Raw Rice Husk.

Figure 2. Composite of Rice Husk and SDUPR.

The Composites in which at least one Component is Polymer is called a Polymer composite. Many different types of polymer composites are made such as Alkaline Polymer electrolyte, Glass Fiber Composites, Different gas sensing Composites conducting Polymer films, Natural Composites of Polymers etc. Composite Material must be made to attain the Properties which can't be attained by an individual material separately. The Distinctive materials should be united in three dimensions. Generally, the Biodegraiblity of Natural Composites of Polymers are beneficiary in respect of Pollution and Environment [2–5].

Reasons to Choose Styrene Diluted Unsaturated Polyester Resin (SDUPR)

The Thermoset Property of Unsaturated polyester resin is better than any other Polymers that's why researcher has gone through Research Work on Natural Composites of Unsaturated Polyester Resin. Unsaturated Polyester Resin are formed by the linear Polycondensation Reaction of Unsaturated and Saturated Acid/Anhydrides and Diols or Oxides. The Resins are of Pale Yellow Colored Oligomers and have a very low degree of Polymerization. The Oligomers may be Viscous Liquid or Brittle Solids, that depends on the Chemical Composition and Molecular Weight (1200-3000 g/mole). The Unsaturated Polyester Resins are widely used throughout the world due to its versatility, and low cost [6–11].

To increase the Mechanical, Chemical and Weather Resistance Properties Unsaturated Polyester Resin is combined with Vinyl monomers such as Propylene, Styrene, Vinyl chloride, Vinyl Acetate etc. The Cross linking reaction between Unsaturated Polyester Resin and Vinyl monomer will give a three dimensional network, which converts the resin system into a Hard thermoset solid from a Viscous liquid. Curing Agents are also added in the Resin such as Inhibitors, Retarders and co- promoters to increase/decrease the Resin pot life, Gel time and Cycle time. At the room temperature the gelation

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process is seen and after the gelation processes the movement of polymer chain is very difficult and the reaction becomes diffusion controlled. In this situation the low styrene residue is seen. While Molding process is going on, to compensate the polymerization Shrinkage Low Profile Additives (LPA) are added to Unsaturated Polyester Resin. The overall reaction of exotherm may decrease because LPA is a non-reactive component in the entire system. It can increase further when Styrene Residue. The resin which is used in the synthesis of natural composites of unsaturated polyester resin is a combination of Phthalic Maleic Propylene Glycol, Hydroquinone, Triphenyl Phosphate and Styrene. So it can be said that it is a Styrene based Unsaturated Polyester Resin. The Rice Husk composites are made using this Unsaturated Polyester Resin. Natural Material (Rice Husk) and Styrene Diluted Unsaturated Polyester Resin are mixed and treated with a curing agent and as a product Composites are formed [12–18].

MATERIAL AND METHODS

First of all, Raw Rice Husk is being taken and crushed it to convert it in Powder form. This powder form of Rice Husk is taken in a glass beaker then add 2% Benzoyl Peroxide as a curing agent to it. Mix it well with Glass rod. Now add Styrene Diluted Unsaturated Polyester Resin (SDUPR) to it and stir properly until all lumps removed. For heat treatment, take an iron plate of sized 260 mm x 260 mm with holes at all corners. The thickness of plate is 12 mm. Teflon sheet sized 180 mm x 180 mm be placed on it, then place the mixture in a square plate sized 150 mm x 150 mm having thickness of 9 mm. and cover it with another Teflon sheet of same size which is used at bottom. Now place the Second Iron plate of same size which we have used at bottom and tight all four corners with Nut and Bolts. Set the oven at 100 degrees Celsius and heat it for Two and half hours. Switch off the oven and give rest the material in Oven for 24 hours. Now remove it from oven and will get the Natural composite of Resin. The composition of Natural Ingredient and SDUPR are changed. 4 sheets of SDUPR with different proportions of Rice Husk and SDUPR are prepared (Table 1). But the proportion of Curing Agent (Benzoyl Peroxide) remains same as 1% of total weight of mixture [19–22].

Table 1. Proportion of rice husk and SDUPR.

Sr. No.	Particular	RHS-1	RHS-2	RHS-3	RHS-4
1	Amount of Rice Husk	100 gm	110 gm	120 gm	130 gm
2	Amount of SDUPR	100 gm	90 gm	80 gm	70 gm
3	Total weight Of Mixture	200 gm	200 gm	200 gm	200 gm
4	Amount of Benzoyl Peroxide	2 gm	2 gm	2 gm	2 gm
5	Ratio (Rice Husk: SDUPR)	50:50	55:45	60:40	65:35

RHS-1= 50:50, RHS-2= 55:45, RHS-3= 60:40, RHS-4= 65:35

To evaluate the product on different parameters, different testing procedures adopted such as Flexural test, Izod Impact test, Rockwell Hardness test and Biodegradability test. To check the Flexibility of the product Flexural test has been conducted, for Impact resistance of material Izod impact Strength Test, Rockwell hardness test for the hardness of the material and Biodegradability test for Degradation of the material.

RESULTS

Izod Impact Test is done for all sheets and impact angles are also varied and different Impact energy is noted (Table 2).

Table 2. Izod Impact Test.

Ratios Rice Husk: Resin	Impact Energy (J/cm^2)	Impact Angle
RHS-1	1.75	134
RHS-2	1.53	143
RHS-3	1.53	144
RHS-4	1.33	144

Rockwell Hardness Test is done by penetrating an indentor to all the sheets. Hardness is measured by using diamond indentor (Table 3).

Table 3. Rockwell Hardness Test.

Ratios Rice Husk: Resin	Hardness (Kg.mm)
RHS-1	24
RHS-2	17
RHS-3	8
RHS-4	5

Specific force is applied to measure the Flexural strength of samples. That force will bend the material and by this stiffness, Flexural rigidity etc. can be known. The results are shown in the tabular form (Table 4).

Table 4. Flexural Strength Test.

Ratios Rice Husk: Resin	Width (mm)	Thickness (mm)	Stiffness (N/m)	Young's Modulus of Bending (Mpa)	Load at Maximum Load (N)	Flexural Rigidity (Nmm2)	Work From preload to Maximum Extension (Nmm)	Preload (N)	Preload Speed (mm/min)
RHS-1	11.25	6.28	33125.25	2166.68	38.91	503089.76	60.50	0.5	2
RHS-2	10.51	7.17	14926.04	702.20	22.43	371191.14	36.87	0.5	2
RHS-3	9.56	8.77	24440.57	690.75	22.51	226689.90	34.23	0.5	2
RHS-4	9.34	7.20	5671.47	296.49	5.19	86135.39	5.68	0.5	2

Biodegraiblity is a very important parameter. It is measured for 30 days cycle and the weight loss shown in the tabular form (Table 5).

Table 5. Biodegraiblity Test.

Ratios Rice Husk: Resin	Weight (before treatment)	Weight (After 30 days)	Weight Loss (In Grams)	Weight Loss %
RHS-1	1.702	1.376	0.326	19.154
RHS-2	1.668	1.318	0.350	20.983
RHS-3	1.789	1.385	0.404	22.582
RHS-4	1.749	1.336	0.413	23.613

DISCUSSION

In Izod Impact Strength Test a Pivoting arm is raised to a specific height and then released. The arm swings down and hits the notched sample and breaks the sample. Here for the different ratios of the sample the impact angles are different. The Impact angles for ratios 50:50, 55:65, 60:40, 65:35 are 134^0, 143^0, 144^0, 144^0 respectively. The impact energy for the ratio 50:50 is 1.75 J/cm^2. Similarly, the impact energies for 55:45, 60:40, 65:35 are 1.53 J/cm^2, 1.53 J/cm^2, 1.33 J/cm^2 respectively. From the Figure 3, it is observed that as the proportion of Rice Husk increases, gradually impact energy decreases.

The Rockwell scale is a hardness scale which is based on indentation hardness of the material. This test measures the depth of penetration of an indenter under a large load compared to the penetration made by a preload. Different types of scales denoted by a single letter that uses different loads and indenters. Various indenters such as Diamond, 1/16" ball, 1/8" ball, 1/4" ball, 1/2" ball etc. are used in the Rockwell Hardness test. For the hardness test of Rice husk sheets HrA scale is used. The preload applied is 60 Kg. This scale is also used for testing the hardness of Carbides, Thin steel, shallow case hardened steel etc. The unit of hardness measured in Kg.mm. From the Figure 4, it is clear that as the proportion of Rice Husk increases the hardness of the material gradually decreases.

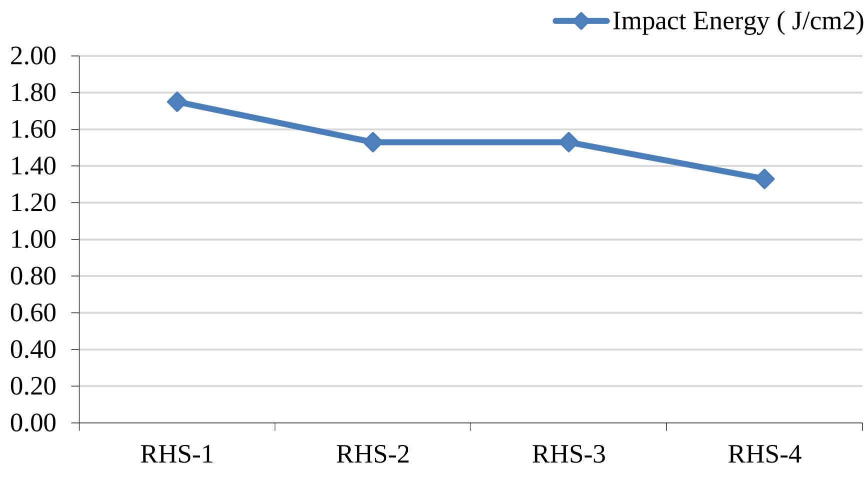

Figure 3. Impact Energy.

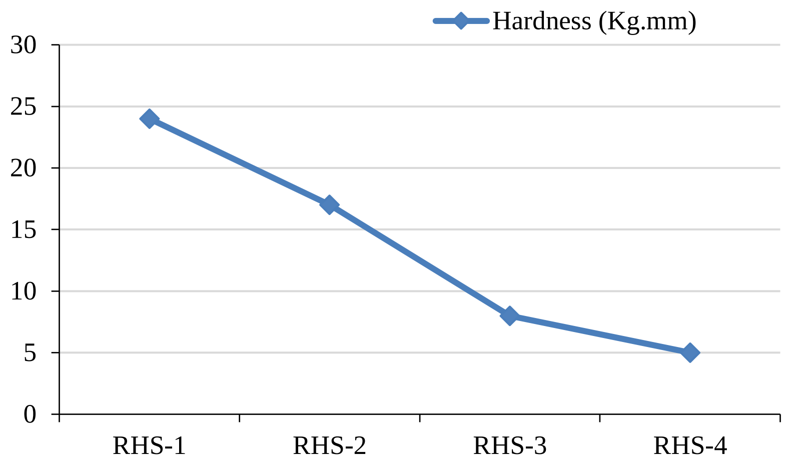

Figure 4. Hardness.

Flexural test measures the force required to bend a beam of plastic material and it also determines the resistance to flexing or stiffness of the material. Flexural modulus shows that how much material can flex before the permanent deformation. The Flexibility of the material mainly depends on two parameters Young's modulus of bending and Flexural rigidity of the material.

By considering Figure 5 and Table 6 it seems that maximum drop in Young's Modulus of bending is seen between the ratio RHS-1 and RHS-2 and there is very slight drop from ratio RHS-2 to RHS-3 and normal drop from ratio RHS-3 to RHS-4.

Table 6. Young's Modulus of Bending.

Ratios Rice Husk: Resin	Young's Modulus of Bending (Mpa)
RHS-1	2166.68
RHS-2	702.20
RHS-3	690.75
RHS-4	296.49

Table 7 and Figure 6 represents that continuous decrease in the Flexural Rigidity while the proportion of Rice Husk is increased. So it is manifested that, while proportion of Resin Decreases, the Flexibility and Flexural Rigidity of the material also decreases.

Table 7. Flexural Rigidity (Nmm2).

Ratios Rice Husk: Resin	Flexural Rigidity (Nmm2)
RHS-1	503089.76
RHS-2	371191.14
RHS-3	226689.90
RHS-4	86135.39

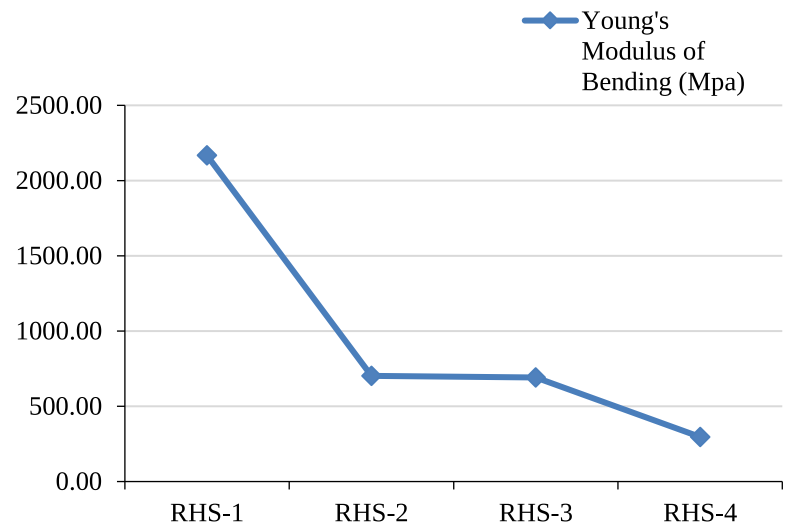

Figure 5. Flexibility.

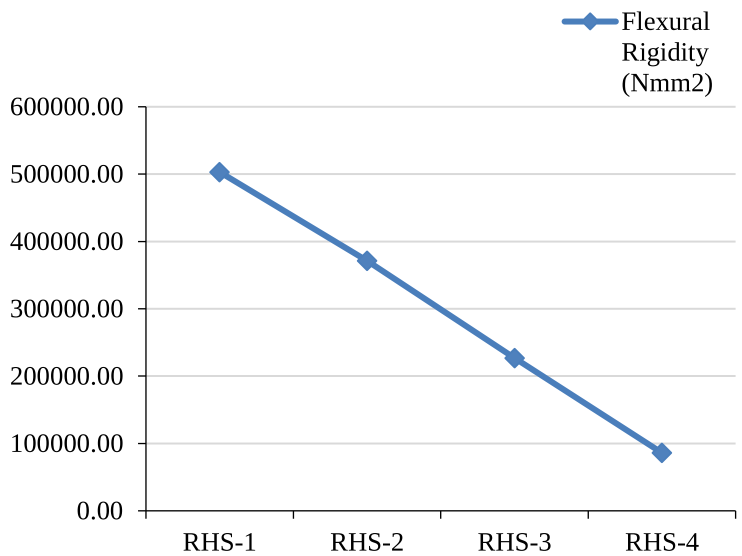

Figure 6. Flexural Rigidity.

For the Biodegradability test four different samples sized 10mmx15mm are pre- weighed having ratios 50:50, 55:45, 60:40, and 65:35 of Rice Husk: Resin initiated. For the testing four conical flasks are taken with 100 ml of Nutrient Broth solution each. Then inoculation of Bacillus Subtilis bacteria performed (Figure7). Bacillus Subtilis is a gram positive catalase positive bacterium. To know about the growth of bacteria Optical Density (O.D.) is taken at interval of 24 hours at 600nm. O.D. measured until growth of bacteria stops. DNSA method adopted to measure the sugar released. After 30 days all samples are removed out, dried properly and their weights are measured. The weight loss of each sample is calculated. According to Figure 8 it is observed that, the proportion of Rice Husk Increases, Biodegradability also increases. It is observed that the Biodegradability is maximum when the ratio for Rice Husk and Resin is 65:35 and pointed that while we increase the proportion of Resin and decrease the proportion of rice husk, the Biodegradability is being decreased.

Figure 7. Bacillus Subtilis.

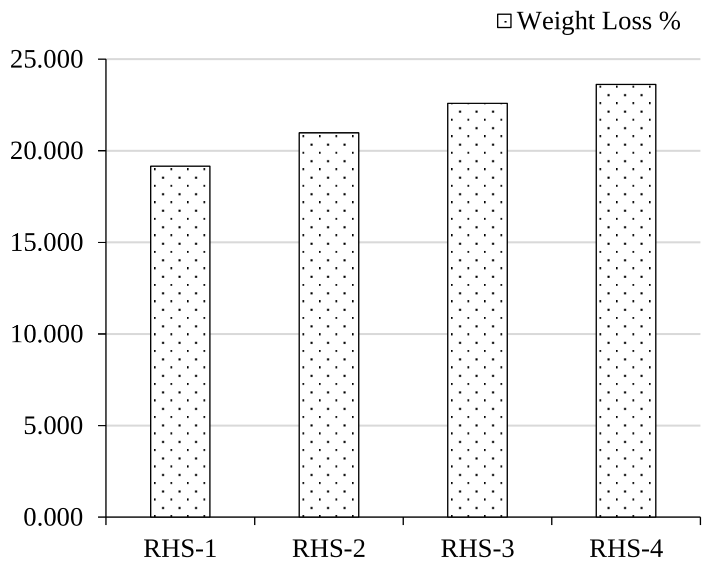

Figure 8. Biodegraiblity.

CONCLUSION

In the current world, one of the most pressing scientific and technical issues is the development of novel materials for novel uses. Different structures of hybrid polymer composites are used for automobile components, sports, boats, aircraft, office items, equipment, marine and many more industries. In the automobile industry, agro-based thermoset hybrid composites are highly used. The influence of fillers, reinforcements, and reinforcement modification on composite properties, as well as their interaction with the matrix, is defined by their concentration, ratio, and reinforcement content. In order to evaluate the performance of the hybrid composites developed, the change in mechanical properties with content and modifying the volume ratios of the fabrics were evaluated. The research of miscible polymer blends has sparked a lot of interest, as seen by the growing number of publications in the literature, although there are just a few papers on unsaturated polyester resin polymer blends. Because of their low production costs and high tensile strength, unsaturated polyester resins have been widely used as one of the most important thermosetting polymers in the industry.

Composites of Rice Husk and Unsaturated Polyester Resin are made in this research. Various tests such as Izod Impact test, Flexural test and Rockwell hardness test are done to know about the mechanical properties of composites. For the purpose of environmental safety and the ecological balancing the demand of eco-friendly materials is increasing. So to check the degradation rate of material Biodegradability test is done. In the present work four different sheets of Rice Husk and Unsaturated Polyester Resin are made. Benzoyl Peroxide powder is added as a curing agent. To make composites Manual layup method is used. Four different sheets are made having ratios 50:50, 55:45, 60:40, 65:35 of Rice Husk: Resin. The comparison among the four sheets is done.

It is noted that as the proportion of Rice Husk increases, loss is seen in the mechanical properties such as Rockwell Hardness Test, Izod impact test, Flexural test etc. For the Biodegraiblity test as the content of Rice Husk increases there is increase is degradation. The graphical representation shows comparison of various sheets prepared by different proportions of Rice Husk and SDUPR. Even though as the proportion of Rice Husk increases there is loss in mechanical properties but it is very beneficiary to environment. There are various applications of this composite such as used to prepare doors, windows, different types of furniture, decorative articles etc.

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