**American Journal of Materials Synthesis and Processing**
2016; 1(3): 32-36
http://www.sciencepublishinggroup.com/j/ajmsp
doi: 10.11648/j.ajmsp.20160103.12

# Utilization of Rice Husk as Reinforcement in Plastic Composites Fabrication- A Review

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**To cite this article:**
Nwosu-Obieogu Kenechi, Chiemenem Linus, Adekunle Kayode. Utilization of Rice Husk as Reinforcement in Plastic Composites Fabrication- A Review. *American Journal of Materials Synthesis and Processing.* Vol. 1, No. 3, 2016, pp. 32-36.
doi: 10.11648/j.ajmsp.20160103.12

**Received**: September 21, 2016; **Accepted**: October 2, 2016; **Published**: October 25, 2016

**Abstract:** This report is based on the utilization of rice husk as reinforcement for plastic composites. Synthetic plastic composites are growing increasingly important as they are been used in almost all areas of life as far as the industry is concerned, this has led to its price escalation, environmental pollution and being mostly by-products of petroleum, these materials are non-renewable. Overcoming these problems gave the motivation for this work; hence this study tends to look at rice husk as a potential reinforcement for plastic composite fabrication by analysing its properties, uses, application as well as the process involved.

**Keywords:** Rice Husk, Composites, Polymer, Fibers, Plastic

## 1. Introduction

The development of science and technology has created a need to develop engineering materials having light weight, high strength with specific properties as per service requirement at low cost and minimum energy consumption. Thus, the concept of composite materials has come into existence partially replacing existing metals, non-metals and alloys in various engineering applications. The idea of composite materials however is not a new or recent one but has been around thousands of years. [1]

Since the early 1960s, there has been an increase in the demand for stronger, stiffer and more lightweight materials for use in the aerospace, transportation and construction industries. Demands on high performance engineering materials have led to the extensive research and development in the field of composite materials. Many composites used today are at the leading edge of materials technology, enabling their use in advanced applications such as aircraft and aerospace structures [1]. Just as mankind has moved from Stone Age to the composite age, so have composites evolved from the chopped straw bricks of primitive times to today's sophisticated ceramic matrix composite and metal matrix composite. There has been an extraordinary explosion in composite usage, research and application. Now composites find unusual and exotic applications such as stealth aircraft and superconductive composite.

Generally, a composite material is made up of reinforcement (fibers, particles, flakes, and/or fillers) embedded in a matrix (polymers). The reinforcement materials provides strength to the composites where as the matrix holds the fibre in desired shape and transfer the load from one fibre to other. [2]

Composites are one of the fastest growing industries and continue to demonstrate a significant impact on the material world. [1]

In recent years, there has been growing environmental consciousness and understanding of the need for sustainable development, which has raised interest in using natural fibers as reinforcements in polymer composites to replace synthetic fibers such as glass. The advantages of natural fibers include low price, low density, sustainable availability and low abrasive wear of processing machinery. Further, natural fibers are recyclable, biodegradable and carbon dioxide neutral and their energy can be recovered in an environmentally acceptable way. [2]

Recent interest on the environmental impact of polymer-based materials has lead to the development of new products prepared with recycled polymers and/or containing biodegradable materials. Lignocellulosic plastic composites constitute an important set within this kind of materials showing several advantages over traditional mineral-filled plastic composites: low density, low production costs, biodegradability, renewability, etc. Stiffness, hardness and dimensional stability of plastics have also been improved by incorporation of lignocellulosic fillers. [3, 4]

However, the use of agro-fibers shows some drawbacks such as degradation at relatively low temperature due to the presence of cellulose and hemicellulose. This early thermal degradation limits the allowed processing temperature to less than 200°C and restricts the type of thermoplastics that can be used with agro-fibres to some commodity plastics such as Polyethylene, Polypropylene, Polyvinyl chloride and Polystyrene [5]. Natural fiber/PP composites have been used in automotive applications and recently they have been investigated for use in construction, such as building profiles, decking, railing products, etc. [3, 6]

Other factors should be considered when designing composites made of lignocellulosic fibers for specific applications, among them its poor resistance to moisture [6]. Outdoor applications have raised the interest on this property since moisture absorbed by the composite led to dimensional changes and to decreasing mechanical performance [7]. These negative effects can be reduced if the fibers are encapsulated in the plastic with good adhesion between the fibers and the matrix.

The addition of a compatibilizer has been a useful tool for achieving such adhesion. Maleic anhydride-grafted PP (MAPP) is the most common compatibilizer used to improve interfacial adhesion for bio-fillers/a polar thermoplastic matrices even so new alternatives are being currently studied. [8, 9]

The use of natural fibers as particulate fillers are known to have different effects when combined with different thermoplastics, and in most cases, improve the impact strength, stiffness, heat distortion temperature and cost reduction. [10]

## 2. Rice Husk, Its Composition and Utilization

Rice husk (RH) is one of the major agricultural residues produced as a by-product during rice processing. Usually it has been a problem for rice farmers due to its resistance to decomposition in the ground, difficult digestion and low nutritional value for animals. [11]. According to Marti-Ferrer [12] the lignin and hemicellulose contents of rice husk are lower than wood whereas the cellulose content is similar. For this reason Rice Husk Flour can be processed at higher temperatures than wood.

Therefore, the use of rice husk in the manufacture of polymer composites is attracting much attention. It is one of the most widely available agricultural wastes in many rice producing countries of the world. They are the hard protecting coverings of grains of rice and removed from rice seed as a by-product during the milling process. It is essentially free as waste product from agriculture sector and forest residues. [12, 13]

### *2.1. Composition of Rice Husk*

Rice husk contains 75-90% organic matter such as cellulose, lignin etc. and rest mineral components such as silica, alkalis and trace elements. [14] Rice husk is unusually high in ash compared to other biomass fuels in the range 10-20%. The ash is 87-97% silica, highly porous and light-weight, with a very high external surface area. Presence of high amount of silica makes it a valuable material for use in industrial application. [15] Other constituents of Rice Husk Ash (RHA), such as $K_2O$, $Al_2O_3$, CaO, MgO, $Na_2O$, $Fe_2O_3$ are available in less than 1%. Rice husk having bulk density of 96-160kg/$m^3$, oxygen 31-37%, nitrogen 0.23- 0.32%, sulphur 0.04-0.08%.

### *2.2. Utilization of Rice Husk*

The interest in the utilization of rice husk as fillers in thermoplastics has increased recently mainly due to the needs in overcoming the environmental problems caused by agricultural by-products. [1]

Kumar S et al [16] in his review reported the various utilization and application of rice husk, depending upon their physical and chemical properties like ash content, silica content etc.

Various applications of rice husk are listed below.

#### *2.2.1. Rice Husk as a Fertilizer and Substrate*

Rice husk can be composted, due to their high lignin content, the process is slow, but in few months, they are converted to organic manure, and it does not affect plant growth regulation. [14, 17]

#### *2.2.2. Brewing*

Rice husk is used in brewing beer to increase the lautering ability of a mash

#### *2.2.3. As an Industrial Fuel*

For generation of process steam, rice husk is used as a fuel. In small sector process industries, rice husk is used as a fuel in low capacity boilers. For producing 1MWH (million watt hour) electricity, 1 tonne of rice husk is required. It is also used as alternative fuel for household energy. [18]

#### *2.2.4. Preparation of Activated Carbon*

Due to the lignocellulosic property of rice husk, rice husk can be applied in the preparation of activated carbon for effective adsorbents due to their complex microporous structure. [19, 20]

#### *2.2.5. As Pet Food Fiber*

It serves as a source of fiber that is considered a filler ingredient in pet foods. [21]

#### *2.2.6. Used for Making Bricks*

Rice husk is used in making bricks, if there is more percentage of rice husk in the bricks, the brick will be more porous and have better thermal insulation. [22]

#### *2.2.7. Toothpaste*

In Kerala, India, Rice husks (Umikari in Malaylam) was used for over centuries in cleaning mouth before toothpaste replaced it.

#### *2.2.8. Pillow Stuffing*

Rice husks are used as pillow stuffing. The pillows are loosely stuffed and considered therapeutic as they retain the shape of the head.

#### *2.2.9. Tire Additive*

Goodyear announced plans to use rice husk ash as a source for tire additive.

### *2.3. Other Uses*

Rice husk is used for production of xylitol, furfural, ethanol, acetic acid, etc. It is used as a cleaning and polishing agent in metal and machine industries. It is also used as building material [23] and also used as industrial raw material example-as an insulating board material, filler in plastics, filling material, for making panel board etc [24].

## 3. Surface Treatment Methods

Adekunle K. F [25] reported that for reinforcement to take place, the natural fibres have to be suitably treated to elevate their properties if they are to be used in technical applications, the effects of various fibre surface treatments actually improve the interfacial adhesion between the fibre surface and the matrix, thereby giving good mechanical properties to the resulted polymer composites, so we look briefly at the two methods of treatment

### *3.1. Physical Method*

Physical methods such as stretching, calendaring, thermo treatment and the production of hybrid yarns have no effect on the chemical composition of the fibres but however they change the structural and surface properties of the fibre and thereby influence the mechanical bonding to polymers [26].

### *3.2. Chemical Methods*

Zeynab Emdadi et al [27] reported a case of replacing chemical desiccants with rice husk, and the rice husk is been treated with alkali and acid solution, after characterization, the composite samples showed higher water absorbance which is attributed to the porosity and improvement of adhesion properties in the prepared samples.

The point is that before rice husk is used, as reinforcement for plastic composites for instance, it was treated chemically, to make it compatible for composite preparation by introduction of a third material that has properties intermediate between those of the other two materials.

This includes the following concepts; the morphology of the interface, the acid-base reactions at the interface, surface energy and the wetting phenomena. [26]

## 4. Rice Husk Plastic Composites

Several works on the application of rice husk as the reinforcing agent in plastic composites have been reported.

Atuanya C. U [28] in his work investigated the effect of rice husk filler loading on the mechanical properties of recycled low density polyethylene (RPE) and mixed with a fraction of virgin polyethylene (MPE) composites it was observed that tensile strength increased up to 10 percent weight fraction of rice husk filler in the composites and later decreased above 10 percent filler loading. Tensile modulus, flexural strength and modulus, and Brinell hardness increases with increased filler loading, but impact strength decreases with increased in filler loading.

Nwanonenyi, S. C and Obidegwu, M. U I [29] analysed the Mechanical Properties of Low Density Polyethylene/Rice-Husk Composite using Micro Mathematical Model Equations and the result showed that there is a distinct variation between the experiment results and results from micro mathematical model equations, the mechanical properties of the composite indicate that it may be useful in some applications that require low strength, high stiffness and hardness

Nwanonenyi S. C [30] in another research investigated on the Effect of Rice-Husk Filler on Some Mechanical and End-Use Properties of Low Density Polyethylene where the Results showed that tensile modulus and hardness increased with increase in filler loading, while tensile strength and % elongation decreased with increase in filler loading. In addition, it was also observed that end-use properties such as water absorption, specific gravity and flame retardant properties increased as filler loading increases.

Dimzoski [31] studied properties of rice-hull-filled polypropylene (PP) composites. Using the concept of linear elastic fracture mechanics, Introduction of rice hulls in the PP matrix resulted in a decreased stress at peak, together with increase of composites tensile modulus and modulus in flexure.

Patricio Toro [32] investigated the increase of the rice-husk charge as natural filler in the PP matrix decreases the stiffness, and in the presence of PP-g-MMI as compatibilizer in PP/rice-husk, the tensile modulus and water absorption of the composite were improved.

Simone Maria Leal Rosa et al [33] studied on the Properties of Rice-Husk-Filled-Polypropylene composites with Maleic anhydride modified propylene as the coupling agent, it was verified that tensile strength decreased with filler loading. The presence of MAPP improved this property showing a strong dependence on the MAPP/RHF ratio

Nak-Woon Choi et al [34] developed a new recycling method for rice husks and waste expanded polystyrene, with a view of using the styrene solution of waste expanded polystyrene as a binder for rice husk-plastic composites, their water absorption and expansion in thickness are decreased with increasing binder content and filler-binder ratio, since the composites formed have a high flexural strength and water resistance, their uses as building materials are expected.

Dr. Shivappa et al [35] carried out a research on rice husk reinforced with vinylester polymer composite, though the work showed a lot of fluctuation on the tensile and flexural strength of the composites, it increased but not steady

Vasanta V Cholachagudda et al [36] used rice husk as an additional fiber with coir fiber to reinforce vinyl ester from observations, there were improvement in mechanical properties of the composite material formed (both in tensile and flexural strength)

From the works reported, it was observed that polyethylene reinforced with rice husk exhibited increase in tensile modulus, flexural strength and hardness during the loading of the filler but tensile and impact strength dropped at the early stages of the loading, then for the polystyrene and polypropylene their tensile modulus, flexural strength increased but showed improvement when a compatibilizer was used on polypropylene composite. polyethylene composites has higher elongation at break more than other polymer composites, that is why rice husk exhibited more useful mechanical properties in its composites both in recycled form, also the tensile strength of rice husk composites increased when used as an additional fiber to coir in reinforcing vinyl ester, showing that they are gradually substituting synthetic fibers and the tensile strength of the composites is not falling.

## 5. Rice Husk Composite Production Method

The rice husk fibers were separated from undesirable foreign materials (matter) and pith and then ground with hand grinding machine. The ground rice husk was then sieved to get very smooth fine textured particles. Then the composite was formed by integrating selected rice husk with a matrix.

The mixture of reinforcement/resin does not really become a composite material until the last phase of the fabrication, that is, when the matrix is hardened [37]

The characteristic of composites depends on the nature of the reinforcement, the ratio of resin to reinforcement, and the mode of fabrication, so the basic methods applicable to rice husk composite fabrication include: extrusion process, injection moulding and compression moulding, the extrusion process is preferable to other methods due to its ability to create very complex cross-sections and to work on brittle materials. [37, 38]

## 6. Problems and Challenges Facing Biocomposites

This effort to develop biocomposite materials with improved performance for global applications is an ongoing process, it has been proved that it has low density, easily affordable, biodegradable, renewable and environmentally friendly it is faced with a whole lot of problems like Low impact strength (high concentration of fiber defects), Problem of stocking raw material for extended time, UV resistance– not better than plastics, Fiber degradation during processing and Fiber orientation and distribution. [39]

Nwanonenyi, S. C and Obidegwu [29] in their research showed that tensile strength and percentage elongation of the composite exhibited a gradual decrease with increase in filler loading while tensile modulus and hardness showed gradual improvement with increase in filler loading.

The mechanical strength of a biocomposite could not match that of synthetic composites and the natural fibers would not replace synthetic fibers in all applications. For the last decades, extensive research is ongoing in order to improve the mechanical properties of biocomposites, while the intrinsic properties of the natural fibers such as biodegradability and low specific gravity of the fibers remain unchanged. [40]

## 7. Conclusion

From the various works reviewed in this study, rice husk has proven to be very good candidate for reinforcement in plastic composites, once they are suitably prepared and treated

As the society still regard rice husk as a non economical viable material, and dwell on synthetic fibres which is costly, non renewable and releases greenhouse gases that causes variation in the climate which is a global problem. Extensive effort need to be made to portray rice husk as a material for sustainable development since it has the potential to reduce greenhouse emissions, reduces material costs and abundantly affordable.

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