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Microstructure, Mechanical and Wear Behavior of Hybrid Rice Straw Ash/Silicon Carbide Reinforced Al-Zn Composites Fabricated via Double Stir Casting

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Abstract

Aluminum is mostly adopted as a structural material in the automotive and aerospace industry due to its light weight and amenability to different processing techniques. Nevertheless, low melting point and inadequate strength are some of the challenges faced by this material. The addition of reinforcement elements such as silicon carbide and alumina particles has been used as an affordable method of solving this problem. However, finding a cost effective and environmentally friendly reinforcement materials has led to the use of agricultural waste. There is little or no literature on the use of rice straw ash as a reinforcement for Al-Zn alloy, Hence, this research work investigated the microstructure, mechanical and wear properties of hybrid Rice Straw Ash/Silicon Carbide particulate reinforced Al-Zn Alloy at varied weight percent of 10% each fabricated via double stir casting technique. Hardness, ultimate tensile strength, impact strength and wear properties of the fabricated composites were investigated. Scanning Electron Microscopy (SEM-EDS) analysis was carried out on as - cast aluminum alloy and composites to assess the structures of developed composites. The SEM result of the unreinforced aluminum alloy shows a single phase with zinc dendrites, while that of the hybrid rice straw ash/silicon carbide composites reveals the dispersion of

reinforcements within the aluminum matrix, and the EDS shows high peaks of aluminum (Al), oxygen (O), carbon (C), Magnesium (Mg) and silicon (Si). The hardness values and ultimate tensile strength of the hybrid reinforced composites increased with increasing percentage weight of the rice straw ash addition. The increase hardness and strength might be due to the presence of hard ceramic phases in the matrix. The As - cast aluminum alloy has the best impact strength, while the impact strength values decrease as the percentage weight addition of the hybrid composites increases. The wear resistance improves as the weight percent of rice straw ash increases. This work has demonstrated the viability of Rice Straw Ash/Silicon Carbide reinforced AMCs for different structural applications as its mechanical and wear properties exceed that of the Al-Zn alloy, hence contributing to the nation's economy by turning the rice straw wastes into a valuable composite material.

Keywords: Aluminum Alloy, Rice Straw Ash, Metal Matrix Composites, Double Stir Casting, Microstructure and Mechanical Properties.

Introduction

Composites are material systems which are composed of reinforcement dispersed in a matrix and it derives its characteristics from its constituent materials. (Surappa, 1997).

They are classified based on the matrix materials as Metal Matrix Composites, Polymer Matrix Composites and Ceramic Matrix Composites. The most commonly used of the composite for industrial application is the Metal Matrix Composite (MMC). They are materials usually metals or alloys incorporated with various reinforcing phases, such as particulates, whiskers or continuous fibers. The reinforcing phases can be metal, ceramic or carbon-based compounds. MMCs are known for the tailored properties which can be imparted on them by appropriate matrix and reinforcement selections, the inbuilt benefit of metal matrix composites compare to the unreinforced alloy is the enhanced mechanical properties occasioned by the addition of the reinforcement materials. (Anshuma, 2017; Joshua *et al.,* 2022a).

The reinforcements are mostly added to the matrix so as to enhance properties such as strength, stiffness, hardness, wear behavior, impact strength, among other properties (Poormesh *et al.,* 2017).

Metal alloys commonly utilized as metal matrices for MMCs are: Aluminum, Magnesium, Titanium, Zinc and Copper (Emara, 2017). Aluminum and its alloys in the last decade have received considerable

attention from researchers as base metal in metal matrix composite for the automobile and aerospace industries as it provides high quality surface finish and amenability to different processing techniques. However, its low strength and low melting point were always an issue. Ceramic materials which include Silicon Carbide (SiC), Alumina (Al_2O_3), Titanium Boride (TiB_2), Boron Carbide (B_4C), Nitrides and Graphite has been the conventional materials that has been used by researchers as reinforcement in the production of aluminum matrix composite (AMCs) to address the aforementioned problems with aluminum alloys due to their high strength, high melting points, hardness and stiffness (Nwigbo and Umoru, 2022; Poormesh *et al.,* 2017). AMCs possess enhanced properties, which cannot be achieved with the use of unreinforced aluminum alloys due to their unique combination of mechanical, physical and chemical properties (Christy *et al.,* 2010).

The wider acceptance of AMCs in the automobile, aerospace, sport and recreational industries has been hinged on their exceptional high specific strength, low thermal coefficient of expansion, high temperature resistance, lower density and good corrosion resistance when compared with steel (Prasad *et al*., 2014; Daramola *et al.,* 2015).

AMCs mechanical and wear behavior can be further improved by the development of hybrid composites with the addition of two or more reinforcement materials using stir casting. Hybrid composites over the years have been noticed to improve strength, hardness, wear behavior, corrosion resistance and modulus of elasticity over metal matrix composites and unreinforced metals/alloys (Prasad and Bandekar, 2015). Stir casting process has been adopted in the production of hybrid composites due to its practicability, simplicity, and applicability for large scale industrial production (Kant *et al.,* 2017).

Despite the huge benefits associated with the use of synthetic reinforcement materials in the fabrication of metal matrix composites and hybrid metal matrix composites, high density, poor interfacial bonding, unavailability and high cost has been a problem. Hence the attention of composite materials researchers from developing countries has been focused on the use of agro-waste and industrial waste as alternative reinforcement in the development of aluminum matrix composites. Agro waste are readily available, possess ow density, eco-friendly, solid waste recyclability and are cost effective (Alaneme and Adewuyi, 2013; Madakson *et al.,* 2012).

Sugar Cane Bagasse, Coconut shells and fibers, Melon Ash, Rice Husk Ash, Palm Kernel Ash, Groundnut Shell Ash, Bamboo Leaf Ash, Corn Cub, Periwinkle Shell, Egg Shells and among others has been successfully used by researchers as AMCs reinforcement over the years (Oghenevweta *et al.,* 2016; Agunsoye *et al*., 2014, Iyasele, 2018).

Most agro waste ashes were known to contain a high percentage of silica (SiO_2) with some other refractory oxides such as Al_2O_3 and Fe_2O_3. The densities of these agro wastes are far lower when compared to that of SiC a synthetic reinforcement (3.18 g/cm^3) and Al_2O_3 3.9 g/cm^3).

Osunmakinde *et al.* (2023) worked on the development of aluminum composite reinforced with selected agricultural residues. (Coconut shell ash (CSA), Rice husk ash (RHA), and Cassava peel ash (CPA). The authors observed that the composites made from the combination of the three reinforcements gave the best physico mechanical properties and hence recommended for engineering applications.

Murahari *et al.* (2024) investigated the effect of agricultural waste residue reinforcement in Al 7075 alloy through rotary stir casting. Their study revealed that a sound composite with increased strength and hardness was produced, the microstructural evaluation shows that the grain structure has undergone substantial refinement, resulting in an improvement in its properties.

Olusesi and Udoye, (2021) studied the development and characterization of AA6061 aluminum alloy/clay/rice husk ash composite. The researchers observed an increase in both the tensile and hardness property of the developed composite as the reinforcement particles increases.

Bawa *et al.* (2020) research on the effect of locust bean pod ash on the hardness and wear rate of heat-treated A 356 alloy metal matrix composite for production of automobile brake rotor. It was observed by the authors that the reinforcement improved the studied properties as the reinforcement percentages increases.

Ezenkwa *et al.* (2024) worked on the influence of rice straw ash on the workability and strength of concrete, the rice straw ash was used to replace ordinary portland cement. The reinforcement was found to improve the workability of the concrete.

Mohamed *et al.* (2022) studied the effect of rice straw ash and palm leaf ash on the properties of ultrahigh-performance concrete, the researchers observed that the rice straw ash and palm leaf ash improved the mechanical properties of ultrahigh performance concrete.

Jerby *et al.* (2020) investigated the utilization of rice straws as fiber reinforcement in rice husk ash cement bonded boards, increasing the amount of reinforcement was observed to increase the mechanical properties of the board.

Rice Straw Ash, one of the agro waste used as reinforcement in this research work has only been used by few researchers in the reinforcement of concrete materials and not as reinforcement of metal matrix composites despite its nominal chemical composition as one of the agro waste with high silica and alumina content.

More so, Nigeria is one of the highest producers of Rice in Africa, which is an indicator that rice straw has been contributing appreciably to the solid waste in the country, which drives it choice as one of the reinforcement materials in this research, while the choice of silicon carbide (SiC) was as a result of its excellent physio and thermoelectric properties and ability to operate in a severe environment where high temperature, corrosive and radiation tendencies are the order of the day.

From literatures above, it was observed that the use of rice straw ash an agricultural waste as reinforcement in the development of metal matrix composites has not been explored, since there is little or no work on the use of rice straw ash and silicon carbide as a hybrid reinforcement material in the development of metal matrix composites which this work seeks to address. The microstructural features, mechanical and wear properties of the developed composites were investigated to ascertain their viability as reinforcement materials in aluminum matrix composites, thereby contributing to the nation economy by turning the rice straw wastes into a valuable composite material.

Materials and Methods

Materials

Aluminum-Zinc alloy was the matrix metal used in the fabrication of the developed aluminum- based composite, its chemical composition is as shown in Table 1. Rice straw was used as one of the reinforcement materials which was sourced from a variety of rice locally called Mass I from a Rice Farm in Abobo Okehi L.G.A., of Kogi State. It was calcined by open burning so as to get it in ash form at an average particle size of 63 μm and its chemical composition was determined through X-ray fluorescence as shown in Table 2. Its selection was hinged on its high content of ceramic compounds of SiO_2, Al_2O_3 and Fe_2O_3 which are said to be pozzolanic material with the sum of its silicon oxide, alumina and iron oxide more than 70% which are known to function as reinforcing materials (Alaneme *et al.,* 2014). While the second reinforcement used was Silicon Carbide of average particles size of 63 μm and purity grade of 99% gotten from Nigerian Institute of Mining and Geosciences (NIMG) Jos, Plateau State, Nigeria.

Table 1. Chemical Composition of Aluminum-Zinc based Alloy

Element	Al	Si	Fe	Mn	Mg	Zn	Cr	Ti	Cu
Composition	82.17	0.6	0.8	0.3	0.6	14.08	0.40	0.5	0.55

Table 2. Chemical Composition of the Rice Straw Ash Reinforcement

Element	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	MnO	NaO	SO_2
Composition	68.92	4.03	2.18	0.36	3.11	2.75	1.95	0.5

Preparation of Rice Straw Ash

The procedure used in the preparation of the Rice Straw Ash was adopted from the work of (Alaneme and Aluko, 2012). A metallic drum with perforations was used as a burner for the Rice Straw. Dry Rice Straw obtained from the threshing of rice was placed in the drum and ignited with the use of charcoal. The straw was made to burn totally in the drum and the ashes were removed after 24 hours. Muffle furnace was then used to heat treat the

ash at a temperature of 700 °C for 120 minutes in order to decrease its carbonaceous and volatile matters. The Rice Straw Ash was then sieved using a sieve shaker to achieve ashes with mesh size under 63 μm. X -Ray Fluorescence was used to obtain the chemical composition of the Rice Straw Ash as shown in Table 2 above.

Composite Production

Double Stir Casting techniques in the order of the work of (MethtaMayor and Sutaria, 2021) was adopted for the fabrication process. Each weight percent of the Aluminum, Rice Straw Ash (RSA) and Silicon Carbide (SiC) particulates required to produce the melts were obtained through charge calculation. The hybrid charges containing 2.5 wt% RSA/7.5 wt% SiC, 5.0 wt% RSA/5.0 wt% SiC, 7.5 wt% RSA/2.5 wt% SiC, 10 wt% RSA and 10 wt% SiC reinforcements weight ratios were used as presented in Table 3. The control sample was the unreinforced aluminum alloy, while the developed composite compositions with corresponding designations are presented in Table 3. The Rice Straw Ash and Silicon Carbide particle reinforcements were preheated first to a temperature of 250 ^{0}C to remove dampness, reduce the temperature gradient occasioned from the addition of cold materials into the melt, and to increase wettability with the molten alloy. After which a gas fired crucible furnace was used to completely melt the aluminum alloy at a temperature of 710 + 30 ^{0}C (above the liquidus temperature of the alloy). The molten alloy was allowed to cool to a semi solid state at a temperature of about 600 ^{0}C. The already pre-heated Rice Straw Ash and Silicon Carbide particles depending on the pre – determined compositions, were added at this temperature, and stirred manually in the semi - solid melt, for 5 - 10 min. The composite slurry was then superheated at 720 + 30 ^{0}C, after which a second stirring was performed on the mixture using a mechanical stirrer. The stirring operation was done at a speed of 400 rpm for 5 minutes to improve the diffusion of the particulates within the molten aluminum alloy. The molten composite was then cast into molding sand and allowed to solidify. The choice of sand casting as the fabrication route was as a result of its flexibility, ease of operation and compliance for marketable production. Several authors had also adopted the technique in the fabrication of aluminum-based composites (Alaneme *et al.,* 2020; Joshua *et al.,* 2022b).

Table 3: Sample Designation and Composite Compositions

Samples	Al-Zn alloy matrix (%)	Rice Straw Ash (%)	Silicon Carbide particles (%)
A	100	0	0
B	90	2.5	7.5
C	90	5.0	5.0
D	90	7.5	2.5
E	90	10	0
F	90	0	10

Microstructural Evaluation of the Aluminum Alloy and Developed Composites

A Carl Zeiss sigma field emission scanning electron microscope system with capabilities for back scattered electron (BSE) mode imaging, secondary electron (SE)- modes imaging, and SEM-EDS analysis was used for microstructural characterization of the unreinforced aluminum alloy and developed composites. Standard metallographic procedures of sample cutting, grinding of sample with silicon carbide abrasive papers with different grit sizes of (220, 320, 400, 600, 800, 1200 and 2400) were followed. After which polishing was done using alumina paste so as to get a mirror like surface. Each of the samples was etched in Keller's reagent. The samples were then rinsed with water and ethanol, and dried in air before the microstructural examination was done.

Hardness Test

The Al-Zn alloy and composites hardness test were conducted using Brinell machine (BHT) model as per ASTM E18 - 20 (2020). Surfaces of samples to be tested were grinded and polished before testing. The Brinell hardness test was performed by applying a load of 100kgf for a dwelling time of 10 s. The indenter was pressed into the two different composite samples surfaces at four different spots per sample and the mean values for all the composites was taken independently and credited as their hardness values.

Tensile Test

The tensile properties for all the samples were assessed as per ASTME8/E8M - 21 (2021) standard. Two samples each were designed from developed composites to dimensions ϕ 4 mm and 40 mm gauge length. Specimens for each composition were tensile at strain rate of 6 x 10^{-3}/s, all carried out at room temperature with an Instron Tensile Machine (model 3369). The tensile properties of the alloy and developed composites was done from the Load displacement plots achieved.

Impact Strength Test

ASTM, (2022) standard was adopted for the **i**mpact strength testing of all the samples. The tests were carried out using Izod Impact Strength Testing method on Houndsfield Impact Testing Machine. Two samples each from the developed composites and alloys were notched at an angle of 45^0.from 28 mm end length of 75 mm. The impact energy for the specimens were read off on the calibrated scale attached to the machine and the average were taken as a measure of impact strength in Joules for each sample.

Wear Abrasion Test Procedure

Dry wear test was carried out on the alloy and developed composites using the pin-on-disc method in the order of ASTM (2022). Load, sliding velocity and sliding distance were the used parameters. The following steps were observed in conducting the test.

1. Initial weight of the samples were taken
2. The specimens were inserted on the specimen holder
3. The specimens were fixed on the specimen holder
4. A load of 10N was applied on the supporting rod so that the stylus pin made a firm contact with the specimen.
5. The electric motor was switched on to rotate on the specimen for just 20 cycles
6. Final weighing of the specimen
7. Measuring the sliding distance

$$\Delta w = (w_1 - w_2) \quad (1)$$

Where ΔW = Weight loss of the specimen

W_1 = Weight of the specimen before test

W_2 = Weight of the specimen after test

Volume loss (ΔV) of the specimen is computed in the following way:

$$\Delta V = (w_1 - w_2) \times 1000 \quad (2)$$

Where ρ=Experimental density of the specimen

The Specific wear rate ((Ws) of the specimen is calculated in the following manner:

$$Ws = \Delta V Fn \times Ss \quad (3)$$

Where Ss = Sliding distance (mm), F_N = Normal load (N)

Wear resistance = Sliding Distance (S)Volume (Vloss x 1000) (4)

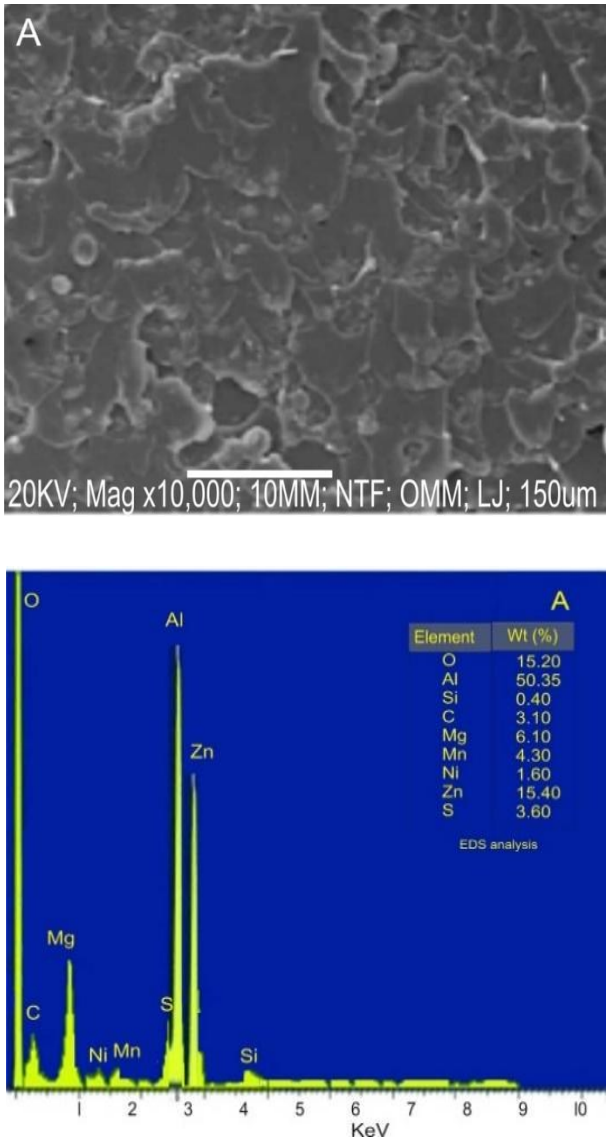
Results and Discussions

Microstructural Analysis Result of As - Cast Alloy

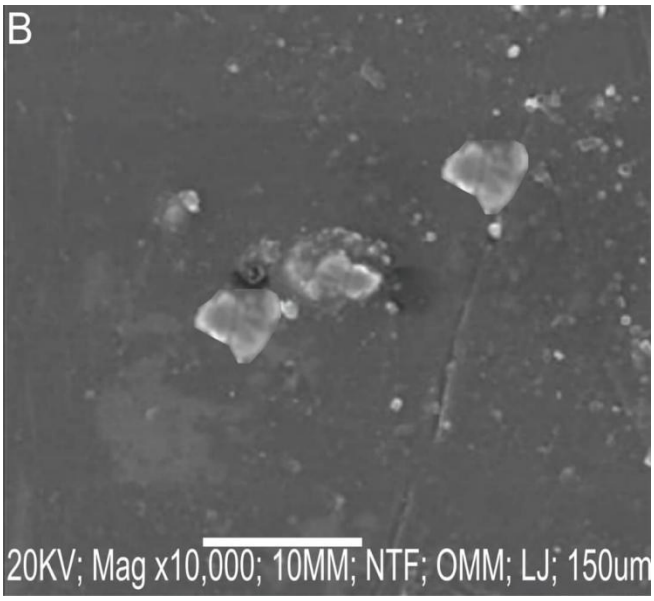
Zinc dendrites are the discernable phases present in the unreinforced aluminum alloy as depicted in the micrograph in Figure 1a. The EDS profile of the Al-Zn alloy shows that it has 15.40% Zinc content, an indication that it is a high aluminum-zinc alloy.

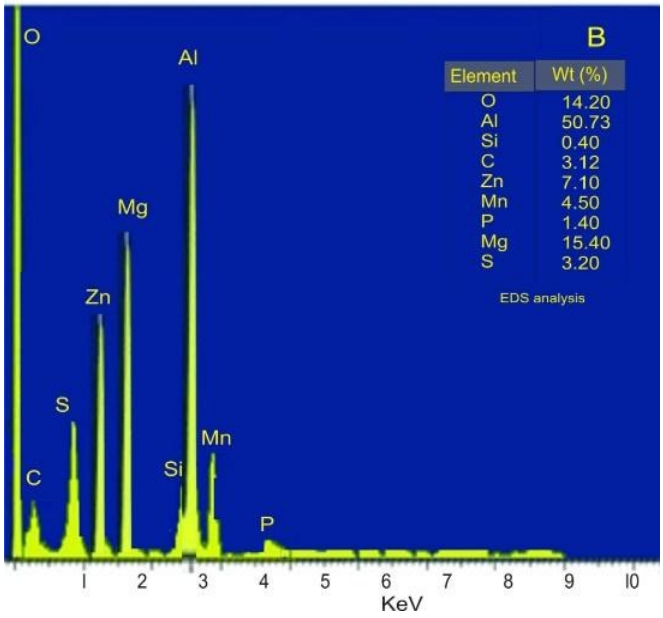
From the SEM representative of the hybrid rice straw ash + /silicon carbide composites, substantial differences in the reinforcement dispersion were noticed. within the aluminum matrix as evident in Figure 1b – 1c respectively, while the EDS profiles reveal the presence of high peaks of aluminum (Al), oxygen (O), carbon (C), Magnesium (Mg) and silicon (Si). The presence of these elements confirms the presence of silicon carbide (SiC), silica (SiO_2), magnesium oxide (MgO), alumina (Al_2O_3) in the composite. [20] observed in their work that silica (SiO_2) and alumina (Al_2O_3) as noticed in the EDS profile in this work are primary constituents responsible for the improved mechanical properties. The presence of these elements confirms that SiC, Zn and Al alloy are the reinforcement and matrix respectively

While the single reinforced composites as shown in Figure 1d, there was a good dispersion of the RSA particulate in the Al alloy matrix while the EDS shows Al, Zn, Mn, Si, and C in the RSA reinforced Al–Zn composite, suggesting RSA particles segregations at the grain boundaries areas.

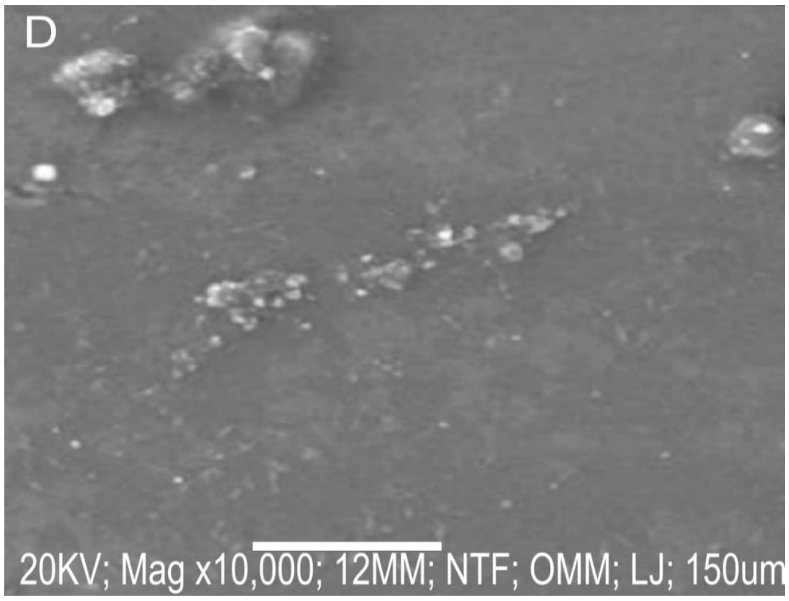


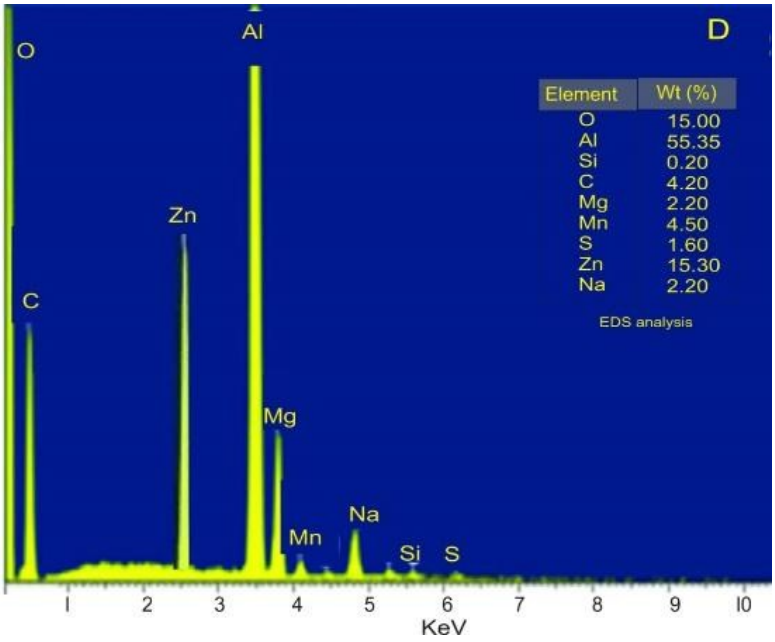
(a) Al-Zn alloy



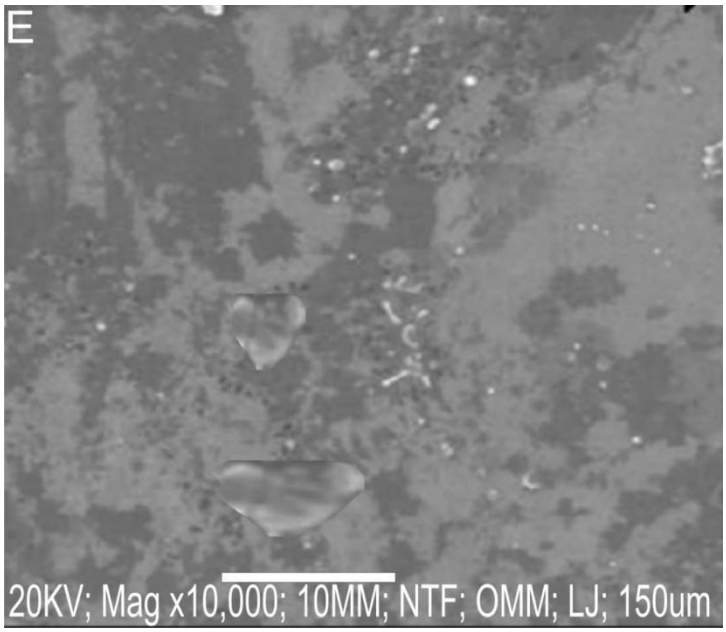


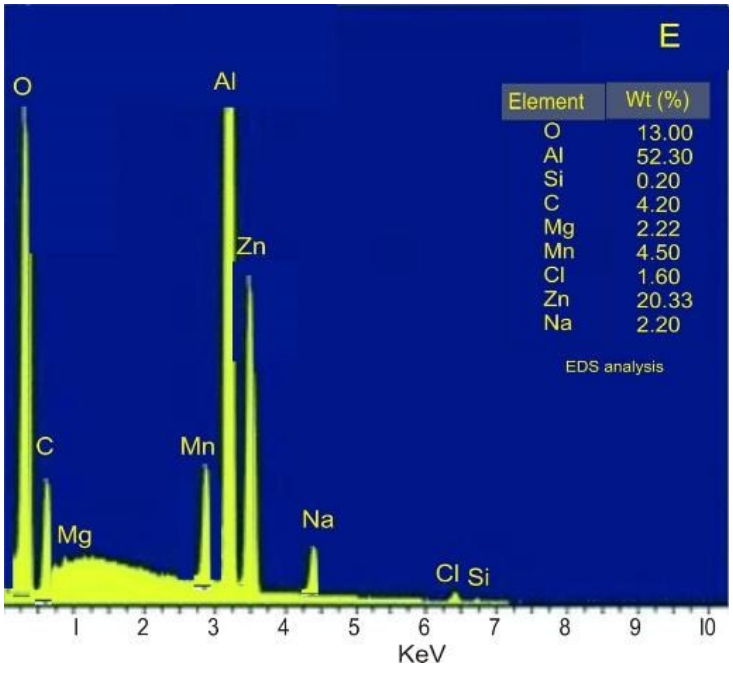
(b) Al-Zn alloy + 2.5% RSA + 7.5% SiC





(c) Al-Zn alloy + 7.5% RSA + 2.5% SiC





(d) Al-Zn alloy + 10% RSA

Fig. 1. Representative SEM micrographs of (a) Al–Zn alloy, (b) Al–Zn alloy + 2.5% RSA + 7.5% SiC, (c) Al–Zn alloy + 7.5% RSA + 2.5% SiC, (d) Al–Zn alloy + 10 wt.% RSA

Mechanical Characteristics

Hardness Test Results

The hardness of the Rice Straw Ash/Silicon Carbide particles reinforced Al-Zn alloy are presented in Figure 2 below. The hardness values recorded for the reinforced composites are all superior to that of the unreinforced aluminum alloy. The increases in the hardness properties were established to be rightly related to the increase in the wt % of the Rice Straw Ash reinforcement particles. Unreinforced aluminum alloy has the least hardness value of 75.11 HBN and greatest achieved hardness value is 117.24 HBN for A + 7.5% RSA/2.5% SiC reinforced Al composite, while comparing recorded hardness values for A + 10% RSA and A + 10% SiC, the composite with A + 10% RSA recorded 82.34 HBN as against 77.23 HBN recorded for A + 10% SiC.

All the reinforced composites (both hybrid and single reinforced composites) recorded higher hardness values in relation to the unreinforced alloy. The considerably high hardness value obtained for the Rice Straw Ash/Silicon Carbide Particulate reinforced composites might likely be linked to the high weight percentage of hard ceramic phases presence of SiO_2, MgO and Al_2O_3 in the Rice Straw Ash as noticed in Table 2.2. The aforementioned materials in the Rice Straw Ash are the conventionally used ceramic reinforcements for aluminum-based composites which on their own are hard and rigid and has been noticed to have improve aluminum-based composites hardness values from previous research works by forming strong bond surface between the matrix and reinforcement (Joshua *et al.,* 2022a; Abdulkareem *et al.,* 2019)

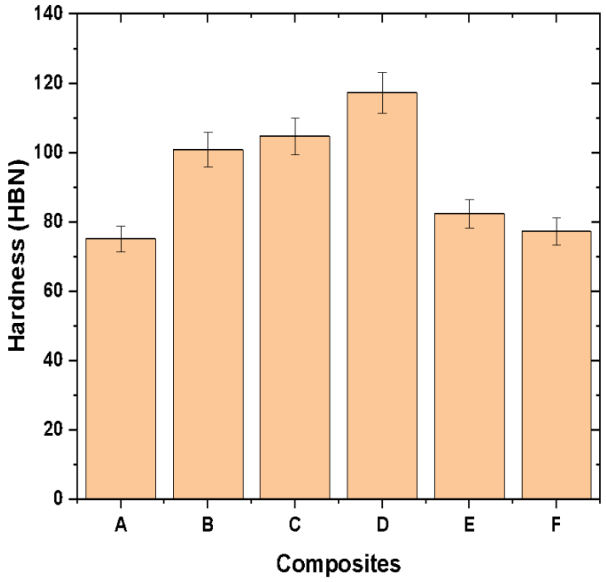


Figure 2: Effect of Rice Straw Ash + Silicon Carbide as Hybrid Reinforcement on the Hardness values of Al-Zn alloy and composite.

Ultimate Tensile Strength

All the reinforced samples had higher UTS than the unreinforced sample which recorded 84.20 MPa.

The trend of tensile strength variation in the developed composites is similar to that of the hardness values. The recorded higher ultimate tensile strength in the hybrid reinforced composites in comparison to the single reinforced composites might be linked to the more Magnesium Oxide, Silicon Oxide, Sulphur Oxide present in the hybrid composites as noticed from the SEM analysis of the representative samples in Figure 1a - e. Literature indicates that the strengthening mechanism in particle reinforced AMCs arises due to load transfer from the matrix material to the particles (direct strengthening) and formation of more dislocations which serve as restraints to plastic deformation (indirect strengthening) [34]. The Ultimate tensile strength for hybrid reinforced composite was 7% for A/2.5% RSA + 7.5% SiC, 13.01% for A/5.0% RSA + 5.0% SiC, 22.6% for A/7.5% RSA + 2.5% SiC. And 19.04% for A + 10% RSA, 16.6% for A + 10% SiC for the single reinforced composites. It was observed from the results that there is a general improvement in the ultimate tensile strength of the composites with increase in weight percent of the RSA-SiC hybrid reinforcement

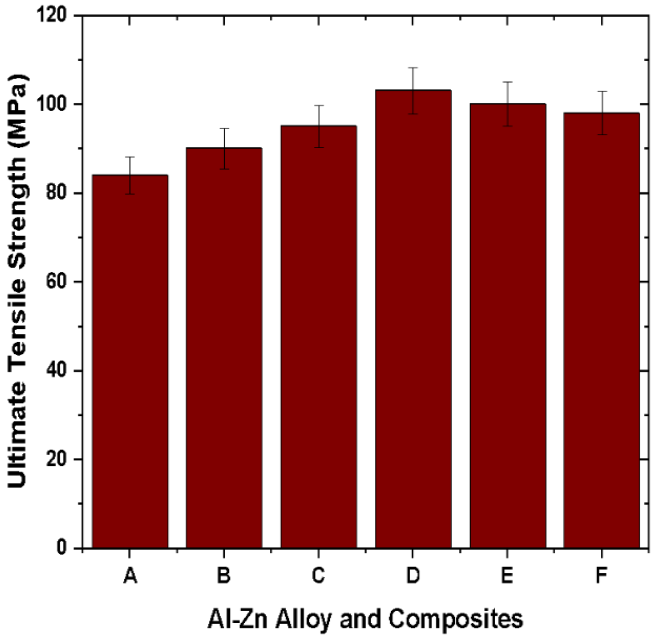


Figure 3: Effect of Rice Straw Ash/Silicon Carbide as Hybrid Reinforcement on the Ultimate Tensile Strength of Al-Zn alloy and composite.

Impact Strength

The impact strength obtained at different percentages of reinforcement is as presented in Figures 4. It is noticed that the unreinforced aluminum has the highest impact strength of 43.62 J, the impact strength was observed to decrease as the weight percent of the Rice Straw Ash increases in relation to decreased Silicon Carbide addition. The aluminum alloy reinforced with Al-Zn + 7.5% RSA + 2.5% SiC has the least impact strength value of 33.21 J among the hybrid reinforced composites. While A + 10% SiC single reinforced composite had 38.91 as compared with A + 10% RSA single reinforced composite with 36.21 J.

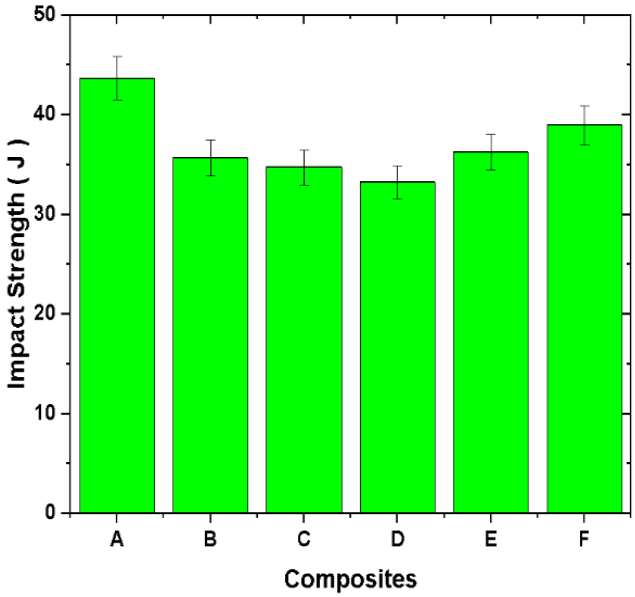


Figure 4: Effect of Rice Straw Ash/Silicon Carbide reinforcement on the Impact Strength of Al-Zn Alloy.

Wear Behaviour

The Specific Wear Rate (mm^3/Nm) and Wear Resistance (mm/mm^3) are presented in Figures 5 and 6. It is observed that wear resistance improves as the weight percent of rice straw ash increases from 2.5% RSA to 7.5% RSA as silicon carbide percentage decreases from 7.5% SiC to 2.5% SiC. while specific wear resistance decreases as wear resistance increases with the hybrid reinforcements. Comparing the wear resistance for 10% RSA and 10% SiC, the wear resistance for 10% RSA 75.18 mm/mm^3 is higher than for 73.67 mm/mm^3 for 10% SiC. Both the hybrid reinforcement and single reinforced composite had higher wear resistance than the unreinforced alloy, with the hybrid reinforcement possessing the highest wear resistance value and with the least specific wear rate. The

control sample had the maximum specific wear rate of 0.0018 mm^3/Nm with least wear resistance value of 55.505 mm/mm^3. The introduction of the hybrid reinforcement rice straw ash and silicon carbide particulates as reinforcement material was responsible for the reduced specific wear rate as experienced in this work and such composites can be used in the applications where friction is of uttermost consideration.

The improved wear resistance with increase in wt. % of rice straw ash in the Al matrix might be due to the presence of hard and brittle phases of SiO_2, MgO, Al_2O_3, and SO_3 in the rice straw ash which enhances the surface hardness of the developed composites as evident in the recorded hardness values in this work there by delivering effective resistance to scratching and penetration by the counter face (Alam *et al.,* 2018; Joshua *et al.,* 2022b).

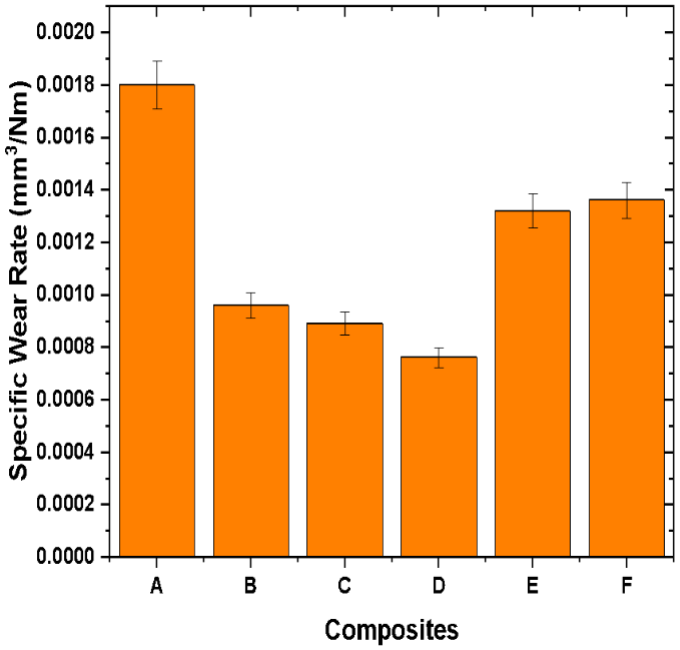


Figure 5: Effect of Rice Straw Ash/Silicon Carbide reinforcement on the Specific Wear Rate of Al-Zn Composite.

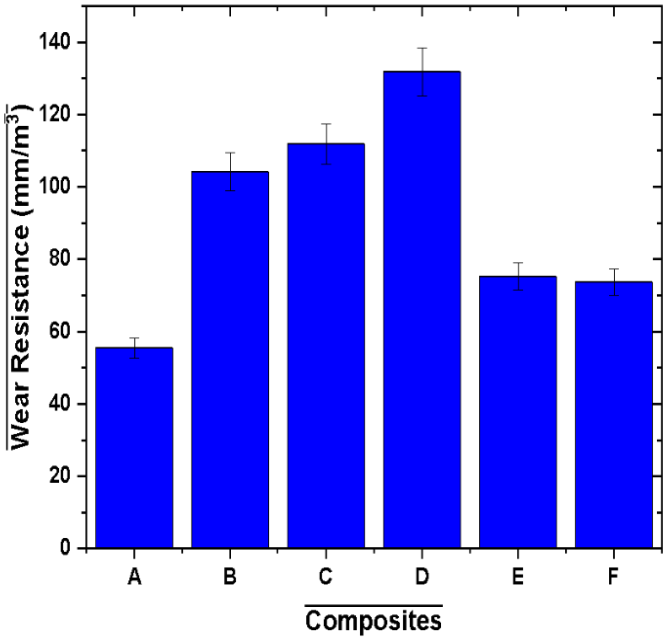


Figure 6: Effect of Rice Straw Ash/Silicon Carbide reinforcement on the Wear Resistance of Al-Zn Composite.

Conclusions

In this research, the microstructural, mechanical and wear behavior of aluminum composite reinforced with rice straw ash/silicon carbide particulates in varying wt % from 2.5% RSA/7.5% SiC, 5.0% RSA/5.0% SiC, 7.5% RSA/2.5% SiC, 10% RSA, 10% SiC fabricated via double stir casting has been investigated. Based on the results of the investigations, the following conclusions were drawn:

- The hybrid reinforced composites were observed to performed better when compared to the unreinforced and single 10% reinforced composites and all were successfully added as reinforcement materials to Al-Zn alloy via double stir casting process.
- The SEM - EDS of the Aluminum alloy used in this work shows that the alloy has 15.40% Zinc content, which reveals that it is a high zinc - aluminum alloy. From the representative SEM - EDS of the hybrid rice straw ash/silicon carbide composites the reinforcing particles can be easily noticed revealing dispersion of the reinforcements within the Aluminum matrix, and the EDS shows high peaks of aluminum (Al), oxygen (O), carbon (C), Magnesium (Mg) and silicon (Si). While the single reinforced composites show in-homogenous reinforcements distribution within the matrix.

- The hardness and tensile values of the hybrid reinforced composites B, C, D increased with increasing weight percentage of the rice straw ash addition due to the presence of hard ceramic phase in the reinforcement. And performed better than the unreinforced and the single reinforced composites.
- The As - cast aluminum alloy has the best impact strength of 43.62J, while the impact strength values decrease as the percentage weight addition of the hybrid composites increases, and the single reinforced composites performed better than the hybrid composites.
- The aluminum alloy has the least wear resistance, and as the weight percentage of the rice straw ash in the hybrid composite increases the wear resistance increases, however, the wear resistance of the single reinforced composites performed better than the unreinforced alloy.

The use of rice straw ash as a complementing reinforcement with silicon carbide is practicable for the fabrication of aluminum matrix composites. Rice straw ash can be use as reinforcement from its general positive effect on the mechanical and wear properties of the developed composites. The developed composites can find applications where high frictional resistance are required. The corrosion behavior of developed samples was not addressed due to inadequate corrosion testing kits. Hence, it is recommended that further studies should be conducted so as to widen the areas of application of the developed samples.

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