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The analysis on electrical conductivity of AA6061/rice husk ash composites

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ABSTRACT

Metal matrix composites are demanded broadly in numerous fields of engineering and industrial sectors. In the current study, the effects of rice husk ash on AA6061 was considered by altering RHA at 2%, 4%, 6% and 8% by weight at a stirring speed of 300 rpm. In the present situation, a pattern of aluminium alloy strengthened with RHA particles fabricated by stir casting method at 600 °C and 750 °C pouring temperatures are formed and analysed. Microstructural analysis was carried out for aluminium alloy and aluminium/RHA composites using an optical microscope. The research shows that as the percentage of reinforcement increases, there is an increase in crystallite size and micrographs results indicate the presence of silica from rice husk ash on aluminium alloy. From the electrical properties examination, The RHA reinforcement increased the conductance of the AA6061 metal matrix thereby, increasing the capacity of the metal matrix to conduct electricity because of the presence of RHA in the developed composites.
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1. Introduction

Aluminium based composites are always by far the best used [1] due to the MMCs properties, which include: low density, high temperature, strength retention, high strength to weight ratio, fatigue and excellent creep. They have abundant potentials for use in place of cast iron and other materials used in engine and brakes. AMMC is the best material for research in producing viable engineering components [2,3]. For the metal matrix metals are an important factor used in MMCs, and they include Aluminum (Al), Magnesium (Mg), Titanium (Ti), Iron (Fe), Silver (Ag) and others are Ni, Be and Co [4]. Al-Cu and Al-Zn based alloys are two crucial materials in the production of these engineering components [5]. AMMC is a composite formed by different manufacturing techniques such as stir casting, powder metallurgy and chemical vapour deposition amidst others. The most commonly used method is stir casting technique [6]. The most commonly used inoculants are SiC and Al_2O_3, but, SiC fortification improves the mechanical properties and wear susceptibility of aluminium and its alloy [7]. Rice husk is cheaply available as a reinforcing agent employed to manufacture silicon carbide whiskers and cutting tools that are ceramic. It is one of the most abundant in silica as raw material which contains about 90–98% silica. It provides high corrosion and wear resistance, low-cost, high-performance aluminium composite, increases in mechanical properties such as ultimate tensile, compressive strength and hardness [8,9]. In the present research, there is an effort to analyse the electrical conductivity of aluminium AA6061/RHA composites.

2. Experimental Set-up

2.1. Selection of matrix and reinforcement

2.1.1. Matrix material

The matrix material used in this work is aluminium 6061. Aluminium 6061 is an alloy of aluminium whose main alloying elements are magnesium and silicon having suitable mechanical properties such as strength and good welding ability. Table 1 shows the elemental configuration of AA6061 aluminium alloy.

2.1.1.1. Reinforcement. The material used as reinforcement was selected based on its properties and individual applications. Rice husk ash is used in this work with a particle size of 75 μm in the

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Table 1
Chemical Properties of AA6061.

Composition	Al	Si	Mg	Cu	Cr	Mn	Ti	Zn	Fe
Weight (%)	97	0.5	1.0	0.3	0.25	0.14	0.13	0.22	0.5

%wt of 0, 2, 4, 6 and 8. RHA was selected for use because it has appealing properties like high thermal conductivity and high strength.

2.1.1.2. Preparation procedure:. The particulate for reinforcement of the aluminium 6061 is rice husk ash that is gotten from drying the rice husk that has been removed from the rice paddy for a few hours under the sun. This dried rice husk is then crushed and ground to powder form. This is then sieved to a particle size of 75 μm and measured in weights of 0%, 2%, 4%, 6% and 8%.

2.2. Microstructural analysis

Microstructure examination was carried out for the produced composites with different percentages of reinforcement at 75 μm particle size with the help of an optical microscope. The microstructural analysis offers information on the particle sizes, morphologies, dispersals of phases; the structures of boundaries between dissimilar phases; and the imperfection and discontinuities that may be present in the materials. Microstructure analysis was carried out on the sample to obtain better microstructure results. The sample was sectioned and passed through the grinding stage, and hard abrasive material was used in the rotating disc for proper grinding of the sample material. The specimen is held by hand and mechanically cramped within the polishing area. Polishing was done after the lapping process to obtain the flat surface, scratch-free and mirror-like surface. Then after polishing, etching is performed to obtain clear and visible microstructure. The type of etchant used in this study is the blend of 0.5% HF solution and 99.5% water solution. Figs. 1 and 2 show the optical micrograph of AA6061 and reinforced aluminium matrix composites respectively. The result of the optical micrograph revealed the presence of silica from the rice husk ash used as reinforcement to improve the properties of the developed composite.

2.3. Mechanical properties

The developed composites at different reinforcements were evaluated in hardness and tensile properties. The Brinell hardness was calculated at a load of 100 g for 15 s. The universal testing machine (UTM) SM1000 was used in this work for testing the material tensile strengths. Tensile test of prepared samples was estimated with SM1000 universal testing machine according to ASTM A370 standards. The UTM was utilized in testing the material strength. The sample used was of diameter 10 mm and gauge length 170 mm which was machined from the cast composites with the gauge length of the specimen parallel to the longitudinal axis of the cast. The machine used a load capacity of 100 kN to determine the strength of the developed material.

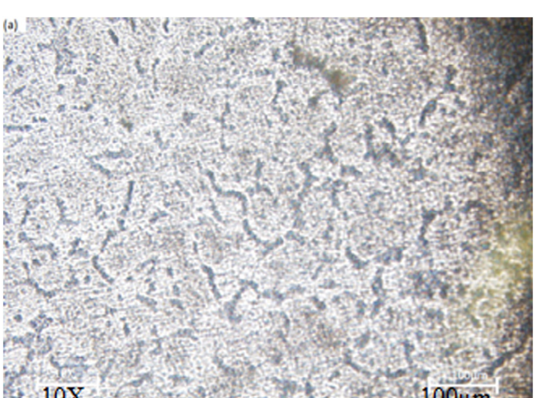

Fig. 1. Optical micrograph starting aluminium sample.

2.4. Electrical property testing

The electrical properties for the starting material and reinforced aluminium alloy specimen were joined in a circuit with a voltmeter and ammeter to measure the current and resistance when a voltage passed through each specimen. The ammeter-voltmeter technique is the easiest and fastest method for calculating resistance. It produces a relatively precise value above the resistances. For this technique, the current through the test resistor and the potential drop across it are measured concurrently. The readings are gotten using ammeter and voltmeter, respectively. The demanded scope of equipment and the supplied voltage is dependent on the dimension and rate of the test resistance [10]. Fig. 3 shows the electrical testing set up.

3. Results and discussion

3.1. Microstructure

The microstructure of the composites was observed using an optical microscope to reveal the surface morphology of the different percentage reinforcement of the composite. The optical view of the specimen was taken at 10x magnification, at a distance of 100 μm. Fig. 1 and Fig. 2 (a –d) show the microstructure results of the sliced part of the starting aluminium sample and developed composites obtained using an optical microscope. The existence of Silica is shown in whitish phase, whereas the greenish-brown phase is the matrix phase (Al alloy). It was found that rice husk ash particulates appear in the final stage of the solidification and enclosed the eutectic phases. From Fig. 3 (a –d) the equitably spreading of the rice husk ash particles was found. The microstructure for AA6061 was not satisfactory due to accumulation of the oxidized film over the surface of the cast. The analysis visibly revealed that as the accumulation of rice husk addition improves in the matrix, the morphological arrangement of the reinforced materials becomes more outstanding and homogeneously distributed. It shows that the addition of rice husk ash results in an enhancement in grain boundaries of the developed composites. The factors that control the dissemination of particles are solidification rate, fluidity, type of reinforcement and the method of incorporation [12].

4. Mechanical properties

4.1. Hardness

Fig. 4 shows that the hardness of the aluminium alloys improved with the inclusion of rice husk ash reinforcements. The increase in the hardness is attributed to the addition of 8 wt% RHA particles which revealed that RHA retains higher hardness

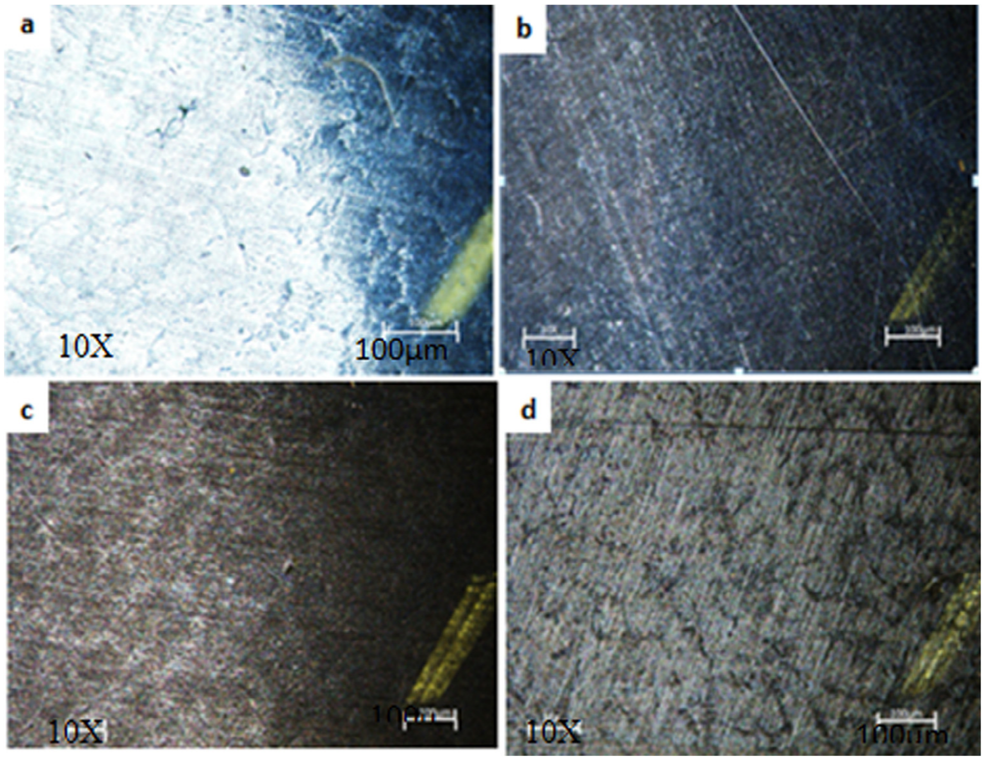

Fig. 2. (a): Optical micrograph for AA6061 + 2%RHA (b) Optical micrograph for AA 6061 + 4% RHA (c) Optical micrograph for AA 6061 + 6% RHA (d) Optical micrograph for AA 6061 + 8% RHA.

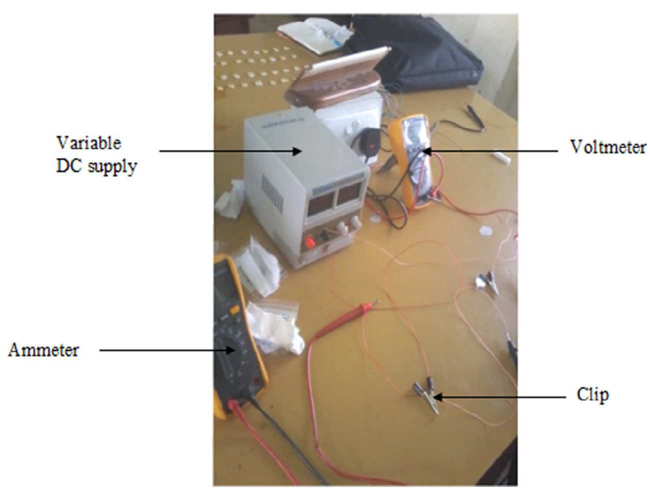

Fig. 3. Electrical testing setup.

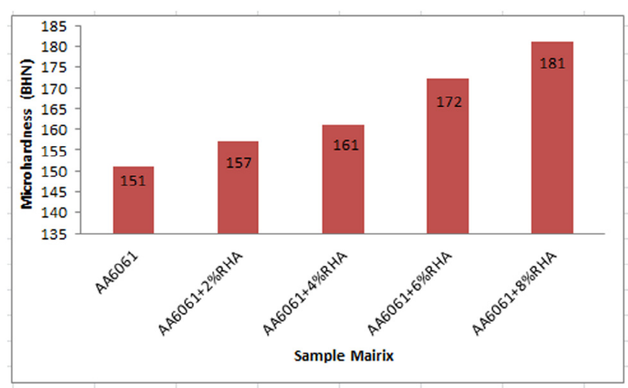

Fig. 4. Effect of RHA content on Microhardness.

and its presence in the matrix enhance the hardness of the composite as shown in Fig. 4. The increase in hardness was in line with a study carried out by Narasaraju, &. Raju, (2015), which marked the enhancement in a fraction of hard and brittle phase of the RHA in the AA6061 [11].

4.2. Tensile test

Fig. 5 shows the graph of the tensile strength of the unreinforced and reinforced aluminium alloy. It was observed that the peak strength is 6442 Kpa for unreinforced aluminium alloy while the peak strength of different reinforcement is more than that of unreinforced aluminium. From the tensile results, it was observed that the tensile strength of reinforced aluminium matrix compos-

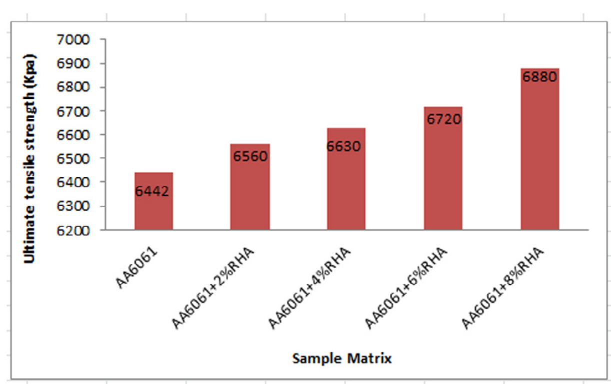

Fig. 5. Effect of RHA particles on Tensile Strength.

Table 2
Electrical Properties values for RHA reinforced AA6061.

Sample designation	Maximum current (amperes)	Maximum voltage (V)	Maximum resistance (Ω)	Conductance (Ωm^{-1})	Resistivity (Ωm)
AA 6061	1.621	2.5	6.17	1.6311	0.61308
AA 6061 + 2% RHA	1.672	2.5	5.38	1.7370	0.57566
AA 6061 + 4% RHA	1.653	2.5	7.86	1.4199	0.70426
AA 6061 + 6% RHA	1.631	2.5	6.13	3.0210	0.33102
AA 6061 + 8% RHA	1.691	2.5	4.73	3.6770	0.27195

ites is higher than unreinforced aluminium alloy. The rise of tensile strength in aluminium matrix composites is caused by applied tensile load transfer to the strongly bonded reinforcements of 8% RHA in an aluminium alloy matrix. From the obtained data, the UTS of the developed composites increased considerably from 6442 KPa control sample to about 6880 KPa for the developed alloy at a level of 6.8%. The improvement in tensile strength of AMCs can be ascribed to the applied load moved to the intensely bonded reinforcements in aluminium alloy matrix [12].

5. Electrical property testing

The electrical properties of the developed composite were examined using the ammeter-voltmeter method. The values are present in Table 2 and Figs. 6 -7. The RHA reinforcement increased the conductance of the AA6061 from 1.63 Ωm-1 to 3.68 Ωm-1. This makes the metal matrix to conduct electricity due to the presence of silica in the aluminium alloy. The resistivity of the aluminium alloy decreased from 0.61 Ωm to 0.27 Ωm showing the degree of functionality of the developed composites. It was observed that the electrical conductivity of all reinforced aluminium alloy was greater than the unreinforced aluminium alloy [12]. It was also noticed that the inclusion of hybrid nano fortified materials leads to an increase in electrical conductivity of the reinforced aluminium alloy [13].

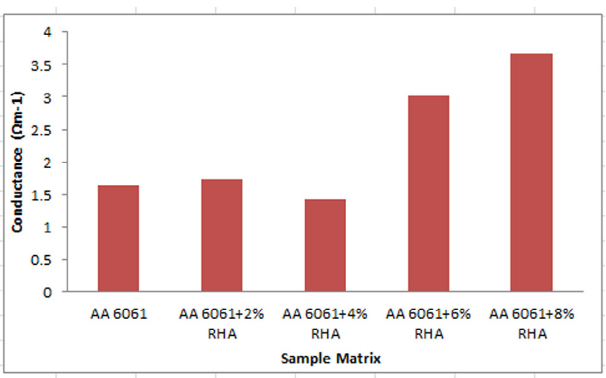

Fig. 6. Conductance of RHA reinforced AA6061.

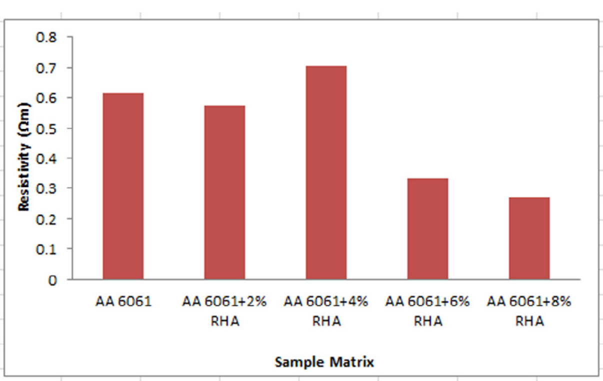

Fig. 7. Resistivity of RHA reinforced AA6061.

6. Conclusion

- AA6061/Rice husk ash composite was expertly fabricated by stir casting technique with different percentage weight of reinforcements.
- The presence of 8% wt RHA in the aluminium alloy increases the mechanical properties to a higher value than the unreinforced aluminium alloy.
- The optical microscope images show the exceptional interfacial bonding and particles are well distributed in the aluminium matrix with 8% wt RHA.
- The RHA reinforcement increased the electrical conductivity of the AA6061 from 1.63 Ωm^{-1} to 3.68 Ωm^{-1} because of the presence of silica in the aluminium alloy.

CRediT authorship contribution statement

N.E. Udoye: Writing - original draft. **A.O. Inegbenebor:** Conceptualization, Methodology, Software, Data curation. **O.S.I. Fayomi:** Visualization, Investigation, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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