A Review Paper on Development of Aluminum Matrix Composite with Organic Reinforcements

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ABSTRACT

The main background of this study is the desire to create materials through sustainable methods that will be environmentally friendly and have low-cost production. Most authors have focused on developing aluminum matrix composites through various inorganic reinforcements. These AMCs have improved mechanical, physical, chemical, and thermal properties as well as improved wear and corrosion resistance. This paper studies alternative reinforcement materials that are organic, inexpensive, and easily available which can be used in place of inorganic reinforcements. Based on the literature that has been studied, various organic reinforcements like aloe vera, coconut husk, rice husk, and so on have been used for developing aluminum matrix composites. It was discovered that the addition of organic materials as reinforcements results in improved mechanical and physical properties of the composite materials, based on the literature review.

***Keywords*: aluminum, reinforcements, composites, organic, inorganic**

INTRODUCTION

Aluminum matrix composites (AMCs) are widely used in engineering industries like automobile, aerospace, construction, etc. due to their excellent mechanical and physical properties (R. Dabral et al, 2017). The most widely used reinforcements in AMCs are inorganic materials like SiC, Al2O3, graphite, and so on, as they have good mechanical, physical, and chemical properties and are non-reactive to the matrix material (Isiaka Oluwole OLADELE et al., 2016).

As most of the reinforcements that are widely used in the AMCs are inorganic materials, it causes concern to the environment and poses health hazards. The availability of inorganic reinforcements is also an issue (Peter Omoniyi et al., 2021). Inorganic reinforcements like SiC, Al2O3, carbon, graphite, etc. are expensive and have high-cost production. This has shifted the researcher's attention to organic reinforcements for developing AMCs (V.S. Aigbodion, 2019).

Organic reinforcements like coconut husk, aloe vera, eggshell, bean pod, and so on are suitable alternatives to inorganic reinforcements as they are inexpensive, readily available, and have low-cost production. The AMCs developed using organic reinforcements have enhanced properties and are environmentally friendly (B. Praveen KUMAR et al., 2017). Currently, researchers are focusing on producing more organic reinforcements-based AMCs and promoting the usage of organic reinforcements as it will benefit the future of our environment (Y. B. Zamri et al., 2010).

This paper studies the different organic reinforcements that have been used to produce AMCs in recent years. This paper also discusses the enhancement of mechanical, physical, chemical, and thermal properties as well as improved wear and corrosion resistance of the AMCs developed with organic reinforcements and encourages for using more organic reinforcements due to their benefits to the environment.

REVIEW OF LITERATURE

An experiment had been carried out to determine the mechanical properties and microstructure of the aluminum matrix composites reinforced with wood particles. Aluminum waste cans were collected as the matrix material. Then it was crushed and melted in the furnace. The composite was prepared through the stir casting method. Five samples were produced with wood particle percentages varying from 0%, 5%, 10%, 15%, and 20%. After the characterization of the samples, it showed that the impact strength, tensile strength, and hardness of the composites were improved with wood particles as reinforcement. The wood particles were present homogeneously in the matrix material (Peter Omoniyi et al., 2021).

Table 1 (Source: Peter Omoniyi et al., 2021)

Element	Aluminum waste can's chemical composition (wt%)
Si	0.59
Fe	0.431
Cu	0.074
Mn	0.388
Mg	2.143
Ti	0.006
Cr	0.008
K	0.013
Zn	0.194
Al	96.043
Others	0.11

Table 2 (Source: Peter Omoniyi et al., 2021)

Content	Wood particulate's chemical composition (wt%)
Ash	8.17
Volatile	73.08
Sulphur	0.12
Nitrogen	0.17
Carbon	48.7
Hydrogen	6.3
Oxygen	44.8

Evaluation of AMC produced with mustard husk as reinforcement was carried out to determine its mechanical properties. Pure aluminum was used as the matrix material and a muffle furnace was used to convert the mustard husk to ash. The AMC was prepared through the powder metallurgy method with mustard husk ashes percentages varying from 2.5%, 5%, 7.5% & 10%. Tests were conducted on the composites and the results showed that reinforcements were present uniformly in the matrix material. Physical and tribological properties of the AMC got enhanced and hardness also improved, but only up to a certain percentage of the mustard husk ash as reinforcement (Tafzeelul Kamal et al., 2018).

Table 3 (Source: Tafzeelul Kamal et al., 2018)

Element	Mustard husk ash's chemical composition (wt%)
O	46.07
Mg	4.48
Al	7.94
Si	18.73
S	1.88
Cl	2.96
K	5.07
Ca	12.87

An AMC had been developed using corn cob ash as the reinforcement to determine its physical and mechanical properties. Al6063 was used as the matrix material. The stir casting method had been applied to prepare the composite having the percentage of corn cob ash as reinforcement varying from (2.5, 5, 7.5, 10, 12.5 & 15) %. The chemical composition of corn cob ash consists of SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, SO_3, Na_2O, and K_2O with a weight percentage of (66.34, 7.48, 4.44, 11.57, 2.06, 1.07, 0.41, 4.92) %. Characterization of the samples showed that the reinforcement was present homogeneously in the matrix material. The wear resistance and hardness of the AMC developed with corn cob ash reinforcement had improved significantly. The developed AMC was more lightweight compared to the unreinforced aluminum alloy (Benjamin Ufuoma Odoni et al., 2020).

An experiment had been carried out to determine the mechanical characterization of AMC reinforced with aloe vera. Pure aluminum was used as the matrix material and aloe vera powder was formed from the leaves of the aloe vera. Constituents of aloe vera comprise of calcium, magnesium, sodium, potassium, phosphorous, iron, copper and zinc with weight percentage of 3.58%, 1.22%, 3.66%, 4.06%, 0.02%, 0.1%, 0.06% and 0.02%. The AMC was developed using a stir casting process. In the experiment fly ash had also been used as reinforcement, so after the characterization, it had been found that ultimate tensile strength and hardness got improved with aloe vera as reinforcement as compared to fly ash as reinforcement or unreinforced aluminum (Ch. Hima Gireesh et al., 2017). In another experiment, an AMC was developed using Al6061 as matrix material and aloe vera powder as reinforcement to investigate its mechanical properties by the stir-casting process. The results showed that the hardness of AMC developed using Al6061 and aloe vera powder was slightly less than that of AMC developed using pure aluminum and aloe vera powder but higher than unreinforced aluminum. The yield strength of AMC (Al6061-aloe vera) was higher than that of AMC (pure aluminum-aloe vera) (Ch. Hima Gireesh et al., 2019).

An AMC was developed using Al2009 as matrix material and bean pod as reinforcements to determine its mechanical and wear properties. Bean pods are waste products of bean seeds. Tests were conducted on the AMC developed using bean pod as reinforcement. The results showed that the developed AMC was lightweight and had better strength compared to the unreinforced aluminum alloy. Tensile strength and hardness also increased in the developed AMC and the wear rate was lower compared tounreinforced aluminum alloy (V.S. Aigbodion, 2019).

A study had been conducted to determine the effect of eggshells as a reinforcement on the mechanical properties and microstructure of the developed AMC. Aluminum alloy 2024 (AA2024) was chosen as the matrix material and eggshell powder had been formed from the chicken eggshell. Three samples were created with reinforcement percentages varying from 7%, 10%, and 13%. The AMC was developed using the stir casting process. Characterization had been conducted on the developed AMC and it showed that tensile and compression strength had improved, but hardness got decreased (Sabitha Jannet, R. Raja et al., 2020).

Evaluation of AMC developed with rice husk ash as reinforcement had been carried out to determine its effect on mechanical properties. AlSi10Mg was used as the matrix material. Three samples were formed with rice husk ash as reinforcement percentages varying from (6, 9, and 12) %. For development, the AMC stir casting method was applied and then the characterization of the samples had been conducted. It showed that the reinforcement was present homogeneously in the matrix material. The results also showed that the tensile strength, compression strength, and hardness also increased compared to the unreinforced aluminum alloy (S.D. Saravanan et al., 2013).

Table 4 (Source: S.D. Saravanan et al., 2013)

Element	Rice husk ash's chemical composition (wt%)
SiO_2	94.04
Al_2O_3	0.249
Fe_2O_3	0.136
CaO	0.622
MgO	0.442
Na_2O	0.023
K_2O	2.49
LOI	3.52

Experimentation was carried out to investigate the mechanical and tribological properties of AMC developed with bamboo leaf ash as reinforcement. Al-4.5%Cu was chosen as the matrix material. The stir casting process had been used to produce the AMC with bamboo leaf ash as reinforcement. Four samples were created with the percentage of reinforcement varying from (0, 2, 4, and 6) %. The constituents present in the bamboo leaf ash comprise SiO_2, CaO, K_2O, C, Al_2O_3, MgO, and Fe_2O_3 with weight percentages varying from (76.2, 6.68, 5.62, 4.2, 4.13, 1.85 and 1.32) %. Testings had been conducted on the developed AMC and the results showed that the hardness and tensile strength had improved as compared to the unreinforced aluminum alloy. It also showed that bamboo leaf ash as reinforcement presents uniformly in the matrix material. The wear rate also got reduced in the AMC reinforced with bamboo leaf ash compared to unreinforced aluminum alloy (Praveen Kumar Bannaravuri et al., 2018).

An aluminum matrix composite (AMC) had been developed using coconut husk ash as the reinforcement through the stir casting process to understand the effect of reinforcement on the properties of the developed AMC. The constituents of the aluminum alloy comprise Al, Cr, Cu, Fe, Mg, Mn, Si, and Zn with a weight percentage of (99.1, 0.03, 0.05, 0.3, 0.2, 0.1, 0.2, and 0.02) %. The constituents of the coconut husk ash comprise SiO_2, Al_2O3, Fe_2O_3, CaO, MgO, SO_3, MnO & K_2O with weight percentage of (14.34, 35.61, 0.18, 33.27, 19.86, 0.004, 0.21 & 1.03) %. After the characterization, it showed that the developed AMC had improved wettability, lower density, and uniform distribution of the coconut husk ash in the matrix material (Siddharth Jain et al., 2018).

An AMC had been developed using palm oil clinker as the reinforcement to determine its tribologicalapplications. Pure aluminum was chosen as the matrix material and samples were created with palm oilclinker as reinforcement with percentages varying from 5 to 12 %. The AMC was developed using the powder metallurgy method. Tests were conducted on the samples; the results showed improvement in thewear resistance and reduction in the rate of wear and propagation of crack (Y. B. Zamri et al., 2010).

CONCLUSIONS

This study has shown that organic reinforcements are proper alternatives to inorganic reinforcements as they enhanced the mechanical, physical, chemical, and thermal properties as well as improve wear and corrosion resistance of the developed AMC. They are inexpensive, easily available, and have benefits for the environment. Researchers should encourage the usage of organic reinforcements and the development of AMCs using organic reinforcements through substantial methods.

REFERENCES

[1]. Dabral, R.,Panwar, N.,Dang, R., Poonia, R.P., Chauhan, A.2017. Wear Response of Aluminium 6061 Composite Reinforced with Red Mud at Elevated Temperature. Tribology in Industry Vol. 39, No. 3 (2017) 391-399.

[2]. OLADELE, Isiaka Oluwole., OKORO,Avwerosuoghene Moses. 2016.The effect of palm kernel shell ash on the mechanical properties of as-cast Aluminium alloy matrix composites. Leonardo Journal of Sciences, ISSN 1583-0233, Issue 28, January-June 2016.

[3]. Omoniyi,Peter., Adekunle,Adebayo., Ibitoye,Segun., Olorunpomi,Olalekan.,Abolusoro, Olatunji. 2021. Journal of King Saud University – Engineering Sciences xxx (xxxx) xxx.

[4]. Aigbodion, V.S. 2019. Bean pod ash nanoparticles a promising reinforcement for aluminum matrix biocomposites. Journal of materials research and technology, 2019.

[5]. Bannaravuri,Praveen Kumar.,Birru, Praveen Kumar. 2018. Strengthening of mechanical and tribological properties of Al-4.5%Cumatrix alloy with the addition of bamboo leaf ash. Results in Physics 10 (2018) 360–373.

[6]. Zamri,Y. B., Shamsul, J. B., Amin, J. B. 2010. POTENTIAL OF PALM OIL CLINKER AS REINFORCEMENT INALUMINIUM MATRIX COMPOSITES FOR TRIBOLOGICAL APPLICATIONS. International Journal of Mechanical and Materials Engineering (IJMME), Vol.6 (2011), No.1, 10-17.

[7]. Kamal,Tafzeelul., Siddiqui, M. Arif. 2018. Evaluation of mustard husk ash as reinforcement for aluminium matrixcomposite.Materials Research Express.

[8]. Odoni,Benjamin Ufuoma.,Odikpo, Edoziuno Francis., Chinasa,Nwaeju Cynthia., Akaluzia, Richard O.2020. Experimental analysis, predictive modelling and optimization of some physical and mechanical properties of aluminium 6063 alloy based composites reinforced with corn cob ash. JOURNAL OF MATERIALS AND ENGINEERING STRUCTURES 7 (2020) 451–465.

[9]. Gireesh, Ch. Hima., Prasad, K.G. Durga., Ramji, K., Vinay, P.V.2017. Mechanical Characterization of Aluminium Metal MatrixComposite Reinforced with Aloe vera powder.Materials Today: Proceedings 5 (2018) 3289–3297.

[10]. Gireesh, Ch. Hima.,Ramji, K. 2019. Experimental Investigation on Mechanical Properties of Al 6061 Metal Matrix Composite Reinforced With Aloe Vera Powder. International Journal of Engineering and Advanced Technology (IJEAT). ISSN: 2249 – 8958, Volume-8 Issue-4, April 2019.

[11]. Jannet, Sabitha., Raja, R., Ruban, S. Rajesh., Khosla, Samuel., Sasikumar, Uppara.,Sai,Nagaruru Balaji., Teja, Papasani Muni. 2020.Effect of egg shell powder on the mechanical and microstructureproperties of AA 2024 metal matrix composite. Materials Today: Proceedings.

[12]. Saravanana,S.D.,Kumarb, M.Senthil. 2013. Effect of Mechanical Properties on Rice Husk Ash ReinforcedAluminum alloy (AlSi10Mg) Matrix Composites. International Conference On DESIGN AND MANUFACTURING, IConDM 2013.

[13]. Jain, Siddharth., Aggarwal, Vidit., Tyagi, Mohit., Walia, R.S., Rana, Ramakant. 2018. DEVELOPMENT OF ALUMINIUM MATRIX COMPOSITE USING COCONUT HUSK ASH REINFORCEMENT. International Conference on Latest Developments in Materials, Manufacturing and Quality Control (MMQC-2016) ISBN No: 978-93-5212-858-7.