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Analysis of the morphological and mechanical characterization of aluminium matrix composite reinforced with chitosan

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Abstract

Recent studies acknowledge that convectional ceramic particulate could be replaced by several agricultural by-products in the development of aluminium matrix composites because of its selected for their low cost and relative ubiquity. This study explores the development of aluminium matrix composite from AA6061 alloy reinforced with chitosan particulates at weight proportions (3, 6, 9, and 12 wt%). The study further characterizes the developed composites using Scanning Electron Microscopy (SEM), Energy Dispersive Spectroscopy (EDS), X-ray Diffractometer (XRD), hardness, tensile and thermal and electrical conductivity test techniques. Results indicated that increasing chitosan content up to 10 wt% enhanced the hardness performance, while tensile strength of the composites increased sporadically, as SEM images observed reinforcement links embedded in grain boundaries. However, the thermal and electrical conductivity diminished due to the addition of chitosan particulates to the alloy matrix. The overall study showed the great potential of chitosan polymer as reinforcement to aluminium alloy.

Introduction

The evolution of the engineering discipline has intimated developments of advanced materials to sustain equipment performance in austere conditions confronted in the energy, aerospace, automotive and construction industries. Scientists have purported metal matrix composites MMC for the enhancement of material strength to weight ratio, dilapidation resistance, and conductivity in industrial machinery [1], [2], [3]. Aluminium is a quintessential metal to human civilization. As noted in literature, reinforcements provide material property customization targeted at specific engineering needs. Aluminium, a copious lightweight metal, has been extensively applied in the fabrication of automobiles and aeroplanes parts, components, and structures. Yet, the laudable corrosion resistance, substantial thermal and electrical conductivity of aluminium influence its utilization as base material in household utensils, sporting equipment, appliances, and electronic devices. Thus, extensive research has sought to extend the application of aluminium by improving certain desirable properties. Subsequently, scientist have developed and investigated aluminium matrix composite reinforced with ceramics: Al_2O_3, aluminium oxide; SiC, silicon carbide SiO_2, silicon oxide; B_4C, boron carbide; and TIC, titanium carbide. However, the prevalent interest on sustainability and the impact of human activities to the environment highlight pollution produced from the synthesis of ceramic reinforcements. Furthermore, concerns over the availability and cost of aluminium metal matrix composites (AMMCs) reinforced with ceramic composites have limited AMMC adoption at a large scale. Accordingly, cost efficient synthesis technique, most notably stir casting, have been adopted as well as the utilization of agricultural waste material as reinforcement in AMMCs. Therefore, agro–waste like rice husk, breadfruit seed, bagasse seed, eggshell, coconut husk, and aloe vera have gained prominence in industry as preferred alternatives to ceramic reinforcements, moreover numerous research work is dedicated to exploring reinforcement materials to attain superior corrosion, mechanical and morphological properties to that of unreinforced aluminium. These waste derivatives of terrestrial and aquatic animals as well as plants have been found to attenuate environmental impact and improve material performance. Hence, this research seeks to employ chitosan particulates of 90 μm sieve size as reinforcement to the AA6061 aluminium alloy matrix developed via stir casting and characterize the composites mechanical, morphological, thermal, and electrical properties.

Section snippets

Ceramic reinforcements of aluminium alloys

Reinforcement of metals to achieve superior performance predates modern civilization [4], [5], however preliminarily contemporary applications of aluminium composites were in the development of aircrafts [6]. Driven, Over the years, scientists have explored reinforcement materials particularly ceramic particulates in developing AMMCs. The

ceramic particulate, alumina, Al_2O_3, is highly prioritized in reinforcements selection for aluminium and its alloys, which is attributed to empirically proven

Material

The materials selected for this research are AA6061 and Chitosan particles of sieve size 90 μm.

Preparation of aluminium matrix composite

In this study, stir casting is employed for the development of composites. Stir casting involves the use of a mechanical stirrer to consolidate reinforcement particulates in a molten metal by creating forced vortexes. The process ensures the homogeneous distribution of the particulates in the base matrix. Thus, obtained chitosan particles were sun-dried and milled to smooth powder, as shown in Fig. 1a

Conclusion

Chitosan of 90 μm sieve-size was successfully coalesced in aluminium alloy, AA 6061, matrix via stir casting in weight proportion 3 %, 6 %, 9 % and 12 %. The characterization of the developed composites resulted in the following conclusions:

- •
  Hardness of the developed composites improved with higher concentration of chitosan particulate; 9 wt% chitosan reinforced sample developed a substantial 4.88 % improvement.
- •
  Composite coalesced with Particulate Reinforcement high percentage of contained

CRediT authorship contribution statement

N.E. Udoye: . **V. Ezekiel:** Data curation, Investigation, Writing – original draft. **O.S.I. Fayomi:** . **I.P. Okokpujie:** . **J.O. Dirisu:** .

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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