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# A review on the mechanical strength of aluminium - clay composites

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**Abstract.** The innovation in the usage of cheaper materials with better quality has been in the mind of many scientists. Recently, more requests have been on the utilization of agro-industrial product to produce materials to curb ecological hazards. Clay could be an alternative to SiC and Al<sub>2</sub>O<sub>3</sub> due to their cheaper rate and availability. Reinforcements can be integrated into the melt using cheap and globally recognized stir casting method. Low - cost eco-friendly waste products that are easily accessible like clay, nanoclay, kaolinite, mica, and carbon are utilized as reinforcement in aluminium alloy. This review paper studied the various compositions of aluminium alloy composites for manufacturing purposes and its usage in automobile, aircraft, marine and the transportation industry. The study revealed that the addition of clay as reinforcement increases the properties of the composites.

## 1. Introduction

The development of cheaper materials, particularly aluminium matrix composite with improved structure, has been the desire of many scientists [1-3]. The examples of cheaper materials include aluminium clay, kaolin groups, smectite groups, illite group, and ceramics. Ceramics is defined as naturally derived materials of inorganic crystalline origin obtained from kaolins after thorough heat action. The existence of mineral impurities in the form of crystalline lattice of the kaolinite gives the natural colour of kaolins [4]. The minerals from clay are needed in virtually all natural ceramic minerals that have their primary application in engineering. Structural kaolin composing of ceramics are gorgeous and irresistible products with robust mechanical properties, low density, excellent corrosion, and high temperature resistance. The five main minerals found in clay are kaolin groups such as kaolinite, dickite, halloysite, and nacrite. Smectite groups in form of dioctahedral smectites such as montmorillonite, nontronite, beidellite, and trioctahedral smectites, illite group which includes the clay-micas, Chlorite group and 2:1 clay types in form of sepiolite or attapulgite [5].

Kaolinite, also called aluminium silicate with chemical formula Al<sub>2</sub>Si<sub>2</sub>O<sub>5</sub>(OH)<sub>4</sub> is the most commonly found mineral in clay. It has a low swell capacity often orange or red colour containing iron oxide abundantly located in the soil. The preparation of clay involves material mixing, removing of big gravels, roots, pulverizing, and final product recovery. Nigerian clays are recognized and identified as kaolin but scientific analyses and its commercial use are not usually considered. However, clay is strong, low - cost, available and environmentally friendly [6]. Clay is a good substitute in replacing high cost of reinforcement because of its accessibility and its major elements in the form of Al<sub>2</sub>O<sub>3</sub>, SiO<sub>2</sub>, Fe<sub>2</sub>O<sub>3</sub>, TiO<sub>2</sub> and Na<sub>2</sub>O. Clay could also be an alternative to SiC and Al<sub>2</sub>O<sub>3</sub> due to their cheaper rate and hardness [7]. Figure 1 shows the particulate sample of kaolinite used for the reinforcement of aluminium alloy.



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**Figure 1.** Kaolinite particulate

## **2. Microstructure**

The vital point considered in the building of composites is the determination of the homogenous distribution of reinforcements in the metal matrix alloy. It is better to protect the accumulation of particles within the matrix during the period of solidification [8-10]. [9] examined the morphology of AA6063/clay particles composites. The authors observed that the addition of the clay particulate is noticed to improve the development of pure grains. The SEM/EDX pictogram revealed the existence of aluminium, silicon, and magnesium in the as - cast sample of AA6063 during the morphological examination. The hybrid reinforcements of a multi-wall carbon nanotube (MWCNT) and nanoclay were uniformly distributed in aluminium alloy 5083 (AA5083) [11-12].

[13] studied the surface morphology of aluminium 7075/mica and kaolinite composites. The authors revealed that mica and kaolinite particulates are equally distributed in the aluminium matrix. This was possible due to the proper stirring and utilization of suitable process parameters. The results show that uniform reinforcement dispersal into the matrix was realized and there is no proof of agglomerate found. The groups devoid of reinforcements were not noticed in this study. The composite material was developed without the presence of defect like voids and porosities [13]. [14] studied the microstructure of chilled aluminium alloy/ kaolinite/ carbon composites. The homogenous dispersal of kaolinite and graphite carbon enhanced matrix structure and enriched mechanical characteristics of the chilled aluminium matrix composites when compared to unreinforced matrix alloy.

### **2.1. Mechanical behavior**

#### **2.1.1. Hardness**

The reinforcements of the metal matrix improved the hardness of the composites. According to [10], the increase in percentage of clay particle results to increment in the hardness values up to 76.7 HV at 15 wt%. [12] reported that increasing the reinforcement of aluminium 5083 will result from increasing in hardness value of the developed composites. [4] stated that increasing the lower density polyethylene and raw/calcined kaolin composite materials improve the hardness of the materials. [13] observed that the hardness value marked improvement as the increase in the amount of mica and kaolinite. The surface hardness of the aluminum 7075 is maximum at 6% of mica and kaolinite composite [14] also confirmed that reinforcement increment improves the hardness of the developed composites.

### **2.1.2. Tensile behaviour**

[10] stated that increasing the clay particulate increases the ultimate tensile strength of the composite samples. Further increment in clay particulate to 30 weight percentage of clay resulted in declining in the ultimate tensile strength to 122.29 MPa. [4] investigated that the tensile strength of low density polyethylene (LDPE) at different reinforcement decreased with increased wt% of kaolin. [11] investigated the mechanical characteristics of multi-wall carbon nanotube/nanoclay reinforced aluminium alloy 5083 Matrix Composite. The outcomes revealed that the tensile strength of composites is superior to the unreinforced Al-alloy. [12] stated that the developed composites could be utilized in a structural application. [14] stated that UTS of the developed matrix improved as the kaolinite ( $\text{Al}_2\text{SiO}_5$ ) content is increased.

## **3. Classification and applications**

### **3.1. AA 6063/clay composites**

The aluminium 6063 reinforced with clay has superphysical and mechanical characteristics than the pure aluminium alloy. The outcomes of the mechanical and tribological examinations showed perfection in the composites with 10–25 weight percentages of clays. Increasing the percentage of clay particles will improve the hardness of the matrix composites. The inclusion of clay particulate enriched the development of pure grains in comparison to the as-cast AA6063. The ductility of the aluminium 6063 affected the quantity of clay particles addition. Hence, these composites are good products utilized in automobile brake pad applications components. [4] concluded that the inclusion of kaolin as reinforcement to low density polyethylene as the matrix enhanced the material structure.

### **3.2. AA7075/ mica and kaolinite hybrid composites**

The hardness and impact strength show noticeable enhancement as the amount of mica and kaolinite increased in the aluminium matrix. The authors observed that mica and kaolinite particulates are homogeneously distributed in the aluminium matrix. These Hybrid developed aluminium matrix can be used in finding applications in automobile, aircraft, space, marine, and the transportation applications.

### **3.3. Aluminium alloy/kaolinite/C composites**

The properties of chilled metal matrix composites are higher to unreinforced matrix alloy. To increase the kaolinite ( $\text{Al}_2\text{SiO}_5$ ) content, result into increase in mechanical characteristics of the developed matrix alloy. The homogenous dispersal of kaolinite and graphitic carbon enhanced mechanical characteristics of MMCs. It was observed that the mechanical properties of metal matrix composites have improved. Therefore they are applied mostly in heavy-duty vehicles and high wear resistance.

## **4. Conclusion**

Clay can be used as a prospective reinforcement for making aluminium matrix composite. The aluminium alloy has been strengthened with various agro-industrial waste products materials such as nanoclay, kaolinite, mica, graphite carbon etc. The majority of the authors used stir casting techniques to manufacture composite materials. In conclusion, clay and kaolinite are the excellent reinforcing agent, and more work need to be done on its usage as reinforcement material. The review also revealed that aluminium matrix composites can be used in numerous industrial applications and the automotive industry. However, Nigerian clays are recognized and identified as kaolin, but scientific analyses and its commercial use are not usually considered. A few studies have been reported on aluminium matrix composites strengthened with kaolinite because both are highly tough and elastic.

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