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The micro structural and mechanical property study of effects of EGG SHELL particles on the Aluminum 6061

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Abstract

The naturally occurring bio hazardous material Egg Shell is added to the aluminum 6061 grade alloy powder and its effects on the micro structures and the properties of the composite Al 6061 with egg shell were studied. The samples of 5, 10, and 15 % by weight of the egg shell in the Al 6061 alloy powder were prepared and studied in by an optical microscope. The properties both physical and mechanical including density and Vicker's micro hardness are estimated. The results showed an improvement of hardness of about 14% with the improvement in the percentage of reinforcement. The SEM images of the specimens showed a good bonding between the egg shell and the Al 6061 alloy powder. The density of the composite reduced significantly with an increase in the composition of the egg shell in the composite.

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1. Introduction

Metal matrix composites (MMCs) due to their tailored mechanical, physical and thermal properties including their low densities, improved thermal and electrical conductivities, strength to density ratio, abrasion resistance etc., have proved to be an emerging class of materials for the aerospace, automotive, and wear applications.

The challenging part of the MMCs is the cost of the composite which depends on the reinforcement as well as the matrix materials. Hence there has been an increasing demand for the low cost reinforcements. The previous studies on the low cost reinforcements were like Kankara clay, fly ash, red mud reinforced to Al-Si alloys which gave the improved mechanical properties reducing the densities.

The earlier studies proved that the Egg Shell is an aviculture by product that is one of the world's worst environmental problems, especially in the countries where the egg product industry is well developed. Egg Shell contains about 95% calcium carbonate and 5 % organic materials. Though there were many attempts to use egg shell in many applications, it has been a

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potential filler in polymer composites. The egg shell has a relatively low density than the mineral calcium carbonate. The egg shell contains 95% by weight of Calcium Carbonate and 5% by weight of materials like Al_2O_3, SiO_2, S, P and Cr_2O_3, MnO.

The general egg shell structure is a protein lined mineral crystals, majorly of the calcium carbonate, these characteristics say that egg shell is a good material for the inexpensive, light weight, and low load bearing composite applications as of in the automotive industry, homes, offices and factories**.**

2. Experimental procedure

2.1. Materials and Equipment

The egg shell that is used in the study was a white egg shell, high purity Al6061 powder. The equipment used are a sieve machine for sieving the egg shell and obtain a uniform sized of the egg shell i.e., 106 µm, a die for the powder metallurgy, an UTM for compaction, a Micro wave furnace for sintering the compacted composite at about 550^0c, Density meter to estimate the density of the composite, Optical microscope, Brinell hardness tester

2.2. Method

The egg shell collected was washed thoroughly in water and dries\d for about 32 hours in sun, the dried egg shell was ball milled at250 rpm. The powdered egg shells were placed on a set of sieves and were vibrated for about 20 minutes and it is repeated for about 3 times and a fine particulate egg shells were collected from the sieves and the size of the egg shell used in the test were 106 µm.

The composite under study is Al 6061 and the Egg Shell with a varying composition of 5, 10, and 15 % by wt of the egg shell in the matrix. The samples were manufactured by using the powder metallurgy technique, a very fine trace amount of copper was added for the bonding of the Al powder with the egg shells during the compaction and sintering.

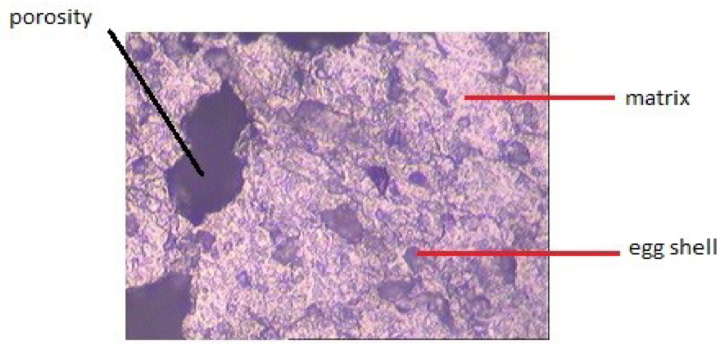
The mixture of the Aluminum powder, egg shell and trace amounts of copper were all thoroughly mixed for about half an hour and the powder obtained is filled in the die. The powder was compacted by using a die under a pressure of 15 tones. The size of the samples obtained was 25.367mm X 14mm. the obtained samples were sintered in the micro wave furnace for about half an hour and a dwell period of 10 minutes at a temperature of about 550^0c.

The density of the samples were calculated using a density meter, the they were polished properly and the micro structures are polished, etched in NITAL solution and the micro structures were taken using the optical microscope of 400X magnification, then the samples were used to find out the hardness of them, using the Brinell hardness tester, the diameter of the ball indenter as 5mm and the load was 250 Kg F.

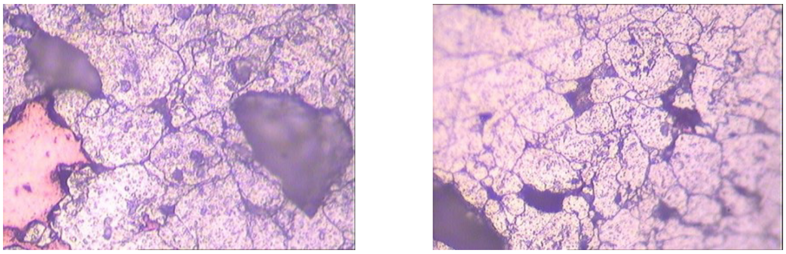
3. Results and discussions

3.1. Micro Structural results

The micro structural study of the samples reveal that they have particles of different size and shapes, porosity, the dispersion of the egg shell and the trace amounts of copper in the aluminum powder. The micro structures reveal that egg shell was uniformly distributed but the trace amounts of copper which was added was equally distributed in the matrix phase because of the difference in size of copper and aluminum powder. The egg shells were retained in the phase is clearly observed in the micro structures.



(a)



(b) (C)

Figure 1: (a) 5% egg shell by wt; (b) 10% egg shell by wt;(C)15% egg shell by wt

The SEM and E-dax of the composites reveal that they possess the elements like Aluminum, Oxygen, Carbon in major amounts and sodium, magnesium, silicon, calcium, zinc, copper in trace amounts. From the SEM images it is evident that the egg shell was clearly retained in the phase of aluminum 6061. No gaps were present between the egg shell and the Al powder thus indicating a good bonding between the reinforcement and the matrix.

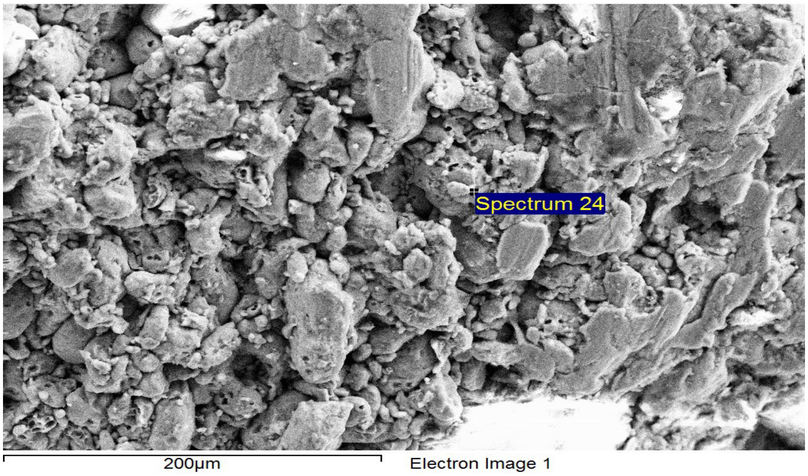


Figure 2: SEM image of Al6061 + 5% by wt egg shell

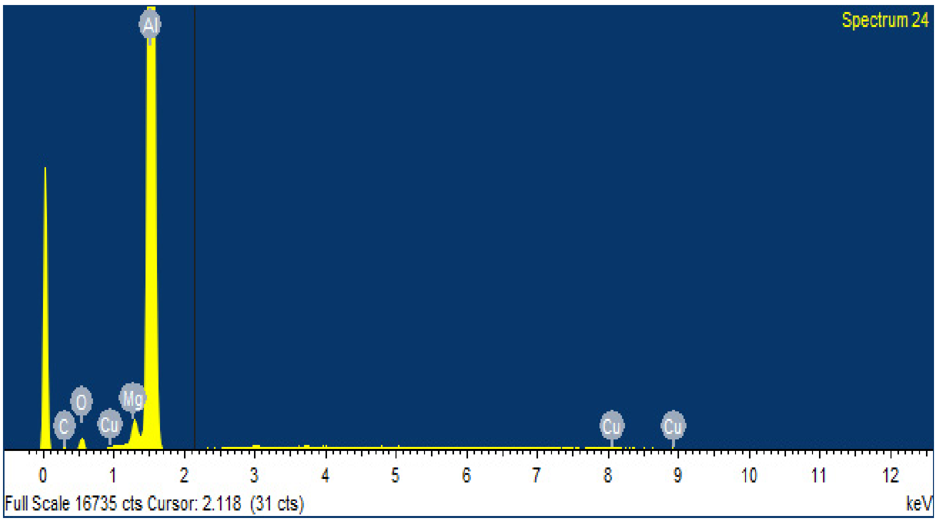


Figure 3: EDAX microstructure of Al6061 + 5% by wt egg shell

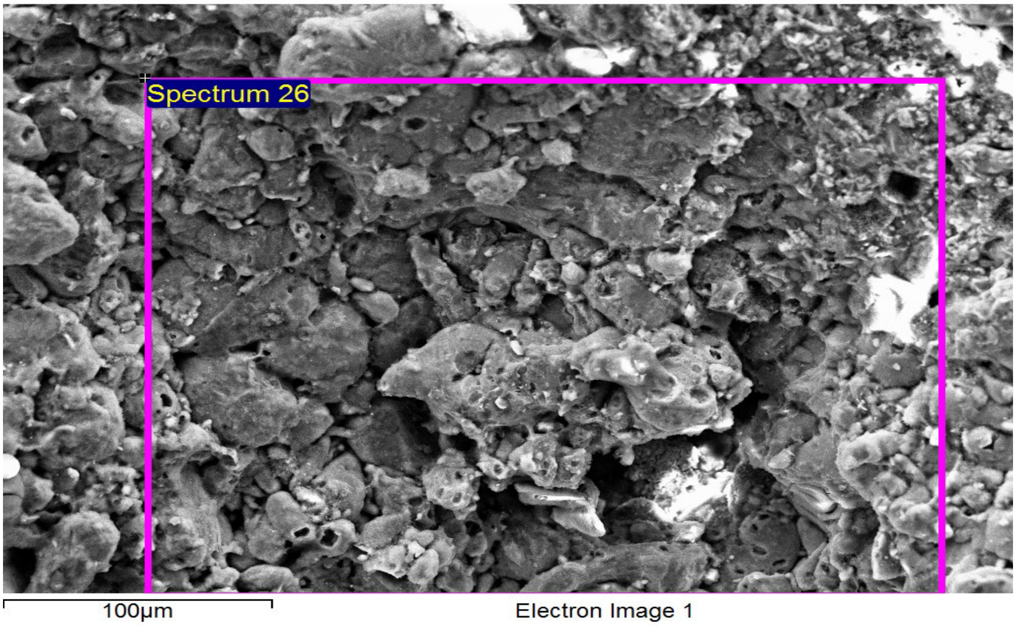


Figure 4: SEM image of Al6061 + 10% by wt egg shell

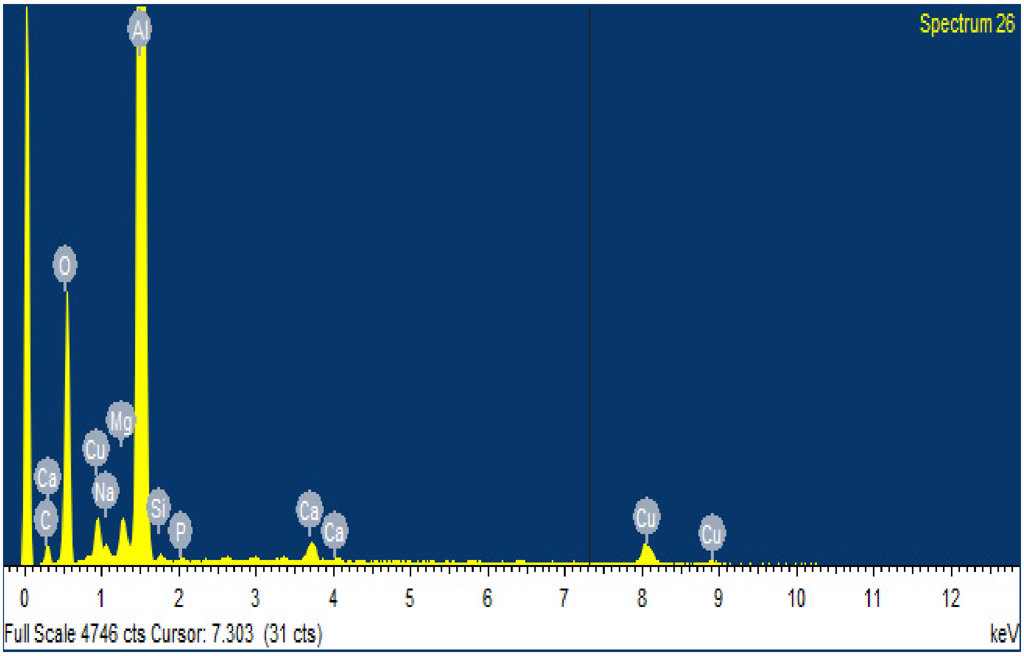


Figure 5: EDAX of the Al6061 + 10% by wt egg shell

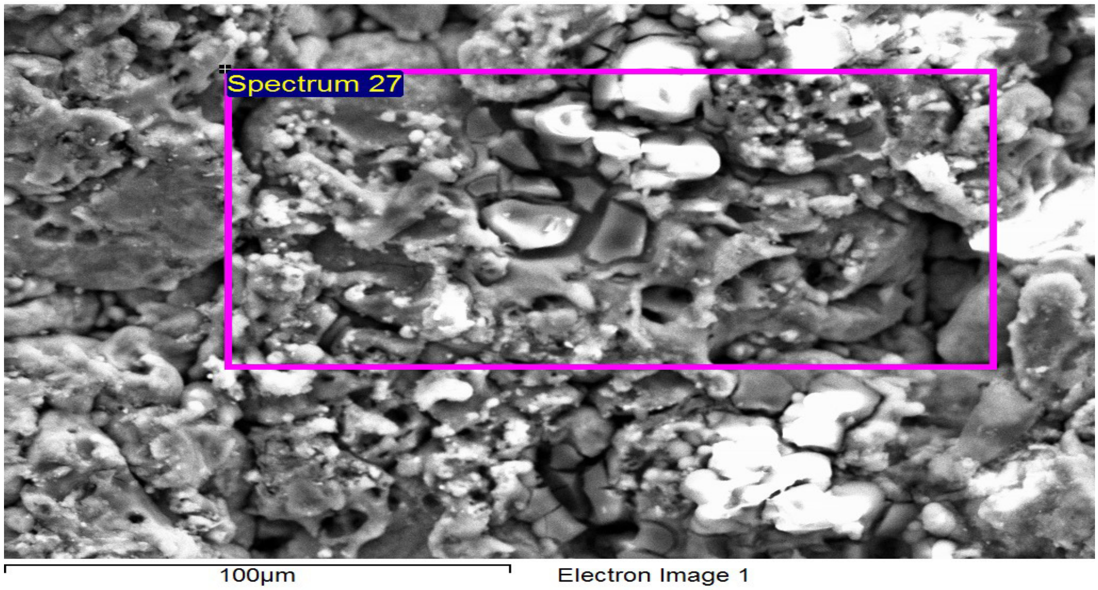


Figure 6: SEM image of Al6061 + 15% egg shell

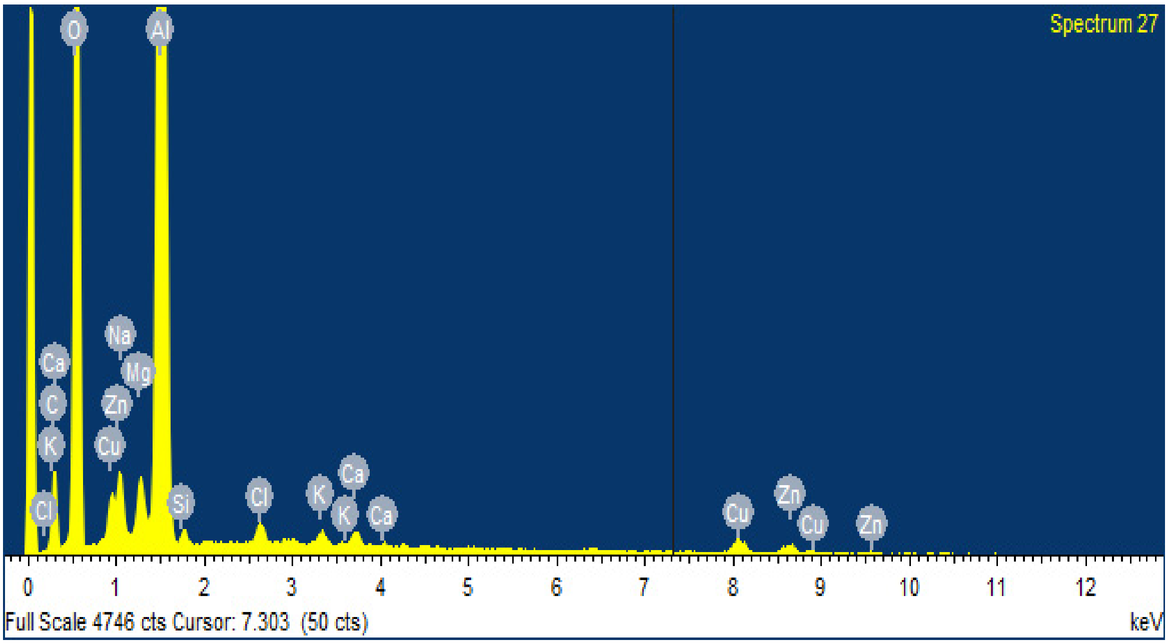


Figure 7: EDAX microstructures of Al6061 + 15% egg shell.

3.2. Density

The addition of the egg shell particles in the Al 6061 powders has reduced the density of the composite significantly. The density of the pure Al 6061 powder is found to be 2.7 g/cc. the density of the composite reduced with increasing percentage of the egg shell composition in the composite. The density decreased from 2.7 g/cc of pure Al powder to 2.28 g/cc at 15% by wt of the egg shell in the composite.

Sample number	Composition	Density (g/cc)
1	5% egg shell	2.35
2	10% egg shell	2.33
3	15% egg shell	2.28

Table 1: Composite composition and density

3.3. Hardness

The Brinell hardness testing was performed on the three samples with a load of 250Kgf and the diameter of the steel ball indenter is 5mm. the impressions made by the steel ball was observed carefully and the diameters of the impressions were used to calculate the hardness value of the samples. The results showed an improvement in the hardness with an increase in the percentage of the egg shell in the matrix material. The improvement in the hardness is less than that of the base Al 6061 metal. This is because of the sintering temperature and the compaction pressure which have a direct Impact on the hardness of the materials.

Sample	Composition	BHN
1	5% egg shell	32.32
2	10% egg shell	33.83
3	15% egg shell	37.13

Table 2: Composite composition and Brinell hardness number

3.4. Electrical conductivity

The aluminum components are very good at the electrical conductivity. Hence they find a varied number of applications in the areas where the conductivities of the products are expected to be very high. The electrical conductivity is the inverse of the resistivity. The resistivity is the constant of the proportionality for the resistance which is directly proportional to the length of the specimen and inversely proportional to the area of the specimen. The results showed that the electrical conductivity of the specimens reduced considerably because the reinforcements, egg shell used in the composite are insulating.

$$\rho = RA/l$$

$$k = 1/\rho \ (\Omega m)^{-1}$$

A= Cross sectional area of specimen
R = Resistance
l = length of the specimen

k = conductivity

Table 3: Composite composition and electrical conductivity

Sample	Composition	Electrical conductivity $(\Omega m)^{-1}$
1	5% egg shell	22.935
2	10% egg shell	21.13
3	15% egg shell	18.56

4. Conclusions

Results conclude that the egg shell particles were successfully incorporated in the Al 6061 by the powder metallurgy methodology. The micro structure and the SEM results reveal that the egg shell is properly and evenly distributed in the matrix phase and has a good bonding between the egg shell particles and the aluminum powder.

The addition of the egg shell particles into the aluminum phase increased the hardness of the composite with the increase in the percentage variation in the egg shell composition. This increase in the hardness of the composite is due to the bonding of the hard egg shell phase with the ductile aluminum phase which leads to increase in the dislocation density at the matrix particle interphase.

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