Microstructure and Density Characterization for Nano and Micro Alumina-Aluminum Composites Produced by Powder Metallurgy Process

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Abstract

Al_2O_3 is a major reinforcement in aluminum-based composites, which have been developing rapidly in recent years. The aim of this paper is to investigate the effect of alumina phases and amounts on the physical properties of fabricated Al-Al_2O_3 composite. Alpha micro and gamma nano of alumina with particle size of 30µm and 20 nm respectively reinforced aluminum matrix of 45 µm. The percentage of reinforcement material were in the range of (5, 10 and 15wt.%) fabricated by powder metallurgy technique. Specimens dimensions were a disc specimens with 11mm diameter and 5 mm thickness. The green density was achieved under compaction pressure of 500MPa, and then sintered under pressure less sintering at 500ºC in a vacuumed tube furnace for two hours Physical properties of the composite samples have been studied such as relative density, sintered density, porosity, microstructure characteristics, particles distribution, agglomeration, grain sizes and granularity accumulation distribution. It has been noticed that at the micro alumina phase, its relative densities are decreased when there is an increase in amount of micro alumina addition, on the contrary in case of nano composites, where the relative density are increasing along with the increase in nano alumina addition. At micro and nano composites, the produced relative densities are less than the pure aluminum relative density. Agglomeration are increasing with the increase in amount of reinforcement, while its more obvious with nano composite. Grain size reduced with the increase in amount of alumina in micro and nano composites, while, the obtained average grain size diameter is less in nano composite than in micro composites. It is obvious from the results that the variation in physical properties and microstructure of Al-Al_2O_3 composite are depends on both of alumina phases (size) and percentages. At 15wt.% of nano alumina higher relative density and lower porosity will be obtained.

Keywords: Ceramic, metal matrix, porosity, nano composite, micro composite, powder metallurgy.

Introduction

Today, as a result of the progression in technology and production, a focus have been increased on material technology science in order to produce new items that are suitably fit with the harsh working industry. A production of new advanced properties of composites have been worked on according to the requirements of engineering fields. Impeding of new particles or fibers in materials are usually called composite. In factories and manufacturing techniques, materials with low specific weight are most preferable. So, materials with light weight have got more attention, also great interest was done on the substitution of iron-based material by aluminum or other light metals like magnesium and titanium **[1]**. Pure aluminum and its alloys have a particular place within the structural materials due to their covenant manufacturing and application properties. While the main lack of AL properties is the low wear resistance and poor heat. Therefore an attention have been turned to improve this lack of properties through the metal processing and creating of new aluminum metal composite. So, producing of new aluminum metal matrix composite have got great interest and helped in overcoming the imperfections of aluminum materials**[1].**

In composite a mechanical and physical properties will be adjusted through the controlling of reinforcement volume fraction. Different ceramic particles are used for producing new composites like, SiC, MgO and B_4C, while Al_2O_3 is strongly the mostly recommended one. Al_2O_3 is more preferable than the other ceramics due to its low tendency to react with the matrix material when subjected to high temperature during sintering, chemically stable and usually does not react to produce new undesired phases**[2]**.

Many manufacturing process are available for the metal matrix composites like solid, liquid, or gaseous state. The most recommended one is the solid state and by the process of powder metallurgy technology because of its low processing temperature and no production of new phases between the matrix phase and reinforcement are obtained. So, when comparing the powder metallurgy process with the casting one, the first will reveal a better control on the microstructure of the produced composite**[3] [4]**.

Studies have been performed in order to understand the effect of volume fraction, particle size, mixing time, subjected temperature and reinforcements on the obtained microstructure,

density, porosity and grain size of the AMMCs. The investigation have been made in order to improve the homogeneity of particle distribution especially with the nano size particles. The main lack of using finer reinforcement particles especially nano size particles is the agglomeration and difficulty of achieving a homogeneity of reinforcement distribution **[5]**.

The effect of particle size on the properties of Al-Al_2O_3 that is the relative density of Al-Al_2O_3 composite was increasing with the decrease in reinforcement particle sizes and the grain size of samples having fine Al_2O_3 particles is smaller**[6]**. The microstructure fabricated of Al-Al_2O_3 with different wt.% of alumina, the retained porosity is exist while the alumina particles were uniformly distributed throughout the microstructure **[7]**. But in the case of Al- Al_2O_3 nano composites fabricated by using the ball milling, it is revealed that the microstructure uniformity of the produced samples were increased with increasing the milling time up to time of steady state condition**[8]**.

Although there have been many research studies on the effect of size and weight percent of nano and micro size alumina particles in microstructure, grains sizes, practical density, relative density and porosity of the particulate reinforced AMMCs, the effect of the specific used weight percentage (5%, 10% and15%) and the comparisons for both of nano and micro alumina is not well established yet. The objective of the present work is to investigate the effect of alumina content with different weight percentages and sizes (nano and micro) on the microstructure, grain sizes, practical density, relative density and porosity when micro alumina and nano alumina reinforced Al matrix. Composites were fabricating by method of powder metallurgy process in a vacuumed and pressure less sintering method.

Experimental procedures:

Raw Materials

The used matrix is aluminum metal with 99.9% purity and particle size of 45 µm and the reinforcements are first micro Alpha- Al_2O_3, 30µm particle size, 3.97 g/cm^3 density and 99.9% purity and second nano Gamma-Al_2O_3 of 20 nm particle size, specific surface area of 230-400 m^2/g , density of 3.97 g/cm^3 and with 99.9% purity.

Mixing and compacting

Aluminum powder mixed with micro and nano alumina powder Al_2O_3 of 5, 10 and 15wt.% respectively, mixing process was executed in a roller mixer with an addition of PCA (2 vol.% of acetone) to reduce segregation of alumina and prevent oxidation of aluminum during mixing **[20]**, a rotational speed set was 75 r.p.m **[9]** and mixing time was six hours without interruption **[3]**. After producing a homogenous distribution of Al_2O_3 with aluminum, the mixed powders were filled in an axial die made of stainless steel metal with an internal diameter of 11 mm, external diameter 16 mm and 70 mm length. Then, after filling the die with the required amount of composite powder, a reasonable the selected compacting pressure of (500 MPa) have been subjected, an average rate of the subjected load increased to 4.00 KN/second, this is to obtain more uniform pressure distribution on the surface of the sample, to provide sufficient time for the trapped air to release and to prevent residual stress concentration inside the specimen. This process ensures a green sample with less porosity and more density to be obtained. The pressure have been kept on the punch for 2 minutes long in order to prevent particles instant spring back when withdrawing the upper punch form the die **[3]**. Increasing the amount of the subjected pressure to high value during compaction were prevented, if the pressure is increased for high value a high friction between the powder and the die will generate. This will cause a stuck of the specimen with the die which might causes a damage of die. After fabricating of the green sample, sintering of the specimen by vacuumed electric tube furnace have been preformed. Vacuumed pressure was $3x10^{-6}$ bar before and during sintering process. The average heat rate of increase at the sintering process starting was 20ºC/min and is maintained until reaches the reasonable sintering temperature of 500 ºC, holding time was 2 hours**.**

Densities and porosities measurements:

The density measurement was done by Archimedes method. After compacting and sintering of the specimens, Archimedes principle have been followed to obtain the porosity and density of samples, by weighing specimens with four digits accuracy balance. Equation (1)**[15][16]** below has been used to calculate the practical density of fabricated samples:

$\rho_s=(m_a.\rho_w)/(m_a-m_w)$…….(1)**[15][16]**

where: ρ_s= Density of sintered or green specimen (g/cm^3), ρ_w= Density of water (g/cm^3), m_a= Specimens weight in air(g) and m_w= Specimens weight while hanging in water(g).

For calculating the theoretical densities of the composites, the percentage of weight of the matrix and reinforcement should be considered as well as their densities. However, the theoretical densities of composites have been calculated according to formula (2):

$\rho_t = 1/[(\frac{wf}{\rho f})+(\frac{wm}{\rho m})]$….(2)**[15][16]**

where: ρ_t =Theoretical density (g/cm^3), w_f= Weight percentage of alumina, ρ_f= Density of alumina which is 3.97 (g/ cm^3), w_m= Weight

percentage of aluminum and ρ_m= Density of aluminum which is 2.7 (g/ cm^3)
Also, the porosity has been calculated according to Archimedes principles as shows in equation (3):

$$E=[1-(\frac{\rho s}{\rho t})] \quad (3)$$ **[16]**

Atomic Force Microscopy (AFM) Examinations

Atomic force microscopy was used to follow the structural changes of powders, morphology of the surface, roughness, agglomeration, segregation, granularity, average diameter of the grains and average percentage of grain sizes in the composites. All samples were mounted in an acrylic material to facilitate their handling, had a surface grinding and then polishing. A microscope model SPM AA3000 Angstrom Advanced Inc., USA. AA3000 was used for AFM investigation. The standard unit is equipped to view the sample areas up to 10 micron by 10 micron. Two ranges of magnification have been used which they were (10000 and 4000 nano meter).

Results and discussion

Density and Porosity measurements:

Relative densities, sintered densities and porosities of micro and nano composites for different weight percent (5, 10 and 15wt% of Al_2O_3)are shown in figure1(a,b&c) and figure2 (a,b& c).

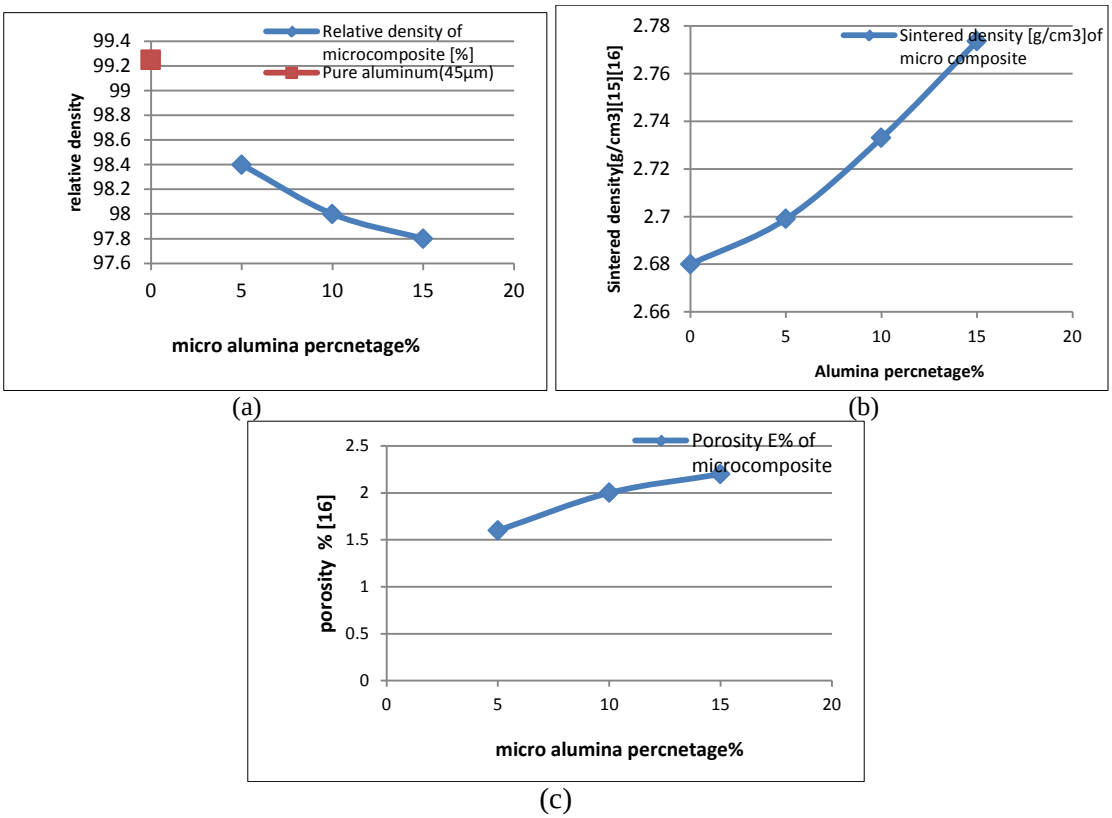


Figure 1: Aluminum and micro alumina reinforcement in Microcomposites AMMC (a) relative density (b)sintered density (c) Porosity

The relative density represent the percent of actual or sintered density to the theoretically calculated density. Fig.1 shows that the relative density are decreasing with the increase in the amount of micro alumina. The micro composites relative densities are less than the relative density of pure aluminum which is (99.2%). Many reasons could be attributed to this decrease than the pure aluminum, one is related to the high hardness of alumina reinforcement that make it works as an obstacle against the pressing capacity of the matrix, and this phenomena will increase along with the increase in the amount of alumina and lead to a decrease in relative density of the produced composite. The second reason is, the high difference in melting temperature between alumina and aluminum at the sintering process (alumina and aluminum melting tempretures are respectively 2045ºC and 660ºC)**[10]and[12]**, this difference will make alumina tendency for making bonds with pure aluminum low, and then will form weak network with the aluminum**[10]**. The third reason is related to the particle size of micro alumina (30µm) while the size of aluminum is 45µm,so due to their sizes, the empty spaces between aluminum particles are not filled

properly with the alumina powder and then a residual empty spaces will still available **[13]and[14]**, this will cause a reduction in relative density and an increase in porosity as shown in fig.1-C. This increase in porosity explained at equation (3) mentioned before which shows the relation between relative density and porosity.

Fig.1-b shows that the sintered densities are increasing with the increase in the amount of alumina additives. This increase in densities are due to alumina density is higher than the density of pure aluminum, which leads to an increase in composite densities after mixing according to the amount of alumina addition.

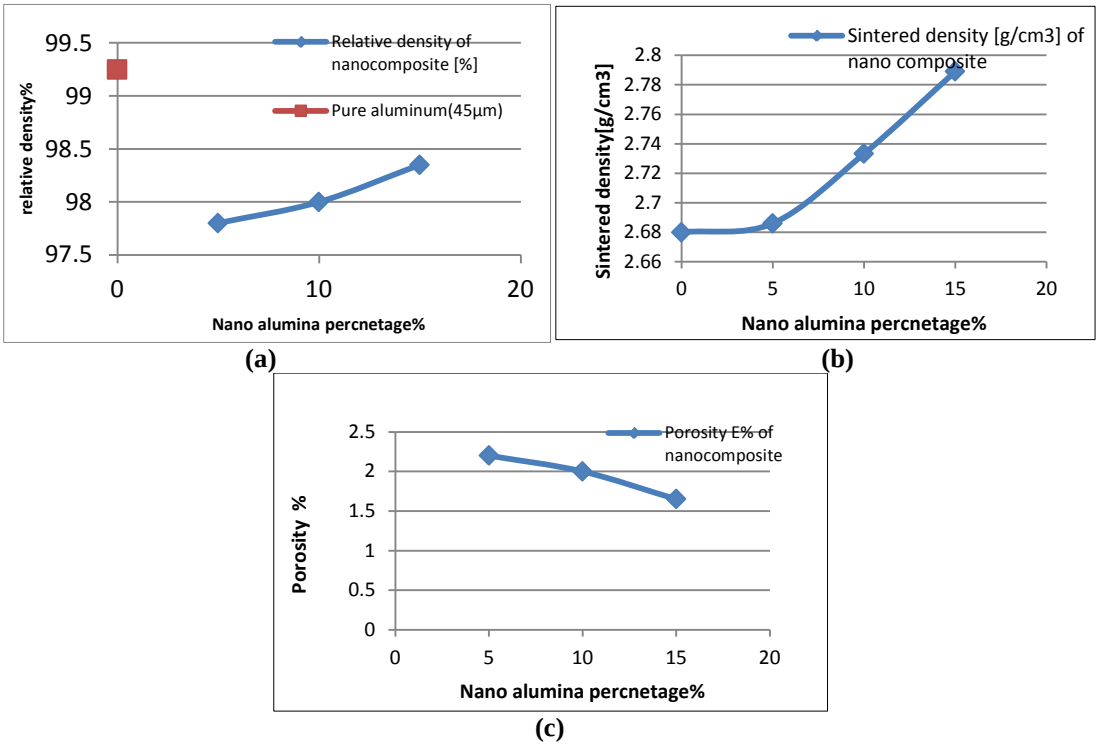


Figure 2: Aluminum and nano alumina reinforcement in Nanocomposites AMMC (a) relative density (b)sintered density (c) Porosity

Fig.2 shows that the relative densities are increasing with the increase in the amount of nano alumina. While, the nanocomposites relative densities are also less than the relative density of pure aluminum. The main reason of this decrease is related to the high hardness of alumina reinforcement where it works as an obstacle against the pressing capacity of samples. Alumina are working as a preventive factor during sintering process because of its high melting temp. in compare with aluminum, and this will cause forming of weak network bonds between alumina and aluminum which leads to a reduction in relative density than in the pure aluminum. Fig.2-b by considering the particle size for both of matrix and reinforcement when dealing with density, due to the very small size of nano alumina, the empty spaces between the aluminum particles will consume more particles and fills more properly with the nano alumina particles, therefore, an increase in relative density and a decrease in porosity will be obtained. Density of alumina is higher than of aluminum, then eventually the density will increase with the increase in the amount of nano additives and then resulting to an increase in the nano composite density.

Fig.3 presents the relative densities variation for both of micro and nano composites and according to the amount of alumina wt.% additives.

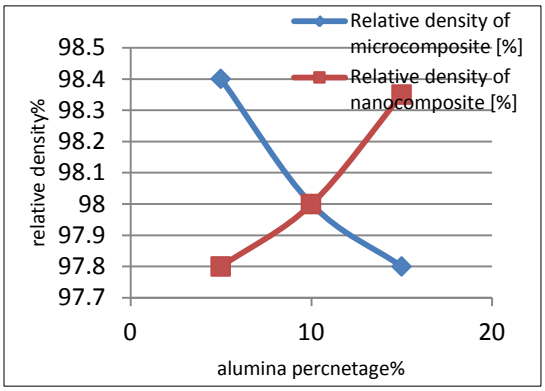


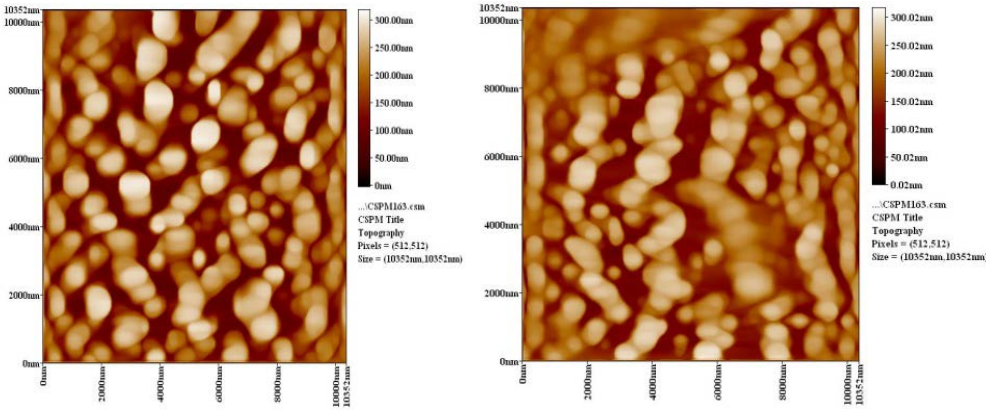
Figure 3: Relative densities variation according to the amount of alumina wt.% in micro composite and nano composite

Fig. 3 shows that the nano composite relative density are increases with the increaes in the amount of nano alumina, the inverse with the case

of micro composite were the relative densities are decreasing with the increase in amount of micro alumina. It could be seen that at 5 wt.% and 10 wt.% alumina, the relative density of micro composite is higher than of nano composite, this could be attributed to the higher size of micro particls which will fill more empty spaces and then produces an increases in density. Another reason is due to micro particle has lower surface area in compare with nano size which make the microcomposite having higher compressibility tendency. When a further amount of micro alumina (15wt.%) have been added, this will causes a decrease in relative density of the micro composite, while at the same wieght percentage of nano alumin (15wt.%) in nano composite an increase in relative density will be obtained, this is because the porosity are increased in micorcomposite, while in nanocompositie and due to its very small sizes, the furtherd amount of nano particls will immerse and intere to fill more gaps of very small spaces between aluminum matrix.

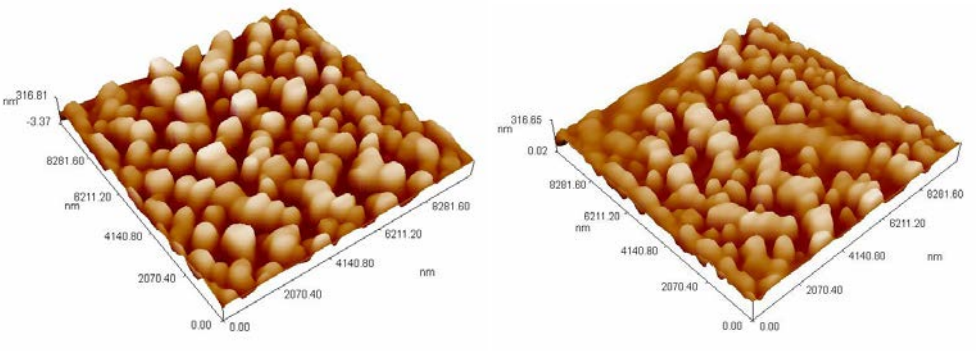
Atomic microscope for micro reinforcement

Figs. 4 to 7 show respectively the AFM images of 10000 then 4000 nano meter magnification for composites of 5wt.% micro alumina and 15wt.% micro alumina for the cases of 2D and 3D images each.



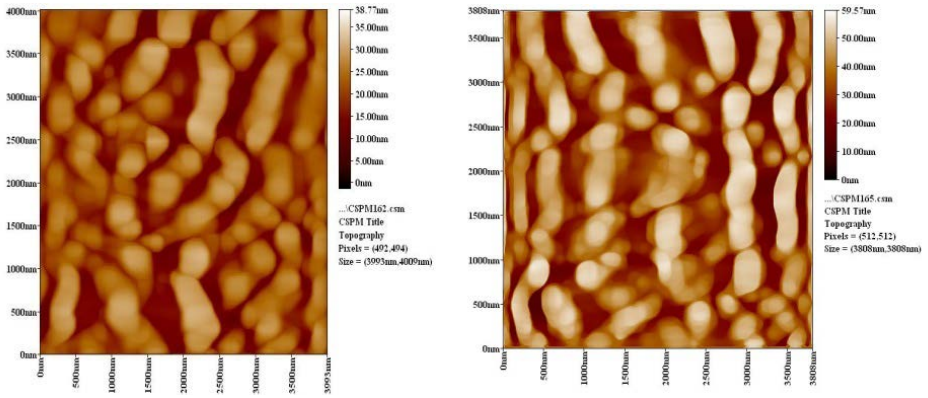
(a) **(b)**

Figure 4 : AFM pictures with 10000 nano meter magnification for aluminum with (a) 5wt.% micro alumina (b) 15wt.% micro alumina



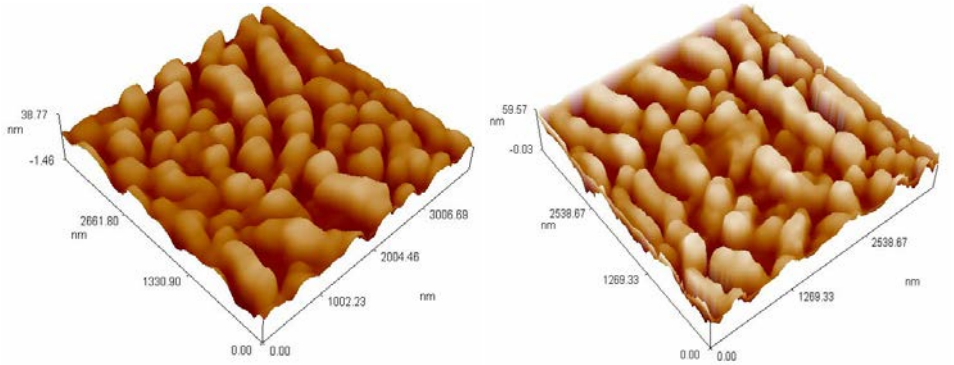
(a) **(b)**

Figure 5 : Three dimensional (XYZ) AFM pictures with 10000 nano meter magnification for aluminum with (a) 5wt.% micro alumina (b) 15wt.% micro alumina



(a) **(b)**

Figure 6: AFM pictures with 4000 nano meter magnification for aluminum with (a) 5wt.% micro alumina (b) 15wt.% micro alumina



(a) **(b)**

Figure 7: Three dimensional (XYZ) AFM pictures with 4000 nano meter magnification for aluminum with (a) 5%wt. micro alumina (b) 15wt.% micro alumina

The used ranges of magnification provides a good indication of the investigation of the morphology of the surface, roughness, agglomeration, segregation and granularity. For the 15wt% micro alumina the particles are formed in rows which gives an indication that an adhesion has been happened between the particles of alumina. In figs. 4,5,6,7 (a) for 5wt.% micro alumina, and for the two ranges of magnifications, particles are seen individually separated and uniformly distributed in the sample. The white area in part (b) are representing the agglomeration of alumina which is more identified and brighter than in section (a) of figs. (4,5,6,7). When comparing the two percentages of additives (5wt.% and 15wt.%), at the same magnification, it shows that agglomeration are more obvious within the increase in the amount of micro alumina additive. Also, the depth of surface are increasingly with the increase in the percentage of alumina additive as shown in figs. 5 and 7. However, figs. 5 to7 show that the uniformity of distribution of the particles in case of specimens containing 15 wt.% alumina are less, the reason is due to the tendency of alumina for clustering and agglomeration with the increase in the volume fraction of mixing.

The grain size, granularity distribution and average diameter of the grains in case of micro alumina additive are explained in graphs and tables of fig. 8, where section (a) represent (composite of 5wt.% micro alumina), and in section (b) represent (composite of 15wt.% micro alumina).

Parts (a) and (b) of fig. 8 reveals that the average grain size and diameter of specimen with 5wt.% is higher than that of composite with 15wt.%. However, that means the size of the grains is in inverse relation with the amount of alumina, this is because of the high melting temperature of alumina which is higher than aluminum metal, alumina particles will work as an obstacle against grain boundary movement during the sintering process and produces a reduction in grains size. However, the grains size will decrease with the increase in the amount of alumina addition.

Also, graphs and tables shown in fig. 8 part a and b, reveals that 90% of grains in 5wt.% micro alumina are with a diameter of 900nm, while, in case of 15wt.% micro alumina, 90% of the grains are having a diameter of 650 nm, those measured

dimensions are confirming that the grain size were reducing with the increase in alumina addition.

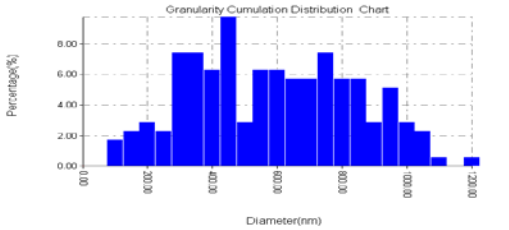
Atomic microscope for nano reinforcement

Figs. 9 to 12 respectively showing the AFM pictures of 10000 then 4000 nano meter magnification for nanocomposites with 5wt.% and 15wt.% nano alumina with two and three dimensional images

At the nano composites images presented in Figs. 9 to 12, when comparing item (a) with item (b) of each indicated figure according to its magnification, it could be realized that the particles distribution is more homogenous in nano composites with 5wt.% nano alumina than at nano composite of 15wt.% nano alumina. Agglomeration can be recognized in nano composites and is continually increases with the increase in reinforcement additive. This agglomeration were due to tendency of nano particles to agglomerate, this tendency for agglomeration are due to higher specific surface of nano alumina in compare to the micro aluminum matrix particles. Obviously, the increase in the specific surface of the contacted particles will lead to a higher inter-particle friction which is consequently will cause a minimize in homogeneity of particles distribution **[11]and[13]**. In regard to surface roughness and depth of particles for nano composites, depth of surface is more in case of 15wt.% nano alumina than that with 5wt.% nano alumina.

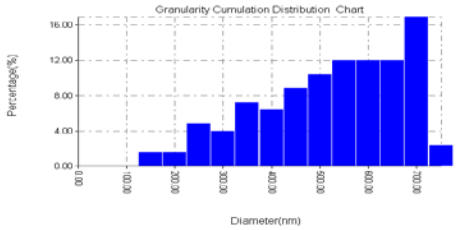
The grain size, granularity distribution and average diameter of the nanocomposites can be recognized form fig. 13, where section (a) represent (nano composite of 5wt.% nano alumina), and section (b) represent (nano composite of 15wt.% nano alumina).

Fig. 13 shows that the average diameter of the grains in nano composite with 15wt.% nano alumina is (104.51 nm) which is less than the average grains diameter of nano composite with 5wt% nano alumina (130.57nm), the reason is due to alumina high melting temp., it's very small diameter and increase in numbers for same weight fraction; therefore, all these parameters will make nano alumina particles to work as an obstacle against grain boundary growth and movement during the sintering process and leads to a formation of finer grains.



Sample: 5wt.% microcomposite	
Avg. Diameter:564.86 nm	10% Diameter:250.00 nm
50% Diameter:550.00 nm	90% Diameter:900.00 nm

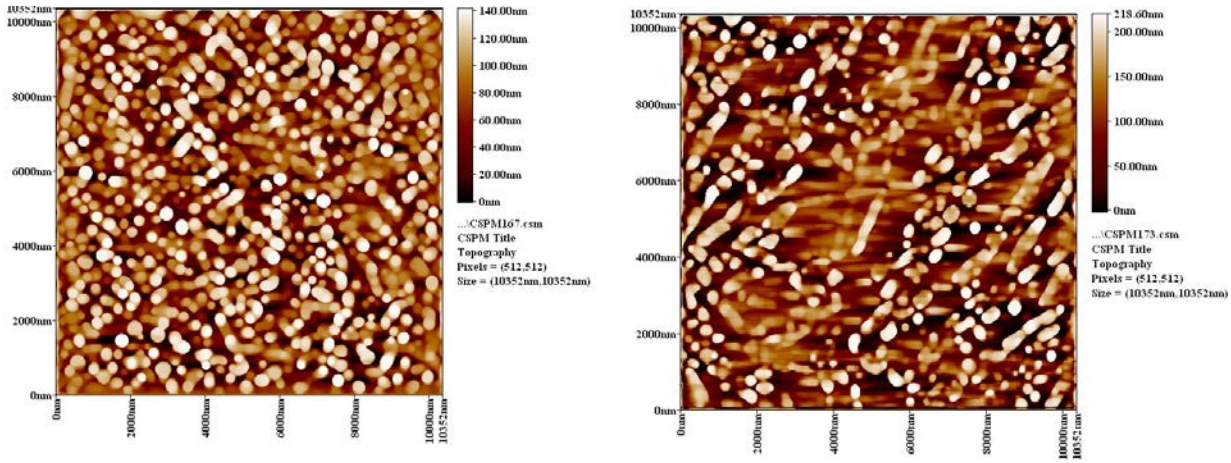
(a)



Sample: 15wt.% microalumina	
Avg. Diameter:497.90 nm	10% Diameter:250.00 nm
50% Diameter:500.00 nm	90% Diameter:650.00 nm

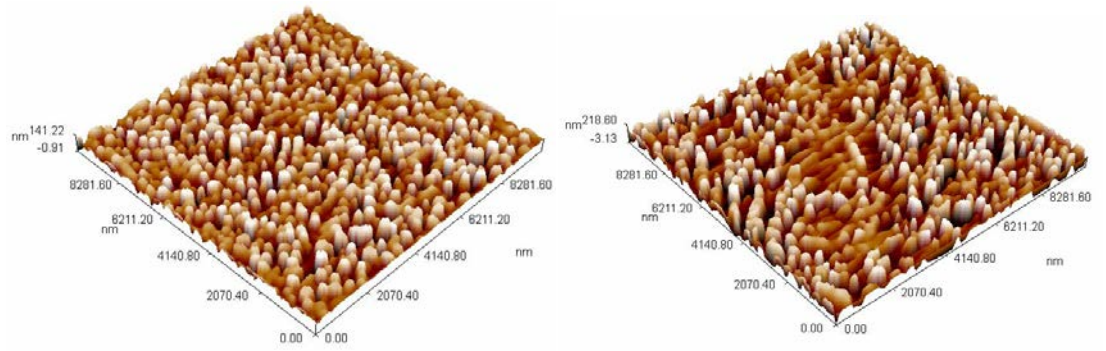
(b)

Figure 8: Granularity accumulation distribution graphs and diameters percentage for composites with an additives of a- 5wt.% micro alumina (M1) b- 15wt.% micro alumina (M3)



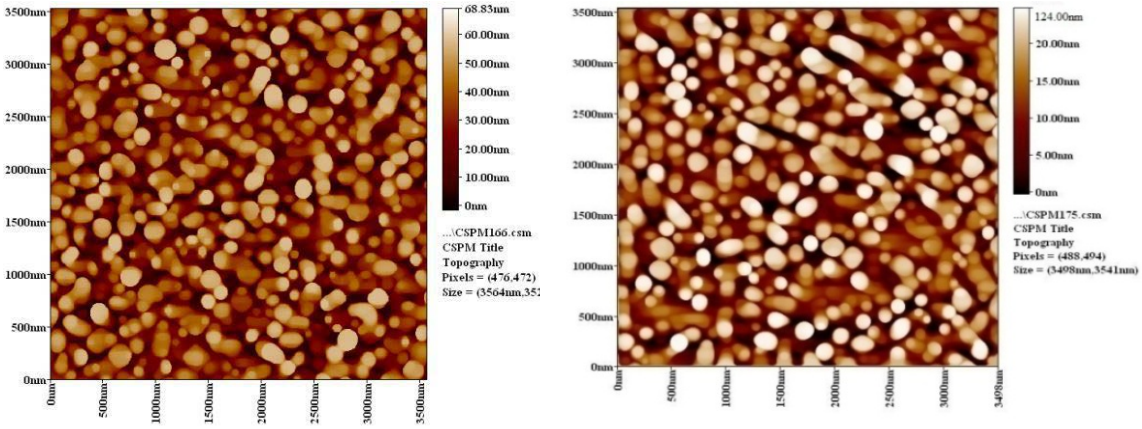
(a) **(b)**

Figure 9 : AFM pictures with 10000 nano meter magnification for aluminum matrix with (a) 5% wt. nano alumina (b) 15%wt. nano alumina



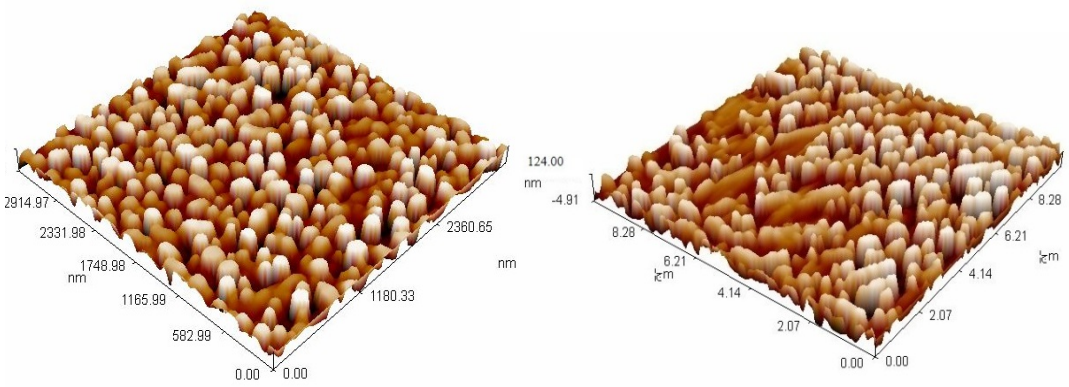
(a) **(b)**

Figure 10 : Three dimensional (XYZ) AFM pictures with 10000 nano meter magnification for aluminum matrix with (a) 5% wt. nano alumina (b) 15%wt. nano alumina



(a) **(b)**

Figure 11 : AFM pictures with 4000 nano meter magnification for aluminum matrix with (a) 5% wt. nano alumina N1 (b) 15%wt. nano alumina N3



(a) **(b)**

Figure 12 : Three dimensional (XYZ) AFM pictures with 4000 nano meter magnification for aluminum matrix with (a) 5% wt. nano alumina (b) 15%wt. nano alumina

By comparing the nano composite with micro composite within the same volume fraction and at same magnification, it is clear that nano phase composite has more agglomeration and clustering than the micro phase composite. This could be analyze with the nano phase having smaller particle size than the micro, so, for the same volume fraction the decrease of alumina particle size will lead to an increase in particles number, then, the contacted specific surface will increase and causes an initiation of inter-particle friction, which results in alumina agglomeration and clustering.

Upon the compare of each graphs of micro alumina composite with nano alumina composite indicated in figs. 8 and 13 within the same percentage of mixing, it is seen that the grain size is smaller in nano composite than in micro one.

The noticed phenomena could be attributed according to equation (4), as the reinforcement particle size decreases, the distance between the particles will reduce**[4]**.

$$\lambda = 4(1-f)r/3f \quad (4)$$

Where (assuming the particles as spherical):

λ= the distance between the reinforcement particles

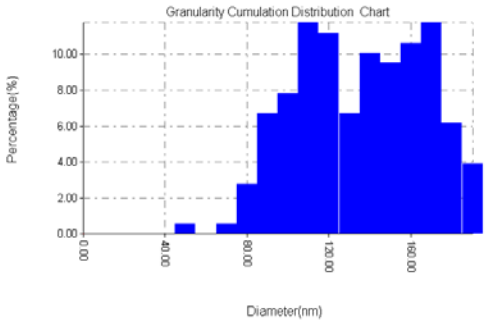
f = particles volume fraction

r = radius of particles

Equation 4 shows that distances between particles is directly proportional to the radius of reinforcement particles. When the distance between particles reduced more hinders will be available against the grain boundary growth and movement, so, smaller distances between particles will leads to smaller grains formation.

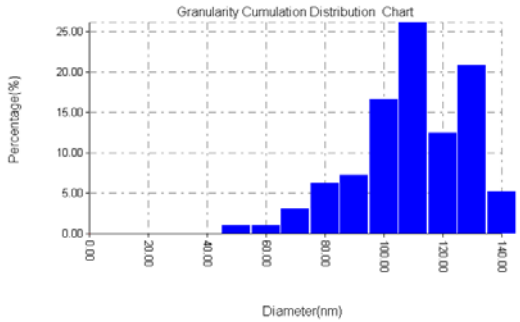
At the graphs of micro composite shown in fig. 8 and at graphs of nano composite shown in fig. 13, it can be seen that the average diameter of the grains are reducing with the increase in the amount of alumina addition. The reason is during the sintering time, alumina particles will act as an obstacles against grain boundary movement and then, more reinforcement will means more obstacles against the grain boundary movement.

Also, upon the changing form micro to nano phase, reducing particle size will mean an increase in number of particles within the same weight percentage, and then this will lead to an increase in rate of obstacles against the grains boundaries movement and result a formation of smaller grains.



Sample: 5wt.% micro alumina	
Avg. Diameter:130.57 nm	10% Diameter:80.00 nm
50% Diameter:130.00 nm	90% Diameter:170.00 nm

(a)



Sample: 15wt.% nano alumina	
Avg. Diameter:104.51 nm	10% Diameter:70.00 nm
50% Diameter:100.00 nm	90% Diameter:120.00 nm

(b)

Figure 13 : Granularity accumulation distribution graphs and diameters percentage for composites with an additives of (a)- 5wt.% nano alumina (b)- 15wt.% nano alumina

Conclusions

The investigation of physical properties related to density, relative density, porosity, agglomeration, surface amorphous and grains sizes of micro composite and nano composite of Al-Al_2O_3 have been studied. In this study several conclusions and outcomes have been obtained from the results, so, the following conclusions can be made:-

1. Addition of 2% PCA (binder) is sufficient to prevent aluminum powder oxidation and segregation with reinforcement phases, however, agglomeration is still notable by AFM analysis;
2. In both cases of micro and nano composites mixing in a horizontal roller mixer for six hours time is sufficient to produce uniformed distribution of composite as indicated by AFM analysis;
3. Compacting stress at 500MPa for two minutes, sintering temperature at 500ºC for two hours is sufficient enough to create phase change;
4. The relative density of micro composite reduces with increasing the weight percentage of reinforcement, while, relative density for nano composite are increasing with the increase in weight percentages of reinforcement;
5. The porosity increases for micro composite with increasing weight percentage of alumina, while, nano composite porosity decreasing with the increase in weight percentages of nano alumina reinforcement;
6. According to the AFM images and Granularity accumulation distribution charts comparisons, the grain size and distribution of nano particles in nanocomposites are less than the grain size and distribution of micro particles in microcomposites. Also, when the amount of micro or nano alumina reinforcement increase in the composites, grain size and homogeneity of alumina particle distribution will decrease.

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توصيف الخواص الهيكلية والكثافات لمركبات النانو الومينا-المنيوم والمايكرو الومينا-المنيوم والمنتجة بطريقة ميتالورجيا المساحيق

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الخلاصة

يعد الالومينا Al_2O_3 من المقويات الشائعة في مركبات الالمنيوم والتي قد تطورت بسرعة في السنوات الاخيرة. ان الهدف من البحث المقدم هو دراسة تأثير طور الالومينا وكميته على الخواص الفيزياوية لمركب Al-Al_2O_3 المصنع. لقد تم استخدام مادة الالومينا بصيغة الالفا وبالحجم المايكروي ومن ثم بصيغة الكاما وبالحجم النانوي وقد كانت حجومهم 30µm ثم 20 nm على التوالي لغرض تقوية مادة الالمنيوم والتي كانت بحجم 45 µm . لقد تم استخدام المواد المقوية المضافة بنسبة وزنية قدرها (5% و 10% و 15%) . تم تصنيع العينات بتقنية ميتالورجيا المساحيق على شكل قرصي وبقطر قدره 11ملم وسمك قدره 5ملم . لقد تم الحصول على العينة الخضراء بتسليط ضغط قدره (500 ميكاباسكال) ومن ثم تمت عملية تلبيد العينات ومن دون تسليط ضغط وباستخدام فرن انبوبي مفرغ لمدة ساعتين وتحت تأثير درجة حرارة مسلطة قدرها (500 درجة سيليزية). تمت دراسة الخواص الفيزياوية لعينات المركبات كالكثافة النسبية والكثافة العملية والمسامية و الخواص الهيكلية وتوزيع الدقائق والتكتل والحجم الحبيبي والتوزيع التراكمي الحبيبي. لوحظ انه في حالة المركبات التي تحتوي على المايكرو الومينا فأن الكثافة النسبية تقل مع زيادة نسبة الالومينا المضافة على العكس عنه في حالة المركبات التي تحتوي على النانو الومينا فأن الكثافة النسبية تزداد مع زيادة أضافة مادة النانو الومينا. علما بان في كلتا المركبات المايكروية والنانوية تكون الكثافة النسبية للمركب أقل من الكثافة النسبية للالمنيوم النقي . لقد لوحظ بان التكتل في المركبات يزداد بزيادة المواد المقوية المضافة وهو اكثر وضوحا في مركبات النانو. يقل الحجم الحبيبي مع زيادة كمية الالومينا المضافة في المركبات المايكروية والنانوية الناتجة على حد سواء، في حين ان معدل قطر الحجم الحبيبي لمركبات النانو هو اصغر منه في مركبات المايكرو. يتضح من خلال النتائج التي تم الحصول عليها بان التغير في الخواص الفيزيائية والهيكلية لمركبات الـ (Al-Al_2O_3) الناتجة يعتمد على كل من طور الالومينا (الحجم) وكذلك النسب الوزنية المضافة . عند النسبة الوزنية 15% من النانو الومينا تم الحصول على اعلى كثافة نسبية واقل مسامية للمركب الناتج.