EVOLUTION OF THE PHASES OF QUASICRYSTALLINE ALLOYS ICOSAHEDRAL/ DECAGONAL $Al_{62.2}Cu_{25.3}Fe_{12.5}/Al_{65}Ni_{15}Co_{20}$ AND OXIDATIVE BEHAVIOR

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ABSTRACT

In this paper, we present an approach and investigation on the evolution of the icosahedral and decagonal phases of quasicrystalline alloys $Al_{62.2}Cu_{25.3}Fe_{12.5}$ E $Al_{65}Ni_{15}Co_{20}$, the oxidation behavior in them. The quantification of the quasicrystalline and crystalline phases present in the quasicrystals provides important information in the mass transport by diffusion, as well as the phase transformations that occurred. For this purpose, X-ray diffraction (XRD) and Rietveld Method Quantification, Scanning Electron Microscopy (SEM) / Dispersive Energy Spectroscopy (EDS), Differential Scanning Calorimetry (DSC) and Thermogravimetric Analysis). The results showed structural aspects of the two compositions of quasicrystals, these were elaborated and obtained in an arc induction furnace. The oxidation of the alloy $Al_{62.2}Cu_{25.3}Fe_{12.5}$ showed intermetallic phases with associations of the elements of the alloy and above 735 °C was observed that the crystalline phase is stable in the icosahedral phase. The quasicrystals $Al_{65}Ni_{15}Co_{20}$, with the interaction of oxygen, happens in the surface of symmetry 10 times plane perpendicular vector. The formation of a thin film of the aluminum oxide with a well ordered hexagonal shape structure, with a domain opposite the decagonal phase with lateral size at about 35 Å.

Keywords: Quasicrystalline alloys; phases; icosahedral; decagonal; oxidation.

1. INTRODUCTION

The technological growth depends directly on the development of new materials, with different properties and applications. Innovation and technology arouse broad interest in the field of research. The discovery of new catalysts for the use in the petrochemical industry moves the national and international market. Researchers show the importance of materials possessing good physical, surface, electronic, mechanical and thermodynamic properties.

The crystallographic formations and structures depend on the type of forces that bind atoms, molecules and ions together. Quasicrystalline solids, also called quasiperiodic crystals, are atomically formed so as to lie between amorphous and crystalline solids. Quasicrystals contain an ordered structure, but the patterns are subtle and do not repeat themselves at regular intervals; therefore, have a complex structure and show a quasiperiodic repetition in the arrangement of the atoms, together with rotational symmetries not observed in crystals.

They are symmetries that are represented by the diffraction pattern, the symmetries of five, eight, ten, and twelve where it originates the structures of the icosahedral, octagonal, decagonal and dodecagonal alloys [1].

The compositions of the quasicrystalline alloys in general are ternary, binary and quaternary, some of these formed systems have already been researched and have been successful for certain applications. Other families of quasicrystals are always evidenced for the study of Al-Cu-Fe and Al-Ni-Co, other solids systems of quasicrystals are investigated with a broad scientific objective, they are; Al-Mn-Pd, Al-Pd-Mg, Al-Cu-Co, Al-Co-Fe-Cr, Al-Cr-Fe, Al-Mn-Cu, are also used in the field of science. These quasicrystalline alloys demonstrate good properties such as: High hardness, Low electrical and thermal conductivity, and Low surface energy, accompanied by a low coefficient of friction, Strong corrosion resistance and good hydrogen storage for use in catalysis [2].

Al-Cu-Fe and Al-Mn-Cu quasicrystalline alloys are generally classified into two families. And are differentiated by atomic clusters (clusters), and the icosahedral phases are structural units resulting from a succession of several atomic and symmetric layers that form a spherical volume of about 10 Å and the diameter containing 55 and 33 atoms. However, these sets of quasicrystals are described by two types, that is; the first is the second model of Bergman and Mackay [3]. Thus, the description of two models Mackay and Bergman can be shown as figure 1.

The quasicrystalline alloys in the icosahedral phase may contain displacements in the movement of the lines and in the crystallographic network. And get a structure with long range order, being very difficult at room temperature, and there may be destruction in the quasi-periodic structure. The crystallographic verification of these quasicrystals in this icosahedral phase are symmetry that share number of symmetrical elements of cubic crystals, which contains four rotation axes triple rotation, three quadrilateral axes, six double axes, nine planes and a center of symmetry. Topological studies have demonstrated that the cubic networks of quasicrystalline solids formed by clusters are closely related [4].

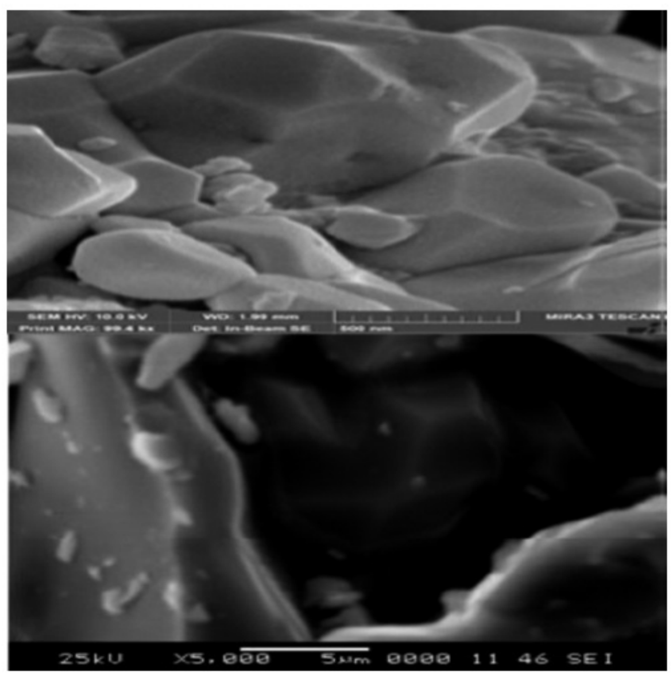

Figure 1. Representation of the clusters model of icosahedral quasicrystals of (a) Bergman and (b) of Mackay.

The formation of the quasicrystal in each phase is different; the two phases the Icosahedral (AlCuFe) and Decagonal (Al-Ni-Co, Al-Cu-Co) in this formation the phases are related to the particulate grain and the elaboration process. Such as, the difference in concentrations of the two quasicrystalline materials to be equilibrated by interdiffusion in a transient region there by forming an AlCo (Cu, Ni) quaternary alloy in a narrow region of the crystal.

The alloy $Al_{65}Cu_{20}Fe_{15}$ the icosahedral phase is in equilibrium with the intermetallic phase of λ-$Al_{13}Fe_4$ (Cu), meaning that there is a decrease in the amount elemental composition of copper, while in the alloy of $Al_{62.2}Cu_{25.3}Fe_{12.5}$ is in equilibrium with the phase β - Al (Cu, Fe), there was an increase in

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the amount of copper in the constitution of the alloy. The composition of the icosahedral phase in Al-Cu-Fe alloys not only depends on the cooling condition and the equilibrium temperature, but also on the coexisting phases which are in equilibrium with the icosahedral structure [5].

The influence of the composition on obtaining the icosahedral phase in the quasicrystal plays an important role in the formation and decomposition of the icosahedral ψ - Al-Cu-Fe phase in this system. First, the cubic phase is the main motive force in the formation of the icosahedral phase; and in the second this solid solution (phase β) regulates the composition of the alloys in the transformation to phase icosahedral ψ [6].

The two compositions of decagonal quasicrystalline alloys (Al-Cu-Co and Al-Ni-Co) have their formation of a solid solution that comes from a common phase between both systems (Al-Co) and the compensation of the copper with respect to the Nickel. But, the decagonal phase is direct to the peritoneal reaction with the liquid phase and amount of aluminum present.

However, it has been shown in the literature that icosahedral and decagonal quasicrystals have stable phases at high temperatures, and transform the crystalline and quasicrystalline phases at low temperatures [7].

Studies that were performed with the decagonal phase in relation to Al-Cu-Co alloy formation revealed that they have a CsCl-type cubic phase and have bright symmetrical features around the decagonal phase; sequential Al_2Cu intermetallic occurs with gray regions between the grains [8].

Accordingly with the representation of Figure 2 below.

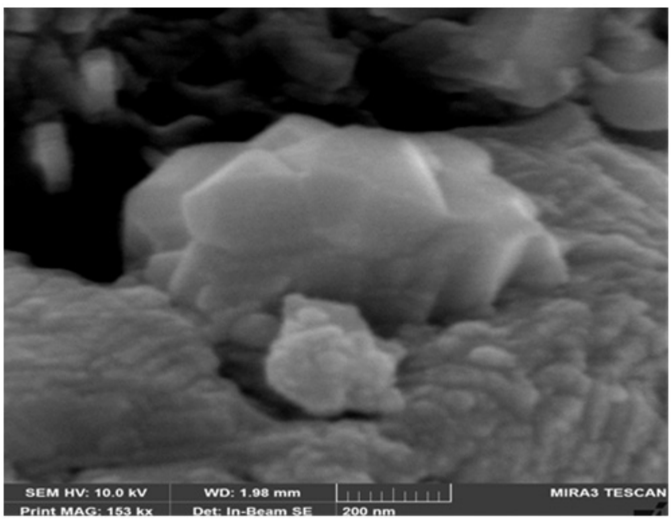

Figure 2. Representation of the surface of quasicrystalline alloy $Al_{65}Ni_{15}Co_{20}$, showing the decagonal phase.

The diffuse dispersion in decagonal quasicrystals spreads over two-dimensional reciprocal planes and perpendicular to the axis of symmetry, whereas icosahedral quasicrystalline alloys spread over three-dimensional reciprocal space.

The study of magnetic property in quasicristal, identify compositional systems in alloy formation. Some important phases occur at low temperature, and another phase with temperature dependence is the quasicrystalline solid.

The magnetic properties of quasicrystalline alloys in some ternary systems have already been investigated and successfully (Al-Pd-Mn and Al-Mn-Ge), which are stable exhibited local magnetic moments; however, it should be said that, depending on the composition and formation of the alloy, it may be shown to be ferromagnetic, diamagnetic, paramagnetic phenomena or spin-glass. Therefore, other families of quasicrystals are being extremely researched is Al-Cu-Fe and Al-Co-Ni in relation to their magnetic properties and their applications [9].

This paper presents a study on the evolution of the icosahedral and decagonal phases, as well as the oxidative behavior of each quasicrystalline system Al-Cu-Fe and Al-Ni-Co. For this purpose of purpose he used the following techniques; X-ray diffraction (XRD), Scanning Electron Microscopy (SEM) and Dispersive Energy Spectroscopy (EDS), Differential Scanning Calorimeter (DSC) , and Thermo gravimetric (TG) analysis.

2. THEORY

2.1 OXIDATION BEHAVIOR OF ICOSAHEDRAL AND DECAGONAL PHASES

Quasicrystals are compositions of metallic elements and, at the initial stage; the evaporation of another metallic element can compete with the electrical oxidation. Phase transformations may also occur; however, the crystalline phase can be observed near the surface layer.

Oxygen generally exhibits different affinities with the elements of the intermetallic compound, leading to selective oxidation. But, the oxygen reacts on the surface of the quasicrystalline alloys formed metal oxides, and in the interface zone beneath the oxide layer is exhausted in the preferably oxidized element. Therefore, at low temperatures, the quasicrystalline alloys i-Al-Cu-Fe, and i-Al-Pd-Mn have similar thermal properties to some oxides, such as those of zirconia, which are considered excellent insulators and possess good resistance to corrosion and oxidation.

The Al-Cu-Fe quasicrystalline alloy, whose main phase is icosahedral, derives from other previous phases. In this mechanism the cubic phase β - Al (Fe, Cu), is predominant because a force forces to the formation of the icosahedral phase.

Investigations on the influence of oxidation revealed for Al-Cu-Fe, that oxidation begins with the growth of Υ-Al_2O_3 in training there is training θ Al_2O_3 consequently, we have strong nuclei of α Al_2O_3 alumina at the oxide / metal interface at random through the growth of the copper layer θ Al_2O_3; then the transformation of θ Al_2O_3; for α Al_2O_3 these stages of occurrence at elevated temperatures.

In quasicrystalline alloys, oxygen reacts on the surface of the quasicrystalline forming metal oxides. The interface zone underneath the oxide layer is exhausted in the preferably oxidized element. Thus the concentration is shifted out of the stability range of the quasicrystalline phase and a phase change may occur [10].

In the Al-Ni-Co quasicrystalline alloy system, it has been verified in the formation of thin layers of oxides, preferably the oxygen is bound to aluminum, while the nickel will continue the metallic state. However, the atomic structure of the oxide layer of the Ni-Al binary alloy (110) is complex has certain similarities with the hexagonal phases of aluminum oxide [11].

The aluminum oxide layer in the icosahedral phase for Al-Cu-Fe was observed in the research a trend of aluminum enrichment on the outermost surface of the quasicrystals. However, the behavior of the intermetallic components of the quasicrystalline alloys in the presence of oxygen shows that the aluminum atoms move from the mass to the surface [12]. It is assumed that it is due to the directional force provided by the exothermicity of the oxide is higher, to the other constituents of the alloy as shown in figure 3 below.

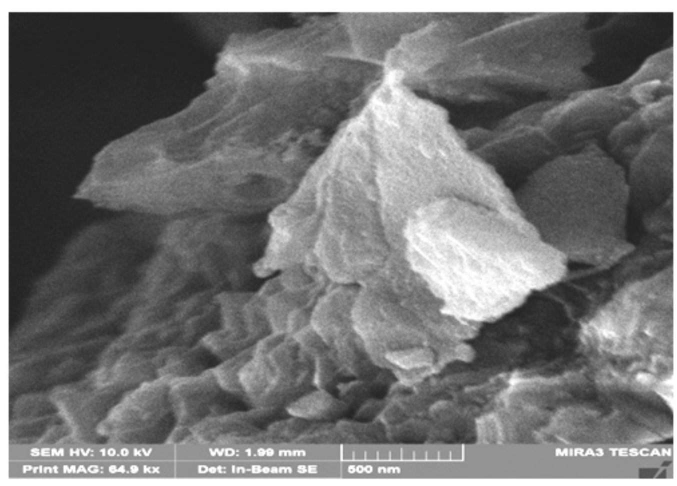

Figure 3. Representation of the fine amorphous formation of Al_2O_3, quasicrystalline alloy.

The quasicrystalline alloy in the i-AlCuFe phase, the initial oxide layer is thin at the temperature about 670 °C. Oxidation of aluminum was still observed even after a long exposure to more than 7000 Langmuir. The existence of a dense layer with damping properties and copper oxidation inhibition since it influences the adhesion/sorption properties [13]. It should be said that it has found the formation of analogous crystalline phase nodules of Al_7Cu_2Fe at 700 °C. As an intermetallic product, the association of copper (Cu) with hematite (Fe_2O_3) is also detected in quasicrystalline alloys, forming a $CuFe_2O_4$ solid called Cuprospinel, which is the last compound formed up to the icosahedral phase of quasicrystals.

3. MATERIALS AND METHODS

The powders of the elements Aluminum, Iron, Copper, Cobalt and Nickel according to their granulometry, having a purity of 99.9%, from Aldrich Chemical, were weighed in the appropriate proportions the compositions ($Al_{62\cdot2}Cu_{25.3}Fe_{12\cdot5}$ and $Al_{65}Ni_{15}Co_{20}$), mechanically homogenized and compacted in the form of a disc with diameters of 10 mm and 2 mm thickness, in a hydraulic uniaxial press. Initially a pre-press was made under a maximum load of 5 ton for 3 minutes. The precursor alloys were obtained by direct fusion of the compacted constituents. The melting was carried out in an arc furnace under a controlled atmosphere of argon. The arc furnace is powered by a BALMER static rectified generator whose power is 22 KVA. To identify the phases, a Shimadzu XRD 6000 diffractometer was used, using CuKα radiation with a wavelength of 1.5406 Å. He made use of the Rietveld method, in order to obtain the refinements of the least squares of the quasicrystals, and the best fit to be reached among the whole diffraction pattern. Thus, each phase was quantitative, since the icosahedral and decagonal phase has its own diffraction pattern characterized by peaks with specific relative intensities and positions.

Scanning Electron Microscopy (SEM) and Dispersive Energy Spectroscopy (EDS) were performed with a SHIMADZU SUPERSCAN SSX-550 with an acceleration voltage of 0.5 to 30kV with a 10V step, after the sample was coated with a layer of gold deposited in vacuum, in order to improve the contrast.

The thermogravimetric (TG) and Differential Scanning Calorimeter (DSC) analyzes were performed on a TG equipment (PerKin Elmer STA 6000 TE). Samples of the quasicrystalline alloys were duly weighed and warmed to room temperature (approximately 27 ºC) to 750 ºC at a heating rate of 10 ºC/ min under an inert atmosphere with a nitrogen flow of 50 ml / min.

4. RESULTS AND DISCUSSION

4.1 X-RAY DIFRATOGRAM

The two figures 4 and 5 show the diagrams of the quasicrystals of compositions ($Al_{62\cdot2}Cu_{25\cdot3}Fe_{12\cdot5}$ and $Al_{65}Ni_{15}Co_{20}$), as shown respectively below. In the diffractogram 4 with the use of the Rietveld method, it observed the location of the main peak of the quasicrystalline alloy in 45° 2θ, is the I-quasicrystalline, the second most evident peak is attributed to the β crystalline phase lies in 30° 2θ; the other peaks are of the monoclinic phase λ-$Al_{13}Fe_4$, the other peaks are related to the cubic structure of the type of CsCl, (β-AlFe (Cu) or τ-AlCu (Fe) and the tetragonal phases θ-Al_2Cu were also detected. However, the crystalline phases are in equilibrium with each other; but between the crystalline phase's ω and the β phase and icosahedral presents a great similarity [14]. The quantification of the present elements of the quasicrystalline alloy $Al_{62\cdot2}Cu_{25\cdot3}Fe_{12\cdot5}$, after heat treatment of 800 ° C in 24 hours, observed that the major part formed in the composition is Iron-delta of 73.9%. The ferrite delta is the first phase that solidifies in low and medium carbon steels, resulting from a reaction called perithecia in carbon steel. Thus, the other mineral present with a significant amount in the composition is hercynite is 10.2%; Hercinite is a $FeAl_2O_4$ spinel with regular symmetry and normal cation distribution, but some disorders occur in its structure. It is constituted by ferrous ions (Fe^{2+}) and aluminum ions (Al^{3+}), however, some ferric ions (Fe^{3+}) may be located in this structure. The remaining elements have the following percentage; iron with 10.6%, copper is 3.4% and iron is 1.9%.

The X-ray diffractogram of Figure 5 shows the AlNiCo sample three decagonal phases. Structure the symmetry has almost periodic planes along the direction perpendicular to these planes. In this sequence Al-Co, Al-Ni, and AI-Co-Ni periodicities of approximately 04.0,8,1,2 and 1,6nm in a specific direction, was meaning that there was a rapid solidification in this composition. For identification of the $Al_{65}Ni_{15}Co_{20}$ alloy planes formed by five reciprocal vectors, corresponding to five adjacent planes with an angle of $\frac{2\pi}{5}$, plus six vectors perpendicular to the other planes [15]. By Rietveld, verified the location of the peak with more intensity in the decagonal phase of the quasicrystalline alloy is 43.5° 2θ, θ-decagonal phase, and other peaks refers to 31.5° 2θ, the -crystalline phase. The quantification of the elements that make up the quasicrystalline alloy $Al_{65}Ni_{15}Co_{20}$, after a 48-hour heat treatment and temperature in a range of 900 °C. It identified a percentage of Nickel with 27.2%; a cubic structure coded 9006039 of 48.4%; a spinel structure with a percentage of 24.4%. The spinel formed in the decagonal quasicrystalline alloy comes from a bivalent anion, which occupied a tetrahedral site, and another trivalent metal cation usually occupies the octahedral site of a crystal of cubic structure. In view, it observes the Rwp factor of the Rietveld refinement, to show in the two diffractograms of the quasicrystalline the least squares between the intensities calculated and observed were of the same value for, $Al_{62\cdot2}Cu_{25\cdot3}Fe_{12\cdot5}$ $X^2 = 1.035$, and $Al_{65}Ni_{15}Co_{20}$ $X^2 = 1.035$.

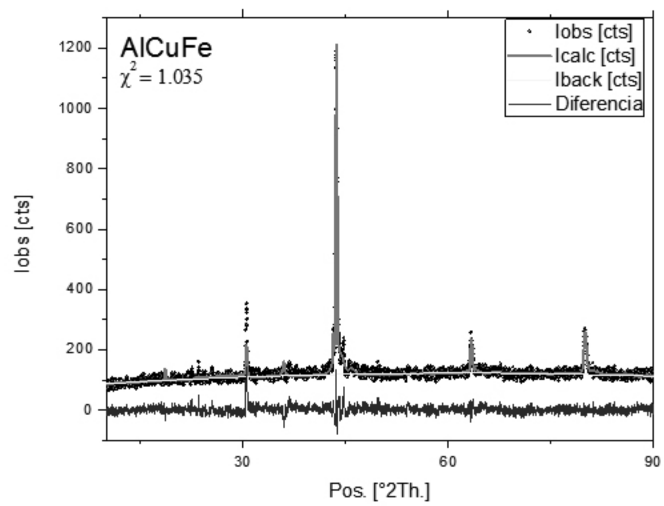

Figure 4. Diffractogram of the $Al_{62\cdot2}Cu_{25\cdot3}Fe_{12\cdot5}$ sample adjusted by Rietved's refinement.

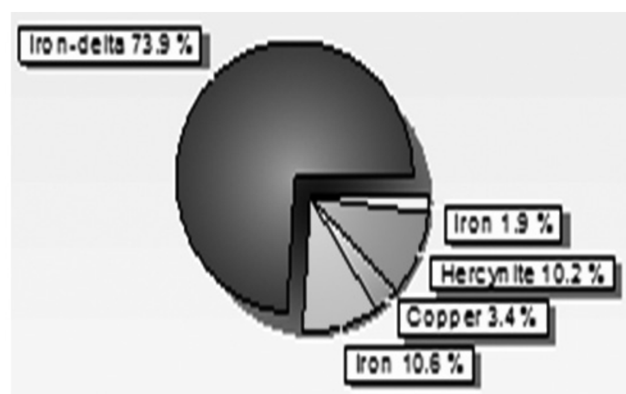

Figure 4a. Graphical representation of the quantitative analysis of the quasicristal $Al_{62\cdot2}Cu_{25\cdot3}Fe_{12\cdot5}$ by Rietveld.

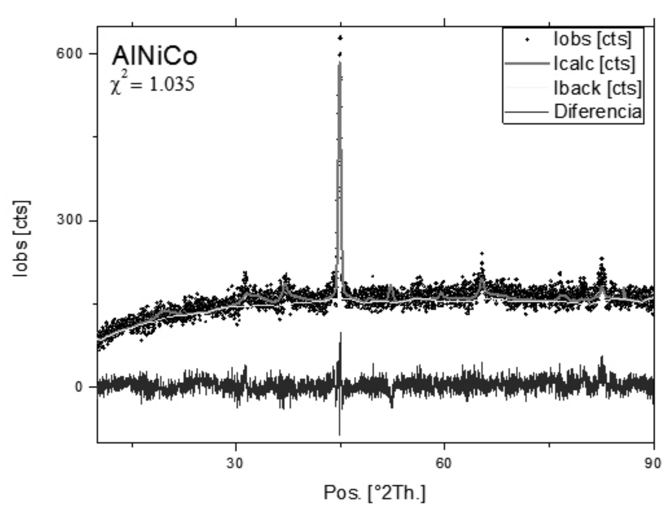

Figure 5. Diffractogram of the sample of $Al_{65}Ni_{15}Co_{20}$ adjusted by Rietveld refinement.

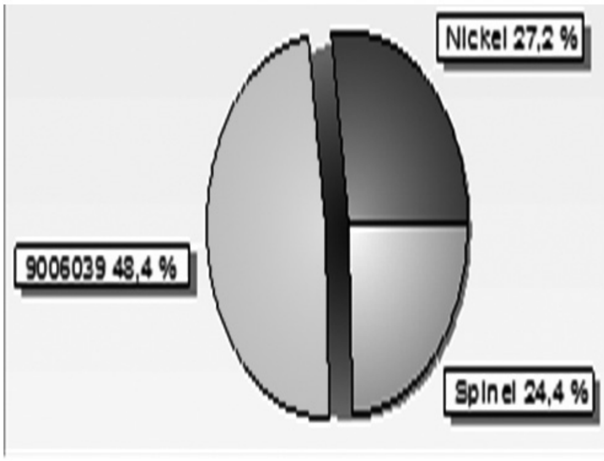

Figure 5a. Graphical representation of the quantitative analysis of the quasicristal $Al_{65}Ni_{15}Co_{20}$ by Rietveld.

4.2 ELECTRONIC SCAN AND EDS MICROSCOPY

In this analysis of scanning electron microscopy, the aim is to verify the surface morphology, together with the EDS spectrum of the two quasicrystalline alloys. The EDS peaks correspond to the different elements present in the samples that were obtained by arc furnace. The surface of Figure 6 of $Al_{62\cdot 2}Cu_{25\cdot 3}Fe_{12\cdot 5}$ observed faceted, with cauliflower-shaped dislocations. It is seen that nucleation of the β phase can occur in such sites; the platelets grow from this interface to the nucleus of small crystals in the form of nodules in the icosahedral phase. But, it is convenient to say that, the refinement at the boundaries of the grains and/or grain surface with protrusions. In this initial phase of oxidation, a topographical surface is observed so as to form a thin layer of oxide with the thickness in micrometers (μm). After a period of two hours, nodules distributed irregularly on a grain surface are observed [16].

In the second microstructure of the SEM, corresponding to figure 7 of the quasicrystal of $Al_{65}Ni_{15}C0_{20}$, in this surface we are allowed to clearly observe unique structural characteristic in the region of facets in defined and remembered layers; several Nano-crystalline crystals incorporated into the matrix of aperiodic structure, where groups of d-clusters take a periodic arrangement to form a rhombic structure based on lozenges [17]. The roof of the surface layer shows an overlap of the atomic arrangement; it is commonly described as a cobalt-rich structure in the decagonal phase of the Al-Ni-Co quasicrystalline alloy, causing asymmetry 10 folds on the surface. Note that in the D-Al-Ni-Co decagonal phase it is seen that oxidation occurs as a consequence of the dissociative adsorption of oxygen, which leads to a chemically very thin layer of oxygen.

Figure 8 shows the regions that were composed mainly of Cu, Fe, O, of a small amount of Al, which can complex with Cu, Al_2O_3, $AlFe_3$, Al_3 Cu, Cu_2O and Fe_3O_4 or $CuFeO_2$, because the phases present in the transformation are due to the strong presence of Fe and Cu conduction electrons, which are protected by the thin layer of aluminum oxide that allows the peritoneal reaction between the liquid γ-$Al_{13}Fe_4$ phases and for forming the dense phase highly ω-$Al_7Cu_2Fe_1$. The nodules represent β-phase droplets formed mainly by a surface tension of the liquid (saturated solution caused by solid reaction) within a bubble or hollow retraction (cavity) solidified in its initial liquid form [18].

The EDS spectrum of Figure 9 shows a more intense peak evidencing the higher concentration of aluminum that is due to the greater amount of cobalt in relation to the nickel in the decagonal phase. The ternary composition Al-Ni-Co in the decagonal phase occurs by a substitution between Co and Ni, a vacancy formation occurs in the structure of the quasicrystalline alloy; this produces a solids-type disorder. The diffuse scattering is often observed in the diffractogram in the decagonal phase [19]. But, it should be noted that the part containing the largest amount of aluminum comes from a continuous band of the solid solution between iso-structural Al-Co and Al-Ni. This Decagonal phase is formed along on $Al_{73}Co_{27}$- $Al_{69}Ni_{31}$.

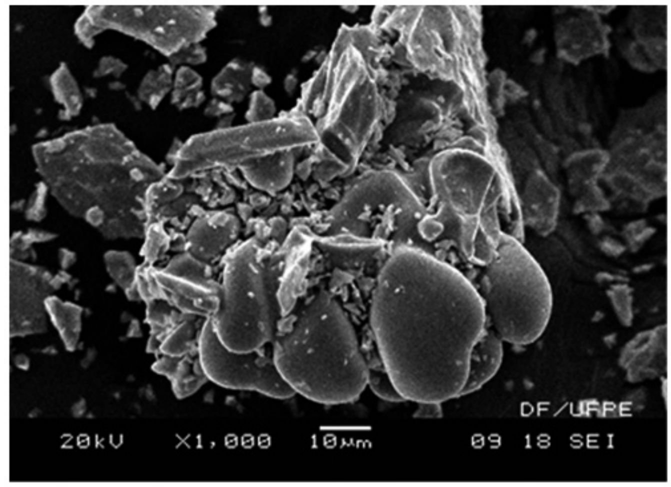

Figure 6. Morphology shows irregular nodules and shapes of quasicrystalline alloy $Al_{62\cdot 2}Cu_{25\cdot 3}Fe_{12\cdot 5}$.

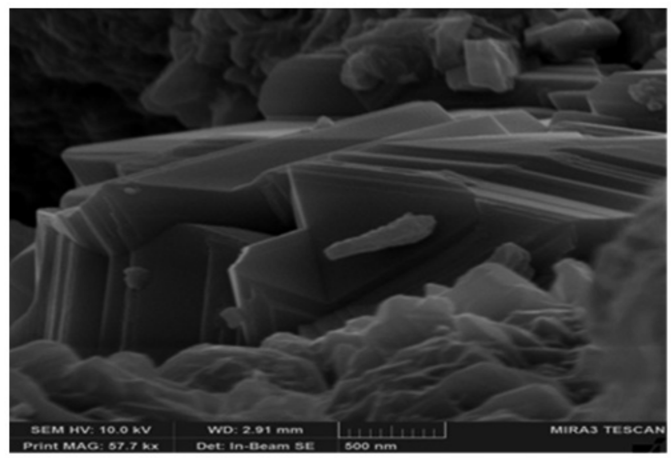

Figure 7. Representation of irregular symmetry and layers with quasicristal folds $Al_{65}Ni_{15}Co_{20}$.

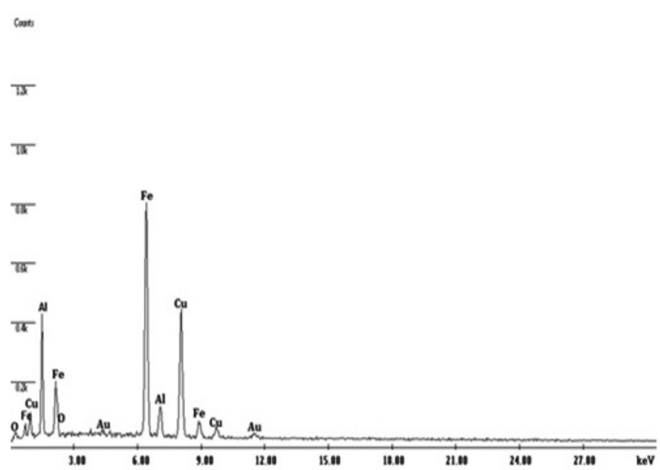

Figure 8. Elemental analysis of EDS of the quasicrystalline alloy $Al_{62\cdot 2}Cu_{25\cdot 3}Fe_{12\cdot 5}$.

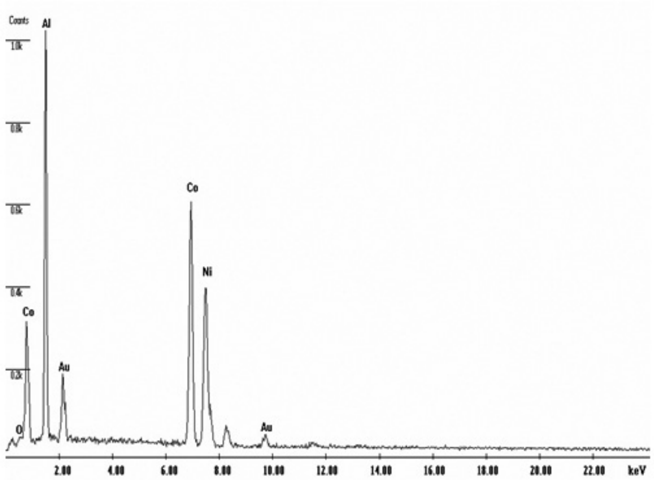

Figure 9. Representation of the EDS of the quasicrystalline alloy $Al_{65}Ni_{15}Co_{20}$.

4.3 DSC and TG THERMAL ANALYSIS

Figure 10 shows the DSC curve as it can be seen; it is very sharp curvature at the temperature of 300 °C to characterize an endothermic peak. Indicating to us that it is the melting points of pure aluminum and copper in the formation of the quasicrystalline alloy. This endothermic peak corresponds to the melting of the pure powder of Al and Cu, accompanied by the liquid dissolution of the iron (Fe), after the mechanical process of casting. Therefore, at this stage in which the Al-Cu-Fe quasicrystalline alloy is being processed by the arc furnace fusions, the Al and Cu elements are coming into contact with each other at low temperature as shown in the graph; it is a reaction to reveal that it is a eutectic fusion. As it is a verified in the literature the binary phase diagram Al/Cu in eutectic temperature. In this stage of the mechanical process, there is a predominance of aluminum to the other copper and iron elements. However, we will have an exothermic peak at the temperature of 800 °C, reporting the occurrence of a series of solid-state transformations from the crystalline phase to quasicrystalline during heating. As homogenization of the alloy composition is gradually completed we will obtain the intermetallic ω-Al_7Cu_2Fe until the main icosahedral stage. The TG curve of the Al-Cu-Fe quasicrystalline alloy occurred small losses of masses at temperatures namely; The first mass loss was at 40 °C for a percentage of 21.4%; Already another loss occurred in 100 °C to 21.6%; The third significant loss occurred 410 °C in 21.9%; With the increase of the temperature of 700 °C it obtained a decrease of mass of 22.6%. However, at low temperatures the thermal decomposition decreases with decreasing particle size, becoming a continuous mass loss that ran between 45 °C to 820 °C. It can be said that the decomposition temperature favors the enrichment of one of the elements that make up the quasicrystal and the impoverishment of one of the elements of the alloy in different regions of the grain.

The quasicrystal of composition $Al_{65}Ni_{15}Co_{20}$ the DSC curve pointed to similar factors with Al-Cu-Fe; but we note that the endothermic peak occurred at a temperature transition between 320 °C and 400 °C. Further, research done previously considered that the phase boundaries are shifted from the use of the mechanical synthesis process. In addition, it is likely that the decagonal phase transformation occurs in structural relaxation. Of course, the cooling and heating peaks of the Al-Ni-Co alloy composition treats reversible martensitic transformation. However, the formation of Al-Ni crystalline domains - Co is predominant of the effect of thermal diffusion, activated only by the Al atom, being caused by plastic deformation in the decagonal phase.

In the TG curve of Figure 11 of the $Al_{65}Ni_{15}Co_{20}$ quasicrystal exhibited the most significant mass loss points in percentage/temperature terms when compared to Al-Cu-Fe. Initially, the first mass loss event occurred at a temperature of 35 °C to 25.65%. Thereafter, the second mass loss took place at a temperature of 395 ° C in 25.8%. The third and fourth points were at 510 °C with 25.9% and 700 °C at 26.0%. The fifth point occurred at a temperature of 805 ° C for a 26.2% mass loss. These mass losses exhibited on the TG curve influence the quasicrystalline oxidation and the atmosphere of the environment.

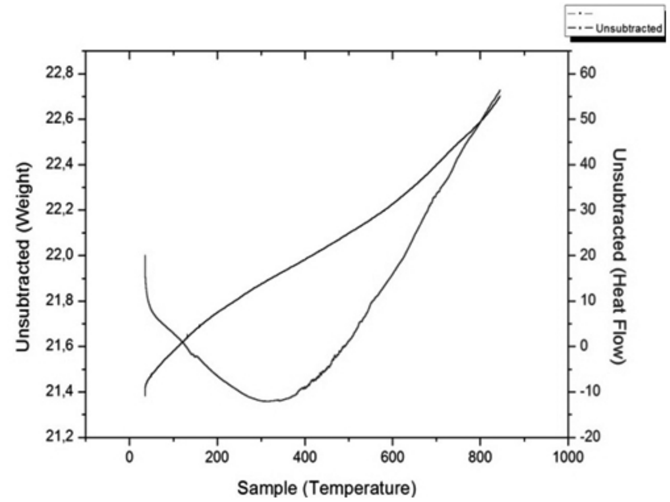

Figure 10. Representation of the DSC and TG curves of the quasicrystal $Al_{62\cdot 2}Cu_{25\cdot 3}Fe_{12\cdot 5}$.

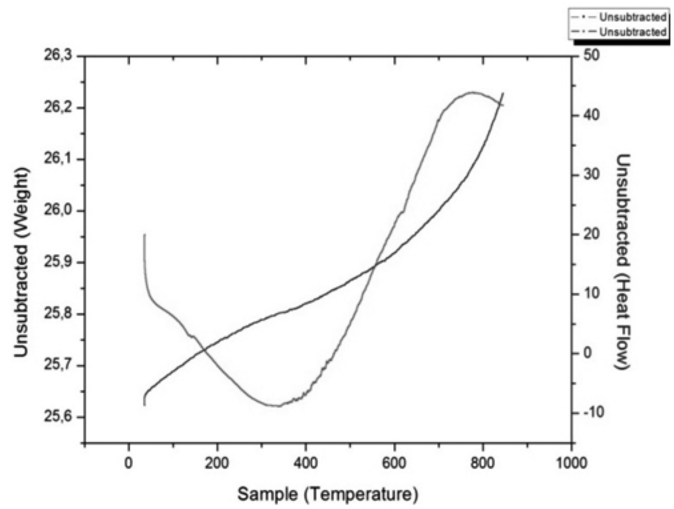

Figure 11. Representation of the DSC and TG curves of energy and mass of the quasicrystal $Al_{65}Ni_{15}Co_{20}$.

5. CONCLUSIONS

The main conclusions are as follows.

(1) The Al-Cu-Fe ternary system particle alignment can be attributed to the aligned grains of the λ phase, are formed in the initial stage of which provides the nucleation positions of the quasicrystals.

(2) The effect of the high temperature causes variations of defects at the frontier of the Al-Ni-Co quasicrystalline grains; these displacements are related to the temperature range to the phason defect.

(3) The quasicrystalline alloy $Al_{65}Ni_{15}Co_{20}$ is of the saturated type with perpendicular plane vector and rich of cobalt atom.

(4) The nodules observed in the SEM of the Al-Cu-Fe quasicrystalline alloy occur in an oxidizing environment to penetrate the oxide layer so that the oxide growth occurred at the oxide-metal interface.

(5) The diffusion volume of the cobalt (Co) atom in the Al-Ni-Co quasicrystalline alloy obtained an anisotropic inverse diffusion behavior for self-diffusion surface along the periodic and aperiodic direction.

(6) Quantifications of quasicrystalline alloys were made by the Rietveld method, it was possible to verify in the two diffractograms the same value of the least squares between the intensities calculated and observed.

(7) The oxidation of aluminum by changing concentration in the area near the surface induces phase transformation. Such transformations are abrupt since intermetallic phases are observed.

(8) The structure of decagonal phase quasicrystals can be interpreted as periodic stacking of quasiperiodic layers over an axis of symmetry 10 times.

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