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Use Alloy Quasicrystalline $Al_{62,2}Cu_{25,3}Fe_{12,5}$ for Steam Reforming of Methanol

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Abstract

This study shows the good performance of quasicrystal $Al_{62,2}Cu_{25,3}Fe_{12,5}$ as catalyst in catalytic reactions. The metal catalyst without being leached with acid or base with the stoichiometric composition of dry $Al_{62,2}Cu_{25,3}Fe_{12,5}$ among the reactions shown to be a partial oxidation occurred , which formation of the products was methanol , methanal + methanoic acid, water and dimethyl ether. For this research used experimental techniques as X-Ray Diffraction-XRD to follow the evolution of the alloy phase, the Scanning Electron Microscopy-SEM allowing the study of surface microstructure, and Transmission Electron Microscopy-TEM studies the morphology of internal phase, and defects quasicrystalline nuclei; tests for the catalytic conversion of methanol and selectivity and products formed from this material used as catalyst. The activity and stability of catalyst quasicrystal for steam reforming of methanol showed sufficient performance compared to other catalysts. The Fe and Cu species highly dispersed in the homogeneous layer quasicrystal catalyst increases the catalytic activity and suppresses the aggregation of Cu particles. We propose that the quasicrystal can be a good catalyst to be used in catalytic steam reforming, with high catalytic activity and excellent thermal stability.

Keywords: Catalytic activity; Quasicrystal; Methanol

Introduction

Quasicrystals are solid materials that exhibit a unique form of matter with long range order without periodicity and symmetries of non crystallographic rotation (To symmetries of order 5, 8, 10 and 12). Since were studied for the first time in 1984 by Shechtman et al. [1], more than 100 binary alloys with metal composition, ternary and quaternary these systems were found.

These alloys containing stable quasicrystalline phases. Moreover, they have good physical properties, high electrical resistance. The low chemical reactivity of quasicrystals is attributed to the presence of pseudo gaps [2], which is a reduction of the electronic density of states at the Fermi surface. This can be interpreted as a low reactivity with oxygen when comparing the reactivity of quasicrystalline league Al-Cu-Fe with their crystalline analogs. In quasicrystalline materials, heterogeneities in the form of second phases, precipitates, segregates, grain boundaries, dislocations and stacking faults exist. In contrast, amorphous alloys are composed of a single phase of homogenous solid solution without any physical and chemical heterogeneity. Thus, alloys quasicrystalline and amorphous with sufficient concentrations of corrosion-resistant elements show superior corrosion resistance that has never been found in any crystalline metallic alloys.

The oxidation of alloys subjected to high temperatures is quite complex, since various technical processes are involved activation. The potential application of interest and quasicrystals for catalysis was investigated by Agostinho [3]. For these alloys have stable equilibrium phases even at high temperatures and can be used in high temperature catalytic reactions. In this study on catalytic activity of quasicrystals did analysis of various alloys Al-Pd-Mn and Al-Cu-Fe in the decomposition reactions in methanol. In the reaction of steam reforming of methanol was studied by Tsai et al. [4]. In the composition of the system quasicrystalline alloy Al-Cu-Fe in icosahedral phase. Some combinations of alloys such as were observed (Al-Pd-Mn, Al-Cu- Fe, Al-Co-Ni and Ti-Zr-Ni) and these show the adsorption and/

or reactivity of simple molecules such as CO, CH_3OH and H_2. In catalytic reaction of interest for increased production of hydrogen gas using a catalyst quasicrystalline be noted that even a good performance achieved by obtaining a greater amount hydrogen gas at a temperature lower than the beginning of the reaction. Several quasicrystalline alloy containing Pd were tested and were highly active for the decomposition of methanol.

According to the studies of Hao et al. [5] reported that the alloy with the chemical composition of Ti-Zr-Co contain a quasicrystalline icosahedral phase showing a high catalytic activity and selectivity for the oxidation of cyclohexane.

However, quasicrystals based on Al have been considered as the most promising candidate for the surface catalysis because of their heat stability and ease of production, because this metal is quite abundant and inexpensive cost. The oxidation of aluminum in the alloy has quasicrystalline a change of concentration in the area near the surface and may induce a transformation of icosahedral phase to the crystalline phase , but emphasizing that the icosahedral phase is predominantly the presence of aluminum.

In the icosahedral phase and in the presence of oxygen atoms aluminum move to the surface, assuming that it is due to the driving

force provided by the exothermicity of the oxide is greater than that of the other constituent of the alloy [6]. In this case forms a thin layer of amorphous Al_2O_3 oxide layer called passivating. This layer is alumina in catalytic reactions is favored due to their structural and chemical characteristics, its intrinsic acidity resulting from the combination of two hydroxyl groups neighbors forming water during thermal dehydration, leaving exposed Al^{3+} ions which by their electron deficiency, act on acid sites Lewis or through the hydroxyl groups retained act as proton donors, or Bronsted acid sites, and the alumina these types of reactions. The copper-based catalyst has a tendency to favor the catalysis of reactions, can be thermodynamically stable, and it is this feature provides better conditions for the steam reforming reaction. The quasicrystalline alloy is used as a precursor and/or a support associated with it, in the case of a zeolite. The research already done with the quasicrystalline alloys, to leached or dry, always obtained good results in catalytic reactions. It is interesting to say in general, the catalytic activity depends on feature the surface, the atomic structure of the surface, the electronic nature of the surface and the surface energy. The reactions involving the conduction electrons, where magnetic for Fe and Cu moments both interact with their electric fields in translational periodicity of quasiperiodic structure and exchange interaction between the conduction electrons in sublevels s-d and the magnetic moments localized on the sublevel Fe, facilitating organic reactions on its surface. But it must be said, the mode of preparation of the catalyst can affect the structure and composition of the catalyst, as well as its activity, but have due care in preparation. So, you want to obtain a good quasicrystalline catalyst for certain purposes reactions in heterogeneous catalysis, with the intention of having some products such as methanol, dimethyl ether, hydrogen gas and olefins.

This paper studies the behavior of catalytic quasicrystalline alloy $Al_{62,2}Cu_{25,3}Fe_{12,5}$ in the reaction of steam reforming of methanol in the review that this league supports high temperatures and maintaining its stability. Whereas, good catalytic activity depends characteristics of the electronic configuration $3d^{n-2}4s^2$, first complete orbital later if the d orbitals. Therefore quasicristal is very promising for reaction catalysis.

Reaction of Methanol in Quasicrystals

The reactions involving alcohols are widely studied due to the high importance of these reagents either as products or even as many catalytic reactions. The high industrial production of methanol and simplicity of their structure makes one of the most studied molecules in terms of the surface [7]. The main industrial reactions involving methanol in metallic and quasicrystalline surfaces. These reactions are usually activated metal catalysts based on Cu, Fe or Pd dispersed in a thin bed oxide matrix.

Given that the OH group is the most reactive part of an alcohol, methanol serves as a model for chemical reactions which involved most carbonated chain alcohols are. The steam reforming reaction is considered promising and has the following advantages over other methods: it does not require oxidation of the fuel, has increased efficiency, reduced size of the system as a whole and produces high hydrogen concentration. The steam reforming of methanol (SRM) is potentially a good process for on board production of hydrogen for mobile fuel cells yielding the maximum amount of hydrogen. Iron and copper based catalysts have been identified as outstandingly effective for the SRM and therefore are subject of intensive research.

The formal reaction network of SRM over quasicrystals based catalysts mainly consists of three reactions. Steam reforming of methanol (Eq.1) is an endothermic reaction which is as good as irreversible at temperatures above 200°C and ambient pressure [8].

$$CH_3OH_{(g)} + H_2O_{(g)} \rightarrow 3H_2 + CO_2 \qquad (1)$$

$\Delta H = 49.6\ KJ.mol^{-1}$

Since this reaction is endothermic, the reactor needs to be heated. This is usually done by catalytic methanol combustion. A side reaction of less importance is the decomposition of methanol (Eq.2), also endothermic and nearly irreversible at temperatures above 200°C and ambient pressure.

$$CH_3OH_{(g)} \rightarrow 2H_2 + CO \qquad (2)$$
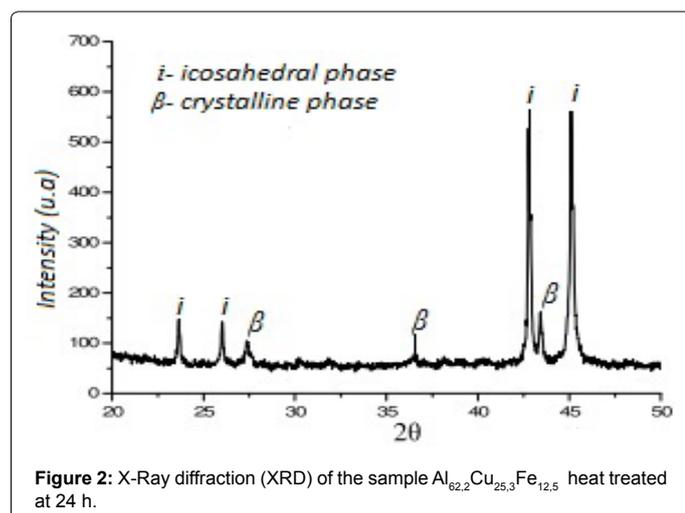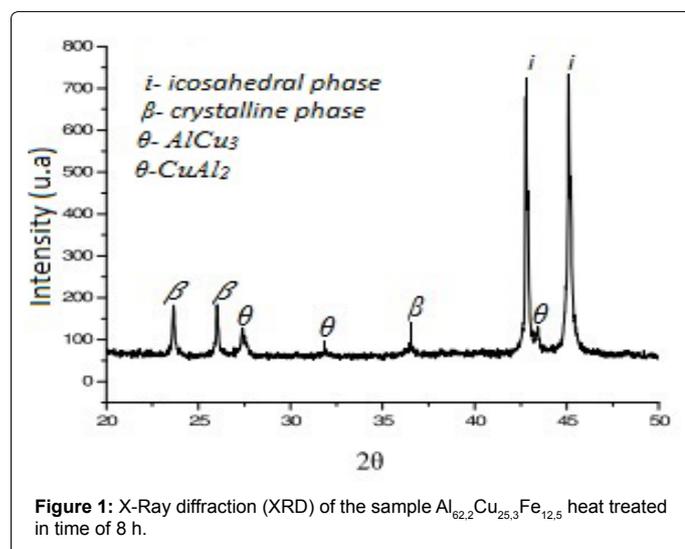
$\Delta H = 90.2\ KJ.mol^{-1}$

The reaction products of SRM suffer the consecutive endothermic reverse water-gas shift reaction (rWGS, Eq.3), which is also known to be catalyzed by amorphous alloys by iron and even the nanostructured zeolite associated with quasicrystalline alloys catalysts.

$$H_2 + CO_2 \rightarrow H_2O_{(g)} + CO \qquad (3)$$

$\Delta H = 41.1\ KJ.mol^{-1}$

Although this reaction is thermodynamically strongly disfavored in the typical temperature range of SRM and due to the presence of water in the reactant mixture, it be-comes important as it was found to be the main reaction pathway for carbon monoxide formation. The reduction of carbon monoxide, due to its poisoning effect on fuel cell electrodes, is an aim of new catalyst development with higher selectivity for SRM. Alternative routes, adding oxygen to the feed (combined reforming of methanol) or using a molar excess of water, lower the carbon monoxide concentration but still not sufficiently for the direct use of the product gas mixture in a fuel cell. Up to now, carbon monoxide needs to be eliminated in an expensive clean-up unit, where carbon monoxide is selectively oxidized. Further by-products re-ported by several research groups are methane, formaldehyde, dimethyl ether and methyl formate as trace components, respectively.

The composition of the product gas from the steam reforming of methane is much less complicated than that from the partial oxidation due to oxygen in fewer chemical reactions. With this causes a decrease and there is less risk of the active surface oxidation of copper oxide (CuO) can be maintained. Although different reaction mechanisms that are proposed, it is believed that the dissociative adsorption of methanol is an essential step of the reaction. This step probably needs a partially oxidized surface CuO, because methanol is adsorbed very weak on a surface of pure copper. Generally two types of adsorbents sites are considered: one absorbs hydrogen, and the other absorbs all the intermediates through oxygen linkages. The first probably corresponds to a reduction of copper; the latter is probably related species of Cu oxidized. After adsorption, the methoxy groups are gradually dehydrogenated, but there is general agreement on the route that leads to $CO_2 + H_2$. Some authors assumed the formation of methyl ethanoate $HCOOCH_3$ as an intermediate which hydrolyzes and $HCOOH$ CH_3OH: HCOOH then decomposes into $CO_2 + H_2$. There formation of the adsorbed methanol is dehydrogenated to formaldehyde, formic acid, and finally CO_2, passing through intermediate dioxometilene. The products formed in the reform of methanol gas are H_2, CO_2, H_2O and CH_3OH not converted. Small amounts of carbon monoxide (byproduct) are observed when methanol is almost completely converted. From the foregoing, it is the most favorable for the production of gas with a high hydrogen content (reaches 75%) process compared with previous processes and also has a high selectivity for carbon dioxide. Another way of producing hydrogen from methanol is a combination of partial oxidation with steam reforming. Its main advantage is that the heat

Figure 1: X-Ray diffraction (XRD) of the sample Al$_{62,2}$Cu$_{25,3}$Fe$_{12,5}$ heat treated in time of 8 h.

Figure 2: X-Ray diffraction (XRD) of the sample Al$_{62,2}$Cu$_{25,3}$Fe$_{12,5}$ heat treated at 24 h.

required for the process can be supplied by the reaction itself (auto thermal reaction). However, the production of hydrogen in the product gas and the conversion of methanol are lower than that of steam reforming of methanol [9].

A metal composition binary or tertiary alloy, quasicrystals in the case of dispersion will improve or alter the electronic structure of a catalyst. More importantly, the presence of a promoter can change the adsorption characteristics of the surface of the catalyst, changing the reducibility of the catalyst or, in some cases, alter the catalytic performance [10]. Generally burning methanol (CH$_3$OH) initially occurs in very high temperature with a catalyst thermal stability for no deactivation of the same at the beginning of the catalytic reaction [11] is necessary. In an early stage of this study it was observed that the Cu/Cr$_2$O$_3$/Fe$_2$O$_3$ high temperature shift catalyst exhibits remarkably low activity and poor selectivity for methanol steam reforming, and this combination will definitely never reach technical application for this reaction. However, this catalyst was not suspended from further experiments since there is a pool of information about a reaction system that cannot be discovered by the analysis and investigation of good and optimized catalysts.

This is the case of the alloy quasicrystalline Al$_{62,2}$Cu$_{25,3}$Fe$_{12,5}$ of the

application is as a catalyst, since this alloy has a thermal stability in the temperature range 1073K.

Materials and Methods

The preparation of quasicrystalline alloys consists of a nominal composition Al$_{62,2}$Cu$_{25,3}$Fe$_{12,5}$ according to their grain size , having a purity of 99,9 % . The alloy was obtained by melting the pure elements of air. The induction furnace was used in controlled atmosphere Argon 5.0, in order to obtain a good homogenization of quasicrystalline phase. The sample preparation was performed at the Laboratory of Physics of Materials-LPM, Federal University of Paraiba Center of Exact Sciences and Earth/UFPB where a high-frequency generator (40 kVA) manufacturing POLITRON was used . Each element that makes up the league quasicrystalline contains 10g, this measurement procedure was performed on a Shimadzu balance. The training method was through solidification in the cold hearth furnace for generating a heterogeneous league, being a common procedure a mixture of quasicrystalline phase to the crystalline phase. To be a proportional increase in quasicrystalline phase in the sample, it is necessary to heat treatment, so that will further the transformation of peritectic phases. This was done using the heat treatment in a furnace Nabertherm resistance mark, in which the samples remained during the period of 8h and 24h at a temperature of 750 °C.

The Ray Diffraction-(XRD) was used to monitor the evolution of the phases and sample stability during casting. Was used for both a Diffractogram SIEMENS D5000 being used the CuKα radiation whose wavelength is Å. To analyze the morphology of the quasicrystalline placed a LEO Scanning Electron Microscope; Model 1430, coupled with an OXFORD probe was used. The samples after casting and were placed in catalytic tests dispersion in isopropyl alcohol solution. The energy dispersive spectroscopy (EDS) of the sample quasicrystalline alloy Al$_{62,2}$Cu$_{25,3}$Fe$_{12,5}$ micrograph was obtained at an energy dispersive analysis after 8 hours heat treatment coupled with the SEM sample which has previously been metallized with gold (average thickness 12 nm). In the description of the structure and morphology of the samples to verify surface defects, dislocations and size of particles , made using a Transmission Electron Microscope (TEM) Tecnai 20 with the tension between 20 kV to 200 kV, and 1.9 Å resolution of point 0 2 nm. The catalytic tests were carried out on the alloy catalytic evaluation unit, Model TCAT -1 at atmospheric pressure, 300mg weighed sample which was introduced in Pyrex reactor heated at room temperature to 450°C at a heating rate of air in an atmosphere (argon) to flow.

After reaching a temperature of 450°C in 2h the sample remained under these conditions to remove the physically firssor life water.

The waste products of the reactor were successively injected "on line" by a 10-way valve on a Varian CP3800 gas chromatograph with thermal conductivity detector at 15 minute intervals until you reach the pseudo-steady state".

Results and Discussion

Diffractogram X-ray

The spectra of X-ray diffraction of the sample stoichiometry, Al$_{62,2}$Cu$_{25,3}$Fe$_{12,5}$ are shown in Figures 1 and 2, respectively, for heat treatment of 8 hours and 24 hours. These diffraction peaks can identify phases; icosahedral phase i-, β- crystalline phase composition Al_{50-x} $(Cu, Fe)_{50+x}$ and θ-AlCu$_3$ tetragonal phases and θ-CuAl$_2$. These results also suggest that the β phase is formed directly from the liquid alloy. In addition, the β phase transforms below 600°C to form the λ and
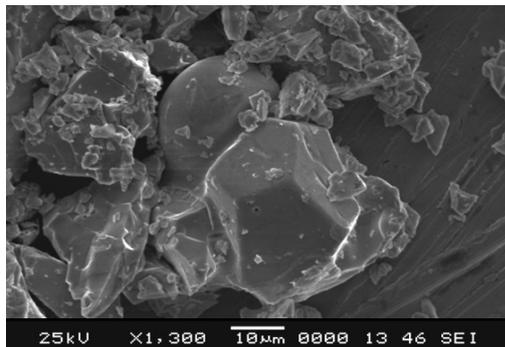
Figure 3a: Image quasicrystalline the surface of the alloy $Al_{62,2}Cu_{25,3}Fe_{12,5}$ showing the icosahedral phase, at 8 h.
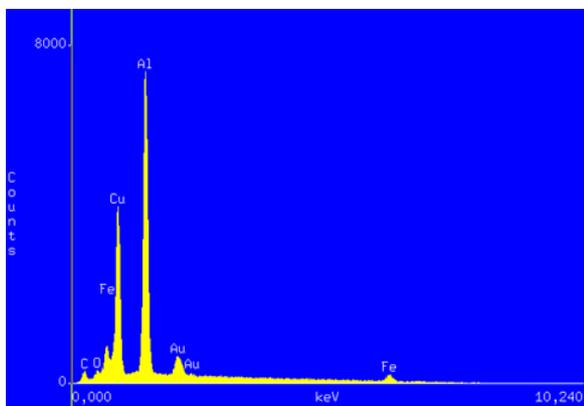

Figure 3b: EDS elemental analysis of quasicrystalline alloy $Al_{62,2}Cu_{25,3}Fe_{12,5}$ showing the icosahedral phase after heat treatment at 8 h.
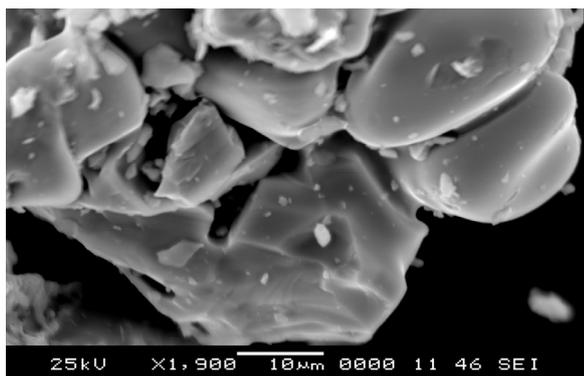

Figure 4: Alloy quasicrystalline $Al_{62,2}Cu_{25,3}Fe_{12,5}$ to 8 h heat treatment and subjected to a catalytic reaction.

θ - phases which are induced by the solubility of Cu and Fe. The $Al_{62,2}Cu_{25,3}Fe_{12,5}$, treatment of the alloy 5 at 850°C solid solution is shown in Figure 1. In Al-Cu-Fe system, icosahedron quasicrystal (i-$Al_{62,2}Cu_{25,3}Fe_{12,5}$) and (β-$Al_{10}Cu_{10}Fe_{10}$) have been proposed to have a close structural relationship from the viewpoint of valence electron correlation in the concentration of electrons free driving in their atomic structure. These two phases are distinguished in the XRD pattern (Figures 1 and 2), namely icosahedral quasicrystalline (i-phase) and tetragonal phases (θ-$CuAl_2$ and θ-$AlCu_3$ and β-Al_3Cu) phase. Intensity

peaks corresponding to the i-icosahedral layer is higher than the peaks are specifically related to the β-phase.

However, the alloy $Al_{62,2}Cu_{25,3}Fe_{12,5}$ fusion, i- phase co-existed with a small amount of AlFe (Cu) solid solution [12].

The crystalline β-phase crystalline phase is a solid solution solubility of copper (Cu) and iron (Fe). The θ-$AlCu_3$ tetragonal phases and θ-$CuAl_2$, they make a sequence corresponding to the gradual increase of temperature in the constitution of the league. The formation of quasicrystalline phase depends on the composition and shape as the transformation of the crystalline phases occurs, that is, with increasing temperature within the range of composition suitable for aesthetic transformation to occur. However the results of the two diffraction patterns of X-ray indicates that the peak intensity is greater quasicrystalline the icosahedral phase. It should be noted when comparing Figure 1 with Figure 2 shows the sample that underwent a heat treatment of 24 h, it is found that the quasicrystalline league became homogeneous, which is almost single phase because the peak of the crystalline β-phase is low intensity almost imperceptible.

Scanning electron microscopy and EDS

Figures 3a, 3b, 4 and 5 respectively show the sample results of scanning electron microscopy in samples of alloy composition quasicrystalline $Al_{62,2}Cu_{25,3}Fe_{12,5}$ catalytic reaction before and after the samples were subjected to catalysis. For catalysts trimetal Al-Cu-Fe in continuing training (one of the promising reactions in this area is the direct synthesis of dimethyl carbonate CO_2 and methane) from CO_2 and methanol.

The Scanning Electron Microscopy (SEM) and Energy Dispersive Spectroscopy (EDS) applied to the sample type $Al_{62,2}Cu_{25,3}Fe_{12,5}$ 5 produced Figures 4a and 4b respectively for heat treatment 8pm. Composition analysis was performed with SDS showed that regions were composed mainly of Cu, Fe, O and a small amount of Al that can complex with Cu, Al_2O_3, $AlFe_3$, Al_3Cu, Cu_2O and Fe_3O_4 or $CuFeO_2$ [13]. The image of the microstructure of the alloy quasicrystalline icosahedral phase of Figure 4a corresponds to a crystal polyhedron formed by a combination of pentagonal and hexagonal phases, with geometric uniformity. In Figure 4b it is observed in the EDS elemental analysis of the spectrum, there is a greater predominance of aluminum than other elements (copper and iron) that makes up the quasicrystalline league. Figures 4 and 5, respectively, show the results of the analysis of scanning electron microscopy in the sample after the catalytic reaction.
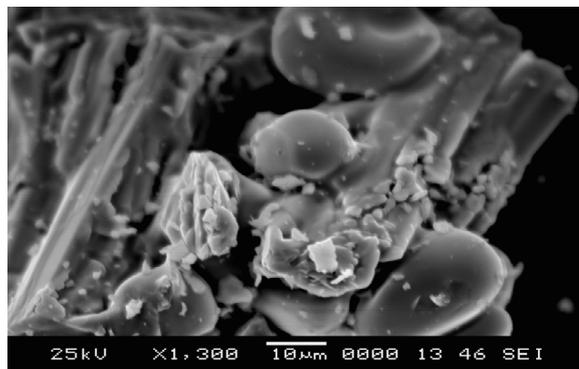

Figure 5: Alloy quasicrystalline $Al_{62,2}Cu_{25,3}Fe_{12,5}$ to 24 hours of heat treatment and subjected to a catalytic reaction.
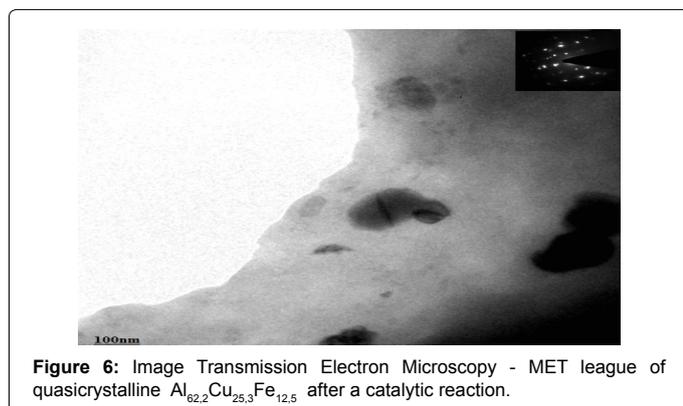
Figure 6: Image Transmission Electron Microscopy - MET league of quasicrystalline Al$_{62,2}$Cu$_{25,3}$Fe$_{12,5}$ after a catalytic reaction.
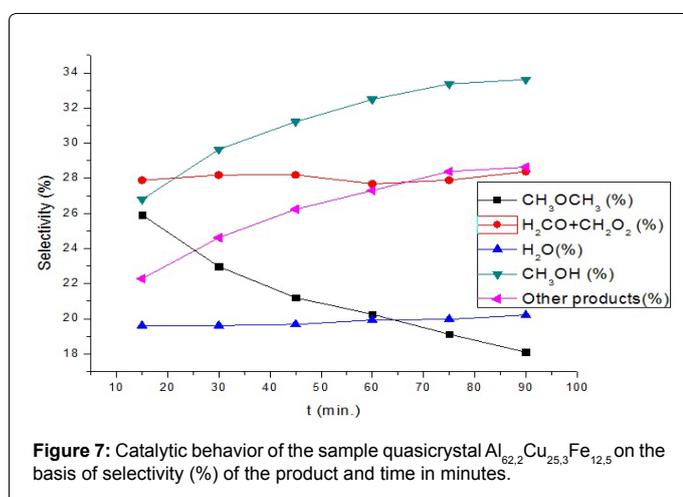

Figure 7: Catalytic behavior of the sample quasicrystal Al$_{62,2}$Cu$_{25,3}$Fe$_{12,5}$ on the basis of selectivity (%) of the product and time in minutes.
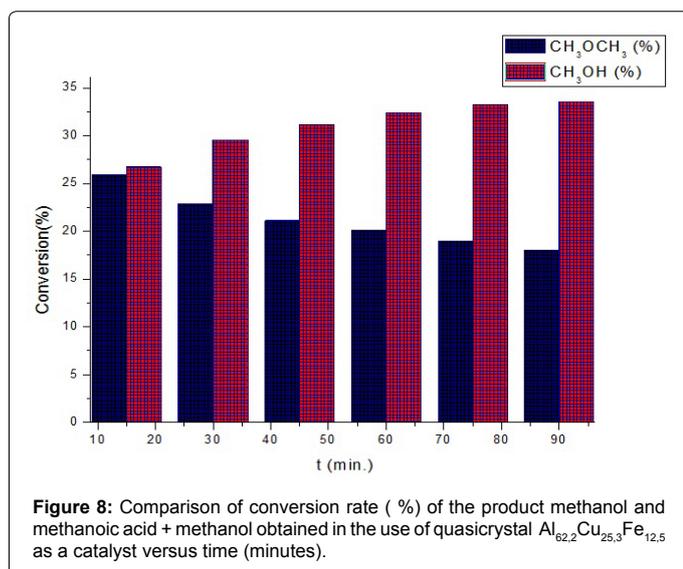

Figure 8: Comparison of conversion rate (%) of the product methanol and methanoic acid + methanol obtained in the use of quasicrystal Al$_{62,2}$Cu$_{25,3}$Fe$_{12,5}$ as a catalyst versus time (minutes).

The microstructure of the alloy samples quasicrystalline Figures 4 and 5 by which underwent the heat treatment of 8 hours and 24 hours process, and also by a catalytic reaction can analyze these figures there quasicrystalline occurrence of decomposition of crystalline phases with strong presence of the intermetallic phase. Of course, the reduction occurred in quasicrystalline phase and the intermetallic phase oxidation, which in turn acted as nuclei or catalytic sites.

Transmission Electron Microscopy (TEM)

The Transmission Electron Microscopy (TEM) sample showed 6 points of diffraction profiles obtained from the dry process, showed a dark layer as shown in Figure 6 that this can be attributed to Cu, Cu$_2$O and Fe$_3$O$_4$. The dry regions generated in quasicristal had uniform composition and consisted of homogeneous mixture of Cu, Fe, Al, and their oxides. Within the area of particle quasicrystal (Al-Cu-Fe) presented symmetry with double reflections with a quasi periodic structure, featuring quasicrystalline surface with standard well defined symmetry. Transverse TEM observations with clear evidence that the microstructure of the layer passivating Dry is heavily dominated by quasicrystalline precursor alloy Al$_{62,2}$Cu$_{25,3}$Fe$_{12,5}$. TEM observations showed taken in a cross-section of the sample revealed a cubic intermetallic phase in the form of spinel Cu$_x$Fe$_{3-x-y}$Al$_y$O$_4$ formed on the outermost layer of quasicrystal after dry heat treatment. The orientation can stabilize the nanoparticles through a binding Cu Cu-Fe-O at quasicrystal for the production of olefins, dimethyl ether and methanol itself. This drastic increase in catalytic activity is responsible for the fine Cu nanoparticles in the composite.

The image in Figure 6 shows a low magnification bright field image of Al$_{13}$Fe$_4$ and defective dendritic shape, and the dark field of small particles of copper (Cu) and iron (Fe) in which elements are alloying. On the other hand, the higher selectivity for methanol reforming and decomposition products and the same is related to the transition metal in this case should tell Cu and Fe, the oxidation reaction of methanol on the surface of copper (Cu) yields the formation of formaldehyde as the main product [14].

Evaluation of catalytic processes

Evaluation of catalytic activity in terms of selectivity (%) of quasicrystalline alloy Al$_{62,2}$Cu$_{25,3}$Fe$_{12,5}$ investigated, and the results obtained from the two tables, it was possible to built the two graphs of Figures 7 and 8 with the curves of selectivity (%) versus time (minutes). Table 2 presents the data conversion (%) of methanol and methanoic acid + methanol obtained as a function of time (minutes).

The results obtained with the catalyst formed by connecting quasicrystalline Al$_{62,2}$Cu$_{25,3}$Fe$_{12,5}$ had its performance tested in a catalytic evaluation unit, which shows the percent yield of methanol plus the product of the reaction. Considering the selectivity of the products obtained, it was observed that there was good selectivity progressed according to length, for products methanol + methanoic acid, water and methanol, except for dimethyl ether.

In the first 40 minutes, the dimethyl ether showed a good

t(min.)	15	30	45	60	75	90
CH$_3$OCH$_3$ (%)	25,91	22,97	21,2	20,25	19,12	18,09
H$_2$CO+CH$_2$O$_2$ (%)	27,89	28,18	28,19	27,68	27,89	28,38
H$_2$O(%)	19,61	19,61	19,68	19,93	19,97	20,21
CH$_3$OH (%)	26,79	29,64	31,22	32,49	33,37	33,62
Other products. (%)	22,28	24,61	26,23	27,30	28,38	28,64

Table 1: Selectivity (%) of methanol in the reaction products as a function of injection time (min).

t(min.)	15	30	45	60	75	90
CH$_3$OCH$_3$ (%)	25,91	22,97	21,2	20,25	19,12	18,09
CH$_3$OH (%)	26,79	29,64	31,22	32,49	33,37	33,62

Table 2: Conversion (%) Products of methanol and methanoic acid methanol + versus time (min).

percentage of selectivity. However, on 50 minutes following a trend of decay was observed. The ethanol + methanoic acid showed a selectivity curve practically constant over the time intervals. The analysis of the selectivity curve of the percentage of methanol showed an increase of nearly 10%. Such growth can be attributed to a complete oxidation of methanol verified later in the reaction of formation of the methoxy radical ($-O$ -CH_3). This radical is considered the most stable intermediate after adsorption on the surface of methanol. In reaction that occurs due to the increase of the methanol temperature there is a decomposition of formaldehyde. Of course, this next stage of formaldehyde yields in varying degree the carbon monoxide CO and carbon dioxide CO_2. In general the reactions occur in sequential steps. We observe, in the first step of the reaction of methanol dehydrogenation one.

Conclusions

The main conclusions of the research are as follows:

1. The league quasicrystalline $Al_{62,2}Cu_{25,3}Fe_{12,5}$ and are thermodynamically stable at high temperatures, one of the favorable prerequisite for the use of catalysis, and their electronic and surface of quasicrystal provides a catalytic activity properties;

2. The microstructure of the sample quasicrystal, $Al_{62,2}Cu_{25,3}Fe_{12,5}$ after the catalytic reaction, it was observed that there was a breakdown of the crystalline phase quasicrystalline with a strong presence of intermetallic phase;

3. The selectivity and conversion of quasicrystalline alloy $Al_{62,2}Cu_{25,3}Fe_{12,5}$ demonstrated the adsorption of the metal surface of methanol quasicrystal influencing the percentage of products obtained from the reaction medium. Particles of copper (Cu) are present on the surface of quasicrystal being and is the metallic transition element that favors the oxidation of methanol;

4. The low cost of alloying encourages their use in catalytic reactions, and is one of the most favored indices showing the possibility of quasicrystal be used as an industrial catalyst;

5. The species dispersed in the Fe homogeneous dry layer increases the catalytic activity and suppresses the aggregation of Cu, producing other products such as formaldehyde, methanoic acid and other olefins produce methanol.

6. This is probably the formation of other olefins formed from the decomposition of methyl formate, the primary intermediate surface quasicrystal due to their electronic properties during the course of heterogeneous catalysis;

7. The quasicrystalline surfaces in these catalysts were dominated by methoxy and formate groups, the intermediate formaldehyde and methyl formate dioxomethylene can be observed during the steam reforming of methanol.

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