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Produce Types of the Egyptian Glass suitable for the Sculptured Glass Tiles in Low Temperature

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Abstract:

The research aims to obtain some of the colored glass mixtures from local materials in low cost, can be melted at low temperature, this to transform them into artistic works and glass products can be formed through the functional changes of the glass sculpture in modern and distinctive vision with transparency and colors graduation features that resulted from the effect of cobalt and chrome. Also the possibility to obtain panel glass has multi grades of such types to be used in facades and the architectural ceilings. Glass considers one of the most important building materials that could seen its using development in the interior and exterior architecture according to its released usage and aesthetical values without any effect on the environment.

Up till now, Egypt still import the colored panel glass and the glass sculptured tiles from the international markets, this despite of the characterized history of the Egyptian and Islamic civilization in the glass manufacturing. That, studies did not try to develop the colored glass in Egypt, so, this made us studying the using of the coloring characteristics of cobalt and chrome, then knowing their effect on the manufactured glass

mixtures with local materials to make types of the panel and shaped glass and tiles through some of the simple technological and designing solutions.

Introduction:

Glass is one of the most important materials that has got great development in the recent time, in particular, in the architecture field according to the achieved of the aesthetical requirements, its function and ability to realize the integration, response and living together with the environment. The used colored plane glass in architecture still imported by Egypt from the international markets up till now, where Egypt's production is concerned on just three types. Although the distinct shiny history of Egypt on the scene of the international civilization and as the works of the Ancient Egyptians still everlasting up till now like Pyramids that characterizing with the firm evidence of the availability of their buildings and artistic miracles that could precede all the world through its wonder civilization innovations and its several environmental resources that helped to establish the said civilization and created many industries such as pottery, sculpture and glass which could be developed at the ancient time, and that history and the world's museums still attest that the Egyptian glass and ornaments have been found prior to 1400 years B.C.

In Metropolitan Museum of Art in New York, there's a wineglass belongs King Tohotmes III its time returns to 1450 B.C. In the Egyptian Museum there's a green jar in the shape of Lotus, some of the colored beads, glass columns and colored eyes that were ornamenting the mummies statues return to the century 1550 B.C., in addition to the mace of Amenheteb III that is kept in Berlin Museum, that consider the oldest glass monuments and confirmed its historical truth by the scientists to be in the year 1797 B.C.

So, Egypt considers from the first countries that was have a precede in the colored glass industry, where we don't know the secret of the declination that attached such industry up till now. Although, the recent scientific studies and researches didn't approach to return the glass manufacturing and development to be as its previous rank in Egypt when Egypt was distinguishing with the different types, colors and properties of the glass. That, and as a result of the several used materials and elements in the mixture, and also the expansion of the manufacturing hand didn't use specialists to make the scientific and laboratory experiments that assisting and interesting them in the said development to be fit with the glass production level and its international flourishing. Form such point was **the Research issue** concerned in recalling the Egyptian glass industry, using the available natural materials with adding colored elements such as cobalt and chrome to obtain sculpture glass tiles in several colors degrees, and decreasing the melting temperature. That, **the Research goal** is to reach artistic works production and producing glass tiles for the architectural facades from the manufactured glass from the available natural materials in the Egyptian environment like sand in Abu Znima area in Sinai, the lime stones that spreading in Samalout area, the dolomite stones that available on the Egyptian shores and also flespar and aluminum that existing in the igneous stones in Aswan and sodium carbonate that spreading in Alexandria Salina areas.

Then making new glass mixtures can add to their specifications reduction in the melting temperature to reduce the energy and life time of glass melting furnaces by adding boron and barium oxide, then increasing the rate of aluminum oxide to the raw materials of the glass mixture with adding cobalt oxides in its different trio and tetramerous valence aspects to obtain different color features. Then repeating the said experiments but by adding a rate of chrome to the transparent glass mixture in a form of chromate and trio or hexamerous valence oxides to obtain color features in different degrees, in low temperature. It shall use such resulted colored mixtures to make three dimensional artistic glass and also making transparent glass tiles for the interior sectors in the architecture, making tiles for walls revetment and the exterior architectural works. Through that, we shall realize our gains from the Egyptian glass industry, in addition to the architecture's development to be fit with the Egyptian environment with artistic works of the glass. To achieve that, we followed the following steps:

- A study to make Egyptian glass in low temperature.
- The possibility to coloring the resulted glass of the research by adding little rates of chrome and cobalt oxides.
- Produce glass artistic works and sculpture tiles of the resulted glass for the architectural beautification.

First: A study to make Egyptian glass in low temperature:

It could make a study to know the chemical elements in the architectural glass mixtures that manufactured locally and internationally and their elements components as follows: (Na_2O– CaO – manganese oxide – Al_2O_3– SiO_2) in the following form: (Si_30,Mg_2,Al,Ca_{14},Na_{11},O_{76}), where it was replaced such oxides and chemical elements with some of the available materials in the Egyptian nature and environment like:

SiO_2: from the areas of Sina, Abu Znima and Kattameyia Cairo. Silicon oxide representing a rate not less than 98%, where such sand considers from the best types of the valid sand for glass manufacturing, and it was used instead of SiO_2.

Lime stones Ca_2O: from Samalout area in Assiut, where it considers from the best areas that giving a rate not less than 65% of CaO, 30% of SiO_2, as it was used instead of CaO in the mixture.

Dolomite $CaCO_3$ – $MgCO_3$: it considers the raw material that replacing MgO in the glass and contains high rate not less than 56% of MgO and 41% of calcium carbonate, where it was replaced instead of MgO.

Na_2O: it is about a substance prepared from ammonia and rock salt solution that producing from new Alexandria Salina areas and Borg El Arab Salina areas to be used instead of Na_2O.

Flespar: a substance is adding to the previous glass mixture to be instead of aluminum molecules, where it can use kaolin or acid igneous rocks like granite, nies and shesnet to be used instead of Al_2O_3.

It could use several glass mixtures from the Egyptian raw materials, melted in different temperature and concluded the affection with the weather and the coefficient of expansion. Table (1) showing such mixtures:

Sample No.	Oxides percentage in the mixture					Melting temperature	Affection with weather	Coefficient of expansion
	MgO_2	Na_2O	CaO	Al_2O_3	SiO_2			
1.	3.5	15.0	8.5	1.0	72.0	1450	99.79	$100x10^{-7}$
2.	4.0	15.0	9.0	1.0	71.0	1430	99.80	$101x10^{-7}$
3.	5.0	15.0	9.0	2.0	70.0	1420	99.81	$101x10^{-7}$
4.	5.0	15.5	9.0	2.0	69.0	1420	99.82	$102x10^{-7}$

Table (1)

After obtaining the Egyptian transparent glass in temperature from 1450° to 1420° and by adding some the chemical elements to obtain features assisting to reduce the melting temperature of the glass material that usually composing of SiO_2 + Na_2O + Al_2O_3 with a rate not more than 2% + CaO + manganese oxide, added to them Pb_2O_5: B_2O_3, and also to know the ability of such types to absorb moisture and water. Often adding phosphor oxide in such component of the glass mixture to be instead of some of MgO_2

molecules in the basic structure of glass network or boron oxide shall be instead of some of SiO_2 molecules, where by that, the melting degree of glass material shall be reduced by changing the resulted ion from such reciprocal additions.

By testing the effect of boron oxide or phosphor and their replacing instead of manganese oxide or SiO_2 molecules in the basic mixture of the transparent architectural glass structure with chemical structure as follows: $Na_{13}\ Ca_4\ Mg_2\ AlSi_{31}\ O_{76}$. Where we find in case of adding boron oxide the mixture shall be in the following form: $Na_{13}\ Ca_4\ Mg_2 \times AlSi_{31} \times O_{76}$ But in case of adding phosphor, the mixture shall be in the following structural chemical form: $Na_{13}\ Ca_4\ Mg_2\ AlSi_{31} - Xpy\ O_7$. Whereas the first mixtures equal the second mixture in the structure, the first mixture is S = 1.75and the second mixture is SS = 1.40, so: $0 \leq X \leq 1.75.0 \leq X \leq 1.4$.

But in case of adding boron and phosphor oxide together in the basic mixture with the same previous rate, we shall obtain a mixture its basic structure is boron and phosphor together and the chemical structure shall be as follows: $0 \leq X \leq 1.75.0 \leq y \leq 1.4$

From this result, it could obtain new type of the compound glass that we depended on its using and development till can obtain the most suitable mixture, the best pure and cheapest for using. In such way, it was increased the rate of the added mixtures with different rates till could reach the best of such mixtures through the different experiments and found that the following mixture is the most suitable, particularly when adding some of the colored metallic oxide to them: $Na_{13}Ca_4MgB_2\ AlSi_{30}\ O_{76}$

By making the coloring experiments on this mixture, it was found that in case of adding cobalt oxide, we shall obtain the best suitable chemical structure for the pure type of blue: $Na_{13}Ca_4\ MgB_2\ Al_1{-}x\ Cox\ Si_{30}\ O_{76}$

But in case of adding serunium oxide in this mixture, we shall obtain the following chemical structure for the most pure type of gold yellow. By adding chrome oxide to this mixture with the same of the previous rates, we shall obtain the green types that its color doesn't change or doesn't affect with temperature or moisture, and its final chemical form as follows: $Na_{13}Ca_4MgB_2\ Al_1{-}x\ Cex\ Si_{30}\ O_{76}$

By adding manganese oxide to the same of the previous transparent mixture to obtain the violet, we find that the best suitable mixture is in the following basic structure:

$Na_{13}Ca_4MgB_2\ Al_1{-}x\ Mnx\ Si_{30}\ O_{76}$

In case of obtaining red and orange colors, it could add cadmium and selenium oxide to the previous transparent mixture, to obtain the required color in the following structure: $Na_{13}Ca_4Mgl\ Cdx\ B_2\ Al\ Si_{30}\ O_{76}\ Sx$

Whereas the transparent basic mixture is the same one of composing, and could use pure chemical substances in the previous experiments, it has considered in this experiment the possibility to replace both of CaO with lime stones and changing the calcium rates in the mixture for the lime stones components and also the pure sand instead of the chemical SiO_2, as it could replace the manganese with flespar that is available in Egypt to reduce the rate of depending on the outer export, as used the pure chemical substances to obtain the coloring value, particularly the percentage of the colored oxides in such mixture doesn't exceed than 2% for every chemical oxide of the following oxide: Se, Cds, Cdo- Co_2O_3, Cr_2O_3, Fe_2O_3

That after being obtained samples of this colored glass materials, it could make the heating and boiling process in the lab with a temperature 600° in platinum pot that is satisfied with water, in the electrical oven with strong solution, its temperature between 1250° : 1500°, where the isometric fixed material was between an hour and two hours in the previous temperature 600°.

By analyzing the glass after making this experiment, it was found the increasing of some components during boiling such as alkali oxides from 5% : 15%, phosphor oxide could be increased till become 10%, through the total mixture that calculating to be 100%. For these reasons, it could make some corrections in the previous mixtures to obtain the most suitable rates in the glass structure by adding any of B_2 B_3 P_2 O_5 or adding them together + B_2O_3 + P_2O_5 then obtaining the mixture's melting temperature from 1450° (1010°:1260°). By that it could save thermal energy when melting each mixture in the oven with the rate 250° lower than the unused glass mixture in the previous elements and oxides. Also could consider that the used mixture with phosphor and boron is resisting the moisture with a rate 99.78%, where the existence of boron oxide was with the rate 2.69% in the basic component in the glass mixture, not only to reduce the temperature, but also to help to increase the transparency and purity of the transparent colored glass and to be assured from the conformity of the produced glass with the international specifications and properties.

Third: the possibility of coloring the resulted glass from the research by adding cobalt and chrome oxide:

After obtaining sample of the transparent glass with the local materials and the international specifications, it could study the possibility of coloring such mixtures by adding rate not less than 0.2% to 1.5% of the colored oxides, particularly cobalt and chrome to obtain several coloring degrees gradual from the light to dark with the same specifications to be used in the glass artistic works.

The properties and affection of cobalt on the glass:

Cobalt is using to color the glass, giving the blue color (tertramerous or hexamerous valence), where cobalt oxide, its color looks like dark black, and also is using for coloring. In some cases becomes as a purifying factor for the manufactured glass from materials contain blotches may change the color such as FeO, it changes the transparent color into green in the glass. Figure (1-a) showing the relation between the wavelength and coefficient of absorption in the glass.

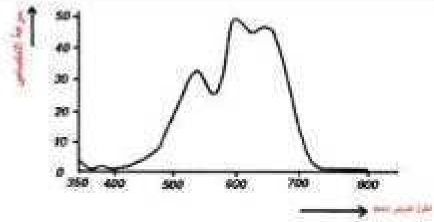


Figure (1) showing the coefficient of absorption of cobalt oxide in soda glass

In case of changing the rate of glass mixtures by increasing SiO_2 and increasing the cobalt's rate, we find that the resulted glass gives blue similar to red. But in case of increasing the boron rate to 3%, we obtain blue similar to green, and changing into pink. This confirming that the percentage of the elements components in the glass mixture whether by increasing or decreasing also affect on the color feature as a result of the cobalt's reaction with some of these elements. Also to study the way of how changing the resulted color in the glass with cobalt's elements components, it may use cobalt in a form of crystal or as a solution, where any of them leads to the same result. We obtain blue in case of used cobalt that surrounded with four oxygen atoms, while we obtain pink in case of using cobalt that surrounded with six oxygen atoms. In case of using a small rate of CoO_4 with CoO_6, pink shall be disappeared and blue shall appear, then by reducing it and by the variation of cobalt, the blue color shall be changed into the pure light as a transparent. That, and because the glass that involving cobalt element allows the red spectrum penetration, using it to detect potassium by heating. Yellow and orange spectrums are absorbed in the blue glass that contained cobalt, while the violet, red and blue spectrums are penetrating through the glass that containing cobalt.

The figure showing the speed of light absorption in samples of the glass that used cobalt in it for coloring.

1. Wavelength and coefficient of absorption in the glass, the cobalt rate in it is 1.5%, and the silicon rate increment is reaching 72%.

2. Wavelength and coefficient of absorption in the glass that added to it the rate 3% of boron oxide.

3. Wavelength and coefficient of absorption in the glass, the silicon rate in it is 69% and calcium rate is 9.5%.

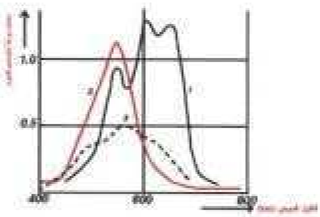


Figure (1-b)

In the structure of glass atoms, we find that Co^{+2} is taking the place of Na^{+} or Ca, and takes the same actions exactly as in the atomic network of the glass. When putting electric field in silica glass, this leads to different ions and then makes cobalt takes the way of forming the pink color instead of forming the blue color. The reason of that, is the glass electrical analysis replacing the alkali, this because have a very weak tie than the negative ions that have higher valence. When putting cobalt, it takes the alkali place, and surrounding with six atoms of oxygen or more. By that, forming the pink color, and as a result of the hard glass structure, it doesn't allow to the surrounded ions to be changed. There're several researches of discussing the affection of cobalt oxide on the various properties of the glass, where it could study the measuring of ultraviolet rays, its density, thermal expansion, electrical conduct, elasticity temperature and chemical resistance of acids and alkali, it was found that the glass is containing big amount of cobalt gives the dark blue and has affection on the light properties of the glass. If desired to use cobalt as a sole coloring, it is difficult to use it as a metallic element, but it must be made in a form of oxides. But in theramerous or hexamerous valence case, and in the case of using cobalt to amend the resulted color from blotches, it is easy to use it in a form of dual valence oxide. That, and to obtain harmonized good distribution mixture in the color, it is better to add cobalt components with mixture's components before melting process till performing the perfect harmonizing process in the resulted glass color after finishing the melting process. That, and after our study to know the features and properties of cobalt oxide, its effect on the resulted glass material from local materials the subject of this research, it could obtain more than 10 color degrees from the dark blue, similar to be red, similar to be green and the transparent blue similar to be turquoise .

Properties and affection of Cr_2O_3 on the glass:

Cr_2O_3 is using to color the glass with several color degrees, as it adds to the mixture before melting in a form of lead chrome that is melting in a temperature lower than cobalt oxide to obtain dark green olivaceous, this returns to the balancing process between the theramerous and hexamerous valence, where in general way, oxidation and stenograph have impression on the color relation that resulted from Cr_2O_3 in the glass.
Figure (2a-b) showing the wavelength and light absorption coefficient of Cr_2O_3 in the glass.

Chrome compounds that using in glass coloring are theramerous and hexamerous valence, they're about a green lead powder, unifying with one of the existed elements in the glass mixture and replacing with a rate of CaO.
In the concerned experiment of the Research, Cr_2O_3 rate doesn't exceed than 3% and not less than 1.9% of total mixture and replacing some of

sodium oxide to give the color feature in the melting temperature. That, if the melting temperature was reduced than the approved temperature in the experiment, the color of Cr_2O_3 shall be changed with acid compounds and to be gradual from the green to blue till reaching the red that is similar to be brown color. The resulted color of the compounds or chrome salts is differ according to the difference of the light type that falling on it. For example; at the day light, it appears green, while at the artificial light is appears in the dark red color.

The following figure showing the wavelength and the light absorption speed for the spectrum of chrome compounds salt in two flowchart lines, one representing the highest absorption in the blue and yellow part, while the second representing the area between them, it is the green that representing the weakest point of them. This means that such area has not spectrum absorption in it. We note that all solutions' concentration of such compound allow to pass the red light through them, while the naked eye doesn't see such light. Green color appears in the lower solutions.

Figure (2-b) showing the wavelength and the absorption speed of the colored glass in the Cr_2O_3 .

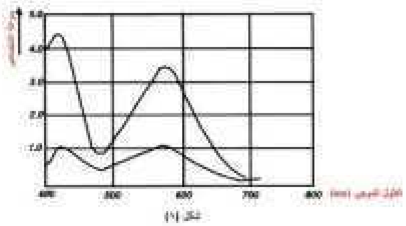


Figure 2 (b)

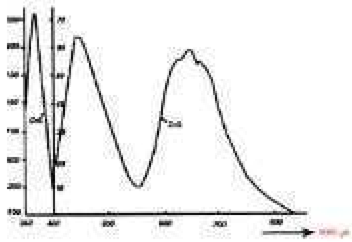
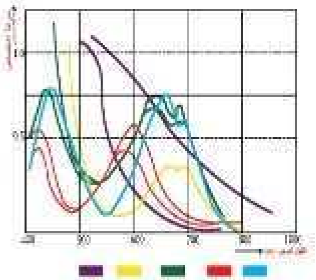


Figure 2 (a)

Chrome affection on the glass:

The glass that contained chrome as a coloring substance appears in green color in case of the glass that has little thickness, and in red color in the glass that has big thickness, this when seeing it through two layers of the glass. The absorption property of the light in the colored glass with chrome is differ when chrome ion is changing from theramerous valence chrome ion Cr+3 to CrO_2, by adding one of alkali's compounds. So, it is impossible to determine the absorption's measuring, only if the dual chrome in the glass could take its place in the net distribution or in the amended network. Cr_2O_3 is similar to corundum in its features when melting the glass mixture. Cr_2O_3 is forming chromes at the existences of oxidizing factors and the potential alkali to obtain the bright framing green color,

Figure 3 (a,b,c,d & e) showing the absorption of spectrum rays of the theramerous valence chrome



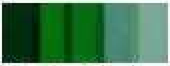
a. the absorption of spectrum rays of theramerous valence chrome.
b. the absorption of spectrum rays of theramerous valence chrome in the glass, and also in water glass solution.
c. spectrum absorption in sodium silicate glass in the stenography circumstances.
d. spectrum absorption of the glass that containing hexamerous valence chrome.

Color in the glass that added to it cobalt compounds or chrome us affecting with some factors, most of them are: melting temperature – melting time – re-forming for another time – cooling temperature () the relation between temperature and the necessary time for melting and formation – the used elements and oxides for coloring – the weight of the coloring elements for the glass mixture – the glass material and its components – the involved atoms types in the glass – the chemical or electrical ties between substances.

Table (2) showing the types of the produced glass from the Research and the samples of illustrating the resulted colored glass.

Glass color	Soda Na_2O	Limestone	Dolomite Mg_2O_3	البورون Ba_2O_3	Flespar P_2O_3	Sand Si_2O_3	Color		Melting Temp.(c)
							Co_2O_3		
Sky Blue	14.5	8.3	2.2	2.5	2.8	69.4	0.3		1130
Light Blue	14.5	8.3	2.2	2.4	2.6	69.4	0.6		1125
Blue	14.5	8.3	2.2	2.3	2.4	69.4	0.9		1120
Dark Blue	14.5	8.3	2.2	2.2	2.2	69.4	1.2		1175
Very Dark Blue	14.5	8.3	2.2	2.1	2.0	69.4	1.5		1175
							Cr_2O_3		
Very Light Green	14.5	8.3	2.2	2.5	2.8	69.4	0.3		1130
Light Green	14.5	8.3	2.2	2.4	2.6	69.4	0.6		1125
Green	14.5	8.3	2.2	2.3	2.4	69.4	0.9		1120
Dark Green	14.5	8.3	2.2	2.2	2.2	69.4	1.2		1115
Very Dark Green	14.5	8.3	2.2	2.1	2.0	69.4	1.5		1115
							Co_2O_3	Cr_2O_3	
Very Light Turquoise	14.5	8.3	2.2	2.5	2.8	69.4	0.1	0.2	1130
Light Turquoise	14.5	8.3	2.2	2.4	2.6	69.4	0.2	0.4	1125
Turquoise	14.5	8.3	2.2	2.3	2.4	69.4	0.3	0.6	1120
Dark Turquoise	14.5	8.3	2.2	2.2	2.2	69.4	0.4	0.8	1175
Oliver green	14.5	8.3	2.2	2.1	2.0	69.4	0.5	1	1100

Table (2) showing some of the colored glass samples that resulted from the Research , temperature and melting



Samples of the glass green color degrees from chrome of the Research subject (Cr_2O_3)

Samples of the glass olivaceous and turquoise color degrees from cobalt and chrome of the Research subject (CO_2O_3), (Cr_2O_3)

Samples of the glass blue color degrees from cobalt of the Research subject (Co_2O_3)

After producing the glass samples, it could make experiments through the thermal differential analysis to know the range of the glass basic elements melting, and also making experiments on the color spectrum rays to know the resulted color degrees from such types as shown in figure (4a,b).

Figure (4-b) showing the resulted flowchart from testing the coloring spectrum rays of the glass of the Research subject

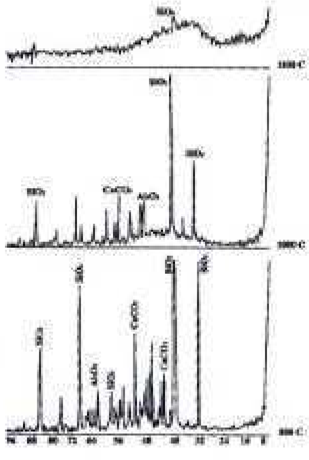


figure (4-1) showing the flowchart of the thermal differential analysis of one of the resulted manufactures glass mixture from the Research at different temperature from 800° to 110° in a time one hour.

Produce artistic works of the glass and sculpture tiles:

After obtaining the resulted colored glass from the Egyptian materials by adding the elements of cobalt and chrome, and obtaining more than a color degree in melting temperature less than $250°$ than the normal glass, and starting to use such types to obtain glass artistic works from the glass melting and the colored glass grinding. The produced glass has been used after making the experiments on it to make glass tiles have design characterizing with the aesthetical and artistic features of the same artist to be used in the interior and exterior architectural apertures and sectors. That, and as the general features and properties if such type of the colored glass is resulted from one mixture, it conforms in all of its natural, chemical and mechanical properties and in the melting and cooling temperature. So, it could use it to make the glass tiles and the free formation (manual blowing).

First: the way of executing some artistic glass tiles:

The glass sculpture forming is depending on the required protruding and hollow design from this work. Is it a quantitative production depends on the traditional distribution in the architecture, or is it an artistic production has specified using shall not be repeated in other works. This what we try to trend in the designing of the glass sculpture tiles and the way of making two types by changeable patterns in production.

The way of producing from the melting glass in metallic patterns (permanent patterns):

The design is making fro gypsum that preparing for sculpture, changing into a wax or polyester pattern, then to be delivered to make a copy of such design with the treated metallic patterns to receive the melted glass, this according to the pouring machine type whether was automatic or semi-automatic machines. After obtaining the pattern considering the conditions such as pressing tolerance, the glass melt and also surface formation and its leveling to be soft free of rippling or salient to put the glass melt after approving the sample of the required glass and the color degree, it shall put the glass melt inside the pattern, then making the pressing process whether by compressed air or by pressing with an internal part from the same cast iron that the prepared pattern is formed in the presence of the glass melt in the formation temperature after melting at 1190°. At this point, take the sculpture from the pattern, then putting it in the cooling oven to reach the normal room temperature 30°.

Figure (5) showing the way of preparing a sculpture artistic work from the glass.

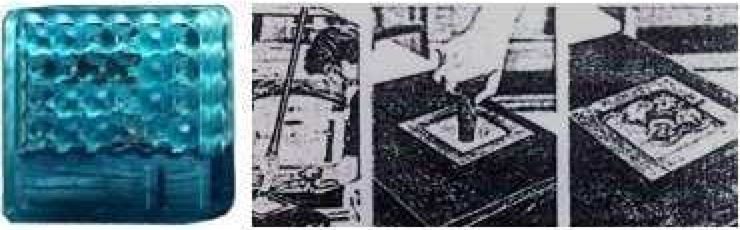


Figure (5)

The conclusions of this experiment: it could reach to produce many artistic works, glass sculpture tiles, some medallions for sport occasions and some of memorial gifts for Africano Village at (Cairo–Alexandria) road.

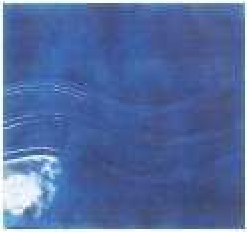
Figure (6a,b,c&d) showing some of the executed sculpture glass artistic works in iron pattern in a panel and shaped form. While figure (7-a) showing one of the used tile in the architectural beautification like interior sectors with such type and in the resulted colored glass from the research results. Figure (7-b) showing one of the memorial works that is distributing in Africano Village for the occasion of passing 10 years for its establishing. Figure (7c,d&e) about some of the memorial glass medallions that were produced to be distributed in the occasion of awarding the Republic's ranks in track and field and rowing.

(a) (b) (c) (d)

Figure (6) some of the executed artistic works in an iron pattern

b. Memorial medallion for Africano Village **c. Track and field medallion**

e. Rowing competition medallion



a. one of the executed tiles through the quantitative production for the architectural curtains

Rowing competition medallion

Figure (7)

The way of producing glass tiles and sculpture by the consumed patterns:

Executing method: using the technique of re-form the grinded glass that resulted from the Research with the required colors to be used and by using the electrical ovens for re-melting till temperature reaching 820°, as it may collect between more than a color in such process.

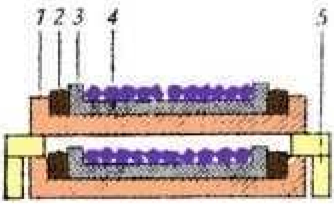
Executing steps:

1. Make the conformed design with the place of executing such sculpture in it. It shall sculpture this design on a pattern from the thermal clay by the way of the protruding and hollow till realize that in the formation of the glass tile. Make a frame for such formed pattern by designing on it and on the glass with the thickness that doesn't allow the glass dissent at the elasticity or melting temperature for the glass grinding.

2. Put two layers of the resulted glass from the Research or some of such glass, each one according to the required color and size for the formation on the prepared pattern previously in the design. Then make an isolated layer between the glass and the pattern by sprinkling an accurate layer of aluminum powder or carbon oxide, then putting the pattern in the electrical oven with its contained glass till its temperature reaching 900° in a time three hours and to be fixed for 15 minutes at the said temperature, then to be cooled gradually by reducing the temperature every hour till reaching the normal room temperature.

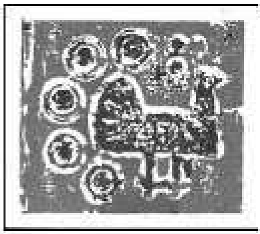
3. After that, break the formation pattern to facilitate the dissent of the sculpture glass work, then making the finishing and polishing process of this work to put it after that in the required place.

Figure (8) showing the way of making the thermal formed pattern.



a. formation of the clay and consuming shamot and designing position

b. clay pattern sculpture to put the glass on it.



clay pattern sculpture to put the glass on it settling the forming patterns in the oven, stating:
1. ferric frame 2. shamot pattern
3. transparent glass
4. colored glass cutting according to the design
5. holders stanchions
c. settling the shamot pattern inside the ferric frame and putting the glass inside it.

Figure (8)

Through this way, it may make a shaped pattern forming inside it through the protruding and hollow sculpture and through a soft surface drawing and decorating it with the glass powder of the dark color, then pouring the grinded glass inside it and putting a core pattern to give the required space of the shaped glass that made of the glass grinding and making the previous experiments to obtain an artistic work from the glass.

Figure (9a,b) showing this process.

a. fragile and has a special adhesive to fix the olivaceous glass grinding

b. the artistic product from green glass, on it decoration in dark olivaceous glass

Figure (9)

Figure (10a,b,c&d) showing some of the executed artistic works by the plane shamot pattern.

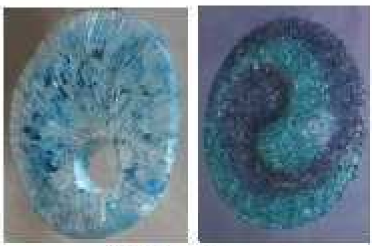
a. Some of the glass tiles with Ancient Egyptian design according to the special requirements in 2cm thickness

b. sculpture piece in the shape of an Egyptian face from the glass melt in 8cm thickness.

c. abstract sculpture piece in 4cm thickness.

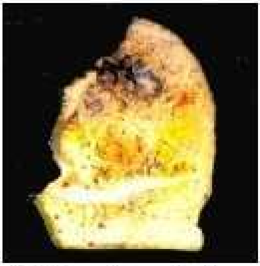
Figure (10)

It may change the glass temperature for the cohesion that beginning from 650° according to the research experiments of the produced glass types of the Research, as it may obtain artistic glass and cohesive tiles have rough or different soft touches, and glass has high transparent or non-transparent crystallized glass. It may be used as artistic units in the public places as in the resulted works from the Research in figure (11a,b&c).



b. could fixing the temperature at 820° to obtain cohesive and melting giving the non-transparent crystallizing feature for the glass sculpture works.

a. could fixing the temperature at 720° to obtain cohesive touches for the sculpture glass.



c. Some of the sculpture mural works from the Research results at 760° in big sizes and behind them light in the murals

Figure (11)

Second: It could use the Research conclusion to make the transparent and colored glass mixtures, using them to make some of the shaped artistic forms by the formation of the free manual blowing, this by blowing and forming the artistic work by the vacuum ferric forming pipe through the transparent glass, and could form on it with the colored glass by the melted columns, dripping or staining with the melted glass. Then it could make the cooling and finishing processes on the work after cooling. Figure (12a-b) showing some of these works. Vase of the transparent glass formed on it with the blue glass some designs of human and animal elements with the protruding lines. Formation during melting is embosoming and conforming process between the artistic formation to the transparent and protruding glass from the artistic elements in the blue glass.

Figure (13) about one of the shaped artistic works in a shape of an abstracted bird in the manual formation in blue color, and with the blowing in some of shaping parts, we note the transparency and the gradual darkness as a result of the artistic work and glass coalition without air.

Figure (14) about the blowing of the blue glass melting in an artistic formation of the copper in the shape of a cylinder, where blowing and formation have been made inside it instead of the assistant pattern to obtain useful aesthetical artistic work.

Figure (15) about a vase of the protruding and hollow sculpture in 35cm height, it relates to the modern sculpture schools. It was concluded from the popular Egyptian vials in an abstracted shape. It was executed from the resulted glass from the Research, whether the transparent, blue, turquoise, the blue similar to red and green similar to black. It could use the glass melt to make the added glass columns to the formation, then adding some of the grinded glass during formation to obtain this work.

Figure (12)

Figure (13)

Figure (14)

Figure (15)

Research Conclusions:

1. The research has concluded to produce colored Egyptian glass by adding cobalt and chrome elements with a rate not more than 3% in a lower temperature, and obtained special color degree through one transparent mixture helped to innovate modern technology for the plane and shaped glass designs.
2. The artist could reach to several manual technological styles to produce the artistic works, the glass sculpture tiles and produce a big collection of such works, this led to great demand to possess the colored glass in the Egyptian architecture and also the shaped artistic works.
3. The artist has participated in the confirmation of spreading the small glass projects to make the poured glass and the blown manual free forming in many touristic places in Egypt.

References:

1. Mohamed Zenhom – Glass art technology – Egyptian Organization for Book, Cairo – 1994.
2. Abdallah Akhmedovishky – Mohamed Zenhom – Using the colored glass in artistic works with modern methods – published research, Academy of Scientific Research, Moscow – 1992.
3. Holland L., The Properties of Glass Surfaces, Champan- Hall London, 1964. P. 50-61.
4. Simpson H., Glass Industry, 1964. No. 2. P. 73. 77.108.118.
5. Ray Flavel and Clavpe Smake, Studio Glass Making, New York, 1974, No. 57.58.
6. Lawrence Lee, George Sedaon, Francis Stepnens Stainep Glass, London, 1982. No.26.30.
7. Soviet Glass, Aurora Art Publishers Logirad, 1981, No. 9 – 41.
8. Sosman R.B The Phases of Silica, Rutgers University Press, New Brunswick, New Jersey, 1965.
9. Pathmann C.L. Mann G.H. and Nofdberg M.E. A new Wiralow – Expansion, Modified Fused Silica and Glass, PPL > OPT Vol. 7 No. 1968.

انتاج نوعيات من الزجاج المصري الملون للبلاطات الزجاجية النحتية في درجات حرارة منخفضة

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ملخص البحث :

الزجاج أحد أهم المواد التي شهدت تطوراً كبيراً في العصر الحديث خاصة في مجال العمارة لما تحققه من متطلبات جمالية ووظيفية وقدرته على تحقيق التكامل والاستجابة والتعايش مع البيئة والزجاج المسطح الملون المستخدم في العمارةمازالت مصر تستورده من الأسواق العالمية حتى الأن. حيث اقتصر انتاجها على ثلاثة ألوان فقط في مصر . وبرغم التاريخ المشرق الذي تميزت به مصر على مسرح الحضارة العالمية والتي لا تزال أعمال المصريين القدماء خالدة إلى الآن مثل الأهرامات التي تحمل الدليل الناطق عن وجود منشآتهم وإعجازهم الفني الذي سبق العالم أسره بابتكاراته الحضارية الرائعة وموارده البيئية الكثيرة التي ساعدت على نشأة هذه الحضارة وإنشاء صناعات كثيرة مثل الخزف والنحت والزجاج. الذي تطور قديماً ويشهد التاريخ وتشهد متاحف العالم أن الزجاج والحلي الزجاجية المصرية قد نشأت قبل ١٤٠٠ سنة قبل الميلاد. ففي متحف المتروبوليتان للفن بنيويورك كأس خاص بالملك تحتمس الثالث يرجع تاريخه إلى سنة ١٤٥٠ ق.م، وبالمتحف المصري إناء أخضر اللون على هيئة زهرة اللوتس وبعض الخرز الملون والأعمدة الزجاجية والعيون الملونة التي كانت ترصع بها تماثيل المومياوات وتعود إلى القرن ١٥٥٠ ق.م. إلى جانب عصى امنحتب الثالث المحفوظة بمتحف برلين وتعد أقدم الآثار الزجاجية التي أكد صحة تاريخها العلماء سنة ١٧٩٧ ق.م. إذا فمصر من أوائل الدول التي كان لها السابقة في صناعة الزجاج الملون ولا نعلم سر هذا التدهور الذي أصاب هذه الصناعة الآن ورغم ذلك فلم تتجه الدراسات والبحوث العلمية الحديثة إلى إعادة صناعة الزجاج وتطويرها لتكون كالسابق بمصر بتميزها باختلاف ألوانه وأنواعه وخواصه. وكنتيجة لتعدد المواد والخامات والعناصر المستخدمة في الخلطة وأيضاً لم تمتد يد التصنيع إلى الاستعانة بالمتخصصين لإجراء التجارب العلمية والمعملية التي تساعدهم وتفيدهم في التطوير ليتناسب مع مستوى انتاج الزجاج وازدهاره عالمياً.