

Production of Colored Ceramic Objects with Sodium Carbonate Vapor

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This study included the production of colored ceramic bodies with sodium carbonate vapor, and a ceramic body mixture of Duykhela clay was formed in the form of ceramic models (vases) using a gypsum shape in the form of a hemispherical and was formed using an electric well. Precise of the ability to produce ceramic objects serving the aesthetic aspect of ceramic art. A special oven was built for the purpose of descending system salting, to maximize the use of heat and sodium carbonate vapor for as long as possible. Liquid gas was used as the fuel for the burning process, with one stove and a chimney. Chromatic oxide was used to color the bodies of sodium carbonate glass, represented by chromium oxide and cobalt. In addition, the researcher divided the research samples into two groups. The first is to activate the clay surface with a hidden layer of flint (SiO₂) at a rate (0.5%) as a smelter. And the second group, its surface was not activated with flint materials, and the aim is to show the difference between the two groups in terms of the thickness of the vitreous layer and the effect of color oxides on the two groups. These two methods were adopted, first for the detection of color results, and the second for the purpose of making a physical comparison of the nature of the resulting surface. (8) models were created, (4) of which were activated with flint materials, and (4) their surface was not activated by flint, and the purpose was to compare, and each of the two models was set in one heart, i.e. four burns for all models and the burning and salting process was completed With sodium carbonate vapor during a time period (8-9), where local sodium carbonate (Nile region) was used in the glazing process, where (10) kg was added during the salting process for all samples. The most important results were: 1- Colored ceramic objects can be produced by sodium carbonate vapor. 2- The results of the samples activated by the flint were more integrated and standardized. 3- Cobalt models were more stable and widespread. 4 Different patterns appeared in the texture. 5- The possibility of lowering the temperature using sodium carbonate.

Key words: *Production, Chromatic, Activated, Comparison, Sodium, Carbonate.*

Introduction

Research Problem

Potter adopts technical foundations in which he deals in his artistic product, such as oxides of metals, dyes, temperatures, types of furnaces as well as local materials, through which the ceramic work is carried out, which in turn imposes aesthetic control on one hand, and composition, on the other hand, thus creating links New with technical (scientific) reality.

Whereas the verification process in ceramics is the steel of its production technology and the most important one, due to the chemical reactions that occur as a result of mixing the verification components with each other, and through heat that is set according to the type of glass (its components), whether it is at a low temperature or a high temperature, and the nature of clay The user, under which the verification process is performed, therefore the search for new techniques and mechanisms for verification using local raw materials occupied potters, due to the role that local materials play in artistic production, but coloring technology using sodium carbonate vapor is an uncommon method of producing glazed ceramic objects in different colors And touch effects, so it was necessary to research and experiment using this technique, adding color oxides by mixing them with sodium carbonate to obtain the evaporated sodium carbonate, and revealing the color results to serve the aesthetic aspect of the achievement of ceramics.

According to the above, the research problem can be identified with the following question:
Is it possible to produce color ceramic objects with sodium carbonate vapor?

The Importance of Research and the Need for it

The importance of current research lies in the following:

- 1- Ceramic body production using colored oxide vapor.
- 2- Potters benefit from the sample under study for technical purposes at a low cost.
- 3- Highlighting the diversity of glazing techniques and their effect on ceramic touches.

Research Objective

The current research aims to:

1. Learn about the possibility to color ceramic objects using sodium carbonate vapor.

Research Limits

- Sodium carbonate (Na_2CO_3) is used.
- Mud body (Kaolenduikhlh).
- Feldspar soda
- Flint
- Kaolin.
- Fire clay.
- Oxides (Cobalt CoO , Chrome Cr_2O_3)

Define the Terms

1- Porcelain Ceramics

The word porcelain was given to the art of making clay, then it was burnt in the fire, which is derived from the origin of the Latin word keramous meaning this is clay pottery (Bakr, 1949, p. 4).

However, there is another definition of ceramics with the first two words (pottery) meaning ceramic utensils, and the word ceramics means shapes made of clay material and includes everything made of those materials and burned in the fire. Pottery is a type of porcelain, and therefore the word (pottery) means the creation of ceramic works (Al-Attar, 1976, p. 2.7).

2- Ceramic Body

It is a body made of inorganic, solid, and non-metallic materials that makes the ceramic body solid by exposing the clay body to the heat required to reach maturity and then slow cooling to increase its hardness (Marii & Ghaidan, 2011, p36).

3- Color

And colors according to (Al-Badry): is the individual psychological experience of visual perception that is stimulated and stimulated by the visible solar spectrum, which is a narrow part of the wavelengths of light of the electromagnetic radiation that has the ability to produce sensitivity when received with human eyes. (Al-Badri, 2002, p. 131).

4- Body Ceramics

The nature of any ceramic body depends on the type of clay used to form the clay work, where the clay body is the basis, and that rotten clay will be the source of problems from start to end, but some potters, especially traditionalists, enjoy the challenge of working with bad clay bodies, including Japanese pottery (Shogehamada), one of the well-known and well-known potters of the century, who said in bad and coarse clay, "It is better to make good pots of bad mortar than to make bad pots of good clay" (Peterson, 2008, p. 28). The ceramic body

also withstands hardness through exposure to the body. Clay is required for heat to reach maturity and then slow cooling to increase hardness. Ceramic materials may have a crystalline or partially crystalline structure, or they may be amorphous (for example, glass). Since the most common is crystalline, the definition of porcelain is often limited to inorganic crystalline materials, unlike amorphous glass. The earliest ceramic pieces made of clay and clay, either alone or mixed with other materials, were hardened in the fire. Later, the ceramic glazes and burns to create a smooth and colorful surface. Ceramics now include local and industrial products, construction and artwork, and new ceramic materials that have been developed for use in advanced ceramic engineering, for example, in semiconductors (Marii & Ghaidan, 2011, p36).

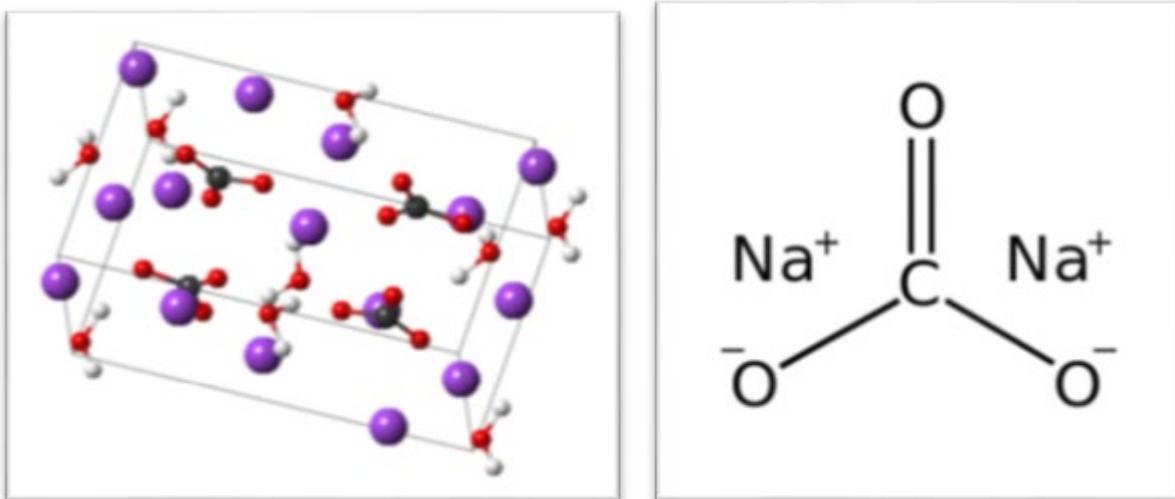
5- Glazing Technology Evaporates

Glass evaporation is one of the modern techniques that potter uses to produce technical and technical variables on the ceramic surface, by making use of the vapors that emit chemicals and chemical compounds after exposure to heat, and the conversion of chemicals and chemical compounds to the vapor varies according to its nature and melting temperature. The degree of evaporation and the state in which these substances are (solid-liquid) (Arnaud, 1986, p. 56).

6- Sodium Carbonate

It is a chemical compound with a chemical composition (Na_2CO_3) Figure (2-1), also called (soda ash) or (washing soda), and is found in the form of white powder, its solutions in alkaline water, and can be found in nature as a mineral, or Industrial, and has many uses, it is used in the manufacture of glass, the manufacture of soap and household detergents, as it is used in pulp manufacturing, as well as its use as an anesthetic solution to relieve pain (Musharraf, Part 4, 2013, p. 1845).

Figure 1. Crystal structure of sodium carbonate (Supervisor, Part 4, 2013, p. 1845)



Sodium carbonate began to be used in the 1970s in the United States of America when it began to search for alternatives that were less polluted than the materials used in sodium carbonate glass, so it was used to produce color and texture effects that distinguished them from sodium carbonate glass.

It is known that sodium carbonate, or what is known as (soda ash) is derived from NaCl (table salt) was originally created by burning seaweed, and filtering the ash with hot water and drying it during the UK Industrial Revolution, (Nichols, 2006, pp. 3-1).

Methods of inserting sodium carbonate into the oven. There are three methods that are followed:

1. The introduction of carbonates can dry the sodium mixed with colored oxides as it is dropped from the (upper hole), the top of the oven where small quantities are inserted several times and at specified time periods, and at the appropriate temperature according to the nature of the material and the burning conditions as in Figure 2.

Figure 2. The nature of the material and the burning conditions (Branfman, 2009, p 120)



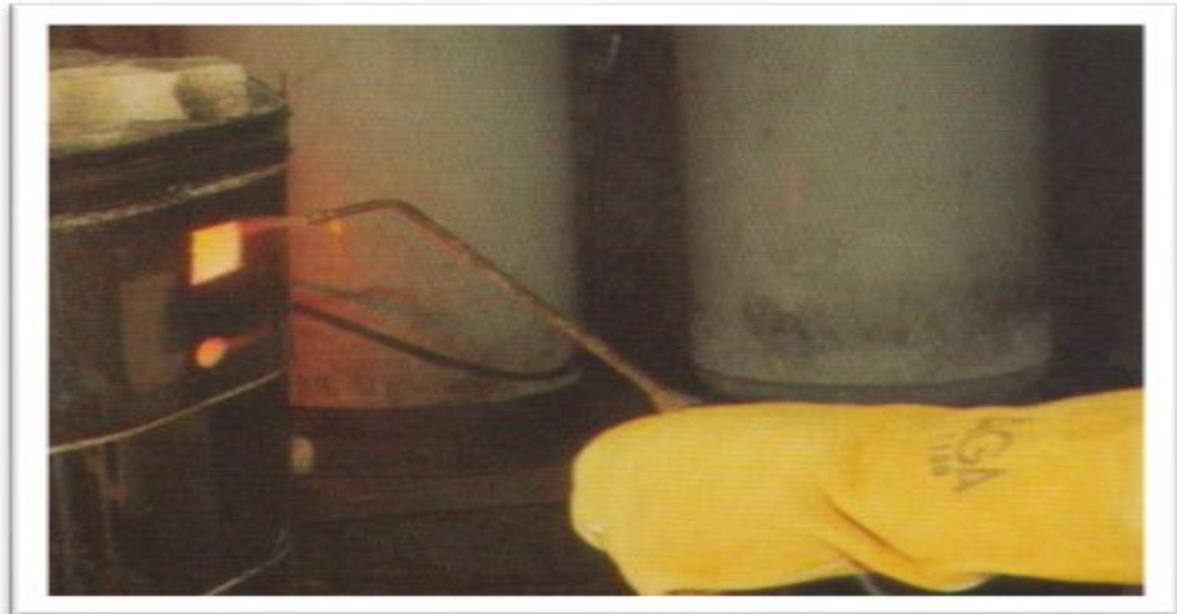
2. Sodium carbonate is inserted with colored oxides in the form of a paste through the combustion opening, after mixing it with water to facilitate the evaporation process, as well as mixing with sodium bicarbonate and calcium carbonate. As in Figure (2-3) (Nichols, 2006, p. 8).

Figure 3. mixing with sodium bicarbonate and calcium carbonate (Jones, 2007, p 98)



3. As for the third method, it is by spraying sodium carbonate and colored oxides in the oven after mixing it with water, and as it is known that sodium carbonate is characterized by its solubility in water, and is not dissolved in acids, as in Figure (4) (Branfman, 2009, p50)

Figure 4. Sodium carbonate and colored oxides in the oven after mixing it with water (Branfman, 2009, p 121)



The purpose of using sodium carbonate in the evaporation glazing technique is that it has the ability to evaporate and volatilize, so it was used at low temperatures (between 950-850 ° C) The introduction of sodium carbonate as an auxiliary or catalyst for vaporization would stimulate colored oxides to fuse. One of the characteristics of colored oxides is that they are of an inert nature at low temperatures as they begin to fuse and evaporate at high temperatures between (1200-1500 ° C) and according to the nature of the oxide. The fumigation glazing technique is mainly based on the ascending and descending fumes from the samples which are originally formed from the decomposition of sodium carbonate by heat, so it is preferable to use a gas oven or wood-burning furnaces with down and currents Finch, 2006, p.18-19).

Previous Studies

After searching and reviewing many of the published and unpublished messages and theses and following the internet pages, the researcher did not find a previous study approaching the current research in its limits, problem, goal, and results.

Research Procedures

In this chapter, the materials used in the application of the research hypothesis and methods of their use in producing colored ceramic bodies with sodium carbonate vapor are presented.

Sample Selection

Terracotta

The kaolin clay (Doykhila) was chosen as one of the commonly used clays in Iraq and it was used according to the experience and sources are seen by the researcher. As shown in Table (3-1)

Table 1: The Chemical Analysis of Tina Duikhleh, citing (Al-Karadi, 2012, p. 41)

Raw Material			Oxide
Kaolin Duykhla%	Kaolin Duykhla%	Kaolin Duykhla%	%
-	-	46.72	SiO ₂
-	-	32.66	Al ₂ O ₃
-	-	1.1	Fe ₂ O ₃
54	-	0.22	CaO
-	-	0.51	MgO
-	55	0.30	Na ₂ O
-	-	-	TiO
-	-	0.09	SO ₃
-	-	-	K ₂ O
45.07	44.07	13.05	L.O.I

Carbonate Sodium

(10 kg) of sodium carbonate was prepared and used in the research hypothesis.

Coloring Oxides

In the current research, we rely on coloring laboratory models with two types of colored oxides, which are the most common.

- 1- Cobalt oxide CoO
- 2- Chromium oxide Cr₂O₃

Preparing the Clay

The clay was prepared in a plastic form, where (8 kg) (fiery clay) was added. Fire Clay (I.e., by 40% and (8 kg) as kaolin, i.e. by 40%, and (4 kg)) as a soda spar, i.e. (20%), to improve clay specifications and to reduce the shrinkage rate on the ceramic surface. Then mix the mixture with water, pass a sieve (60 msh) on a piece of cloth, and left for a period of (7) days to dry its soft form, then store the clay in nylon bags to be ready for the modeling process.

Forming Forms

In the current research, the models were formed in the form of small vases and for the purpose of obtaining similar models in terms of shape and size, a gypsum mold was made by the researcher and measured (16 x 8 cm) in the form of a half ball as in figure (5).

Figure 5. Half a sphere cast



Drying Forms

After the models are finished forming and installing, they are left to dry in a closed cabinet away from the air currents, so that the drying process is slowly finished, in order to keep the clay forms for 10 days.

Forming mixtures of colors

In the current research, two methods of glazing were adopted:

- 1- Add colored oxides to sodium carbonate by adding (100 g) of colored oxides for each (2 kg) of sodium carbonate and mix it with water at a rate of (1 liter) per (1 kg).
- 2- The verification process is carried out by spraying the colored mixture inside the oven at a previous temperature.

Mixes of the Research Samples

Table 2: Showing mixes of research samples

Flint	Oxide	Sequence
0.5%	Chromium oxide	1
-	Chromium oxide	2
0.5%	Cobalt oxide	3
-	Cobalt oxide	4
0.5%	Cobalt oxide	5
-	Cobalt oxide	6
0.5%	Chromium oxide	7
-	Chromium oxide	8

Preparing the Sodium Carbonate Oven and Performing the Glazing Process

A special gas salting oven is built, which is a DC oven. A draft hanging using the liquid gas cylinders as a heat sink, the burning process is carried out through the gas stove No. (1) Through the combustion opening in the oven, and the oven has one large outlet for gases and the oven measuring (40 cm x 60 cm x 40 cm) from the inside as in the figure (3-3).

The clay models were placed inside the oven and behind the fire prevention wall by two models for each burning, then gradually starting the burning process using one incinerator and low gas pressure in order to maintain the integrity of the clay models because this burning is the first pride, so rapid burning leads to damage and fragmentation of the clay parts To measure the temperature and check the speed of the oven height. An electronic scale (thermocouple with an electronic board) was used to measure temperature. Then the oven temperature is gradually raised to 100 degrees Celsius within an hour and to 200 degrees Celsius within an hour and a half and to 300 degrees Celsius within an hour and a half and after that the temperature rises with maximum energy and high pressure. In gas until a temperature of 950 ° C within 4 hours, after that the process of spraying the sodium carbonate mixture with dyes is carried out through the combustion opening and through the mullet flame (burning) during 10 minutes between each spray of the mixture. The amount of mixture in each process (a quarter) kg. Using the envelope method again and again using the spray method, as in the following figure (5), which shows the oven and the burning process to reach the final results.

Results

Discuss the Results

Glazing here does not depend on the glass mixture, as usual, but using another method, which is glazing with sodium carbonate vapor, a type of glass with special effects, so the researcher relies on obtaining the glass, by relying on the components included in the kaolin clay used in The research, and the silica and alumina it contains, as well as its completion with the third element, which is alkali sodium oxide, to complement the glass components, and this interaction mechanism is a subject.

The researcher added some materials to the kaolin clay used in the research hypothesis, which is 40% Fire Clay, 40% Kaolin and 20% feldspar soda to improve the clay specifications to suit this technique.

The researcher used the ionic coloring system, which depends on the addition of colored oxides, which are atomic Tran saturated transitional elements that tend to lose or gain one of the outer orbital electrons. This movement in nature needs energy and this energy for these transitional elements falls within the energy of the spectrum. Visible solar energy, showing us different colors, according to the activation energy of each element.

In addition, the researcher divided the research samples into two groups, the first of which was to activate the clay surface with a light layer of flint (SiO_2) at a rate of (0.5%). And the second group, its surface was not activated with flint materials, and the aim is to show the difference between the two groups in terms of the thickness of the vitreous layer and the effect of color oxides on the two groups.

The Researcher Adopted two Methods of Glazing and Coloring the Samples

The first is by inserting moist sodium carbonate into the oven and through the combustion opening, that is, through the fire stream to obtain sodium carbonate vapor in the samples of vitrification samples, then spraying the mixed color oxide with sodium carbonate water inside the oven staining the steam with sodium carbonate, and this method is used in the models (1,2,3,4).

The second method is to mix the coloring oxide with wet sodium carbonate directly and put it in the oven through the combustion opening, and during the fire in order to vitrify and color the sodium carbonate vapor at the same time, and this method was applied in the models (5,6,7,8).

In sample No. (1) Colored with chromium oxide, whose surface has been activated by flint (0.5% (%)), we notice that the sample color is generally green, with green spots or spots spread across the surface of the ceramic body, with the color difference from area to other.

It is known that chromium oxide is distinguished by its green color with alkali glass, and its melting is very weak, and since the sodium carbonate glass is alkaline glass because it depends on its formation on sodium, therefore the color results were not explicit, and it was not applied to the entire ceramic surface, in addition to the ceramic body that It is characterized by full glass and the layer of glass was characterized by somewhat black, and the reason for this is the effect of chromium oxide, which tends to affect towards a stronger opacity in the layer of glass, which in turn affects the staining strength.

As for the texture, the sample came with a semi-smooth surface, and reflects the nature of this type of porcelain (special effects) and is not homogeneous in terms of the surface, where we note that there are places with good smoothness and others with a texture that may reach the raw. It should be noted that in this model the first method was applied in vitrification and coloring, depending on the sodium carbonate vapor formed by inserting moist sodium carbonate and spraying the oxide coloring mixed with sodium carbonate water in the oven.

As for sample No. (2), with the consistency of the shape (clay) and the application of the same method of glazing and coloring used in sample (1), and the surface of the body not being activated with flint, we find that the results here are completely different from the sample (1) knowing that it was burned in the same time, except that it showed only some slight effects of chromium oxide, and its surface was not completely covered with a glass layer, but it was confined to a very light layer of glass spreading irregularly over the surface of the ceramic.

However, it should be noted that the ceramic body exhibited a tougher, tougher effect in most of its parts, the reason for this being the weakness of the vitreous layer, and this led to it reflecting a completely different official appearance from the specimen (1).

In sample No. (3), which was stained with cobalt oxide (CoO), it is one of the strongest and most popular colored oxides by potter because it is characterized by a very high reactive nature and results in an explicit blue color in almost all types of glass, and indifferent combustion conditions, and differ Its color strength depends on the percentage added to the glass mixture.

Cobalt oxide is known to give the alkaline glass a stronger shine, and this is what happened with the sample (3) as the glass layer became thicker and brighter than the sample (1) Note that the vitrification method and stains are the same in both samples, in addition to the color being more prevalent on The surface, although it did not differ much from the sample (1) in

terms of color spots, and it is noticeable that the effect of the flint that was added to the surface of the clay object became evident by the cobalt oxide, through the layer of glass, color, and texture, where the texture became smoother and brighter. Due to the thickness of the glass layer, in addition to the value of the color of the cobalt, it should be noted that the first method was applied in vitrification and coloring as in the sample (1,2).

Whereas the sample (4) whose surface was not activated with a layer of flint, and despite being entered with the sample (3) in the oven and exposed to the same combustion conditions, i.e. by adopting the vitrification method using sodium carbonate vapor, i.e. introducing wet sodium carbonate into the oven. The oxide solution was sprayed with sodium carbonate water inside the oven, but it did not acquire the vitreous layer exactly as in the sample (3) and the vitrification in it was confined to the areas spread in pimples covering the entire surface unevenly from one place to another, and to confirm the hypothesis, research. In the importance of adding flint as a glass hardener on the surface, we find the success of this hypothesis in the models (1, 3,5,7) we also find a difference in the results of color intensity, texture, and fusion, as well as the thickness of the vitreous layer.

As for sample No. (5) whose surface was activated with flint materials, the researcher adopted the second method in vitrification and coloring, which is mixing the coloring oxide represented by (cobalt) with wet sodium carbonate, where the researcher adopted this method for the purpose of comparison with the samples of the first group through Results. Obtaining the two methods, from the thickness and spread of the vitreous layer, the strength of its luminosity, texture, and color, confirms the hypothesis of research in the sample (5), where the color results were less clear and widespread than the sample (3) and cobalt oxide stained as well, meaning that the effect of color is characterized by heterogeneity. It came in the form of colored spots or color points, and this coloring came due to the technique of coloring with sodium carbonate vapor, where the evaporation inside the oven becomes a reason for the coloring method due to the evaporation of water, so the colored oxide remains with the sodium element, and therefore adheres to the surface of the ceramic body and interacts with it to form this color. And glass layer.

The glass layer here was thicker than the sample (3) and was less diffuse on the ceramic surface. As for the texture, it was characterized by a type of roughness that varies from place to place according to the spread and thickness of the glass layer.

In sample No. (6), the results of combustion, glazing, and stains came as in sample (4,2) in terms of color, texture, and glass layer, although the oxide used here is cobalt. However, due to the lack of activation of the ceramic surface with a layer of flint, the effect is little from cobalt staining, in addition to the effect of sodium carbonate vapor represented by sodium, which represents molten alkaline bases, in the formation of a shiny glass layer, where the

appropriate glass layer did not form, where from It is known that the increase in the proportion of flint with an alkaline temperature and a high temperature (1200) in sodium carbonate glass, a layer of glass is formed, and this of course with the presence of alumina, but the situation differs here, first, the ceramic surface is not activated with flint materials, and secondly, The second method is used for staining the glass that gives less results than the sample group is activated by the flint, which in turn is reflected on the surface texture, which is characterized by roughness.

In sample No. (7), the researcher relied on different materials in the process of glazing and coloring, by replacing sodium chloride (table salt) with sodium carbonate (Na_2CO_3) as well, using local red clay, and applying these materials the researcher wanted to obtain a colored salt glass By reducing the temperature to (950) because the melting point of sodium carbonate ranges between (850-950) which is less than the melting point of sodium chloride, the researcher activated the surface of the sample using flint. The researcher used chromium oxide to observe the difference in chromatic effect in sodium carbonate glass and compare it with sodium chloride. We note that the chromatic effect here has become more diffuse than the sample (1), but it did not cover the entire surface of the sample, but it gave a different color value between dark green and light green, as a layer of glass came different here, in terms of the spread and thickness of the glass layer, and it should be noted here to The method by which chromium oxide is mixed with wet carbonates has been approved and introduced to the furnace through the combustion opening, while the surface is characterized by the color opacity and a clear feeling of roughness.

As for sample No. (8) whose surface was not activated by flint, where the same sample materials (7) i.e. sodium carbonate, chromium oxide and red clay were used, and they were subjected to the same burning conditions and the same temperature, but they did not get the value of color and the desired glass layer that came with The previous sample, in addition to the fact that the sample did not bear the thermal shock because the red clay is characterized by a high shrinkage coefficient more than the kaolin clay, so we find that the model did not withstand the thermal shock, so it is preferable to treat the red clay bodies with anti-shock materials, and also because they were closer to the fire exit It was broken, and there was no chromatic effect on the chrome, with the exception of the effect of the color of the minerals present in the red clay, especially iron oxide, where we note that the specimen was overshadowed by the color of the walnut with the graduation of the flashlight, in addition to the fact that the texture is characterized by a clear roughness due to the lack of glass surface Ceramic for sample.

Conclusions

- 1- A ceramic surface was obtained stained with sodium carbonate vapor.
- 2- The samples came (1,3,5,7) (the surface of which is activated by the flint, and more responsive to the stains than the samples) 2,4,6,8) whose surface is not activated by the flint.
- 3- In the sample (7,1) there was color opacity.
- 4- In the sample (5,3) the vitreous layer is brighter and thicker.
- 5- The difference in texture results from one sample to another due to the difference in the behavior of the colored materials and the vitreous layer.
- 6- The samples (5,3) that color the cobalt oxide was more brilliant in color and luster than the samples (7,1) that colored the chromium oxide.
- 7- The samples that were applied to the first method by glazing and coloring were more homogeneous in terms of the color and thickness of the glass layer than the samples applied to the second method.
- 8- Samples (2,4,6,8) whose surface were not activated by flint, and did not acquire the appropriate color and layer of glass.
- 9- Samples of colored chromium oxide gave little color value and weakness in the vitreous layer.
- 10- The possibility of lowering the temperature using sodium carbonate.

Research Samples







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