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THE PROTECTIVE EFFECT COATING OF MODIFIED NANO SILICA AND ZYCOSIL ON THE SEVEN COLORS TILE OF THE QAJAR ERA *(CASE STUDY THE TILE OF NASER-AL-DIN MIRZA'S HOUSE IN TEHRAN)*

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ABSTRACT

We investigated a modified thermal evaporation method in the growth process of ZnO nanowires. ZnO nanowires were fabricated on p-type silicon substrates without using a metal catalyst. A simple horizontal double-tube system along with chemical vapor diffusion of the precursor was used to grow the ZnO nanowires. The substrates were placed in different temperature zones, and ZnO nanowires with different diameters were obtained for the different substrate temperatures. In addition to the nanowires, ZnO micro discs with different diameters were obtained on another substrate, which was placed at a lower temperature than the other substrates. The optical properties and crystalline quality of the ZnO nanowires and micro discs were characterized by room temperature photoluminescence (PL) and Raman spectrometers. The PL and Raman studies demonstrated that the ZnO nanowires and micro discs grown using such set-up had good crystalline with excellent optical properties. Rectifying behavior of ZnO/Si heterostructures was characterized by a simple DC circuit.

1. INTRODUCTION

Tiles as an element in building long past has been used in architecture. According to archaeological findings, were the oldest examples of usage glazed bricks from the first half of the second millennium BC. Zomarshidi [1] the seven colors tile in "Spain" literally was well-known "dry string". Ajand [2] the tiles painted for accepting with pigments which were separated from each other. And to prevent from slipping down by an oily substance mixed with manganese, leaving a dark sideline after cooking. Also on some tiles such as azure, gold foil and red color went to work [3].

The seven colors tile desired dimensions is going to be built and often in the form of a square. Purpose of the seven colors tile always doesn't mean which seven colors are used on a tile. James [4] it may be Of course being necessary to set up coordination with motifs around tiles to be used on a piece of a tile in different colors. But this does not mean that you should always use seven colors to paint it Kiani [5]. The intention of the seven-color tile, it means could be used seven different colors to paint it. For example, you can have seven pieces with seven different colors. Or it is possible to build few meters inscription with white third lines of seven colors tile you use only of azure color [6].

The size of the tile approximately is 20 × 20 or 15 × 15 centimeters. Common seven colors in this type of tile are including: white, black, azure, cyan, red, grass-green, canary yellow or fawn. This type of tile is much used in the architectural monuments reminded from the past especially at different parts of palaces and historical mosques [7].

Although the tiles of the materials are resistant to environmental factors, however, the tiles could be destroy by various factors such as, humidity, acid rain, kind of salts, harmful biological factors, light, temperature changes as well as building movements and etc…, as time goes by. Abbasian [8] cracks on the glazed tiles could stand as one of the most important causes of degradation. The need to strengthen and prevent the erosion mechanism is doubled, because the source of humidity to the layer under the glaze, high quantity of brick glazed and tiles in buildings, including historical buildings, on the one hand, and their vulnerability to over the years in the face of environmental factors on the other hand [9].

In strengthening of glazed tiles should be noted use of a factor that can mediate between the physical and chemical performance and the strength of glazed surface to somehow cover until to prevent the entry of humidity to the surface and create tension in it Sharveh [10].

There are many tile coatings in the field of protection including Paraloid; but for the use of organic solvents such as acetone or toluene the polymer should be used, and the evaporation of these substances creates problems for the environment cause of their evaporation, it was decided to use a resin-based aqueous solution to solve this problem. Beheshti [11] Nano-Silica and Siloxane polymers are mining, As a result glaze as well as silica tiles are match with more structure and is compatible with the field. However according to the Siloxane hydrophobicity characteristics it is far better than Paraloid [12].

8 For this purpose Zycosil and Nano-Silica was considered as a protective coating for tile and the impact in terms of optimization and hydrophobicity coating on the tile surface features of durability, color, and reversibility, studied as cover for preserving historical tiles.

2 MATERIALS AND HOW TO TEST

2.1. Case Study

Profile of the case study is presented in Table 1; Glaze has been experiencing discoloration and distortion in the most part. Branch cracks can be seen clearly as well as Glaze has struck mildew in some spots. As seen in Figure 1

Table-1. Characteristics of the sample

Tile's Location	Historical Era	Sample size	Sample
Naser-al-Din Mirza's House in Tehran	Qajar	19×20cm	Seven Colors Tile

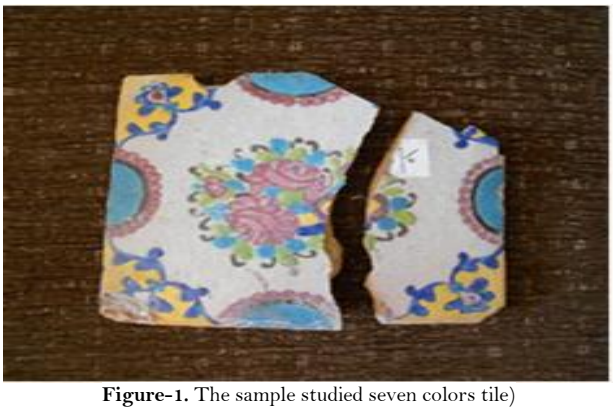

Figure-1. The sample studied seven colors tile)

2.2. Zycosil Profile

Zycosil is an Organo-Silane compound which its features are given in Table 2. This combined reacts in its active groups with mineral surfaces (non-organic) containing Silanol groups (Si-OH) such as cement, concrete, stone, brick, reinforced concrete and so on [13].

Table-2. Characteristics of Zycosil

Flash point	Viscosity	Specific Gravity (25 c˚)	Appearance	Name of the Material
Non- ‹>100˚C flammable	500-800 CPS	1/05	□Clear to pale yello	Zycosil

Zycosil is a new generation of nanotechnology which designed to waterproof surfaces. Zycosil itself has all three premium features for waterproofing material; because:

1) It is Nanotechnology and could make water-proof the inorganic substrates at molecular level.

2) It is Eco-friendly and can be used as a water-soluble and its voc significantly applied for per square meter less than similar technology-based solvents.

3) Since this product is very reactive and based on Organ-Silicon chemistry, hence, it reacts in underside inorganic layer then becomes part of its structure that's why long-term storage [14].

Zycosil has a unique resistant composition which protects against damage from ultraviolet solar, radiation temperature changes and steady rain. And also are able to resistance withstand the wind erosion because of the influence Nano-Particles as well as preserve hydrophobicity nature for more than 20 years. This product is very affordable and its cost is also 1 to 20 percent of the solvent-based Silane technology's costs (ibid: 3).

Zycosil and its product are non-flammable; it is also easily possible to apply without pressure by a brush, roller as well as spray. Additionally, its use doesn't need safety measures and means. A water clear solution arises by dissolving Zycosil in entry water. Zycosil creates a chemical bond with the surface of concrete and building materials (ibid: 4).

Typical coatings are based on chemistry confinement layers (Film Forming) and leading humidity within substrates to the lamination layer of paint inside the building. But the chemical bond structures Zycosil maintains breathability and will not cause the color flaked. Zycosil is highly resistant and penetrate enough level in surface as well as provides low concentration affordable and effective protection (ibid: 4). It is certified by IS-ISO-DIN-ASTM labs and authoritative international organizations [15].

2.3. Nano-Silica

Silica or Silicon Dioxide is a Nano-Sized substance which it is considered due to high purity, high surface area, and its unusual particle characteristics. Its details are presented in Table 3. Mohammadi [16] this material is a white powder and very soft But it seems clear or colorless, when add to fluids and polymers. Its Applications are included: coatings, adhesives and insulating materials, cosmetics, inks, plastics, rubber, food and drugs [17].

Table-3. Characteristics of Silica

specific gravity	weight	Formula	Appearance	Name of the Material
-1.217 1.197	60.08 G / mol	SiO2	colorless	LUDOX LS

Source: Corporate brochure exir-e-shargh

2.4. Preparing the Solutions

We need solutions prepared in accordance with Table 4, and the tiles are divided into four equal parts after preparing the solutions. We apply the coating by brush on the tile as shown in Figure 2. Next, to accelerate testing and exposure in the QUV, the tiles must be cut into four parts.

Table-4. Profile solutions

ratio	Sample Characteristics	solution No.
Zycosil 1 gr + distilled water 10 cc	Zycosil	Solution 1
Zycosil 1 gr+ distilled water 10cc + Nano-Silica 1 cc	Zycosil+ Nano-Silica 1%	Solution 2

Source: Corporate brochure exir-e-shargh

Picture-2. Coating solutions on the tile

2.5. Experiments

2.5.1. Petrography Examination of Seven Colors Tile

First, the thin sections were prepared and samples were studied using petrography polarizing microscope of James Swift model in the laboratory of the Research Institute for Conservation and Restoration works [18].

The results of this study are as follows:

The sample submission is a ceramic glaze and can be seen in thin sections abundance of minerals in the clay of the tile. The study sample has porphyry texture of petro-fabric (Figures 3 and 4).

Image-3. Sample before cutting (coarse crystals of fine crystal pieces)

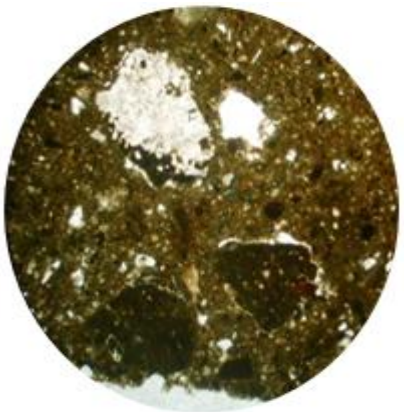

Image-3. The porphyry tissue samples

Reference: Research Institute for Conservation and Restoration

Typical components in order of affluence are as follows: Quartz (in the form of phenocrysts and polycrystalline), Iron oxide, Stone nap, Debris, Remnants of Igneous Rock, Calcite (microcrystalline), Feldspar, Amphibole and pyroxene. Glaze has a form of glass. Due to the isotropic glass darkly seen in the cross light microscope and to study the glaze should be used polarized light.

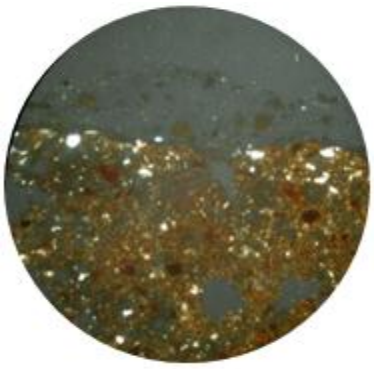

Image-5. glazed sample margin

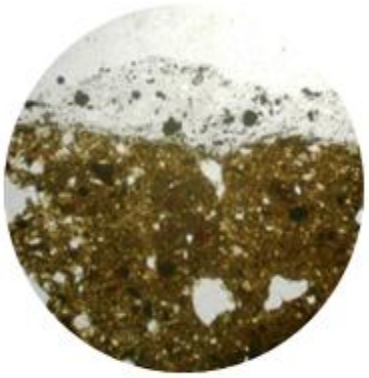

Image-6. same Figure 5 in a cross-polarized light

Image (5) glazed sample margin. Glaze without color with dark spots has seen in this image. Image (6) is the same Figure 5 in a cross-polarized light. Glaze margin has seen dark in the light. Empty space in the sample is also too dark while in Figure 5 the empty space can be seen in bright color (bottom arrow).

Reference: Research Institute for Conservation and Restoration

Quartz in the sample can be seen in form of Phenocrysts, it has a margin of angular to sub-rounded and smaller than 1.0 mm. And it constitutes about 20% of the total volume of the sample (Figure 7).

Iron oxide minerals can be seen in abundance as a red- dark red color in the sample, it also looks great up to two millimeters and total volume of the sample is formed about 15% (Fig. 8). Other components of sample are remains of Igneous Rocks, Feldspar, Amphibole and Pyroxene which is partially seen in the sample (Figures 6, 7, 8).

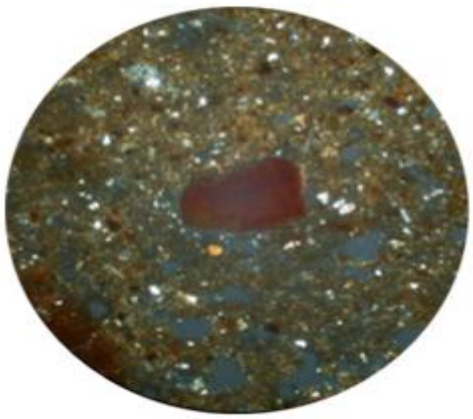

Image-7. light-colored mineral quartz and is seen angled margins, light (XPL).

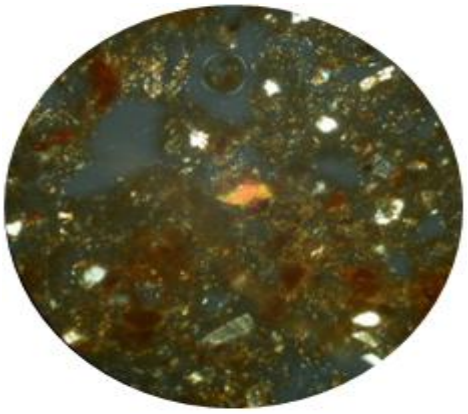

Image-8. Image 8 Light-colored mineral quartz and is seen angled margins, Light (XPL).

Figure 8 iron oxide minerals in the center of the image, ground finely mineral crystals consisting of fine clay crystal and fine crystal quartz, light (XPL).

Reference: Research Institute for Conservation and Restoration

Components of the Stone nap: The components in the sample are seen more as phenocrysts with angular margins (Figure 9.12). These components make up about 5% of the total volume of the sample.

Calcite: The mineral can be seen in form of Microlite (fine crystals) in the sample and its affluence is about 3-5% of the total volume of the sample. Existence of the Calcite mineral or its equivalents show that the pottery firing temperature is not exceeded of 800 ° C (Figure 10, 11). Empty space in many instances constitute about 10-15% of the total volume of the sample.

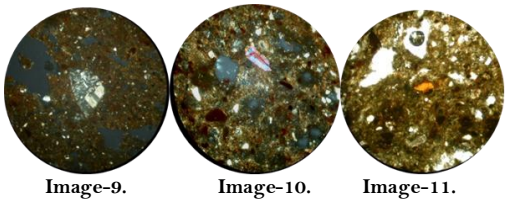

Image-9. Image-10. Image-11.

Image (9) the piece of Igneous Rock in the center of the image, light (XPL[1]).
Image (10) the mineral pyroxene with purple color, end of arrow, light (XPL).
Image (11) Amphibole minerals with orange-red color in the center of the image, light (XPL).
Reference: Research Institute for Conservation and Restoration

Figure-12. Stone nap components with dark and light colors and dark in finely clay crystal context, which Porphyritic texture is clear in this picture, Polarized light (PP[2]L).
Source: Research Institute for Conservation and Restoration

2.5.2. Scanning Electron Microscope (SEM)

The thickness of the glaze layer with zoom X100 (Figure 5-16), it has been found at a point 615 microns and 544 microns in another point. In another image (Figure 13) which photographs with X60 zoom, the thickness of the glaze layer is 348 and in another point is 427 microns. Dark spots indicate the sinking holes. Cracks are well-represented in the picture (14).

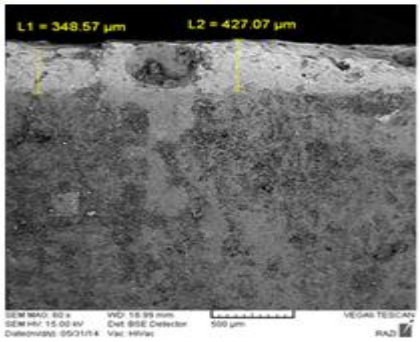

Image-13. thickness of the glaze layer

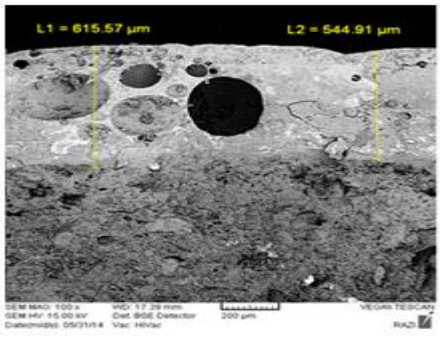

Image-14. Cracks are well-represented in the picture

Scanning electron micrographs: Reference Razi Research Institute

In Figure (15) which is photographed with zoom X 100, the thickness of the glazed layers is 418, 294, and 403 microns. Also in the image (16) which is photographed with zoom X200, the thickness of the glaze layer is obtained

1 Crossed light

2 Polarized light

on three points. It has recorded in 3portions; first one is 347 microns, second one is 368 microns and the last one is 328 microns.

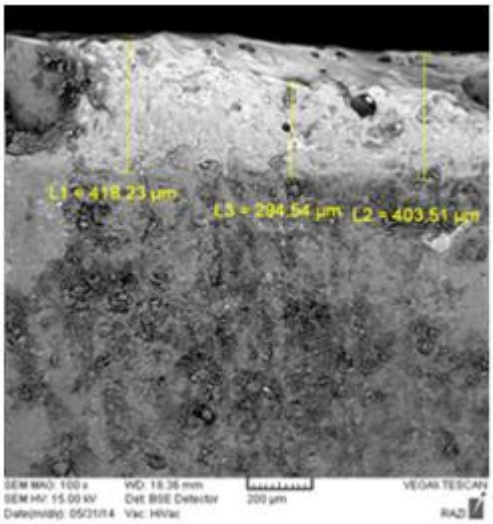

Image-15. zoom X100

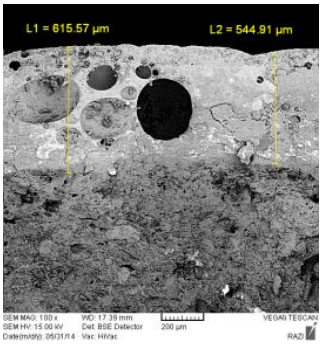

Image-16. Zoom X200

Reference: Razi Metallurgical Research Center

Figure (17) proves the existence of tiny holes with an X100zoom. Figure (18) represents a big hole on the right with, a zoom X200, and cracks, small and large bubbles are clearly visible.

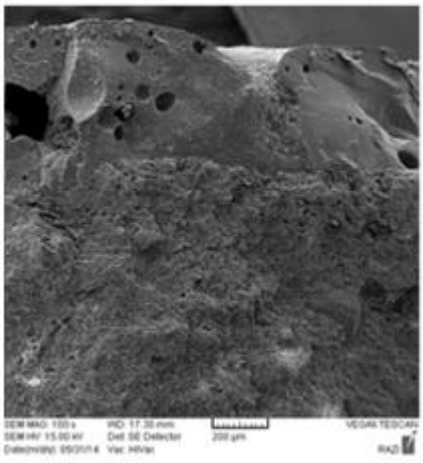

Image-17. zoom X100

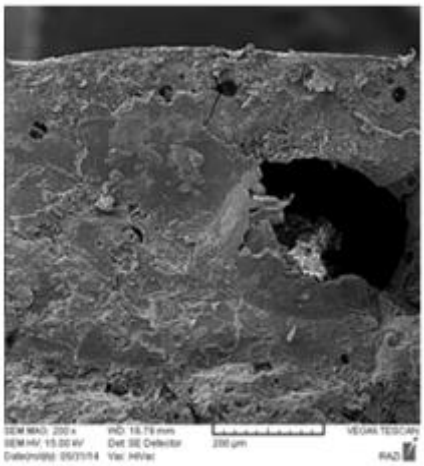

Image-18. zoom X200

Reference: Razi Metallurgical Research Center

Elemental analysis is taken of the two parts A and B as well as the body of the tile shown in Figure 19. A (zone a) B (zone b)

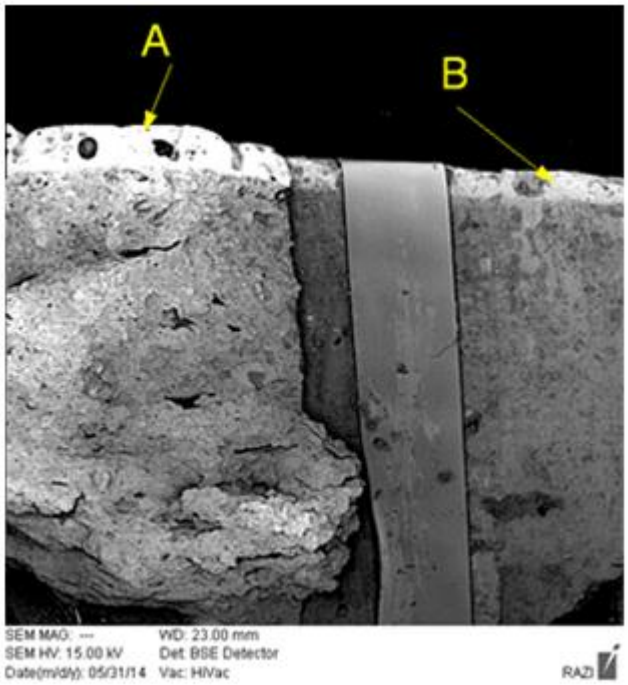

Figure-19. Scanning electron micrographs (Cross-tile)
Reference: Razi Metallurgical Research Center

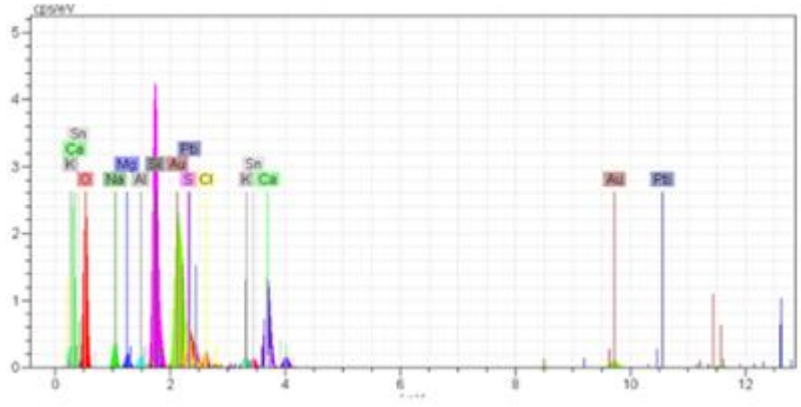

Chart-1. Elemental analysis the tile glaze- ZONE A
Reference: Razi Metallurgical Research Center

Table-5. Elemental analysis the tile glaze- ZONE A

Spectra :Zone A				
Element	**Series**	**Unn.c**	**Norm.c**	**Atom.c**
		(wt.-%)	(wt.-%)	(at.-%)
Oxygen	k Series	28.11	27.59	57.15
Sodium	k Series	1.64	1.61	2.32
Magnesium	k Series	0.79	0.78	1.06
Aluminum	k Series	0.69	0.68	0.83
Silicon	k Series	14.56	14.29	16.86
Sulfur	k Series	4.03	3.96	4.09

Reference: Razi Metallurgical Research Center

The presence of these elements in the amount of: Oxygen 27.59, 1.61 Sodium, 0.78 Magnesium, 0.68 Aluminum, 14.29 Selenium and 3.96 Sulfur are evident in the ZONE A. The existence of the elements; Lead (Pb), Gold (Au), Calcium (Ca), Tin (Sn), Potassium (K) and Chlorine (Cl) has been identified in Figure 1.

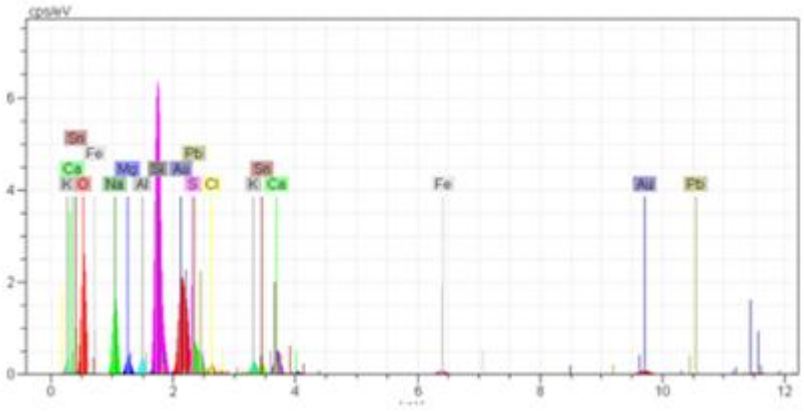

Chart-2. Elemental analysis the tile glaze- ZONE B

Table-6. Elemental analysis the tile glaze ZONE B

Spectra :Zone B				
Element	**Series**	**Unn.c**	**Norm.c**	**Atom.c**
		(wt.-%)	(wt.-%)	(at.-%)
Oxygen	k Series	25.20	24.01	50.14
Sodium	k Series	6.25	5.95	8.65
Magnesium	k Series	1.41	1.34	1.84
Aluminum	k Series	1.20	1.14	1.41
Silicon	k Series	21.02	20.03	23.83
Sulfur	k Series	0.16	0.15	0.16

Reference: Razi Metallurgical Research Center

The presence of these elements in the amount of: Oxygen 24.01, 5.95 Sodium, 1.34 Magnesium, 1.14 Aluminum, 20.03 Selenium and 0.15 Sulfur are evident in the ZONE B. Silica have been reported in ZONE B more than ZONE A, also Sulfur and Oxygen in ZONE B has been found less, as well as Sodium, Magnesium, and Aluminum, more than ZONE A. In addition to the elements listed in ZONE A the presence of Iron (Fe) has been reported in ZONE B.

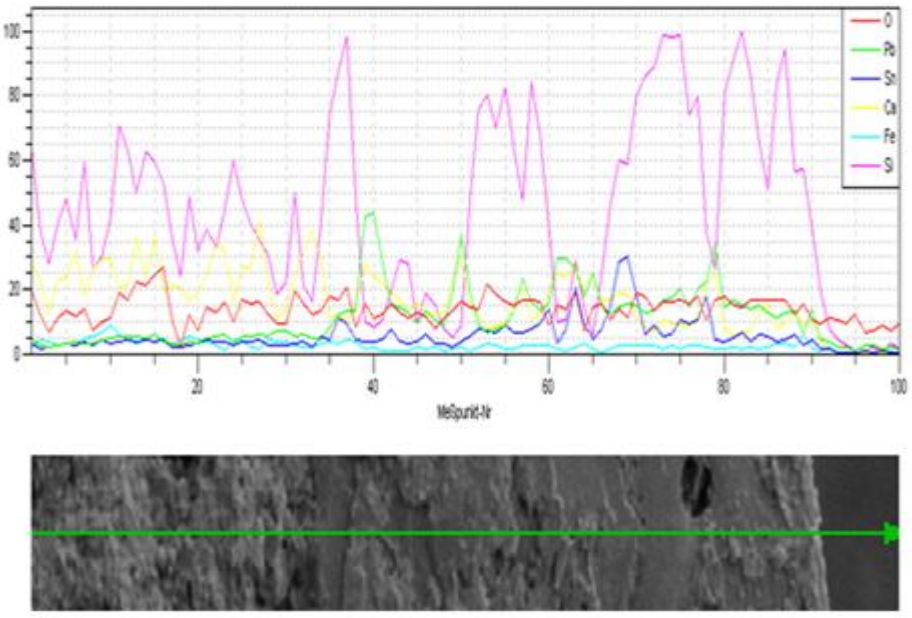

Figure-3. ZONE A in a linear scan

Reference: Razi Metallurgical Research Center

The linear scan of ZONE A confirms the presence of Lead in tile glaze. In part which the element Lead (Pb) (green) has came down is the tile body, so it can be concluded that glaze penetration rate was very slight on the tile body. This graph has been investigated by the Silicon element existed. Since there is large quantities of the Silicon in the glaze and body of the tile, this element has been removed for a better other elements' view in the later linear scan.

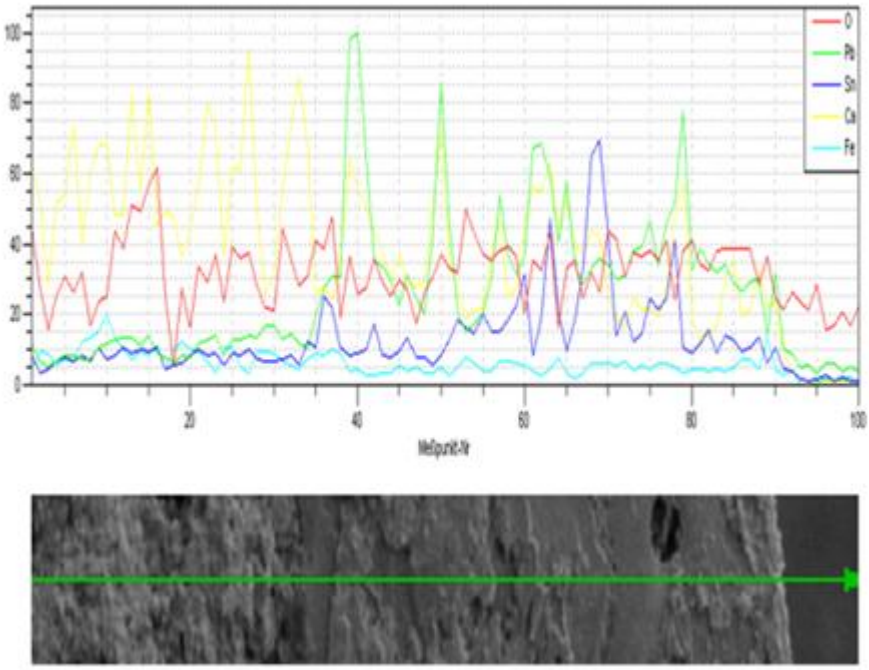

Figure-4. Linear scan ZONE B without the presence of Silica
Reference: Razi Metallurgical Research Center

In Figure 4 the line scan clearly shows a large amount of silicon element. According to the results of the thickness of the glaze layer, it can be understood that the thickness of the glaze layer were different in different parts.

Table-5. The results of the contact angle test before aging

Description of the Sample	Solvent	Test Method	Test results	Environmental Conditions		Test Name
Zycosil and Nano-Silica	Water	Manual-0	109.7	Temperature	Humidity	contact angle measuring by G10 Device
				25°c	%30	
Zycosil	Water	Manual-0	99.6	25°c	%30	
Control Sample	Water	Manual-0	73.5	25°c	%30	
Zycosil and Nano-Silica	Diiodomethane	Manual-0	60	25°c	%30	
Zycosil	Diiodomethane	Manual-0	55	25°c	%30	

Reference: Polymer and Petrochemical Institute

2.5.3. Measurement of Contact Angle of Seven Colors Tile

To determine the contact angle in this case study was used the drop method, which is a common technique to designate the characterization of the solid surface wetness. A drop of distilled water was placed on the sample surface by using a syringe. Initially, photographs were taken by a camera from the drop contact angle with the

surface of the tile. Contact angle is shown by calculating the angle between the tangent to the drop at the point of contact and a line drawn along the surface of the tile [19].

The test is done both water and solvent as well as Diiodomethane before and after exposure in the Weathering device. Surface energy was taken from the results of two solvents.

Table-6. The results of the contact angle test after aging

Test results	Test Method	Solvent	Description of the Sample	Environmental conditions		Test Name
97.7	Manual-0	Water	Zycosil and Nano-Silica	Humidity %30	Temperature 25°c	contact angle measuring by G10 Device
85.1	Manual-0	Water	Zycosil	%30	25°c	
58.8	Manual-0	Water	Control Sample	%30	25°c	
57.8	Manual-0	Diiodomethane	Zycosil and Nano-Silica	%30	25°c	
54.3	Manual-0	Diiodomethane	Zycosil	%30	25°c	
44.1	Manual-0	Diiodomethane	Control Sample	%30	25°c	

Reference: Polymer and Petrochemical Institute

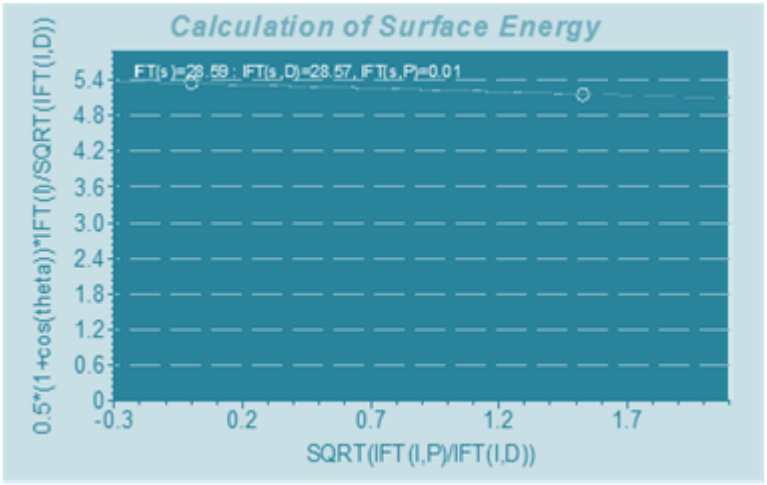

Figure-5. Zycosil and Nano-Silica surface energy before aging
Source: Polymer and Petrochemical Institute

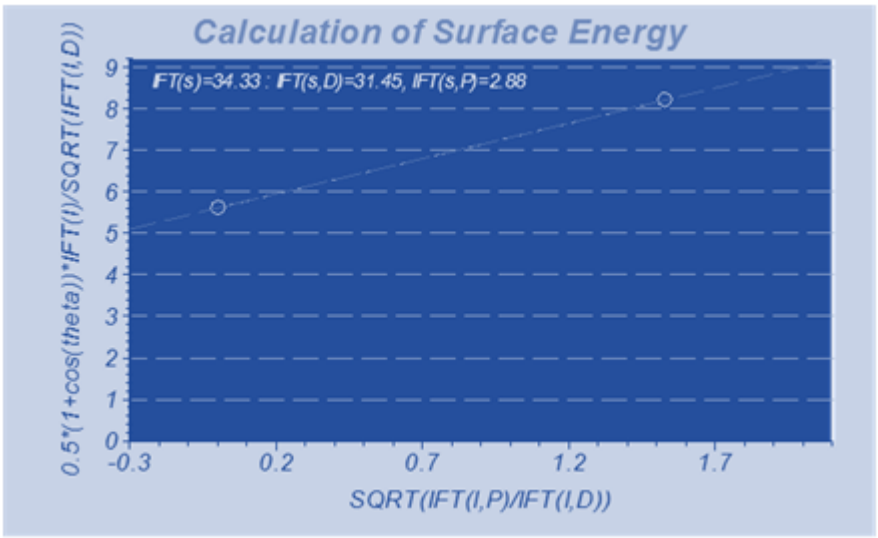

Figure-6. Zycosil and Nano-Silica surface energy after aging
Source: Polymer and Petrochemical Institute

Zycosil total surface energy coatings and Nano-Silica shows 28.59 before aging and respectively non-polar as well as polar parts are 28.57 and0.01. In compare Chart 5 with chart 6, it can be concluded that the overall level of energy aging is increased and also changes were more in the non-polar part.

2.5.4. Atomic Force Microscopy AFM Test on the Seven Colors Tile

Two types of image are obtained in the AFM test, which is given in Figure 20:

1- Topographical image are usually provided by the unit of length (mμnm.) And base on its surface topography, are specified surface roughness.

2- Phase images to identify regions of different phases, is set to show uniform or non-uniform multi-phase of system.

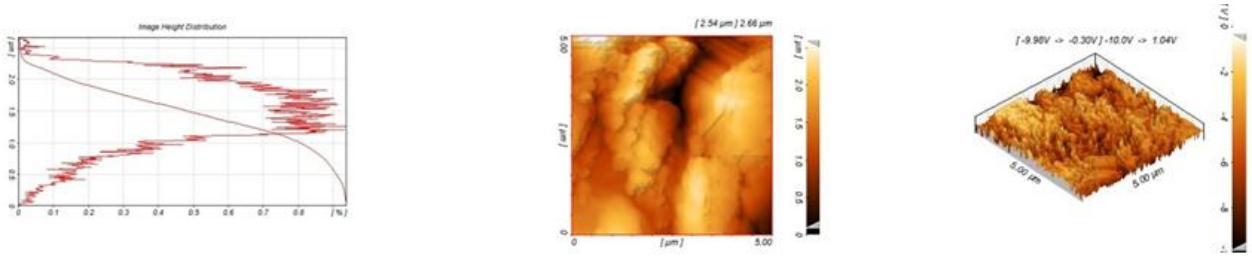

Figure-20. Atomic Force Microscopy (AFM); topographic image, curve of the points' height and three-dimensional image (Zycosil and Nano-Silica sample)
Reference: Research Institute of Color & Coating

The result of this experiment is match to test the contact angle, because by the adding of Nano-Silica also increased hydrophobicity of coating and roughness is spread unevenly. If roughness with long intervals were together, it caused the hole in the coating and water could penetrate the cavity. But in the results of Nano-Silica and Zycosil coating, it was determined that the water can be uniform on the surface because of roughness. Hence it is the reason to protect the tile.

2.5.5. Resistance Test Against to Artificial Weathering (Weathering)

The test is determined for corrosion coating resistance against weathering, water, and changes in the color of the sample under ultra-violet radiation in the QUV / Spray device in accordance with standard ASTM G 154-06. The samples were conducted base on a cycle under the UVB light bulb for 4 hours, at a wavelength of 313 nm, and intensity of 71.0 watts per square meter at a temperature of 60 ° C as well as then for 4 hours in 100% humidity without light at a temperature of 50 ° C.

2.5.6. Colorimetric Test on the Seven Colors Tile

Color measurements test is done with a colorimeter device Mini-scan° XE PLUS 45/0, according to ASTM D 2244-11 standard, at an angle of 10 degrees and a light source D65 before and after placing the samples in accelerated conditions. The colorimetric parameters (L) (a) (b) or CIELAB used to measure and report in these days. The test results are shown in Table 10.

Table-10. Results colorimetric (buff color field) before aging after 50 hours and after 100 hours

ΔE	L	a	b	Time in the QUV	Sample Characteristics
	68.94	2.71	10.45	Before placing the sample in the machine	Zycosil and Nano-Silica sample
4.10	67.94	2.64	14.42	After exposure for 50 hours	
3.23	68.24	2.51	13.60	After exposure for 100 hours	
	68.92	-1.36	9.78	Before placing the sample in the machine	Zycosil Sample
0.92	68.81	-1.42	10.69	After exposure for 50 hours	
1.30	68.22	-1.40	10.88	After exposure for 100 hours	
	67.89	3.81	11.73	before placing the sample in the machine	Control Sample
0.99	67.97	3.76	12.72	After exposure for 50 hours	
0.96	68.13	3.71	12.66	After exposure for 100 hours	

Source: Polymer and Petrochemical Institute

The results of the color measurement test and the variations of parameter L or the same color's reflection of color in protected-sample by Zycosil represent a slightly fading the color out.

In other words, the sample had been the least amount of blur in 50 and 100 hours at the QUV device. The blur can be seen more in the Zycosil and Nano-Silica sample. The parameter or distinguish colors (red-green color channel) increased in Zycosil sample, in the case of the conditions before aging which it has inclined to the green. While the Zycosil and Nano-Silica sample as well as Control Sample (a) has fallen, it has inclined to the red. The parameter (b) or saturated color (yellow-blue channel) in all three, Increase in compared to the situation before aging which this increasing has been reported less rather in Zycosil sample. Therefore, it can be interpreted that all three samples tend to yellow. We can say about color generalities that, the control sample, Zycosil sample, Nano-Silica and Zycosil respectively have recorded the fewest changes color.

2.5.7. Spectroscopy Test (FTIR) on Seven Colors tile

To examine and identify the building coatings applied on the tile the infrared spectrum FTIR was used before and after aging. To this end, samples were prepared for tuberculosis solid powdered sample was mixed with KBr powder, and then placed under pressure by the tablet device maker.

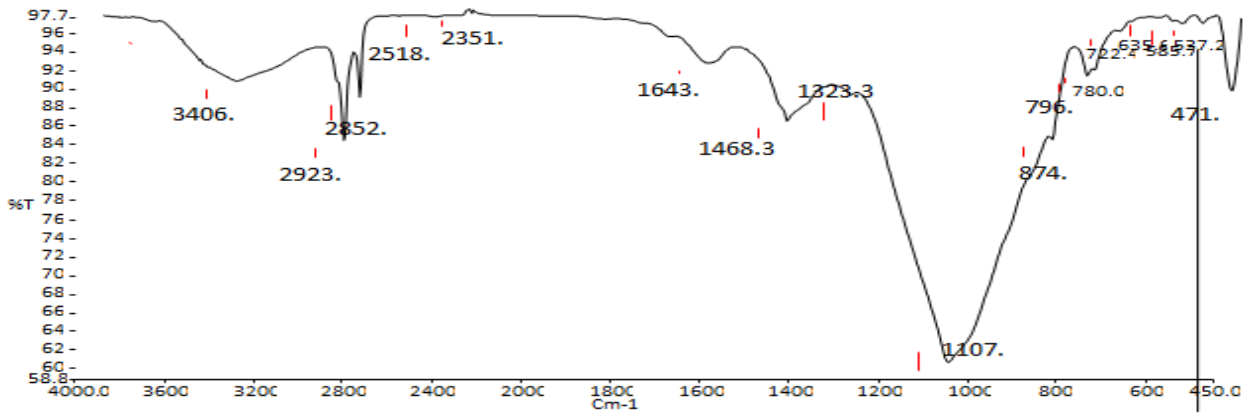

Figure-5. FTIR spectroscopy of Zycosil and Nano-Silica sample before aging
Reference: Research Institute of Color & Coating

The FTIR spectrum of Zycosil and Nano-Silica is representing the pass band in 3400 areas of Connectivity O-H (hydroxyl group). There is no change after aging and range 470 show the Nano-Silica Spectrum, hence; it is not much change after aging. The Range 2800-3000 also reflects the connections C-H (Methylene group) and the range 1300-1400 are connections C-H.

The FTIR spectrum of sample (2), the bond can be seen in the area 900-700 which has been changed after the aging. The spectrum of 900-1300 is related to the (C-O) connections.

By comparing the results after aging in the sample, it seems that significant change has not occurred in the bonds of Zycosil and Nano-Silica. It indicates that the uses of Nano-Silica have not made constructional significant changes; While Zycosil has more significant changes compared to Zycosil and Nano-Silica sample.

3. CONCLUSION

This research was tested and evaluated, the Protective effect of Zycosil coating and modified Zycosil on the Seven Colors Tile of the Naser-al-Din Mirza's House in Tehran which had a lot of damage. The sample has porphyry textures (coarse crystal components in the field of micro-crystals) from the petro-fabric point of view. Typical components include: Quartz, Iron Oxide, Stone Nap, Rock Debris, Remnants of Igneous Rock, Calcite, Feldspar as well as Amphibole and Pyroxene. The Pottery fragments have been used previously as filler.

The Particle sizes from morphology point of view were evaluated by using a Scanning Electron Microscope (SEM), and the result of SEM examination shows that the thickness of the glaze layer is different in different parts. So, the glaze influence slightly happened on the body and much existence of Lead element in tiles glaze confirms that it has been a kind of Lead. Holes, cracks, small and large bubbles can be seen also in microscopic images.

In continue, to investigate the topography and roughness of the surface was used Atomic Force Microscope (AFM). Zycosil and Nano-Silica coating surface morphology images showed that coatings made with uniform roughness. By adding Nano-Silica It proves that coating roughness has good adaptability to the tile surface.

Height distributions of the samples are as follow: control sample 0.6micro, Zycosil sample 1.6micro, Zycosil and Nano-Silica sample 2.5micro. The roughness coating has a considerable impact on the coating features and their hydrophobicity.

The Contact Angle Test was used In order to evaluate the hydrophobic coating of the surface. This method was measured by using distilled water solvents and Diiodomethane, the surface energy was investigated so on.

The results showed that the contact angle has increased in both Zycosil and Nano-Zycosil samples before aging in compare with control sample. But this increasing is impressive in the Zycosil and Nano-Silica samples. The contact angle of the samples has decreased than before after accelerated aging. These changes for the samples are as follow: Zycosil and Nano-Silica 97.7, Zycosil 85.1 and control sample 58.8, which specifies the Nano-Silica and Zycosil samples still better hydrophobicity than the control sample. The result of this test confirms the AFM Test.

Results of the Contact Angle and AFM tests prove that, a homogeneous mixture is created by adding the Nano-Silica into Zycosil, which helps the coating adhesion, hydrophobicity, surface roughness and chemical resistance. Sample tile is reduced due to unique property of Zycosil, speed and or vulnerability mechanisms. After all tests, it can be concluded that Zycosil coating features and modified Zycosil by Nano-Silica has not changed before and after aging.

These results were analyzed by FTIR testing and prove that significant chemical structure changes unformed and properties of matter are not gone. Also QUV Chamber was used to study erosion and corrosion resistance properties of humidity, temperature, and ultraviolet light. Discoloration was measured before aging and after 50 and 100 hours. It represented that the Zycosil sample had the least amount of color changing.

The various percentages of silica which is added into Zycosil could have an impact on the color of the glaze. According to the results of colorimetric, Nano-Silica and Zycosil samples had more relatively color changes than the Zycosil. It can be concluded from this experiment that more percentages of Nano-Silica have adverse impact on the color of the glaze. Visually, adding more percent of Nano-Silica into tiles glaze will cause its blurring and opacity [20].

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