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Parlatılmış Porselen Karoların Leke Direncini ve Temizlenebilirliğini İyileştirmek için Dolgu Malzemesinin Sol-Jel Yöntemi ile Üretilmesi Bölüm II: Proses parametrelerinin koruyucu malzemenin performansına etkilerinin incelenmesi

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Anahtar kelimeler
Hibrit sol-jel, Parlatma,Porselen karo

Özet

Bu çalışmada, yeni geliştirilen koruyucu malzemenin performansının parlatma adımlarındaki proses parametrelerinin etkisi araştırılmıştır. Parlatma esnasındaki karonun sıcaklığı, karo üzerindeki koruyucu malzeme miktarı, fırçanın karo üzerindeki mesafe aralığı, parlatma esnasındaki fırçanın karoya uyguladığı kuvvet proses parametreleri olarak incelenmiştir. Bu parametrelerin etkisi ve yeni geliştirilen sol-jel kaplamanın performansı, parlatılmış porselen karoların leke dayanımı göz önünde bulundurularak incelenmiştir. Karo yüzeyinin temizlenebilirliği ve leke dayanımı ISO-10545-14 standartına göre ölçülmüş ve sonuçlar standart koruyucu malzeme ile karşılaştırılmıştır.

Production of Sealing Material By Sol-Gel Method To Enhance Stain Resistance and Cleanability of Polished Porcelain Stoneware Tiles Part II: Investigation of The Performance Depend on Process Parameters

Key words
Hybrid sol-gel; Polishing; Porcelain tile

Abstract

In this study, the effects of process parameters of the polishing step on the performance of the newly developed sol-gel coating as a sealing material were investigated. Process parameters such as temperature of the tile during polishing, amount of the protective material on the tile, distance between brush and tile, force of the brushes during polishing, were examined. Effect of these parameters and performance of the newly developed hybrid sol-gel coating were investigated considering stain resistance of the polished porcelain tiles. The stain resistance and the cleanability of the tile surface were measured by following the ISO-10545-14 standard and results were compared with standard protective material.

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1. Introduction

Porcelain tiles, which are generally used for covering the open areas, have excellent technical characteristics such as low water absorption (according to ISO 13006, less than 0.5%), high fracture toughness, frost resistance, abrasion resistance and chemical resistance (Zanelli et. al. 2008, Martin-Marquez et al. 2008). Porcelain stoneware tiles are glass-bonded materials and they can be classified as glazed and unglazed porcelain tiles in general. The unglazed porcelain tiles are usually utilized after a polishing procedure and hence they are also called as polished porcelain tiles. Unfortunately, although the polishing process improves the aesthetical appearance, it often decreases stain resistance of the tiles. Stain resistance is one of the most important properties which determines applications of the polished porcelain tiles for both indoor and outdoor applications (Suvaci and Tamsu, 2010).

Porcelain stoneware tiles can be classified as glazed and unglazed porcelain tiles in general. Surfaces of the unglazed tiles are polished to enhance their aesthetic and performance. Polishing the working surface of porcelain stoneware tile has become a widespread process in the production line. However, after this treatment the working surface of the tile is particularly sensitive to staining agents (Sanchez et al. 2006). For increasing the stain resistance of the polished porcelain tiles, a protective material mainly used after the polishing step. These protective materials consist of nanomaterials and/or hybrid materials and they are generally prepared by sol-gel technique. By this way, inorganic materials (glassy or ceramic) and inorganicorganic (hybrid) polymers can be processed to form coatings. The aim of this study was to increase the performance of the newly developed organic-inorganic protective material via optimisation of the process parameters depend on the stain resistance of the polished porcelain tiles.

2. Experimental Procedure

The newly protective material composition was prepared by using organic and inorganic (hybrid materials) polymers. As a result of the analysis and tests (Suvaci and Tamsu, 2010), the application method of the protective solution during polishing to fill the pores of the tiles were found to be more considerable effect to the stain resistance of the body. For this reason, newly protective material which was prepared by adddition of IPA (Isopyropyl alcohol), Recipe 4S which shows the best performance represented in Part I , applied on the tile surfaces. After application of te protective material, the performance of newly developed protective material was investigated by consider different process parameters such as temperature of the tile surface, effect of the brushes during polishing. For completion of the whole reaction, at the end of a week after application of the protective material, the stain resistance and washability tests were carried out. Microstructure of the surfaces investigated by scanning electron microscopy (SUPRA-Zeiss-50) at different magnifications and stain resistance test was applied by using ISO 10545-14 (Ceramic Tiles”-Part 14:Determination of Resistance to Stains) standard. The test method consists of maintaining various staining agents (green staining paste-chromium oxide particles in light oil, olive oil, and iodine solution) in contact with the working surface of the tile for an established time, then cleaning with various agents and finally a visual inspaction to detect any changes. In addition to the standard staining agents other stainin agents which are commonly encountered in daily life such as tea, coffee, red wine, methylene blue solutions, potassium permanganate and black joint filler) was used for the staining tests. 3-4 drops staining agents putting into the surface and then closed with watch glass and hold on approximately 24 hours. After duration, cleaning process has been beginned. The amount of staining was determined by visual inspection after each cleaning step:

1. mild washing with warm water:
2. washing with warm water plus a neutral detergent;
3. vigorous brushing with a rotary equipment plus an alkaline detergent.

For investigation of the effect of the process parameters, the temperatures of the tile surfaces was researched. Different temperatures (Table 1) was applied on the tile surfaces.

Table 1. Temperature of the tiles during polishing step.

Porcelain Tile	Temperature of the Tile Surfaces
(40x40 cm^2)	60-70 °C
	80-90 °C

The temperatures was checked out by pyrometer (TROTEC Infrared Thermometer/Pyrometer BP20 Model, Germany). After reached the target temperature protective material was and then new protective material was applied on the tile surface with pasteur pipette and solution was distributed on the tile surface by a tissue for penetration into the pores.

3.Results and Discussion

3.1. *Effect of the Tile Surface Temperatures*

For this part, newly developed protective material was applied diffent surface temperature. Fig. 2 shows the staining behaviour of uncoated tile at (60-70°C) and coated tile with solution 4S at (60-70°C). For uncoated tile, all of the stains remained on the surface and they were not clarified. For coated tile with Solution 4S, only methylene blue, chrome oxide and tea remained on the surface after stain resistance test.

Figure 2. Comparison of the stain resistance test between uncoated tile and coated tile with solution 4S at (60-70°C).

Fig.3. shows the staining behavior between uncoated tile at (80-90°C) and coated tile with solution 4S at (80-90°C). For uncoated tile, all of the stains remained on the surface and they were not clarified. For coated tile with Solution 4S, only methylene blue was remained on the surface, out of methylene blue, all of the stainin agents were clarified. These results show that increase of the tile surface temperature result in incease of the stain resistance.

The enhancement of the stain resistance can be related to microstructure. In accordance to the SEM images presented in Fig. 4 and Fig. 5, the later system exhibits more effective due to the penetration of the protective material into the pores. These results suggest that decreasing viscosity of the protective material result in more penetration into the pores also favours stain resistance of the polished porcelain tiles.

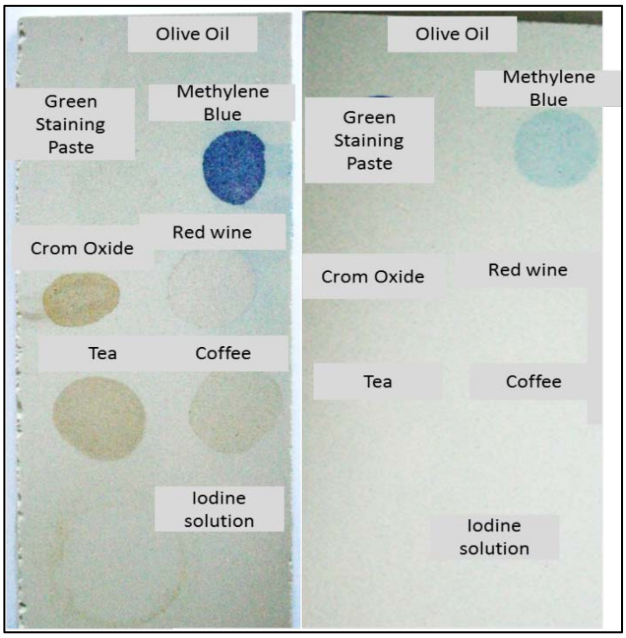

Figure 3. Comparison of the stain resistance test between uncoated tile and coated tile with solution 4S at (80-90°C).

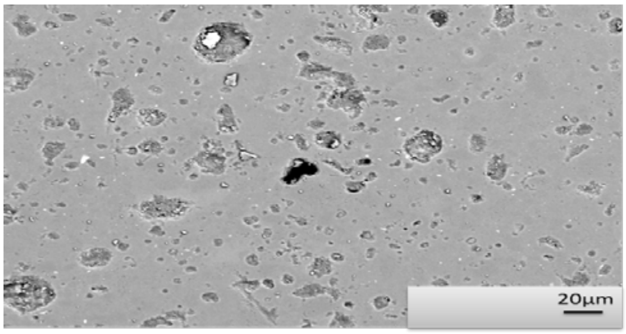

Figure 4. SEM micrograph of the tile surface coated with solution 4S at (60-70°C).

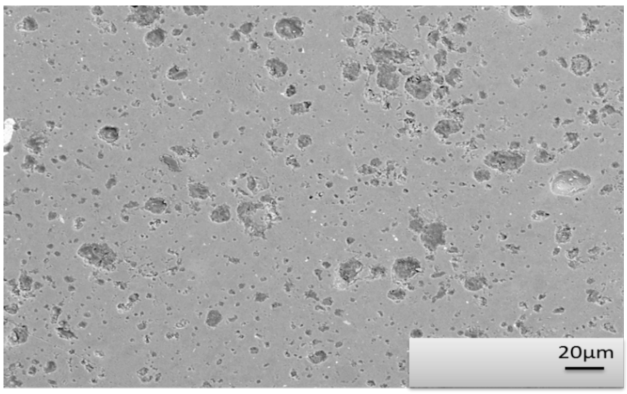

Figure 5. SEM micrograph of the tile surface coated with solution 4S at (80-90°C).

3.2. *Effect of Distance Between The Scrub Brush Heads During Polishing*

After firing, porcelain tiles are carried with the help of belt conveyors and in this stage protective solution is applied on the surface by spraying. Solution is distributed with primary and secondary brushes with rubbing movement. In the first stage of the brushing consists of 3 main brush heads and they provide distribution of the protective material on the tile surfaces. For this study effect of the distance of the brushes heads was investigated. The simulation of the first stage of polishing.

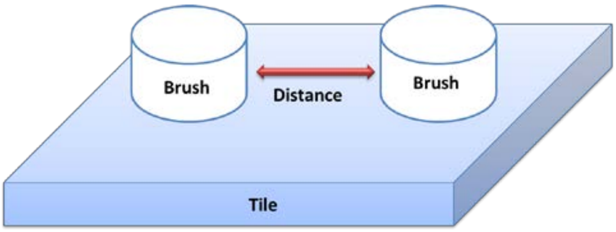

Figure 6. Simulation of the first stage of polishing with different distance.

Fort his part, different polishing brush head distances were investigated. 10cm and 17 cm distances were carried out. Fig. 7 shows the microstructure of the polished tiles which was polished the higher distances between the brush heads (17 cm).

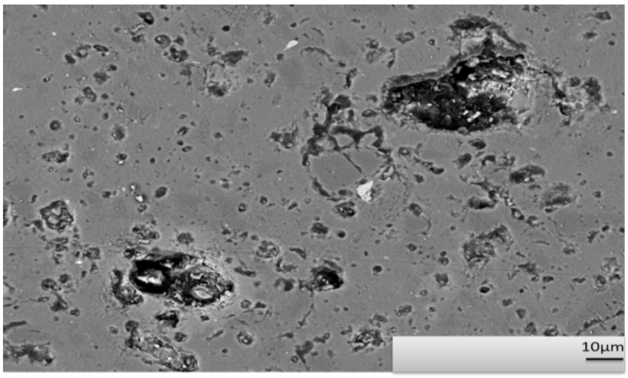

Figure 7. The microstructure of tile which was polished 17 cm distance between polishing heads.

Fig. 8 shows the microstructure of the polished tiles which was polished the lower distances between the brush heads (10 cm). These results suggest that decreasing distance between polishing heads result in more effective penetration of the protective material inyo the pores. This means that higher distance induce to eveporation of the alcohol from the protective material and hence results in less efficiency to protective application on the surface.

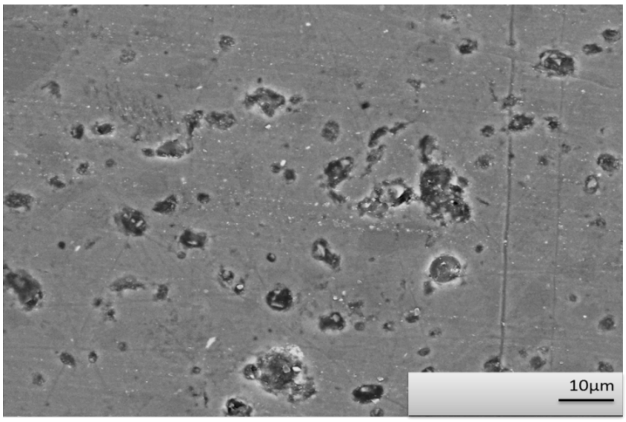

Figure 8. The microstructure of tile which was polished 10 cm distance between polishing heads.

3.2 *Effect of Soft Brushes Functionality on Microstructure of the Polished Porcelain Tiles*

Tiles are brushed by polishing brushes in a row. At the final stage, a soft brush passes through on the tile surfaces. Therefore, effects of the brushing stages on the performance of the newly developed protective material were investigated. For this part, the existance of the soft brushes and their effects to the solution performance considering by microstructure. Fig. 9 shows the microstructure of the polished porcelain tiles without soft brushing during polishing. It can be seen in the microstructure, the pores were not filled protective material homogeneously.

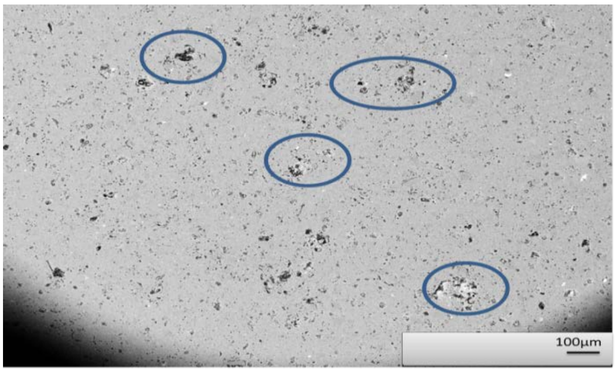

Figure 9. The microstructure of polished porcelain tile without soft brushing.

Fig. 10 shows the microstructure of the polished porcelain tiles without soft brushing during polishing. Efficiency of the pore filling was higher with soft brushing during polishing. It can be explained by higher performance to distribute the protective material.

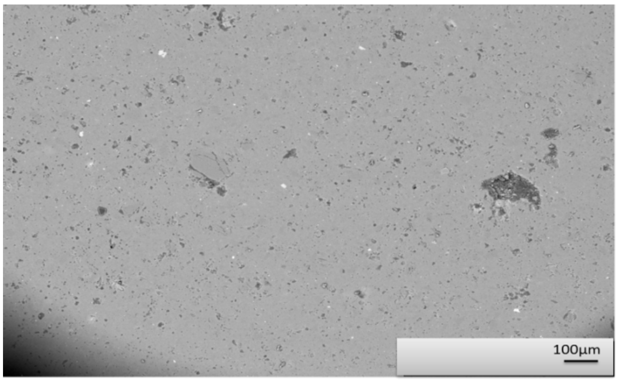

Figure 10. The microstructure of polished porcelain tile with soft brushing.

4. Conclusions

1. In this study, it has been shown taht newly protective material performance can be successfully utilized to optimising polishing process parameters. In addition, it has been found that the temperature of the tile surfaces, therefore effective distribution of the protective material and low temperatures such as 60-70°C temperature range was inadequate for increasing performance of the protective material. In this study 80-90°C temperature range was successful to application of the newly developed material.
2. For increase the performance of the protective material distance of the scrub brush heads was investigated. Decreasing of the distance between brushing heads results in higher distribution of the protective material considerin micrıstructure.
3. Other parameter was investigation of the existance of soft brushes during polishing. Fort this part, efficiency of the pore filling by protective material was higher with soft brushing than without soft brushing step.

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