Abstract

Glazes are hygienic, decorative, glassy coating layer which have resistance to chemicals. In this study, Nevşehir, Acığol-Tatlarin region’s basalt added to transparent glaze at 5, 10, 15, 20, 40 and 60 wt. %. These glaze recipes applied to slip cast plates and sintered at 1000 °C. No significant color change was observed for 5-15 wt. % basalt additions but color turns to black with the increasing amount of basalt after 20 wt. % addition amounts. Phase development of the glazes with 0, 20, 40, 60 wt. % basalt addition were performed with X-ray diffraction (XRD) and microstructural development of the glaze with 60 wt. % basalt addition was investigated by scanning electron microscopy (SEM).

1. Introduction

Basalt is a magmatic rock which has high chemical durability, high resistance to abrasion and corrosion [1-2]. Natural basalts are cheap raw materials that are present in significant quantities [2]. The technology of basalt ore processing is ecologically clean and the products obtained are not cancerogenous. Basalt from its deposit is black color and has a high level of aesthetic decorative properties [3].

Basalt and basaltic tuffs are rocks used both in Turkey and abroad, in ceramics and glazes, frit and glass-ceramics, composite materials [1-30]. However, no study has been conducted on the use of basalt, except the usage as cut stones and pebbles in the Nevşehir province borders. The aim of this study is to be able to improve the properties of transparent glazes with the use of Nevşehir basalt.

2. Experimental Procedure

Basalt from Nev Beton Basalt Plant (Nevşehir, Acığol-Tatlarin) was ground to smaller particle size than 100 μm with a porcelain jet mill in wet basis. Dried basalt was added to the transparent base glaze at the ratios 5, 10, 15, 20, 40, 60 wt. %. The solid concentration of the glaze recipes was held constant at 50 % by mass. Glazes were applied on slip cast plates with a brush. Firing of the glazed plates was performed at 1000 °C in a Refsan Kaleo-27 furnace.

Chemical composition of basalt was determined by X-ray fluorescence (XRF-Bruker Tiger S8). Color measurement of all glazes was carried out using Minolta CM-3600d color measurement equipment. X-ray diffraction (XRD) was used for the qualitative determination of the crystalline phases present in the basalt and glazes containing 0, 20, 40, 60 wt. % basalt. This procedure was performed using a Rigaku Miniflex 600 diffractometer (with CuKα-radiation) at 40 kV and 15 mA. The samples were scanned from 20, 5 to 70°, at a scanning speed of 2°/min. The microstructure development of the glaze containing 60 wt. % basalt was analyzed using a Zeiss EVO 50 EP scanning electron microscope (SEM) along with an energy dispersive X-ray (EDX) spectrometer.

3. Results and Discussion

Chemical composition of basalt was given in Table 1. The basalt has 9.74 wt. % Fe₂O₃. An XRD analysis of the basalt was conducted and shown in Figure. 1. The main crystalline phases of the basalt were observed as quartz, magnetite and anorthite. It was determined with XRD analysis that Fe₂O₃ was magnetite phase.

Table 1. Chemical composition of basalt.

<table>
<thead>
<tr>
<th>SiO₂</th>
<th>Al₂O₃</th>
<th>Fe₂O₃</th>
<th>CaO</th>
<th>Na₂O</th>
<th>MgO</th>
<th>TiO₂</th>
<th>K₂O</th>
<th>P₂O₅</th>
<th>MnO</th>
<th>L.I.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>48.6</td>
<td>18.38</td>
<td>9.74</td>
<td>7.45</td>
<td>4.67</td>
<td>4.55</td>
<td>2.16</td>
<td>1.17</td>
<td>0.55</td>
<td>0.16</td>
<td>0.53</td>
</tr>
</tbody>
</table>

L.I.*: Loss of Ignition

Figure 1. XRD pattern of basalt (Magnetite: ◆, Anorthite: ♦, Quartz: ●).
The firing colors of glazed samples with changing basalt amount were shown in Figure 2. L* value of samples decreases with the increasing amount of basalt (Figure 3). The lowest L* value was obtained for transparent glaze with 60 wt. % basalt addition. a* value changes between 2.46 and 3.66 (Figure 4). Basalt addition was not a significant effect on a* value. As can be seen in Figure 5, the b* value increases 10.08 to 20.35 with an increase of basalt amount up to 20 wt. %, but it decreases with the basalt amount changes from 20 wt. % to 60 wt. %.

The slight shift in the diffraction pattern occurs due to the volumetric expansion of the crystalline lattice [31]. Peak positions are changed with the level of dopant or substitution atoms [32-36]. If there were any substitutions of the Si atoms by other atoms in the silica structure, a shift in XRD peaks of SiO$_2$ would appeared due to the differences in atomic radii of these two atoms [37]. In this study, quartz peak was shifted to the right with increasing amount of basalt addition according to XRD studies from Figure 6.

The microstructure of glaze containing 60 wt. % basalt was investigated by SEM. According to the SEM-EDX results of the glassy phase, regions contain 3.65±1.19 wt. % Na$_2$O, 1.57±0.11 wt. % MgO, 18.06±3.82 wt. % Al$_2$O$_3$, 63.99±2.93 wt. % SiO$_2$, 2.54±0.74 wt. % K$_2$O, 7.56±1.99 wt. % CaO and 2.64±0.83 wt. % FeO in Table 2. This result showed that Fe$_2$O$_3$ in basalt a certain amount dissolved at glassy phase. Though the dissolution of Fe$_2$O$_3$, Figure 7 revealed that there had been still undissoled Fe$_2$O$_3$ crystals in the glaze.

<table>
<thead>
<tr>
<th>Oxides</th>
<th>Minimum (wt. %)</th>
<th>Maximum (wt. %)</th>
<th>Average (wt. %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na$_2$O</td>
<td>4.49</td>
<td>2.81</td>
<td>3.65±1.19</td>
</tr>
<tr>
<td>MgO</td>
<td>1.64</td>
<td>1.49</td>
<td>1.57±0.11</td>
</tr>
<tr>
<td>Al$_2$O$_3$</td>
<td>15.36</td>
<td>20.76</td>
<td>18.06±3.82</td>
</tr>
<tr>
<td>SiO$_2$</td>
<td>66.07</td>
<td>61.92</td>
<td>63.99±2.93</td>
</tr>
<tr>
<td>K$_2$O</td>
<td>3.06</td>
<td>2.01</td>
<td>2.54±0.74</td>
</tr>
<tr>
<td>CaO</td>
<td>6.15</td>
<td>8.97</td>
<td>7.56±1.99</td>
</tr>
<tr>
<td>FeO</td>
<td>3.23</td>
<td>2.05</td>
<td>2.64±0.83</td>
</tr>
</tbody>
</table>
In this study, basalt addition as a natural pigment to transparent glazes was investigated. The amount of basalt used is 60 wt. %, the lowest L*, a* and b* values are obtained. The glazed sample containing 60 wt. % basalt is the blackest one. For a maximum b* value, the amount of basalt used is 60 wt. %, the lowest L*, a* and b* values are obtained. The glazed sample containing 60 wt. % basalt is the blackest one. For a maximum b* value, the amount of basalt should be 20 wt. %. The study shows that Nevşehir basalt could be used as a colorant for transparent glazes.

4. Conclusion

In this study, basalt addition as a natural pigment to transparent glaze was investigated. When the amount of basalt used is 60 wt. %, the lowest L*, a* and b* values are obtained. The glazed sample containing 60 wt. % basalt is the blackest one. For a maximum b* value, the amount of basalt used is 60 wt. %, the lowest L*, a* and b* values are obtained. The glazed sample containing 60 wt. % basalt is the blackest one. For a maximum b* value, the amount of basalt should be 20 wt. %. The study shows that Nevşehir basalt could be used as a colorant for transparent glazes.

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References


Figure 7. EDX analyses from glaze containing 60 wt. % basalt labelled spectrum 1.


Unlike glass, basalt fibers feature no secondary materials. The process requires only a single feed line to carry crushed basalt rock into the melt furnace. On the other hand, basalt fiber manufacturers have less direct control over the purity and consistency of the raw basalt stone. While basalt and glass are both silicates, molten glass, when cooled, forms a noncrystalline solid. Like glass filaments, basalt filaments are formed by platinum-rhodium bushings. As they cool, a sizing agent is applied and the filaments are moved to speed-controlled fiber stretching equipment and then on winding equipment, where the fiber is spooled. Because the basalt filament is more abrasive than glass, the expensive bushings once needed more frequent refurbishing. Basalt and basaltic tuffs are rocks used both in Turkey and abroad, in ceramics and glazes, frit and glass-ceramics, composite materials [1-30]. However, no study has been conducted on the use of basalt, except the usage as cut stones and pebbles in the Nevsehir province borders. The aim of this study is to be able to improve the properties of transparent glazes with the use of Nevsehir basalt.

2. Experimental Procedure.

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