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Chemical resistance and cleanability of glazed surfaces

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Abstract

Adhesion of soil on glazed surfaces and their cleanability depends on chemical composition, phase composition, and roughness of the surface. The surface can be glossy consisting mainly of a smooth glassy phase. A matt and rough surface consists of a glassy phase and one or more crystalline phases. The origin and composition of the crystalline phases affect the chemical resistance and the cleanability of the surface. Fifteen experimental glossy and matt glazes were soaked in a slightly alkaline cleaning agent solution. The surfaces were spin-coated with sebum, i.e. a soil component typical for sanitary facilities. After wiping out the soil film in a controlled manner, the surface conditions and the soil left were evaluated with colour measurements, SEM/EDXA and COM. The results show that wollastonite-type crystals in the glaze surfaces were attacked in aqueous solutions containing typical cleaning agents. This corrosion led to significant decrease in the cleanability of the surface. The other crystal types observed, i.e. diopside and quartz crystals were not corroded, and the cleanability of glazes containing only these crystals was not changed in the cleaning agent exposures. Also the glassy phase was found to be attacked in some formulations leading to a somewhat decreased cleanability. The repeated soiling and cleaning procedures indicated that soil is accumulated on rough surfaces and surfaces which were clearly corroded by the cleaning agent.

Keywords: Scanning electron microscopy (SEM); Corrosion; Crystallization; Surface roughening; Polycrystalline surfaces; Crystalline–glass interfaces; Grain boundaries; Ceramics

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1. Introduction

Traditionally a glazed surface is regarded as an easy-to-clean surface. However, surface pitting and degradation in service diminishes its cleanability because of increased surface roughness. Surface degradation can also lead to opening of closed porosity in the glaze thus leading to micro-scale holes, which are often hard to clean by conventional cleaning techniques. Glazed surfaces have recently been coated with special functional layers to achieve soil-repelling surfaces. Mechanical properties and durability of new soil-repelling surfaces in service is still poorly understood. If the original glazed surface has a good chemical resistance in different environments, surface properties are likely to be further improved by special functional coatings. However, a surface failing in every-day environments gives a poor base for special coatings. Thus, basic knowledge of surface properties is essential for developing better glazes and functional coatings to be applied on glazes.

Chemical resistance in service, especially in corrosive liquid environments, is a major reason for applying glazes on ceramics [1,2]. When glazed tiles are used for floor covering, slip resistance of the surface should be considered. Slip resistance is usually attained by adding in the surface crystalline components or by adjusting the glaze composition is such a way that crystals are nucleated and grown in the surface during firing. Thus, a glaze might contain both a glassy phase and different crystalline phases for achieving desired properties. The amount of crystalline particles can be up to 20% in traditional mat glazes, while transparent and highly glossy glazes consist almost entirely of a homogeneous glassy phase. Differences in durability of crystals and glassy phase can lead to selective corrosion of the surface in certain environments. Chemical durability of glazes is usually discussed in terms of durability of the glassy phase in accordance with glasses. Glasses react in acidic environments by ion exchange of alkali ions by hydrogen ions. In alkaline environments the network structure of glass is destroyed by hydroxyl attack [1–5]. The influence of different oxides on durability of commercial glasses and glossy glazes is well understood. However, chemical resistance of glazes consisting of one or several crystalline phases embedded in a glassy matrix has not been widely studied. Wollastonite and anorthite crystals devitrified from a fritted glaze have been reported to be attacked by acidic solutions [6]. Wollastonite crystals in fast-fired raw glazes are attacked by acidic and also slightly alkaline water solutions [7,8].

Raw glazes are mixed of powdered water-insoluble minerals, while the main component in fritted formulations is a pre-melted glass. When using fritted formulations, the development of different phases in the glaze during firing is quite easily mastered. Raw glazes are because of their lower cost attractive for ceramics fired to above 1200 °C, i.e. floor tiles, sanitary ware and porcelain. The high firing temperature and several hours' firing cycle in traditional firing ensures that even the slowest reaction, dissolution of quartz, will be completed. The formation of crystalline phases in traditionally fired glazes takes place according to equilibrium reactions and is controlled by the total oxide composition of the glaze. However, in a modern fast-firing process of floor tiles the short firing cycle of 60–90 min restricts the extent of raw material reactions. Crystalline phases reported in fast-fired raw glazes are typical for primary reactions between the raw materials [9]. The surface is often unmature and its chemical and mechanical properties are poorly understood.

In this work chemical durability, soiling and cleaning properties of fast-fired raw glazes were studied with the focus on phase composition and topography of the surface. Altogether more than 30 different compositions have been tested for the development of surface phase composition and chemical resistance. Soiling of selected surfaces has been performed by model soils typical for sanitary facilities, i.e. environments where glazes surfaces are commonly used. Chemical resistance has been tested with model detergents containing components typical for household chemicals.

2. Experimental

Experimental glazes were ball-milled of commercial grade raw materials of kaolin, feldspar,