Porcelain gres tiles with photocatalytic properties for a better environment

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Keywords: micro-sized-TiO_2, fired surface, photodegradation, self-cleaning, methylene blue, NOx

1 Introduction

Porcelain gres tiles are characterised by their very low water absorption rate of less than 0.5%, and are manufactured under high pressure by dry-pressing fine processed ceramic raw materials with large proportions of quartz, feldspar and other fluxes. Afterwards, the body of these materials is fired at high temperatures (1200 - 1300°C) in a roller kiln. The final material is characterized by lack of porosity, durability, high breaking and wear resistance properties and a complete frost resistance.

In the past decades porcelain gres tiles underwent significant transformations in terms of appearance and size. At the beginning of the industrial productions, porcelain gres tiles were considered as just a technical material characterized by strong resistance to both abrasion and acid attack, almost lack of porosity, but aesthetically not very beautiful. Today thanks to new industrial production methods, both properties and beauty of these materials completely fit the market requests. In particular, the possibility to prepare slabs of large sizes is the new frontier of the building materials.

Beside these noteworthy architectural features, new surface properties have been introduced in the last generation of these materials. The present paper reports the research at the base of a new kind of fired tiles able to carry out a specific antibacterial and self-cleaning action and to reduce polluting molecules thanks to its new photocatalytic properties due to the surface presence of photoactive micro-TiO_2.

2 Experimental

2.1 Preparation

Commercial tiles by GranitiFiandre SpA were covered at the surface with a mixture of pure anatase micro-TiO_2 (1077 by Kronos) and a commercial SiO_2-based compound. To ensure the requested product stability, at the end of the preparation procedure tiles were treated at high temperature (min 680°C) for 80 min and then brushed to remove the powder present at the surface and not completely stuck and that could alter (artificially increase) the photocatalytic results (samples name: White Ground Active (WGA)). For the sake of comparison, samples were also prepared with the same procedure but without adding the photoactive oxide into the SiO_2-based compound (samples name White Ground (WG)).

2.2 Characterization

Pure powder samples (TiO_2 and SiO_2-based compound) and both photoactive and non-photoactive tiles were fully characterized. Results are reported in [1].

Contact angle measurements were performed to evaluate the hydrophilicity degree of the material. Measurements of the contact angle values monitoring the degradation of an oleic acid film on the tiles, under UV light for 76 h, were also performed following the ISO 27448-1 rules.

2.3 Testing procedures

All the prepared samples were tested in both the liquid and gas phase.

Methylene blue was degraded in an aqueous solution that was in contact with the active surface by UV radiation, with light not capable of inducing the direct photolysis of the dye, with the overall result being the discoloration of the solution. The amount of dye remaining in the solution was determined at regular intervals during the UV-radiation period using UV/vis spectroscopy [2].

NO_x degradation in air was followed in a static experimental setup already described in [3]. Tests with an NO_x amount of 1000 ppb and lower were performed with the following conditions: RH: 50%, 20 W/m^2, $V_{reactor}$= 20 L

Nicotine degradation in air was performed in a static experimental setup already described in [4].

Self-cleaning tests on the tiles surface were performed leaving a round stain of a dye dissolved in suitable solvent. Rhodammine B and Erytrosin were chosen for the present investigation.

3 Results and Discussion

Commercial TiO_2 (1077 by Kronos) is an anatase pigment manufactured by the sulphate process, free of coarse particles by means of a special screening process [5] with a surface area of 11 m^2/g [1]. The choice of using a TiO_2 with a so large crystallites size is a specific requirement of the company to avoid possible release of nanoparticles in the environment so to protect both the workers in the factories and the public safety [6], even if a loss of TiO_2 from the fired silica surface is an extremely remote possibility.

SEM images of WGA samples show a very homogenous surface characterized by a surface amount of Ti of ca. 20%$_{wt}$ (EDX measurements) (Fig.1).

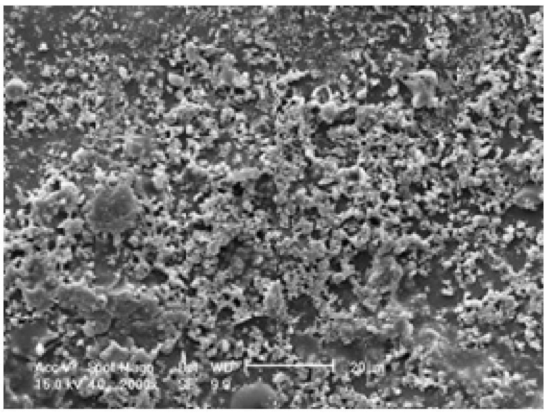

Fig. 1 – 2000x SEM image

The degradation of methylene blue in water was performed for 3 hours. The discoloration of the solution was visible at naked eye and a final conversion of 22.5% was calculated for WGAs, compared with a 1.8% for the non-photocatalytic WG tiles.

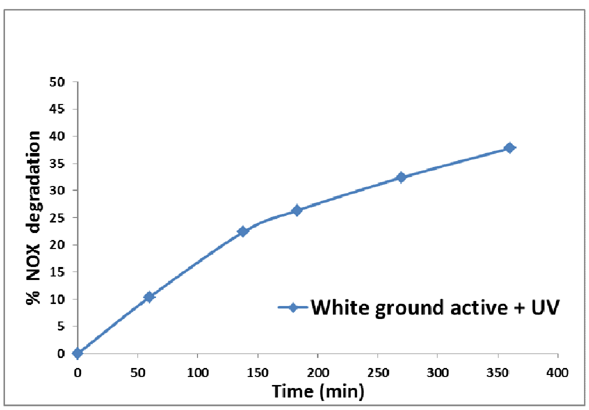

Fig. 2 – NOx degradation vs. time (6h)

Fig.2 shows the NOx degradation trend in 6 h. A final conversion of 38% was obtained starting with 1000 ppb. Further tests, performed with lower NOx amounts, suitably chosen in order to reproduce the alert values reported on the European Directive (2008-50-CE [7]), confirmed the photocatalytic efficiency of WGA especially in conditions of real pollution levels [1].

4 Conclusions

The preparation and characterization of photoactive tiles were described. These new materials show stable and specific antibacterial and self-cleaning actions as well as reproducible anti-pollutant properties. In this latter case, WGA samples show good degradation rates towards both NOx and complex molecules like nicotine.

The distinctiveness of the present materials is the use of micro-sized photoactive TiO_2 which guarantees both a satisfactory photocatalytic efficiency and a preventive safety towards the possible, even if remote, release of TiO_2 particles.

5 References

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