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Results of the research: Ceramic tiles with photocatalytic surface

In the frame of the research that Graniti Fiandre has committed to Centro Ceramico Bologna, it has been set up a product, ceramic tile, with surface photocatalytic properties, and the corresponding methodology for their production.
The photocatalytic activity, given to the ceramic tiles, is able:
- to degrade several different organic pollutants (such as hydrocarbons, VOCs) and inorganic pollutants, such as nitrogen oxides;
- to suppress different bacteria.

In the present research, a new methodology to prepare photocatalityc ceramic tiles, different from the ones already known, was set up. In particular the titania powder, used as photocatalyst, was not nanometric, but micrometric, in order to avoid any risk for human health, that could arise if rather sophisticated protection system are not used. Furthermore, the set up processing did not use sol-gel systems, for the difficulty to industrially control them, and for the potentially dangerous organic compounds emissions, during production. In the present research, the titania photocatalyst was made adhering to the ceramic surfaces by using an intermediate inorganic adhesive, directly applied on the ceramic surface.
The photocatalytic activity of the set up product has been evaluated by specific tests, in liquid and gas phases, and by bacterial resistance tests.
The following results have been achieved by measurements on a lot of ceramic tiles supplied by Granitifiandre and marked:
"***Extra White Naturale, as fired surface, 60x30cm, industrially produced in Castellarano (I) according to the Patent PCT/IB2009/006002***".

- Photocatalytic activity in liquid phase

The photocatalytic activity, of the set up ceramic samples, in liquid phase was evaluated by monitoring, in the time, the degradation of the organic compound, indigo carmine (IC), with a spectrophotometer (at the wavelength of 610nm). The ceramic samples were irradiated by a 9 W mercury vapour lamp (Philips PL-S 9W/08/2P, NL) with λ_{max} = 370 nm. The photodegradation index, η, was calculated following (1):

$$\eta(\%) = \frac{C_0 - C_s}{C_0} \times 100 \qquad (1)$$

where C_0 is the initial concentration of IC, 1ppm, and C_S is the concentration after a defined period of irradiation. The results of the photodegradation index, η, after 30 hours of irradiation, are reported in Table 1.

Table 1

	η %
Ceramic tile without photocatalyst	<10
Ceramic tile with photocatalyst	70

- Photocatalytic activity in gas phase

The photocatalytic tests in gas phase were carried out in accordance with the UNI-11247-2007 Standard. The variations in the concentration of nitrogen oxides were analysed using chemiluminescence measurements. The photocatalytic activity, A_F, expressed in m/h, was calculated following (2):

$$A_F = \frac{C_B - C_L}{C_B} \times \frac{F}{S} \times I \qquad (2)$$

where C_B and C_L, in ppm, are the concentrations of the nitrogen oxides after having reached a constant value in the dark and under irradiation, respectively, S is the area of the sample, in m^2, F is the flow of gas in m^3/h, and I is the dimensional intensity of the light flow, obtained by relating the experimentally measured intensity I' (expressed in W/m^2) to $1{,}000 W/m^2$, corresponding to approximately 100,000 Lux, i.e. the mean value that sunlight reaches at midday in the month of July (I =1,000/I'). The results of the photocatalytic tests in gas phase are shown in Table 2, in terms of removal of the NO_x (NO_2+NO), also the values for NO are reported. NO is a more reliable probe than NO_2, because its decrease is only due to the photocatalytic effect.

Table 2

	A_F, m/h	NO_x	NO
Ceramic sample without photocatalyst		23.3	31.4
Ceramic sample with photocatalyst		69.4	107.3

The fluxing gas contained 0.55ppm of NO_x (0.15ppm of NO_2 and 0.4ppm NO) with a flow of gas of 1,000 cm^3/min

- Bacterial resistance tests

The tests allowed to quantitatively evaluate the surviving, on the surface of the ceramic samples under irradiation, of bacteria such as *Escherichia coli* ATCC 25922. The number of living bacteria was counted, after 24 h of contact time under illumination by using a light source of 9 W mercury vapour lamp (Philips PL-S 9W/08/2P, NL) with λ_{max} = 370 nm. The survival rate, S, was obtained by comparing the number of living bacteria on the examined tile sample, Ne, with that of a conventional tile sample, Nc, following (3):

$$S = \frac{Ne}{Nc} \times 100 \qquad (3)$$

The results are shown in Table 3.

Table 3

	Survival, %
Ceramic tile without photocatalyst	100
Ceramic tile with photocatalyst	0

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The Director
(Prof. Ing. Giorgio Timellini)