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Micro-TiO_2 as a starting material for new photocatalytic tiles

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ABSTRACT

New industrially produced photocatalytic tiles provide not only good photocatalytic performance, but also meet standard requirements with respect to hardness, lack of porosity, vitrified surface, durability. These characteristics were obtained mixing the photocatalytic materials with a commercial SiO_2-based compound conventionally used to create vitrified surfaces. In the preparation, a commercial micro-TiO_2 was used to avoid the use of traditional nanomaterials in powder form. Anatase form is maintained even after thermal treatments at 680 °C, as confirmed by both band gap and XRPD measurements on the final material. Photocatalytic degradation tests performed in water and air using methylene blue and NO_x as a model pollutant, respectively, confirm the good performance of the tiles in both liquid and gas phase.

1. Introduction

Market consumption of nanomaterials is growing. In the field of construction materials, nano-sized TiO_2 is particularly common since it has been traditionally used as a white pigment.

Nowadays TiO_2 is being used in air purification devices and as a surface treatment and additive in ceramics, cement, transportation infrastructure and glass. These products are being used or evaluated for their depollution, self-cleaning, antifungal, and environmental improvement attributes [1]. Incorporation of nanophotocatalysts into cementitious materials has been an important achievement in the field of photocatalytic pollution mitigation [2].

The increased presence of nanomaterials in commercial products has raised a growing public debate on whether the environmental and social costs of nanotechnologies outweigh their numerous benefits [3]. Up to now, few studies have investigated the toxicological and environmental effects of direct and indirect exposure to nanomaterials and nanoparticulate and no clear guidelines exist to quantify these effects [4].

Although TiO_2 is chemically inert, nanoTiO_2 can cause negative health effects. Investigations of Trouiller et al. found that TiO_2 nanoparticles can induce genotoxicity, oxidative DNA damage, and inflammation in a mice model [5].

There are no specific regulations on nanoparticles, except existing regulations covering the same material in bulk form [6]. Difficulties abound in devising such regulations, beyond self-imposed regulations by responsible companies, because of the likelihood of different properties exhibited by any type of nanomaterial, which are tunable by changing their size, shape and surface characteristics [7].

To avoid such possible drawbacks, in the present paper a new generation of photocatalytic tiles were prepared starting from a commercial micro-sized TiO_2 in the anatase form. Physical–chemical properties of the tiles were correlated with photoactivity results, obtained both in water and air using methylene blue and NO_x as a model pollutant, respectively, and fully discussed.

2. Experimental study

2.1. Preparation of vitrified tiles

Commercially available white tiles by GranitiFiandre SpA (White Ground Active®) were covered at the surface with a mixture of micro-TiO_2 (Kronos 1077) and a commercial SiO_2-based compound prepared via ball–mill. To achieve the desired product stability, at the end of the preparation procedure tiles were treated at high temperature (680 °C) for 80 min and then brushed to remove the powder present at the surface and that could alter the photocatalytic results (sample name: White Ground Active (WGA)). Temperature was precisely chosen to maintain the anatase form of the semiconductor and allow the vitrification of the tiles surface. Tiles were also prepared with the same procedure but without adding the photoactive oxide into the SiO_2-based compound for the sake of comparison (sample name White Ground (WG)).

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