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Photocatalytic degradation of dyes in water with micro-sized TiO_2 as powder or coated on porcelain-grès tiles

Claudia L. Bianchi[a,*], Enrico Colombo[a], Sara Gatto[a], Marta Stucchi[a], Giuseppina Cerrato[b], Sara Morandi[b], Valentino Capucci[c]

[a] Università degli Studi di Milano, Dipartimento di Chimica & Consorzio INSTM-UdR, Milano, Italy
[b] Università degli Studi di Torino, Dipartimento di Chimica & NIS Centre of Excellence & Consorzio INSTM-UdR, Torino, Italy
[c] GranitiFiandre SpA, Castellarano, MO, Italy

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ABSTRACT

Some particular drawbacks due to the industrial use of nano-sized TiO_2 (safety, recovery) in photocatalytic processes for water remediation can be avoided choosing micro-sized TiO_2. Tests on both micro-sized TiO_2 powder and industrially prepared photocatalytic tiles, having the surface of porcelain-grès tiles hot-coated with the same photocatalyst, were performed. Good photocatalytic performance in the degradation of three organic dyes (rhodamine B, crystal violet and methylene blue) in water phase were achieved. Photocatalytic tiles can really represent a good alternative to TiO_2 suspensions and pave the way for the fully industrial use of photocatalysis in environmental remediation.

1. Introduction

Titanium dioxide (TiO_2) is worldwide considered as one of the best semiconductor to be used as photocatalyst for pollutants degradation. Exposition under UV light promotes redox reactions and charges separation that lead to oxidative processes as reported by Razavi et al. [1]. TiO_2 is often used in powdery form as nano-sized particles with high surface area, so as to enhance its photoactivity. Most of the literature reports consequently the use of nanometric TiO_2 materials for many purposes, from disinfection [2] and air purification [3] to decomposition of organic matter [4] or heavy loads metals in waste waters [5]. However, some recent papers have underlined the possible side-effects on human health due to both use and exposure to nanoparticles [6,7], as the ultra-small particles can penetrate inside human body from skin and nose especially when they are used in products like paints or simply cold-coated on materials surfaces for air purification and a loss of photoactive powder cannot be neglected.

Problems can be observed in liquid phase as well, where nano-sized powder can affect the catalyst recovering at the end of the reaction, hindering an industrial use of TiO_2 nanopowders, due to the extreme difficulty in the final filtering necessary to separate photocatalytic powder and the cleaned solution, as reported by Schulze et al. [8].

On this basis, a great attention is focused on the potential of TiO_2 micro-sized powders to be used as photocatalyst for the degradation of organic contaminants. Recent results for both NOx and VOC degradation in gas phase seem to be very promising [9] but no data are available for the degradation of pollutants in liquid phase yet.

Main target of the present work is to investigate the performance of a commercial micro-sized TiO_2 (1077 by Kronos) used as photocatalyst in the degradation of three different dyes (rhodamine B, crystal violet and methylene blue) in water. Micro-sized sample was used as received, so to compare the obtained results with the classical nano-sized commercial P25 by Evonik, always used as photocatalyst reference material.

Previously Marcos et al. [10] reported the deposition of TiO2 layers on common ceramic glazed tiles using the screen-printing process, which is a low cost and common technique used for decoration in the ceramic industry. Labrincha et al. [11] deposited several commercial titania powders by jet spray on ceramic tiles, then fired to stabilize the layers. In both cases a good activity of nano-sized TiO2 photocatalytic layers on ceramic tiles was demonstrated in the degradation of Orange II dye. In the present case, micro-sized 1077 was industrially hot-coated at the surface of a porcelain-grès tile (Orosei Active™). Tests using photoactive tiles were carried out to verify the efficacy of the coated catalyst to

* Corresponding author at: Università degli Studi di Milano, Dipartimento di Chimica, Via Golgi 19, 20133, Milano, Italy. Tel.: +39 0250314253.
E-mail address: Claudia.bianchi@unimi.it (C.L. Bianchi).

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