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Photocatalytic degradation of acetone, acetaldehyde and toluene in gas-phase: Comparison between nano and micro-sized TiO_2

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ABSTRACT

Volatile organic compounds (VOCs) are prevalent components of indoor air pollution. The photocatalytic degradation could be an interesting method to degrade them.

This paper reports the photoactivity study of two classical nano-sized and two micro-sized commercial TiO_2 powdered samples. Photocatalytic tests have been performed following the degradation of acetone, acetaldehyde and toluene in the gas phase under UV light. An accurate study of the intermediate oxidation products was performed. XPS and FTIR analyses allowed to highlight the relationship between TiO_2 surface properties and reactivity toward VOCs explaining the different behavior of the photocatalyst in case of hydrophilic and hydrophobic pollutants.

1. Introduction

Past and recent literature is full of new synthesis routes to prepare tailored nano-TiO_2 in order to enhance the photocatalytic efficiency of such material [1–3]. The aim is to reduce the particles dimension toward the very small nano-sized (few nanometers), to allow the preparation of very photoactive TiO_2 with complex and tailored shapes and also to obtain a powdered sample with particles all of the same size avoiding the mixture of big size and ultrafine.

However this scientific run does not take into account the possibility that nano-sized materials could be dangerous for the human health. Many papers were recently published on this topic [4–7]. Brun et al. showed the in vitro evidence of disruption of the blood-brain barrier function after acute and repeated/long-term exposure to TiO_2 nanoparticles [8]. Green et al. noted that the scientific community is faced with the challenge of developing new risk assessment methodologies capable of identifying exposure characteristics and adverse effects of engineered nanoparticles [9].

It is well know that TiO_2 is not toxic by its chemical nature and it is also true that nanoparticles tend to aggregate in some environments, including biological environment, to form clusters of a bigger size [10]. The main question is if it is necessary the use of nano-sized particles in an exclusive way. Kwon et al. stated that nanocatalysts having small particle size, high surface area, and a high density of surface coordination unsaturated sites offer improved catalytic performance over microscale catalysts but this does not imply the impossibility *a priori* to use these latter in selected conditions [11].

The main target of the present paper is to identify possible features of large-sized TiO_2 particles so to exclude *a priori* their use in photocatalysis or, vice versa, to highlight similarities between nano and larger-sized samples to identify a possible role of larger size particles especially in formulations. Therefore, the photocatalytic behavior of four commercial powdered TiO_2 was compared. Two samples were well-known benchmark TiO_2 chosen among all the commercially available nano-sized photoactive TiO_2. The other two materials were chosen among the commercial

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