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Research Article

Micro-sized TiO_2 catalyst in powder form and as coating on porcelain grès tile for the photodegradation of phenol as model pollutant for water phase

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Abstract

In presence of TiO_2 and irradiation, phenol can be degraded by hydroxyl radicals or directly via photogenerated carriers, as occurs in photocalytic processes. In this work a commercial micro-sized TiO_2 sample in powder form and industrially coated on porcelain grès tiles were tested in water remediation with phenol as model molecule. Firstly, we investigated the behaviour of the commercial micro-sized TiO_2 comparing the results with reference nano-sized catalyst in the phenol photodegradation process, widely studied in the last decades. Following the phenol concentration as well as the main intermediates formation over time by HPLC analysis, and the mineralization by TOC analysis, we presented results about the photocatalytic behaviour in terms of adsorption, by-products formation, and reaction rate at different phenol starting concentrations. In particular, with the photocatalytic tiles, phenol photodegradation percentage is almost the same at 15 ad 25 ppm (78% and 73% respectively), and much lower at 50 ppm (46%) after 6 hours of test.

Introduction

Phenol and phenolic derivatives are the major pollutants of the aquatic environment because of their widespread use [1,2]. The European Union (EU) has already classified several of them as priority contaminants, and the 80/778/EC directive certifies a maximum concentration of 0.5 µg/L for total phenols in drinking water [3]. Phenols are known as recalcitrant organic compounds or persistent organic pollutants (POPs), firstly because they show a great chemical stability and secondly because the degradation of the aromatic ring requires a strong oxidation power to decompose it in simpler mineralized products [4,5]. The traditional physical techniques such as adsorption on activate carbon, ultrafiltration, reverse osmosis, coagulation by chemical agents, and ion exchange on synthetic adsorption resins are only able to transfer organic compounds from water to another phase, thus creating secondary pollution [6-9].

Photodegradation using semiconductor materials was found to be an effective Advanced Oxidation Process (AOP); the mechanism in water phase is widely studied using different types of photocatalysts in variable experimental conditions, with the aim to investigate the influence of various parameters, such as specific surface area, crystal structure, and porosity, as well as the impact of different classes of organic compounds, the amount of the catalyst loading, the initial pH, the energy source, and the starting pollutant concentration on the efficiency of the photo-oxidation [10,11]. Photocatalysis is able to induce total oxidation reactions in most cases, leading the most part of the elements to their higher oxidation state, namely CO_2. The UV irradiation on a semiconductor oxide in aqueous phase produces charge carriers generation at the surface, electrons e^- and holes h^+, which have sufficient oxidizing power to react with both hydroxide ions and water molecules, producing hydroxyl radicals [12].

Titanium dioxide (TiO_2) is considered one of the best semiconductor as photocatalyst, owing its outstanding features including photocatalytic activity, inertness, physical and chemical stability, full availability even as commercial product, and low cost. In spite of these advantages, many authors evidenced serious problems connected with the use of nano-sized materials: on one hand difficulty on sample handling, separation and collection, on the other hand possible side-effects on human health [13-17].

Recently, some papers reported the behaviour of photocatalytic films of TiO_2 immobilized onto tiles for the degradation of different organic molecules, but in all cases the authors made use of nano-TiO_2

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