Applied Catalysis A: General 504 (2015) 130–142

Contents lists available at ScienceDirect

Applied Catalysis A: General

journal homepage: www.elsevier.com/locate/apcata

Sol–gel iron-doped TiO_2 nanopowders with photocatalytic activity

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ARTICLE INFO

Article history:
Received 25 August 2014
Received in revised form 13 October 2014
Accepted 18 October 2014
Available online 26 October 2014

Keywords:
Sol–gel nanopowders
Titanium dioxide
Fe-doped TiO_2
Structural study
Nitrobenzene photodegradation

ABSTRACT

The aim of the present work was to establish the influence of the Fe-dopant on the structure and photocatalytic properties of the sol–gel TiO_2 nanopowders. The relationship between the synthesis conditions and the properties of titania nanosized materials, such as thermal stability, phase composition, crystallinity, morphology and size of particles was investigated. Undoped, 0.5, 1, 2 and 5 wt% Fe-doped TiO_2 samples have been prepared and structurally characterized by the XRD method. Lattice parameters, crystallite sizes, internal strains, as a measure of structural disorder, were determined. X-ray photoelectron spectroscopy (XPS) and magnetic measurements completed the structural data study. The acceptance of the dopant by the titania lattice was proved by the XRD measurements and the positive values of the magnetic susceptibilities. Its addition is responsible for supplementary defects in the crystalline lattice (paramagnetic behaviour). The dopant was present in the low spin state (LS) of Fe^{3+} in the sample with 0.5 wt% iron concentration and in the high spin state (HS) in the other samples. It influenced the photocatalytic properties. The photocatalytic activity of the prepared nanopowders has been tested in the degradation of nitrobenzene from water, as a first mention in literature. The sample with 0.5 wt% Fe dopant concentration thermally treated at 400 °C presented the best photocatalytic activity.

1. Introduction

The photochemistry of nano semiconductor particles has been one of the fastest growing research areas in the physical chemistry field in the last time. The semiconductor assisted photocatalysis is considered an economic and environmental friendly water treatment technology in order to efficiently remove the organic pollutants from wastewaters [1]. The toxic and refractory pollutants like nitroaromatic compounds represent a special class of pollutants. Their variety (nitrobenzenes, nitrophenols, nitrotoluenes), toxicity and persistence directly affect the ecosystems health and the human beings by the contamination of surface and ground water supplies [2–4]. The effective removal of nitroaromatic pollutants from wastewaters has become a necessity and a duty, in order to assure a good management of water resources.

It is well known that among the various photocatalysts, titania occupies a very important place, due to its high photocatalytic activity, excellent functionality, high chemical stability, thermal stability and non-toxicity. In search for a photocatalyst with optimal features, titania remains a benchmark against which any alternative photocatalyst must be compared. Enormous studies have been focused to the research of TiO_2 material, which led to many promising applications in different fields, ranging from optics to gas sensors via solar energy [5–9]. These applications can be roughly divided into "energy" and "environmental" categories, many of which depending not only on the properties of the TiO_2 material itself but also on the modifications of the TiO_2 material host and of the interactions of TiO_2 materials with the environment [10,11]. Recently, titanium dioxide has been extensively used for the decomposition and finally mineralization of environmental pollutants as a possible alternative to conventional water treatment technologies [12–15].

Generally, doping of TiO_2 with transition metal cations was reported as a good tool to improve photocatalytic properties and for enhancement of visible light response [16–19]. The selection of synthesis technique constitutes an important factor for the

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http://dx.doi.org/10.1016/j.apcata.2014.10.031
0926-860X/