Optik 144 (2017) 397–405

Contents lists available at ScienceDirect

Optik

journal homepage: www.elsevier.de/ijleo

Original research article

Fe_2O_4/ZnO-nanowires synthesis by dip-coating for Orange II-dye photodegradation

A. Benaboud[a,*], M. Zaabat[a], M.S. Aida[b,*], B. Boudine[c], S. Benzitouni[a], T. Saidani[a]

[a] Laboratoire des Composants Actifs et Matériaux (LCAM), Université Larbi Ben M'hidi, Oum El Bouaghi 04000, Algérie
[b] Department of physics faculty of sciences King Abdulaziz, University Djeddah, Saudi Arabia
[c] Laboratoire de Cristallographie, Université de Constantine 1, Constantine 25000, Algérie

ARTICLE INFO

Article history:
Received 18 March 2017
Received in revised form 11 May 2017
Accepted 26 June 2017

Keywords:
Nanowires
Photocatalytic
Dip-coating

ABSTRACT

Fe-doped ZnO nanowires (FZO-NWs) in microfibrous regime were successfully synthesized via a facile dip −coating method. The post deposited films were characterized by X-Ray diffraction (XRD) analysis, scanning electron microscope (SEM), Atomic Force microscope (AFM) and UV–vis spectrophotometer. Besides this, their photocatalytic activities were investigated through orange II dye (O-II) degradation. XRD analysis showed that FZO-NWs have been attached to the bulk wurtzite ZnO and $ZnFe_2O_4$ crystalline phases. SEM images clearly show the perfect hexagonal geometry of NWs in micro fibrous regime, with a width size ranged from 0.75 to 3.93 μm. The RMS surface roughness are varied in a wide range (7.57–4.,9 nm). The UV–vis absorption threshold is shifted from 3.25 eV to 3.15 eV. The recorded data demonstrated that FZO possessed significant photocatalytic activity. Especially, 5% Fe-ZnO-NWs gave the best degree of decolarization 42% then pure ZnO 25% within 350 min.

1. Introduction

During the last decade, most of research has focused on a new class of dye degradation techniques such as advanced oxidation processes [1–5], biological treatments [6] and heterogeneous photocatalysis using heterojunction semiconductors [7–11] as well as doped and codoped semiconductors [12–15]. These technologies have already shown their potential application in the treatment of toxic organic polluants and "biologically recalcitrant". Recently, all works have been focused on the development of photocatalytic activities of heterogeneous-system that enhances photocatalytic response and increase charge separation such as Cu2O/BiOCl [8], Fe_2O_3/TiO_2 [9], Cu_9-Mg_7A_5-LDA [7], Cu_2O/TiO_2 [16], Ag_2S/ZnS [17] and $CuBi_2O_4/SnO_2$ [18]. Among of all metal oxides, ZnO as a photocatalyst shows high performance in degradation of polluants because of its low cost, high photocatalytic activity and no-toxic nature. To improve the photocatalytic efficiency of ZnO, various dopants have been adopted to extend the photoresponse of ZnO into UV/Visible-irradiation and suppression of electron/hole pair recombination such as a works [19,20]. The iron dopant as electron donors and donor states (oxygen vacancies/defect) act like a sink to electron-hole pair recombination that results a higher production of $HO^{\bullet}$ radicals leads to

* Corresponding authors.
E-mail addresses: ah_benaboud@yahoo.com (A. Benaboud), aida_salah2@yahoo.fr (M.S. Aida).

http://dx.doi.org/10.1016/j.ijleo.2017.06.108
0030-4026/

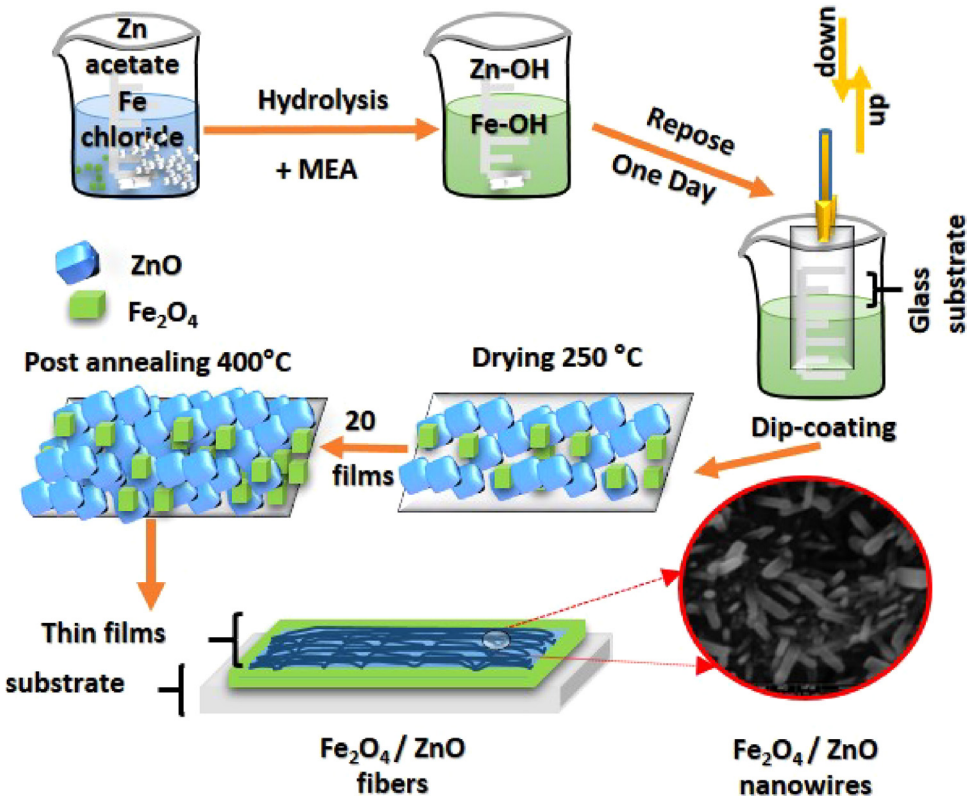

Fig.1. Schematic view of the procedure for stepwise fabrication of FZO-NWs in fibrous regime; the sol–gel solution preparation, Dip-coating the glass substrate into a solution to fabricate the thin film, and finally annealing treatment.

greater decomposition mechanisms. In other hand, the Fe dopant used to enhance the texture properties of ZnO. Therefore, the doping effect of Fe on photocatalytic activity of ZnO was investigated.

In this study, Fe_2O_4/ZnO-nanowires were grown successfully on glass substrate without any additional seed layer as well as pressure and temperature control. It is only fabricated by a simple, rapid and inexpensive dip-coating technique. The effect of Fe-doping concentration on the ZnO-photocatalytic activities has been investigated.

2. Materials and methods

2.1. Materials

Zinc acetate dehydrate, ACS reagent, ≥ 98% | Zn $(CH_3COO)_2$, $2H_2O$| Sigma-Aldrich, Iron (III) chloride anhydrous, reagent grade, ≥ 97% |$FeCl_3$, H_2O| Sigma-Aldrich, absolute ethanol ≥ 99.8% | C_2H_5OH | Sigma-Aldrich and Monoethanolamine ≥ 99% | $NH_2CH_2CH_2OH$| Sigma-Aldrich were used for preparing Fe-doped ZnO thin films in order to degrade of an azo-dye Orange II [4-{hydroxyl-1-naphthylazo, 99%, MERCK].

2.2. Preparation of Fe-doped ZnO thin films

Fe-doped ZnO thin films (FZO) were prepared by sol-gel dip-coating method using materials previously mentioned [21,22]. These materials were dissolved in absolute ethanol with a total molarity of 0.3 M. Monoethanolamine (MEA) was added to the mixture as a stabilizer with molar ratio of 0.85. The mixture was stirred at 60 °C for 2 h. The glass substrates were cleaned in an ultrasonic bath in acetone, ethanol and distilled water successively. The layers were deposited by immersing a substrate in the solution using a computer controlled dip-coater (KSVDCX2) Instrument with a pulling speed of 0.41 cm s^{-1}, and then dried at high temperature (250 °C) for 3 min in an electric furnace (Nabertherm B-180). The procedure from immersing to drying was repeated 20 times. The films were then annealed at 400 °C for 2 h. To investigate the effect of iron-doping concentration on the photocatalytic activities of ZnO thin films, zinc oxide was fabricated at several contents of Fe: (0, 1, 3, 5 wt%), in the following their samples are labeled ZO, FZO1, FZO3 and FZO5, respectively. Fig. 1 shows the procedure for stepwise fabrication of FZO—NWs in fibrous regime (Fig. 2).