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Enhanced photocatalytic behaviour of synthesized nickel oxide nanoparticles on Fluorescein under different irradiations

K. Perumal Raj[a,*], V. Thangaraj[a], A.P. Uthirakumar[b]

[a] Department of Chemistry Anna University (BIT Campus), Tiruchirappali, India
[b] Nano-COED, SONA College of Technology, Salem, India

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ABSTRACT

The NiO nanoparticles were synthesized by the solution method and its enhanced photo catalytic activity on Fluorescein, a synthetic dye, was studied. The as synthesized nanoparticles were characterized by the various characterization techniques like powder-X-ray diffraction (XRD), scanning electron microscopy (SEM) and Transmission electron microscopy (TEM) analysis. The degradation of Fluorescein under Sun light, UV and CFL irradiation was evaluated. From the results it was found that the synthesized NiO nanoparticles exhibited higher photo catalytic activity under Sun light and then the Compact Fluorescent Light (CFL) irradiation.

1. Introduction

Recently a number of research works going on for the elimination of synthetic organic dyes in contaminated water using photo catalysts [1–3].The metal oxides are act as efficient photo catalysts and are used for the degradation of synthetic dyes under different irradiations [4,5].

The removal of organic dye pollutants in waste water is done effectively by using the photocatalytic degradation techniques because of its advantages such as eco friendly, low cast and simple procedure. In some research works the metal oxides have been used as photo catalysts for water splitting and photo degradation of organic dyes [6–8].

Nano scale NiO have specific magnetic, catalytic and electronic properties [9–11]. Further NiO nanoparticles have some peculiar applications like gas sensor, semiconductor, environmental remediation etc., [12–14]. The nano scale NiO has potent photo catalytic activities for the degradation of organic dyes [15]; therefore the synthesis of NiO has been receiving considerable attention during the past decades.

Several synthetic routes have been cited in the literature for the synthesis of NiO in the nano scale. The technically assisted methods, solvothermal methods and simple methods such as Sol-Gel processes, Chemical routes have been reported. The NiO nanomaterials are synthesized by using a simple solution method [16]. In this research work the NiO nanoparticles were synthesized by using solution method and the growth is assisted with some organic solvents.

Fluorescein is an Organic dye appears yellow–green in colour (Fig. 1). This phthalic indicator dye is also called by the names Resorcinolphthalein; Solvent Yellow. Fluorescein sodium absorbs blue light, with peak excitation occurring at wavelengths between 465 and 490 nm.

The fluorescent properties of this dye have made it in useful in a variety of industrial, scientific, military, and medical applications. Fluorescein sodium was the first fluorescent dye used for water tracing purposes [17]. Fluorescein is particularly valuable as an assessment tool in clinical studies of dry eye is also used extensively in photographic retinal vasculature imaging monitoring corneal epithelial defects, corneal ulcers [18]. Hence this work focused on the photo degradation of Fluorescein in the presence of as synthesized NiO nanoparticles.

2. Materials and methods

2.1. Synthesis of organic solvent assisted NiO nano particles

The chemicals used for this synthetic work were of analytical grade; hence they were used as received. Nickel sulphate ($NiSO_4$) was used as the starting material for the preparation of Ni precursor material. It was dissolved in double distilled (DD) water and Ammonia (NH_3, 18%) solution was added, drop wise, until the formation of a pale green precipitate. The precipitate was completely dissolved by further addition of ammonia solution; At pH 10.2, a

* Corresponding author. Tel.: +91 8122179949.
E-mail address: perumalrajk@gmail.com (K. Perumal Raj).

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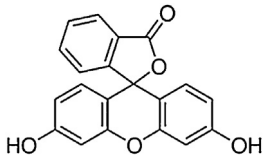

Fig. 1. Fluorescein.

clear, blue coloured, solution was obtained. The colour change was due to the formation of the aqueous Nickel-ammonia complex ion ($[Ni(NH_3)_4]^{2+}$).

The Ni-ammonium complex ion solution (clear blue coloured solution) was used as the precursor for the Nickel source. Two parts of this solution were diluted with one part of ethanol, the organic solvent. The content was stirred by a magnetic stirrer for about 5 minutes and kept in a water bath at 50 °C for 26 h. Pale green coloured material were collected by filtration and washed with DD water twice and finally with alcohol. The resulting material was heated in a muffle furnace for 300 °C and hence the NiO nanoparticles are formed. The final product was named as NiO–Et. Here, the Et represents ethanol, the organic solvent assisted the growth of the NiO nano particles. The same procedure was carried out for the synthesis of NiO–Met, where Met is methanol. A standard (NiO–std) was also synthesized without the addition of the organic solvent.

2.2. Degradation study on synthetic dye

The photo catalytic degradation study was carried out on a synthetic organic dye, namely, Fluorescein, using the synthesized NiO nanoparticles under Sun light, Ultra Violet (UV) and Compact Fluorescent Lamp (CFL) irradiation. The dye solution in DD water (10^{-4} M) was mixed with 10 ml of 1 wt% of NiO nanoparticles and stirred in a magnetic stirrer for one hour in a dark room. The dye molecules were absorbed by the NiO nanoparticles UV lamp was used for the UV irradiation for the photo catalytic activity study. Aliquot samples were collected at different time intervals and the photo catalytic degradation was noted. The same procedure was performed under CFL irradiation and under Sun light.

2.3. Characterization of the synthesized nanoparticles

By using an array of techniques the as synthesized NiO nanoparticles were characterized. The powder X-ray diffraction (XRD) of the samples was obtained with a Rigaku powder X-ray diffractometer. [Cu-*K*α ($\lambda = 1.5406$ Å). The size of the particle was calculated by the Scherer formula. The surface morphologies of the as synthesized NiO nanoparticles were analyzed by Scanning Electron Microscopy (SEM, Hitachi S-4700) and Transition Electron Microscopy(TEM, JEOL-2010).The UV-Visible spectra were measured by Bio-Spectrometer (UV-ELCO Bl-198) for the Photo catalytic degradation study.

3. Results and discussion

The as synthesized NiO nanoparticles were characterized and the results were discussed. The powder X-Ray diffraction study exhibit the formation of NiO nanoparticles. The XRD pattern of the NiO nanoparticles was given in Fig. 2.The XRD data are well correlated with the standard (JCPDS file No:73-1519). The peaks revealed that the solvent assisted growth of NiO nanoparticles are nanocrystalline in nature and are perfect when compared to that of the NiO nanoparticles without the assistance of the organic solvent i.e., direct growth. The Scherrer formula was used to calculate the particle size.

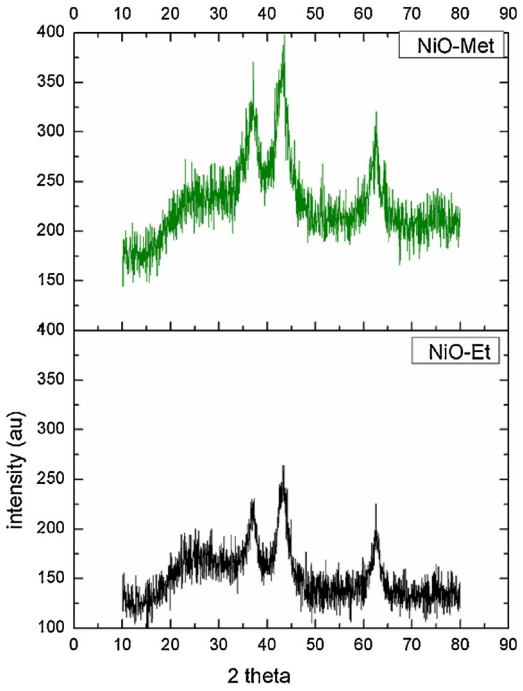

Fig. 2. XRD pattern of synthesized NiO.

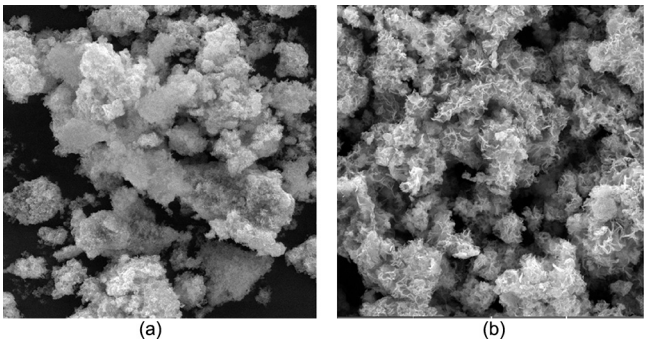

Fig. 3. (a) SEM image of NiO (Direct Growth). (b) SEM image of NiO (Organic solvent assisted growth).

Fig. 3a and b correspond to the SEM images recorded for the NiO-Et nanoparticles by the solution method without organic solvent and with the organic solvent respectively. In the absence of ethanol, the organic solvent, the shape of the NiO nanoparticles is not clearly found in its morphology (Fig. 3a); whereas in the presence of organic solvent a regularized pattern is noted (Fig. 3b).

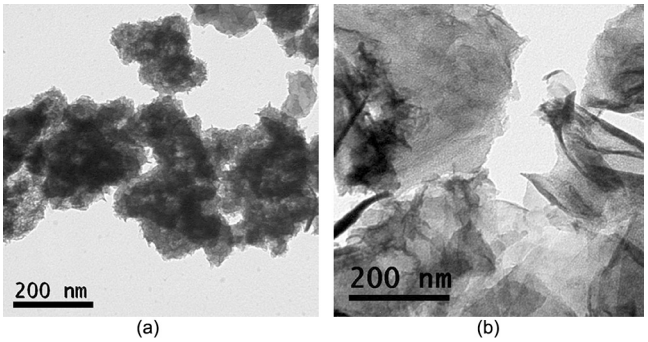

Fig. 4. (a) TEM image of NiO (Direct Growth). (b) TEM image of NiO (Organic solvent assisted growth).