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Research Article

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Fast and novel synthesis of NiO cabbage-like in water using microwave irradiation

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ABSTRACT

NiO with Cabbage-Like morphology were prepared by microwave irradiation using Ni (II) acetate and acetyl acetone (acac) as the template and water as solvent. The nanotubes of NiO with structure were characterized by X-ray powder diffraction (XRD), scanning electron microscopy (SEM), and FTIR Spectroscopy.

Keywords: NiO, Nanotubes, Cabbage-Like morphology, Microwave irradiation.

INTRODUCTION

Nickel oxide (NiO) is a p-type oxide semiconductor with a wide band gap (3.6−4.0 eV) and ~1.8 eV conduction band energy [1-2] which has been considered as a promising materials for optical, electronic and catalytic applications. NiO nanoparticles also may have many applications such as in the manufacture of super paramagnetic materials, p-type transparent conducting films, gas sensors, catalyst, alkaline batteries cathode, dye-sensitized solar cells, and solid oxide fuel cells anode [3–6].

Therefore, it is very important to develop methods for the synthesis of nickel oxide nanoparticles in which the particle size and the crystal structure of the products can be controlled. There are many different methods used for the synthesis of nickel oxide nanoparticles with different morphologies such as; ultrasonic radiation, hydrothermal synthesis, carbonyl method [7], laser chemical method, pyrolysis by microwave [8-9], sol-gel method, precipitation-calcinations, micro emulsion method [10], anodic arch plasma method [11], thermal deposition method and so on as discussed elsewhere [12].

In this paper, we report a simple and novel method for the preparation of NiO Cabbage-Like morphology by using microwave irradiation. It was found that this method is fast, mild, energy-efficient and environmentally friendly rout to produce NiO nano particles.

EXPERIMENTAL SECTION

All chemicals (analytical grade) are purchased from Merck and used as received without further purification.

2.1. Instrumentation

A microwave oven with 1000 W power (Butane) was used. Powder X-ray diffraction (XRD) patterns of prepared NiO were recorded by diffract meter (SEIFERT PTS 3003) using a Cu Kα radiation (λ=1.54Å). The FTIR spectra

were obtained on KBr pellets using a Bruker FTIR spectrometer (Tensor27). The morphology was examined by a (Philips XL30) scanning electron microscope (SEM).

2.2 Preparation of NiO Nanotubes

In a typical procedure, amount aqueous solution of Ni (II) acetate was mixed with 25 ml aqueous solution of 0.4 M sodium hydroxide. After stirring for several minutes, a aqueous solution of acetyl acetone (acac) was added to the reaction mixture. Finally, the mixture was placed under microwave irradiation (60% power) for 10 minutes. The solid product was filtered, washed with distilled water and dried in air at room temperature. It was then calcined at 400°C for4 h.

RESULTS AND DISCUSSION

3.1. XRD Analysis

Figure 1 Shows the XRD pattern of NiO nanostructures. The XRD pattern exhibits prominent peaks at 37.3°, 43.3°, and 63°which indexed as (111), (200), and (220) respectively and represents face-centered cubic (FCC)crystalline structure of nickel oxide. All these diffraction peaks, not only in peak position but also in their relative intensity, are absolutely matched with the standard spectrum (JCPDS, No. 04-0835) [13].

3.2.SEM Characterization

The SEM of NiO produced by microwave irradiation is shown in Figure2. As seen, nano tube structures exhibit uniform morphology with 40–60 nm diameters and a maximal length of 600nm which have many junctions and have created cabbage-like collections.

3.3. FTIR Spectroscopy

The FTIR spectrum of NiO in KBr matrix is shown in Fig.3. There is a broad band with very low intensity at 3493 cm^{-1} corresponding to the vibration mode of water OH group indicating the presence of small amount of water adsorbed on the Ni surface. The band at 1600 cm^{-1} is due to the OH bending of water. A strong band at 1000 cm^{-1} is attributed to the Ni-O stretching band which is consistent with that reported before [14].

3.4. Possible growth mechanism for NiO nanotubes

The chemical reaction between nickel acetate and NaOH is as follows:

$Ni(CH_3COO)_2 + 2\ NaOH \rightarrow Ni(OH)_2 + CH_3COONa$

Nickel hydroxide decomposes by microwave irradiation to nickel oxide as:

$Ni(OH)_2 \rightarrow NiO + H_2O$

As for cabbage-like NiO nanostructures, acac plays an important role in nucleation and growth of NiO nano tubes. In alkaline solution, $Ni(OH)_2$ can quickly dehydrate to give birth to large quantities of NiO nuclei. As described in our previous work, the presence of templates, such as acac, leads to oriented growth of nano rods (along c-axis) [15].

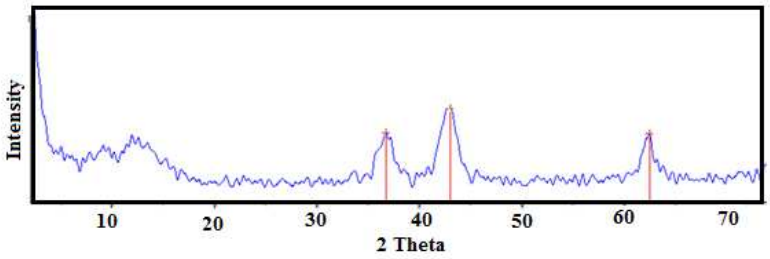

Fig.1.The XRD pattern for the NiO nano particles

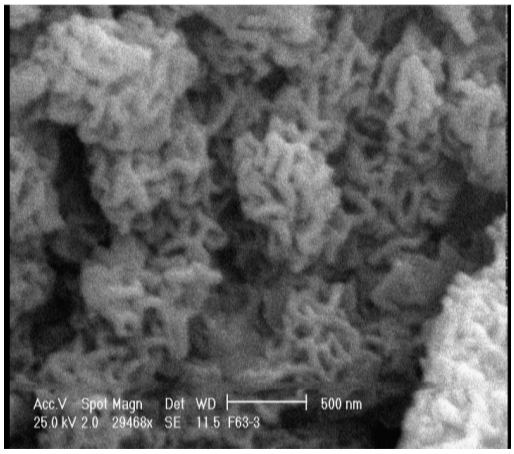

Fig.2. SEM image of NiOCabbage-Like

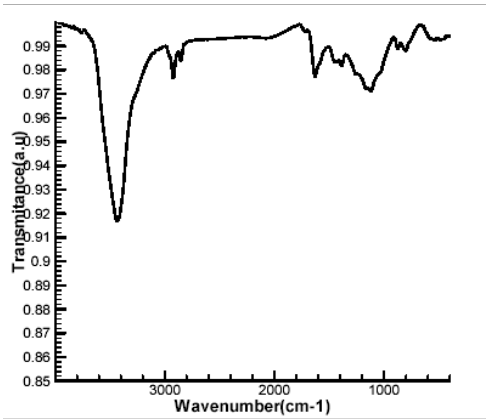

Fig.3. FTIR Spectrum of NiO

CONCLUSION

Compared to the other methods, NiO nano particles with cabbage like morphology were prepared using microwave irradiation as an easy and very fast method. XRD results showed that the obtained NiO nano particles were composed offace-centered cubic (FCC) crystalline structure with very good crystallinity. SEM confirmed that tubes were about 60 nm in outer diameter and unique cabbage-like morphology. The FTIR spectrum confirmed the presence of NiO nano particles.

This simple, novel and cost effective synthesis method will be useful for industries for the preparation of nickel oxide nanosized particles.

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