SYNTHESIS AND CHARACTERIZATION OF NICKEL OXIDE NANOPARTICLES WITH WIDE BAND GAP ENERGY PREPARED VIA CHEMICAL PRECIPITATION METHOD

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A B S T R A C T

Nickel oxide (NiO) nanoparticles were successfully synthesized by the reaction of nickel Carbonate hexahydrate ($NiCo_3.6H_2O$) used as precursor with sodium hydroxide at room temperature via Chemical precipitation method. Characterization of NiO nanoparticles were investigated by transmission electron microscopy (TEM), Fourier Transform Infrared spectroscopy (FTIR) and UV-visible spectrophotometer. The surface morphological study from TEM depicted spherical particles with formation of clusters. The sharp peaks in FTIR spectrum determined the purity of NiO nanoparticles. The broad band at 3394 cm^{-1} is assigned to the hydrogen bonded water molecules. UV-visible spectrophotometry showed the strong absorption peak at 266nm corresponds to the formation of nickel oxide nanoparticles. The wide range of band gap energy with value of 4.6eV for NiO nanoparticles was calculated.

Keywords: NiO nanoparticles, Chemical precipitation method, Optical properties, Band gap energies

1.Introduction

Nickel (II) oxide is a notable and well-studied material among various transition metal oxides because of its unique advantage in terms of properties and applications. It has attracted increasing attention owing to potential use in a variety of applications such as solar energy conversion, non-linear optics, varistors, pigments, gas sensors, cosmetics catalysis, battery anodes, electrochromic films and magnetic materials [1-9]. NiO semiconductor becomes an interesting material in the new area of research. Because of the quantum size effect, volume effect and the macroscopic quantum tunnel effect, nanocrystalline NiO is expected to possess many improved and advanced properties than those of bulk NiO particles. NiO is an antiferromagnetic transition metal oxide which is considered to be a semiconductor with p-type conductivity and band gap 3.51eV [10]. Various methods like mechano-chemical processing, metal alkoxide hydrolysis, nonhydrolytic sol–gel reaction process, non-aqueous synthesis and salt-assisted aerosol decomposition, chemical precipitation have been used to synthesize nickel oxide [11-14]. Among these methods chemical precipitation method is most promising method to prepare NiO nanoparticles. Furthermore, the products formed are poorly crystalline and exhibit broad particle size distribution. The aim of this study was to synthesize nickel oxide of low dimension and investigation of morphological and optical properties on the particle size.

2.Experimental

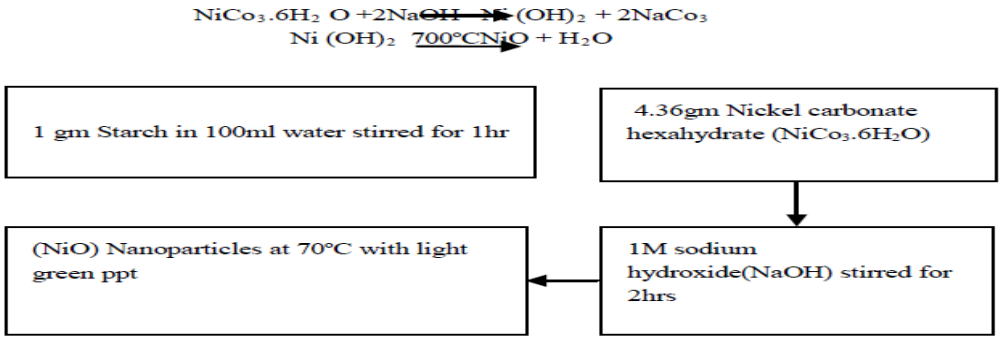
2.1 Chemicals

All chemicals used in this experiment were of reagent grade and used without any further purification. Nickel carbonate hexahydrate ($NiCo_3.6H_2O$) was purchased from Merck, sodium hydroxide (NaOH) was purchased from Sigma-Aldrich. Ethyl alcohol and acetone were received from Merck. All solutions were prepared with deionized water.

2.2 Synthesis of NiO Nanoparticles

Nickel oxide (NiO) nanoparticles were prepared by the simple approach of chemical

precipitation method in which, 1gm starch solution prepared in 100ml distilled water was added in 0.1M nickel carbonate hexahydrate ($NiCo_3.6H_2O$) solution and the mixture was stirred at room temperature for 1 h. Then 1M sodium hydroxide (NaOH) was added drop wise in the solution under constant stirring for 2h. After complete addition of sodium hydroxide, the solution with light green ppt was filtered using membrane filtration assembly and washed with deionized water and ethanol to remove the impurities and then dried at 70°C in hot air oven [15]. Dried sample was treated at different temperatures in order to maintain the stability of compound. The color of the sample was changed from green to faint gray at 100°C to 700°C. So, nanoparticles of NiO were fabricated by chemical reaction as follows:



Scheme1. Schematic presentation of NiO nanoparticles

3.Characterization

Transmission electron microscopy image was obtained using Jeol/JEM-2100 TEM with resolution 2.3Å. FTIR spectra were performed on Thermo Nicolet, FTIR-370A Spectrophotometer in the wavelength range of 400–4000cm^{-1}. The optical absorption spectra were carried out using UV-5000 double beam spectrophotometer.

3.1 Results and discussion

TEM analysis was carried out to confirm the actual size of the particles, their growth pattern and the distribution of the crystallites. TEM pictograph was used for the morphological study of nanoparticles of NiO as shown in "Fig. 1". This analysis shows high homogeneity emerged in the sample surface at 700°C temperature. The morphology of the NiO particles shows the spherical shape with less agglomeration. The average size of the NiO nanoparticles observed from transmission electron microscopy image is found to be dimensions about 10 nm [16-17].

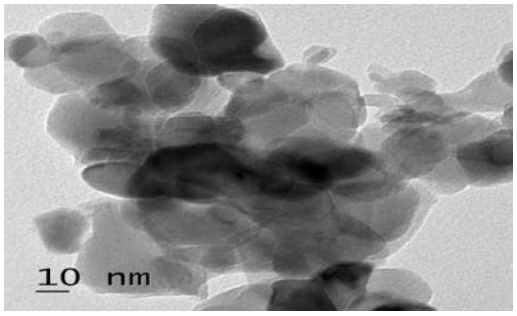


Fig.1-TEM image of NiO

"Fig. 2", shows the FT-IR spectra of NiO nanoparticles. After calcinations the FT-IR Spectra of NiO nanoparticles shows strong band at 428 cm^{-1} corresponds to the vibration of Ni-O bond. The broad absorption band centered at 3394 cm^{-1} is attributable to the band O–H antisymmetric stretching vibrations, due to the fact that the calcined powders tend to physically absorb water. The absorption peaks at 1422cm^{-1} and 1114cm^{-1} corresponds to the bending vibration of OH bond and Ni–OH stretching vibrations respectively [18-19]

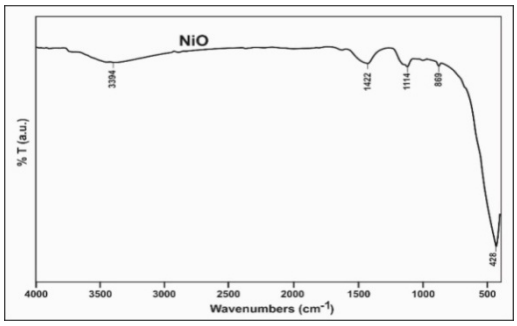


Fig.2 - FTIR of NiO

"Fig. 3", depicts the UV-visible absorption spectrum of the NiO nanoparticles obtained at room temperature and dispersed in Dimethyl formamide. The value of the absorption edge of NiO nanoparticles were 266nm and 716 nm respectively. These peaks correspond to the formation of nickel oxide nanoparticles. The optical band gap of NiO nanoparticles has been calculated from the absorption spectrum using energy wavelength relation is given byequation "(1)".

$$E_g = \frac{hc}{\lambda} \qquad (1)$$

where E_g-Energy and λ-Wavelength

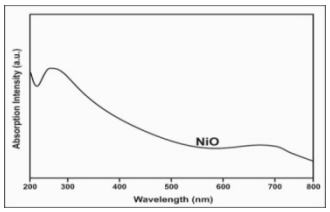


Fig.3- UV Spectra of NiO

The increasing trends of the band gap energy upon the decreasing particles size is likely due to the defects or vacancies present in the intergranular regions generating new energy level to reduce the band gap energy [20-21]. The corresponding band gap energies of NiO nanoparticles at different wavelength are shown in table 1.

Table 1 –Band gap energies of NiO nanoparticles

Sr. No.	Wavelength λ (*nm*)	Band Gap E_g(*eV*)
1.	266	4.6
2.	716	1.7

4. Conclusion

Nickel oxide nanoparticles have been successfully synthesized by chemical precipitation method. TEM result shows the spherical morphology of NiO nanoparticles with less agglomeration. FTIR spectra of NiO nanoparticles show band at 428 cm^{-1} corresponds to the vibration of Ni–O bond. From UV absorption spectra; it is observed that increased value of band gap associated with smaller particle size of NiO. Finally, one goal of this study is to motivate further applications of NiO Nanoparticles in lithium ion battery.

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