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Investigation on the Properties of Pure and Strontium Doped NiO Nanoparticles by Co-Precipitation Method

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ABSTRACT

Pure and strontium doped nickel oxide nanoparticles were synthesized by co-precipitation method and calcinated at 400 °C from nickel chloride as precursor agent and strontium chloride as doping agent. The samples have been studied by various characterization techniques such as UV-visible, FTIR, XRD and FESEM. The crystallite size and structure of NiO nanoparticles were calculated from XRD pattern. The morphology and particles shape were analyzed by FESEM studies. The SPR absorption peak and band gap value were calculated by UV-visible absorption spectra.

1. Introduction

An inorganic nickel oxide nanoparticles has been received great attention because of its unique electrical, magnetic and catalytic properties compare to bulk material [1] and NiO shows p-type semiconducting nanomaterial with a wide range of band gap value (3.6-4.0 eV) and this leads to a great applications in various field due to their above mentioned properties such as electrochromic films [2], catalysts [3], solar cell, lithium batteries [4] and gas sensor [5]. Several methods have been proposed to prepare nickel oxide nanoparticle such as simple liquid phase process [6], thermal decomposition route [7], sol-gel method [8] and sonochemical method [9]. Among these methods, co-precipitation method has a clear advantages including simplicity, low cost, easy procedure and produce a mass collection of samples. The size, morphology and shape of nanoparticles depends on the synthesis method, precursor concentration, surfactant and calcination temperature.

In this present work, pure and strontium doped nickel oxide nanoparticles preparation by co-precipitation method and their material properties have been discussed.

2. Experimental Methods

2.1 Materials

All chemicals used in this work were analytical grade reagents and used without further purification. Nickel chloride, sodium dodecyl sulfate, strontium chloride and sodium hydroxide (NaOH) were purchased from Merck Company. Deionized water was used in this present work.

2.2 Preparation of Pure and Strontium Doped Nickel Oxide Nanoparticles

The required amount of nickel chloride, sodium dodecyl sulfate, strontium chloride and sodium hydroxide were dissolved separately in double distilled water and stirred it for 30 minutes. Then sodium dodecyl sulphate solution was added into nickel chloride and this mixture was stirred for 30 minutes. Then sodium hydroxide solution was added drop by drop into the mixture of solution and color of the solution was changed from deep green to light green as stirring was continued for three hours. A gel like green colour precipitate appeared at the bottom of beaker. The precipitate was washed several times with distilled water and ethanol. The precipitate was dried at 80 °C using a hot air oven. Then final product was calcinated at 400 °C for 3 hour using muffle furnace. A similar procedure was followed to prepare strontium doped nickel oxide particles. Strontium solution was added into the mixture before adding sodium hydroxide solution. The final solution was stirred and the precipitate was washed and dried. Then sample was calcinated at 400 °C for 3 hour using muffle furnace.

2.3 Characterizations

UV-visible absorption spectra were carried out using Lambda 35 UV-visible spectrophotometer in the wavelength range 300–800 nm. FTIR characterization is analyzed in the spectral range from 400-4000 cm^{-1} using Shimadzu Fourier transform infrared spectrometer. The powder XRD pattern was carried out by Enraf Nonius CAD4-F diffractometer with the CuKa (λ=1.540 Å) radiation. The field emission scanning electron microscopy characterization was taken out by FESEM quanta 20 spectrophotometer.

3. Results and Discussion

3.1 Optical Analysis

Fig. 1 shows UV-visible absorption spectra of pure and strontium doped nickel oxide nanoparticles.

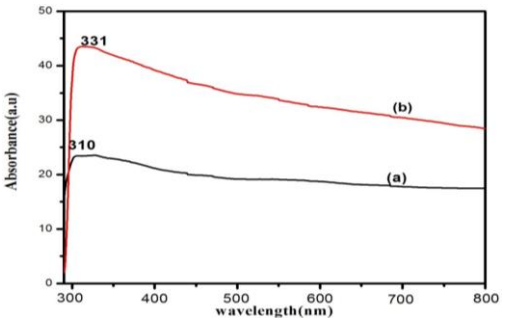

Fig. 1 UV-vis. spectra of (a) pure and (b) strontium doped nickel oxide nanoparticle

The pure and strontium doped NiO nanoparticles shows SPR absorption peak maximum at 310 nm and 331 nm respectively. The spectrum

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obtained due to optical absorption can be analyzed by the energy band gap of the semiconductor nanomaterials and its calculated by this simple energy equations, E=hc/λ, where h is the Planck's constant, c is the light velocity and λ is the wavelength of absorbed peak. The energy band gap values calculated was found to be 4.00 eV for pure NiO nanoparticles and 3.7 eV for strontium doped nickel oxide nanoparticles respectively.

3.2 Functional Group Analysis

Fig. 2 shows FTIR spectra of pure and strontium doped nickel oxide nanoparticles by co-precipitation method. The peaks appear at 3366 cm^{-1} was assigned to OH stretching mode of vibration and this peaks reveal that water was absorbed on metal oxide surface [10]. The peaks absorbed at 1619 cm^{-1} was correspond to H-O-H bending mode of vibration. Then peaks absorbed at 1113 cm^{-1} represents the O-C=O symmetric stretching mode of vibration. The peaks appear at 893 cm^{-1} was assigned to N-H stretching vibration and after this peak we could clearly see that strontium doped NiO peaks were slightly shifted from pure NiO peaks. This shifted peak was due to strontium as a doping agent on metal oxide nanoparticles. The peaks absorbed at 607 cm^{-1} and 471 cm^{-1} were assigned to Ni-O mode of vibration [11] and this confirms that pure NiO compound was successfully formed. The peak absorbed at 445 cm^{-1} was assigned to Sr-Ni-O stretching mode of vibration.

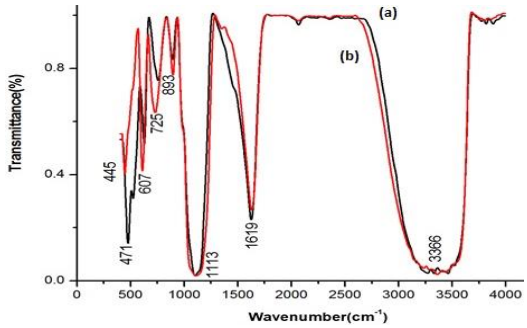

Fig. 2 FTIR spectra of nickel oxide nanoparticles (a) pure (b) strontium doped

3.3 Structural Analysis

Fig. 3 shows the powder XRD pattern of pure and strontium doped nickel oxide nanopowder. The samples were calcinated at a temperature 400 °C. The diffraction peaks (003), (202) and (021) correspond to rhombohedral structure of nickel oxide with lattice parameter a=b = 2.954 and c = 7.226 Å and it is good agreement with the reported values (JCPDS Card 89-7101). No additional peaks of other phases have been found in XRD and this confirms that the formation of pure rhombohedral structure of nickel oxide. In the strontium doped nickel oxide diffraction pattern, there was small peak shifts in the lower 2θ angle respect to pure nickel oxide was observed.

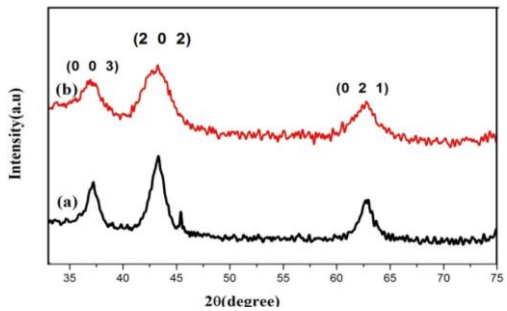

Fig. 3 XRD patterns of nickel oxide nanoparticles (a) pure (b) strontium doped

The crystallite sizes were calculated using Debye Scherrer's equation, D=kλ/βcosθ, where, d is particle size in nanometer, λ is wavelength of the radiation, k is constant equal to 0.94, β is the full width at maximum intensity and θ is peak position. The crystallite sizes of the pure and strontium doped nickel oxide nanoparticles size were found to be around 6.7 nm and 4.3 nm respectively.

3.4 Morphological Analysis

Fig. 4 shows FESEM images of pure and strontium doped NiO nanoparticles calcinated at 400 °C. From this image it is observed that pure NiO nanoparticle shows cluster like morphology along with some agglomerations exist between the nanoparticles. Strontium doped NiO sample exhibits non-uniform spherical shape and random distributions were observed. Thus dopant can control the particle size and also avoid the particles agglormeration than pure metal oxide nanoparticles.

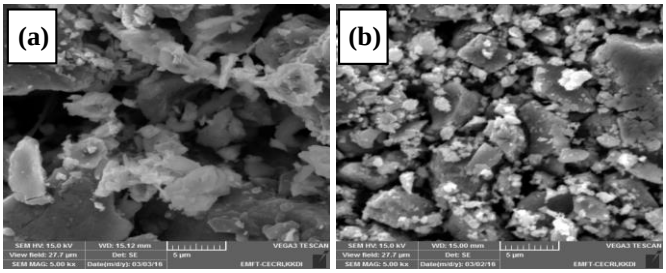

Fig. 4 FESEM images of nickel oxide nanoparticles (a) pure (b) strontium doped

4. Conclusion

Pure and strontium doped nickel oxide nanoparticles have been successfully synthesized by simple co-precipitation method. The band gap energy has been evaluated for pure nickel oxide and Sr doped nickel oxide and the values are found to be 4.0 eV at and 3.7 eV respectively. The XRD results show a slight shift in the peak positions due to doping agent, however structure of crystallites remain the same and also crystallite size of strontium doped nickel oxide nanoparticles are smaller than pure nickel oxide nanoparticles. The surface morphology of pure nickel oxide and strontium doped nickel oxide exhibit cluster like morphology along with some agglomerations.

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