Study the structural, functional groups and morphological properties of co-precipitated technique synthesised NiO nanoparticles

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***Abstract*- In this investigation presented the structural, optical and morphological properties of co-precipitated technique synthesised nickel oxide (NiO) nanoparticles. For the synthesis of NiO nanoparticles initially nickel nitrate and sodium hydroxide were used with 1:2 ratio. The synthesis NiO nanoparticles were examined by X-ray diffraction (XRD) spectroscopy for structural properties and phase purity. Functional groups of the synthesized NiO nanoparticle were confirmed via Fourier transform infrared (FTIR) spectroscopy. The surface morphology of the synthesized nanoparticles has been examined by the scanning electron microscopy (SEM).**

Keywords: **Nickel Oxide; Co-precipitation, XRD, FTIR, SEM.**

1. Introduction:

Nowadays nanotechnology is the advanced technology which provides the various types of materials in the nanoscale range. Typically, nanotechnology originate the advanced materials with different types of shapes such as nanorod, quantum dots, nano cubes etc. [1]. Fundamentally nanoscale materials give the best properties compared to their bulk materials counterparts. Nanosized materials have the excellent structural, electrical, optical, electronic, magnetic, thermal, mechanical, and catalytic properties [2]. Owing to these extraordinary properties' nanomaterials employed for the various technological applications. Nanoparticles can be synthesized by various techniques such as sol-gel, coprecipitation, laser ablation, solid state etc. Among these techniques coprecipitation techniques have the advantages such cost effective, easy, eco-friendly, can tailor the particles size as well as morphology etc. [3,4].

Recently metal oxide nanoparticles gain the much more attention due to their extensive applications. From the family of metal oxide, nickel oxide (NiO) has been extensively studied and applied for the various applications due to their excellent properties. NiO nanoparticles have the properties such as large surface areas, unusual adsorptive properties, surface defects, and fast diffusivities [5]. Due to these extraordinary properties NiO nanoparticles can be used for the various applications such as in the manufacture of capacitor, films, magnetic materials, p-type transparent conducting films, gas sensors, catalyst, rechargeable batteries alkaline (lithium ion) batteries cathode, and solar cells, solid oxide fuel cells etc [6].

The main aim of the of this work is the synthesis of NiO nanoparticles by eco-friendly chemical precipitation process and study the structural, optical and morphological properties.

2. Experimental and characterization:

All chemicals used in present investigation are analytical grade (AR) and used without any further purifications. Nickel nitrate hexahydrate (Ni $(NO_3)_2 6H_2O$ and sodium hydroxide (NaOH) were purchased from Molychem India. chemical coprecipitation method was adopted for the synthesis of nickel oxide (NiO) nanoparticles. In short, the aqueous solution (0.1 M) of nickel nitrate ($NiNO_3$) and the solution (0.2 M) of NaOH in 100 ml deionized water prepared separately. Then at room temperature under vigorous stirring NaOH solution was slowly added into zinc nitrate solution. The milky white precipitation was obtained after the 2 hours of stirring. The obtained white product was filtered using the Whatman's filter paper and washed 2-3 times with distilled water. The washed NiO nanoparticles dried overnight at room temperature and calcined at 500 ^{O}C for 3 hr.

X-ray diffractometer (XRD) (Mini Flex II, Rigaku, Japan) with CuKα radiations of wavelength 1.5406 Å and scanning electron microscopy (SEM) technique using (JEOL JSM-6360, USA) used to study the structural and morphological features of NiO nanoparticles.

3. Result and discussion:

3.1 Structural and morphological study:

X-ray diffractometer (XRD) technique was used explored the structural, phase purity and crystalline size of the synthesized NiO nanoparticles. Fig. 1 represents the diffused XRD pattern of synthesized ZnO nanoparticles with pattern of (JCPDS card number: 96-432-9326) [10]. The sharp peaks with definite line broadening in the XRD pattern of synthesized NiO nanoparticles clearly confirmed the synthesized material is in nanoscale range. The average crystalline size of the synthesized nanoparticles calculated via Debye Scherrer's (equation 1) relation and it exhibited the ~ 57 nm.

$$\text{Average Crystlline Size (D)} = \frac{0.9\,\lambda}{\beta \cos\theta} - - - - - - (1)$$

Where, λ is the wave length of X-ray used (1.54060 Å), β is the FWHM in radians and θ is Bragg's diffraction angle.

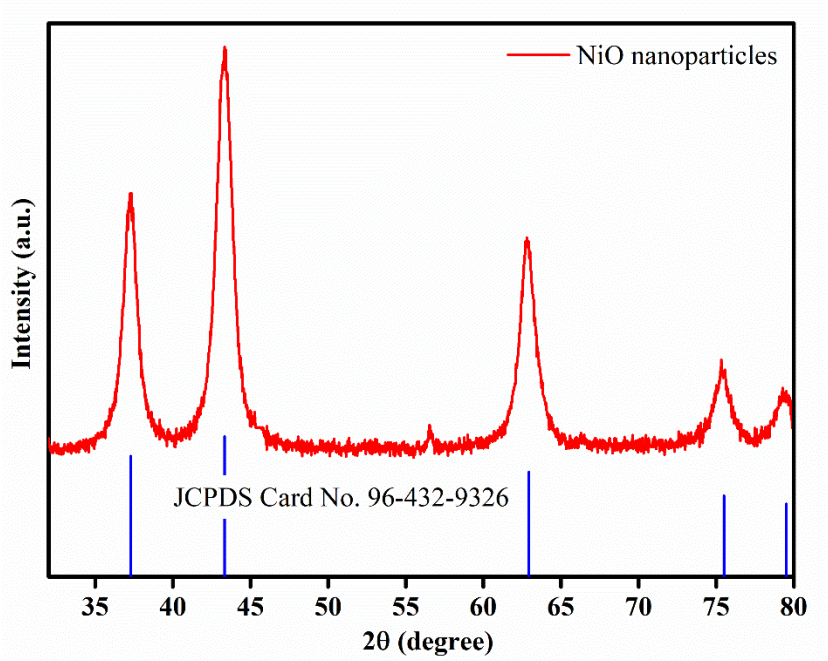

Fig. 1 XRD of as-synthesized NiO nanoparticles along with JCPDS card

The diffused XRD patterns reveals the well-defined diffraction peaks at $2\theta = 37.28^{O}$, 43.32^{O}, 62.93^{O}, 75.48^{O}, 79.48^{O}, which correspond to (111), (200), (202), (311), and (222) were observed. The phase of the synthesized nanoparticles shows the cubic [7]. Table 1. shows some physical properties of the synthesized NiO nanoparticles. The surface morphology of the synthesized nanoparticles confirmed by the SEM fig. 2 micrography and it shows the high agglomeration form.

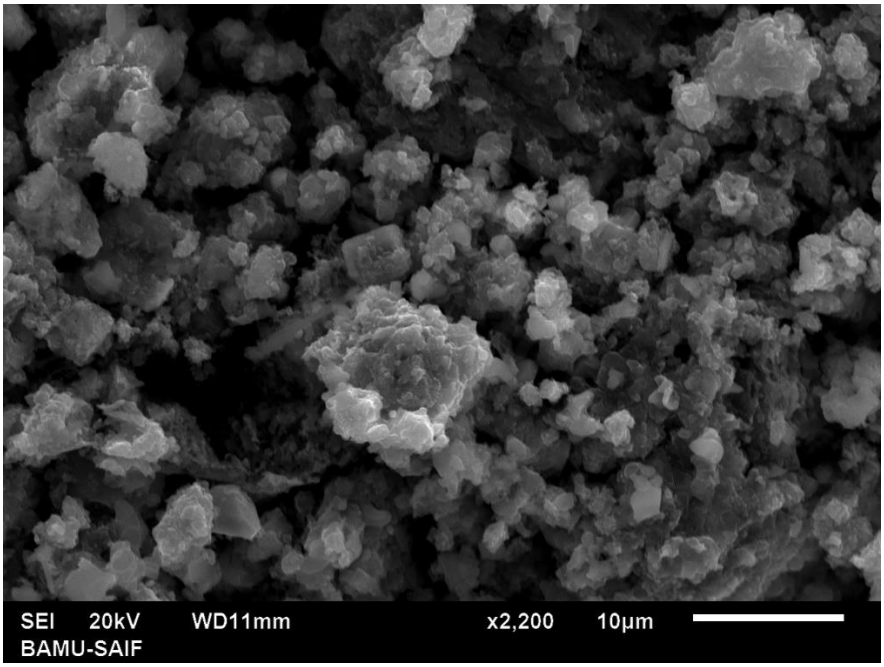

Fig 2. SEM picture of NiO nanoparticles

Table 1. Physical properties of the synthesized ZnO nanoparticles

Properties	**Synthesized NiO Nanoparticles**
Lattice Parameters $a_0 = b_0 = c_0$	4.1771 Å
Space group	F m -3 m (225)
Crystal system	Cubic
Calc. density	6.80600 g/cm^3
Avg. crystalline Size	57.3462 nm

3.2 Fourier Transform Infrared (FTIR) Spectroscopy:

Fourier transform infrared spectroscopy (FTIR) was used to study the functional group present which confirmed the purity of as synthesised NiO nanoparticles. Fig. 3 reveals the FTIR spectrum of the NiO nanoparticles and it confirms the expected functional groups concerned to the NiO nanoparticles. The FTIR spectrum of NiO nanoparticles was recorded in the range from 4000-500 cm^{-1}. The various bands exhibited in the spectrum the absorption bands exhibited in the 500-600 cm^{-1} are associated to Ni-O vibration bond and Ni-O-H stretching bond. The absorption bands between 1400-1600 cm-1 are assigned for hydroxyl groups and existence of carbonates. The all expected absorption peaks the confirmed formation of pure NiO nanoparticles [8,9].

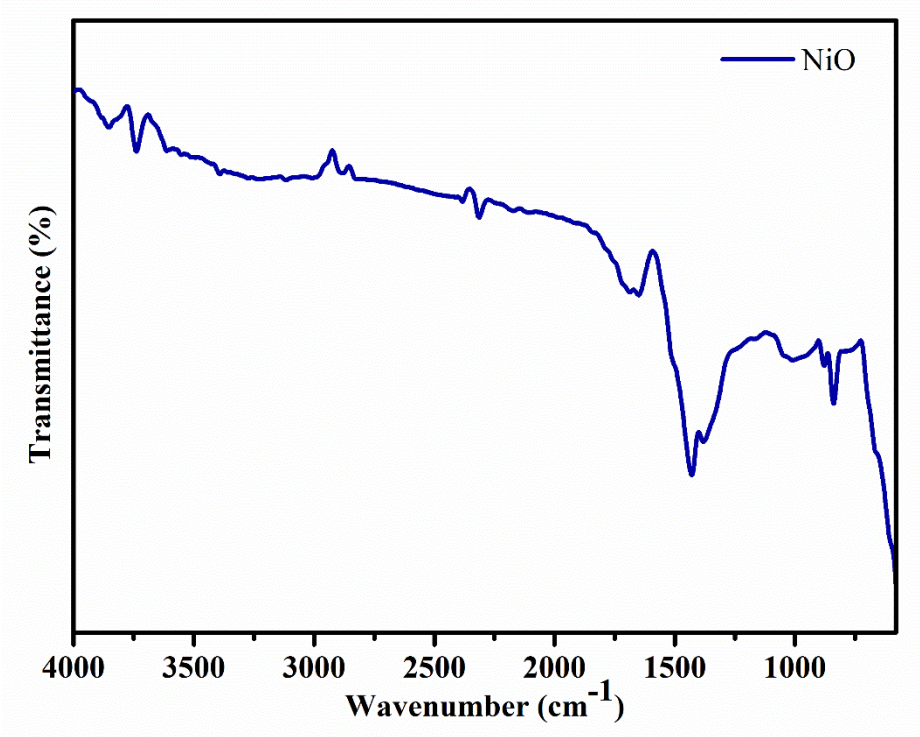

Fig 3. FTIR of NiO nanoparticles

4. Conclusion:

This investigation described the preparation strategy of metal oxide NiO nanoparticles by chemical coprecipitation method. The structural and phase purity study of the synthesised nanoparticles confirmed by XRD characterization and it reveals the cubic phase. The crystalline size was calculated by Scherrer formula and it shows ~57 nm. All the expected functional groups exist concerned to the NiO nanoparticles confirmed by FTIR spectroscopy. The morphological investigation shows the synthesized NiO nanoparticles in nanoscale range.

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