

## “Synthesis and Characterization of Neodymium Doped Nickel Oxide Nanoparticles”

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**Abstract:** Nd doped NiO nanoparticles have been synthesized successfully by simple sol-gel method using ethanol glycol(eg) as capping agent. The nanoparticles have been characterized by using a combination of experimental techniques like X-ray diffraction(XRD), Fourier transform infrared spectroscopy (FTIR), photoluminescence spectroscopy (PL), including UV visible absorption. The effect of Nd doped NiO surface morphology composition structural and optical properties, an empirical relation between the optical band gap given from absorption measurement and the particle and grain size given from XRD measurements has been developed and compared to the similar relation found in the literature. The structure study confirms the formation of the hexagonal wurtzite NiO without any secondary phase in the Nd doped NiO sample. The optical observation measurement indicates the red shift in the absorption edge upon NiO doping. [1-5]

Experimental results have demonstrated that the optical properties of glucose solution can be altered by the addition of nickel oxide nanoparticles. This finding is significant for optical glucose sensors. The present work is mainly focused on the growth and characterization of NiO nanoparticles suitable for gas sensing applications. Further investigations will be concentrated to improve the electrical properties of NiO nanoparticles by doping with appropriate elements and also to improve the gas sensing properties

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### I. INTRODUCTION

NiO has been widely studied material for the past decades; the renewed interests are focused on the modifications in various physical properties by rare earth dopants. It has been shown that doping rare earth ions enable NiO as a multifunctional system[3]. There are many reports on the structure and luminescence properties of rare earth doped NiO.

In this NiO is doped with neodymium element. Neodymium is a chemical element with the formula Nd. Neodymium is classed as a rare earth element. The color of neodymium compounds—due to the Nd<sup>3+</sup> ion—is often a reddish-purple but it changes with the type of lighting, due to the interaction of the sharp light absorption bands of neodymium with ambient light enriched with the sharp visible emission bands of mercury, trivalent europium or terbium. Neodymium doped glass are used in lasers that emit infrared with wavelengths between 1047 and 1062 nanometers and because of this they are used in high power application. Neodymium is also used with various other substrate crystals, such as yttrium aluminum garnet in the Nd:YAG laser. This laser usually emits infrared at a wavelength of about 1064 nanometers. The Nd:YAG laser is one of the most commonly used solid-state lasers. Another use of neodymium is that they are used in making of high strength neodymium magnets. These magnets are used in ear headphones, microphones, loudspeaker etc. [6-12]

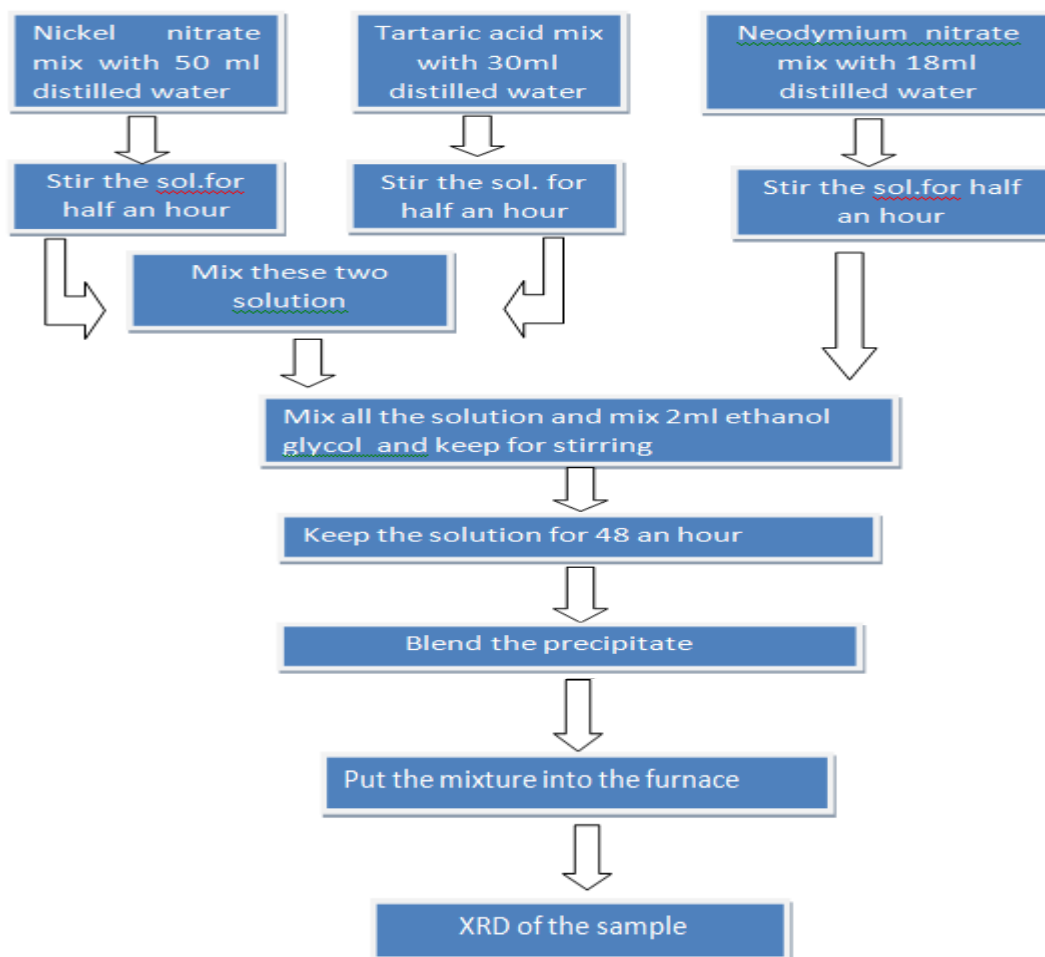
Present work aims to determine optimum solubility of Nd in the host NiO and to understand the physical properties when Nd ions are doped in dilute concentration of 10%. The sol-gel route is chosen in the present study for the synthesis because of low cost, high yield, high purity and relatively easier process as compared to other synthesis methods. Further the structural and optical properties of Nd doped NiO samples are characterized by different methods such as FTIR

techniques, UV spectroscopy, X-ray diffraction technique (XRD), photoluminescence (PL). [13-16]

### II. EXPERIMENTAL WORK

#### Sol-gel synthesis of Nd doped NiO nanoparticles:

Firstly 48 ml distilled water is taken in which 2ml of ethylene glycol is mixed. Now nickel nitrate is added into it of 2.79 gm and tartaric acid of 3.75 gm also. Now allow to stir the solution with the magnetic stirrer for half an hour and then add 2ml ethylene glycol and then again stir for 1 hr. After this heat the solution on heater for 48 hours. Now the solution is dried and a powder is formed which is kept inside the furnace at a temperature of 1700 deg C. This gives Nano particles of NiO.



**Fig.1** Flowchart of the synthesis process of Nd doped

### III. RESULTS AND DISCUSSION

XRD pattern provided information about crystalline phase of the nanoparticles as well as the crystallite size. A considerable broadening of diffraction peaks is the characteristic feature of the x-ray diffraction patterns of films and ultra-dispersed powders of Neodymium sulfide. This broadening of the diffraction peaks is associated with the small sizes of particles in powders

Fig 2, and 3 shows the XRD pattern of sample pure NiO, and Neodymium doped Nickel Oxide respectively. X-ray diffraction studies confirmed that the synthesized materials were NiO **cubic** phase and Neodymium doped Nickel Oxide the entire diffraction peak agreed with the reported JCPDS data. It was found that the Neodymium doped NiO Oxide nanoparticles are identified as  $\beta$ - Neodymium doped Nickel Oxide, which belong to the cubic crystal system. The XRD pattern of a typical Neodymium doped Nickel Oxide sample exhibits peaks at  $2\theta$  values of , 33.72, 38.601, 42.6, 52.6, 53.6, 63.1 can be readily indexed as (111), (200), (220), (311) and (222) crystal planes of the bulk Ca doped NiO as well as pure NiO respectively. All the reflection can be indexed to face centered cubic (fcc) NiO phase with lattice constant (a): 40175 Å. The broadening of the diffraction peak provides information about crystallite size. As the width increases, the particle size decreases and vice versa (Banerjee et al., 2000).

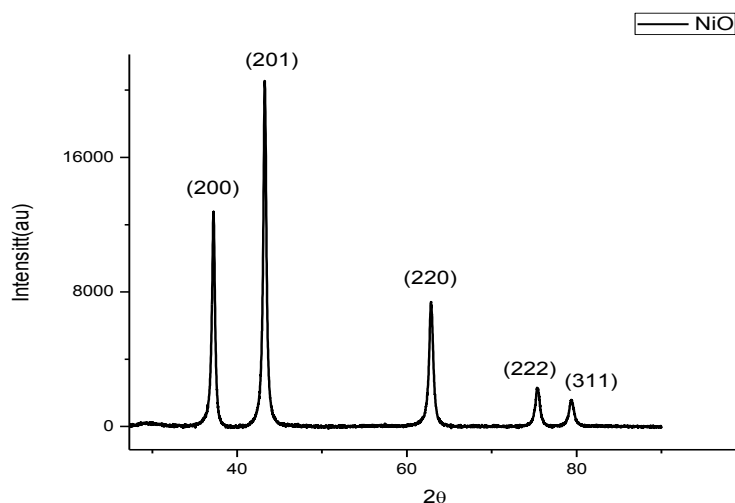


Fig 2 XRD of pure Nickel Oxide

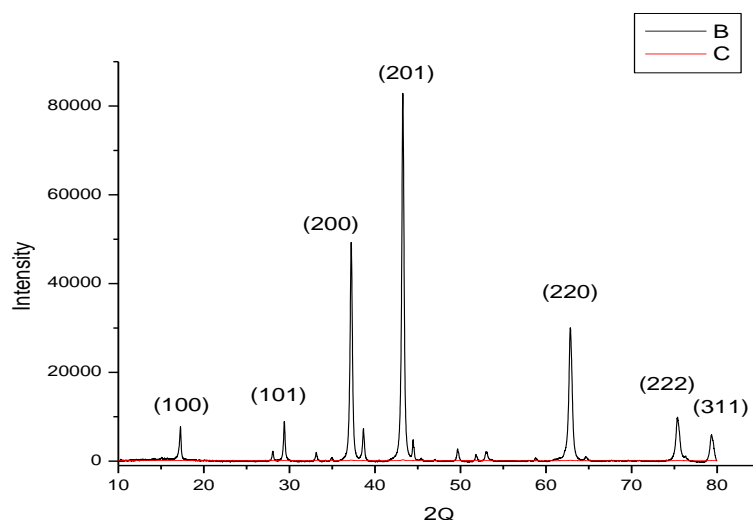


Fig.3 X-ray pattern Neodymium Doped Nickel Oxide

Table.1 for caluating paricle size

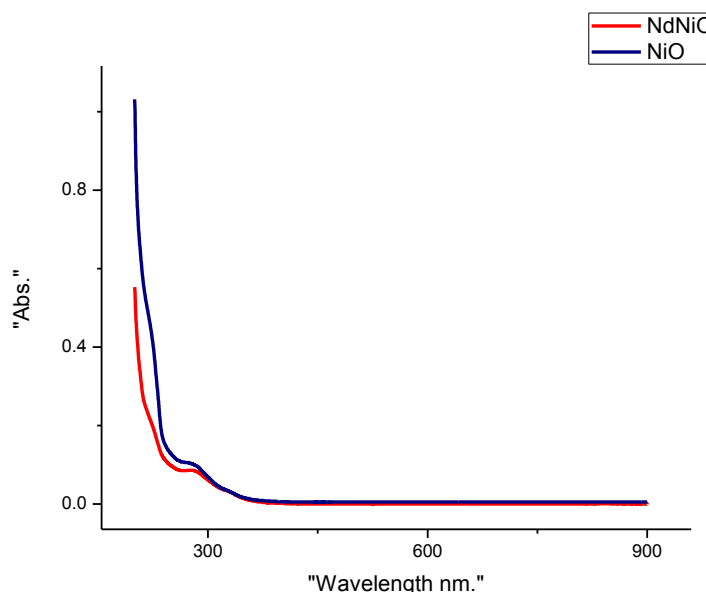
Sample	FWHM (A <sup>0</sup> )	Peak No	2θ (degree)	h k l	Inter planar spacing d values (A <sup>0</sup> )		Phase	Grain Size ( nm )
					Observed d(A)	Standard d(A)		
NiO	0.24	1	37.28	111	2.40	2.45	cubic	35.56
		2	43.50	2 00	2.07	2.121	Cubic	
		3	62.52	220	1.48	1.7621	cubic	
		4	75.65	311	1.25	1.52	Cubic	
		5	79.09	222	1.21	1.47	Cubic	
Nd doped NiO	0.28	1	37.83	111	2.37	2.45	Cubic	30.26
		2	43.71	2 00	2.06	2.06935	Cubic	

	3	63.09	220	1.477	1.76531	Cubic
	4	75.47	311	1.257	1.52	Cubic
	5	79.66	222	1.202	1.47	cubic

**Table 1**

#### IV. UV ABSORPTION ANALYSIS :

**Fig 4.** shows the UV Vis Spectrum of pure NiO and Neodymium doped NiO nano particles. The absorption spectra of pure NiO and Nd doped NiO nanoparticles were recorded using Vis-Cary 5E model spectrometer in the wavelength range 200 – 900 nm by dissolving the nano samples in deionised water. The spectra were recorded for IR, visible and UV region. From the absorption peak, the optical band gaps were calculated and the natures of transitions were also identified. The spectra are shown in Fig. 4. From the spectra, it is evident that the absorbance is not registered due to its excellent optical behaviour from 300 nm to 900 nm. Negligible absorption in the region between 300 to 900 nm is an added advantage, as it is the key requirement for nanomaterials having NLO properties. Energy band gap ( $E_g$ ) of materials is related to absorption coefficient ( $\alpha$ ) or  $(\alpha h\nu) = A (h\nu - E_g)$  where 'A' is a constant, 'h $\nu$ ' is the photon energy, 'E $_g$ ' the band gap and 'n' is an index which assumes the values of 1/2, 3/2, 2 and 3 depending on the nature of the electronic transition responsible for the absorption n = 1/2 is taken for an allowed direct transition. The extrapolation of the straight line gives the value of the energy band gap. The energy bandgaps for NiO and Nd doped NiO nanoparticles were found to be .25 and .28 eV. From the data it clear that the shift in the band gap.



**Fig 4 UV- Vis Spectrum of pure Nio and Nd doped Nio**

Before the uv characterization we have dissolved 10 mg of each sample in 50ml distel water to form the mono dispersed solution after this aech sample was sonicated at 30 miniute at 50 degree celissi bothe the sample are not have any peaks in the visible region. A UV visible spectra is used for band gap calculation but it require the wavelength at which spectra start to take off, but it is difficult to obtain take off wavelength manually.

#### V. PHOTOLUMINCE ANALYSIS

Figure 5 given below shows the PL spectra of PURE NiO and Neodymium doped Nickel Oxide nano particles under 350 nm wavelength excitation at room temperature .The NiO sample with a higher crystallinity and larger particle size shows a stronger band band PL emission at 434 nm .

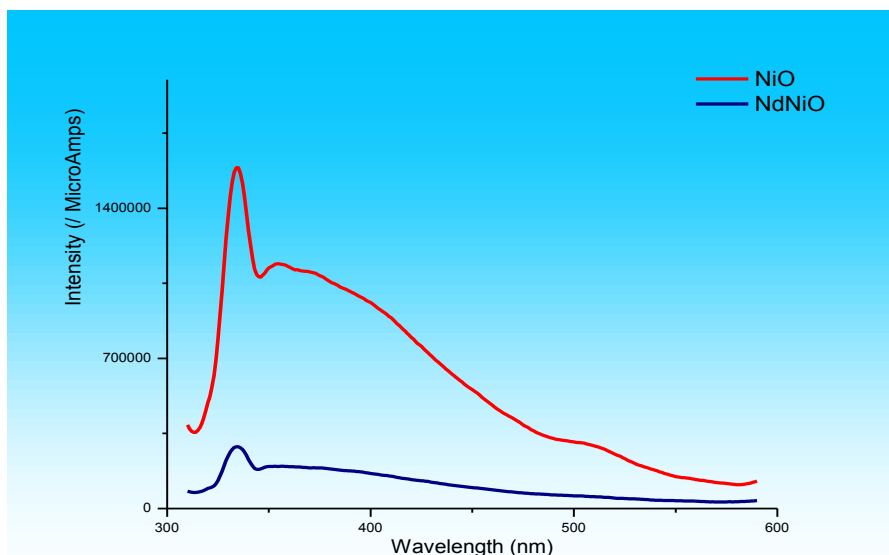


Fig 5 PL spectrum of pure NiO and Nd doped NiO

The stronger the band PL intensity of NiO particles, the higher the recombination of photoinduced electron-hole pair. The deeply trapped holes are more or less localized at deep traps, exhibit a lower oxidizing potential, and prefer to react with physically adsorbed substance. Heat treatment may result in a slight deviation from NiO stoichiometry and the cation vacancy oxygen trapping in the NiO lattice leads to two shoulder peaks at 496 and 540 nm in green emission band confirmed of such defects in NiO lattice. Nickel vacancies can be produced due to the charge transfer. As seen in the figure 4, all the sample showed the excitation PL emission band at 2.86 eV (434 nm) resulting from the surface oxygen vacancies of NiO. Black emission in PL spectrum with a strong band centered at 434 nm confirmed the presence of Nd-doped NiO nano.

**Fourier transform Infrared Spectroscopy (FTIR) :**

The samples were subjected to FTIR characterization in the range of 750-4000  $\text{cm}^{-1}$  using Bruker model vertex 800 at UIT-RGPV Pharmacy, Bhopal. In Fig 6 the peaks were observed at 750 and 3800  $\text{cm}^{-1}$  in the graph shows Nd-doped NiO basal bond axial bond respectively. Another peak was observed at 2800  $\text{cm}^{-1}$  shows about the oxygen deficiency in Nd-doped NiO. The anionic surface adsorption by tetrahedral oriented material is well recognized due to the presence of residual dipole moment in structure. It is well established that Nd-doped NiO has tetrahedral molecular bonding. In ideal tetrahedral molecule, the axial and basal bond lengths are equal leading to neutralization of net dipole moment.

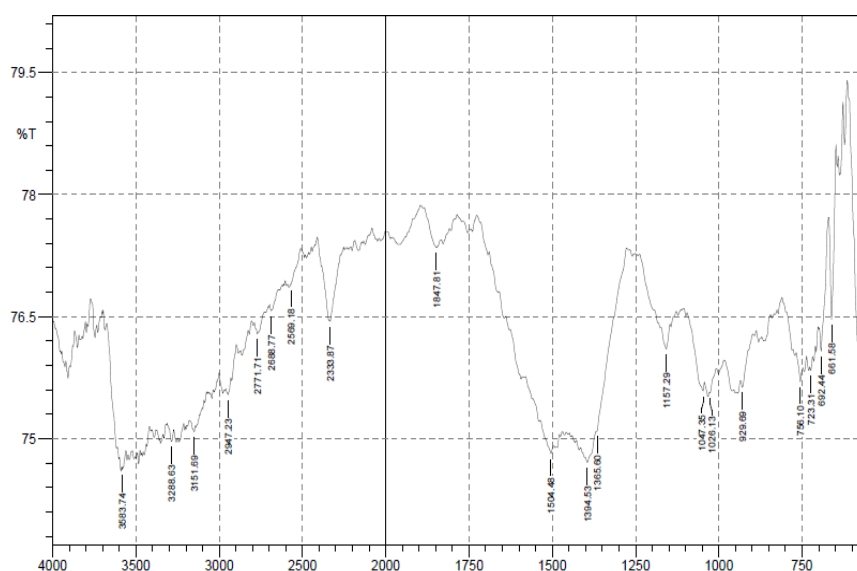


Fig 6 Pure form of NiO

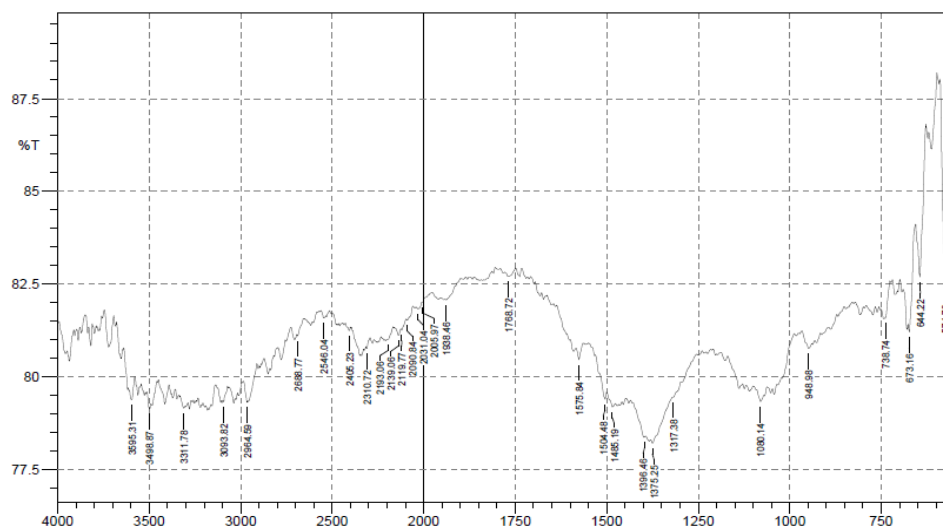


Fig 7 Nd Doped NiO

## VI. CONCLUSION

We successfully synthesized two sample first is Nd doped NiO and pure form of NiO with varying sintering temperatures using sol-gel method. XRD confirmed the phase purity and hexagonal symmetry by XRD analysis also find particle size and strain and by combining the particle size, as extracted from the XRD data of the samples. FTIR spectroscopy revealed that sample Nd doped NiO is free from defects induced by oxygen deficiency. UV-Visible spectroscopy suggests that both the samples are transparent in visible region. Combined, the synthesized samples can be used as IR blocking transparent windows. PL analysis confirmed that the prepared material has a high purity and the presence of elements. From this measurements it is apparent that the fluorescence are shifted to longer wavelength as the particles grow, but it also seems like the fluorescence intensity normalized to particle mass decreases with increase particle size.

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