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SYNTHESIS AND CHARACTERIZATION OF NICKLE-OXIDE NANOPARTICLES BY SOL-GEL METHOD

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ABSTRACT

Nickle oxide (NiO) nanoparticles have been synthesized via modified Sol-gel method. Sol-gel technique is modified in such a way that it becomes simple and low cost synthesis technique. In this modified method, oxalic acid was replaced with citric acid which was mixed with ethylene glycol to form a homogenous gel. Here we replaced ethyl alcohol with ethylene glycol. Ethylene glycol here acted as a sol stabilizer. The metal nanoparticles were characterized by XRD, UV-Vis and FT-IR spectroscopy. The results obtained from XRD, UV-Vis and FT-IR spectra analysis confirms the formation of nickle oxide nanoparticles.

Keywords:* *Citric Acid, Ethylene Glycol, FTIR, Nio Nanoparticles, Sol-Gel Method, XRD

I. INTRODUCTION

Nanotechnology is the science of production and use of nanosized materials to produce novel products and processes [1]. Nanomaterials show significantly different properties like mechanical, electronic, magnetic, thermal, catalytic and optical properties as compared to the bulk material, and attracted much interest [2, 3]. Nickel oxide (NiO) already has received much attention due to its excellent electrical, magnetic and catalytic properties [4]. They have wide range of applications in many fields included the fabrication of catalysis [5-7] fuel cell electrodes [8], and gas sensors [9-11], battery cathodes [12-16], magnetic materials [17-20], photovoltaic devices [21], electrochemical supercapacitors [22]. But, most of these applications need particles with a small size and a narrow size distribution.

For these advanced applications of nanoparticles, there is urgent requirement of synthesizing metal nanoparticles with functionalized characteristics properties in terms of their size, morphology, microstructure, composition purity, crystallizability, and so on, which are the most essential factors which eventually determine the performance of the final products.

For the preparation of metal oxide nanoparticles many techniques have been developed such as sol-gel method, ultrasonic radiation, pyrolysis by microwave, hydrothermal synthesis, precipitation- calcination method, laser chemical method, mechanochemical processing, microemulsion method, flame spray pyrolysis, solid-state method, co-precipitation method and so forth [23, 24]. In the middest of them, the simplest and low-cost techniques is the wet chemical method of sol-gel preparation for synthesizing pure transition metal oxides with relatively high specific surface area at low temperature [25-27]. This method has many advantages also, which includes operational simplicity, high purity and high yield of product, low energy consumption and no special equipment required.

In continuation to our earlier study [28-32], present study is focussed on developing a novel synthesis technique to synthesize NiO nanoparticles using modified sol-gel technique by using $Ni(NO_3)_2{\cdot}6H_2O$ as the inorganic precursor. The samples were characterized by FTIR, UV-VIS and XRD.

II. EXPERIMENTAL

2.1. Chemicals and Apparatus

All chemicals used in experiment were of analytical grade. The chemicals used in the synthesis were $Ni(NO_3)_2.6H_2O$, citric acid and ethylene glycol. All the solutions were prepared in double distilled water.

2.2. Synthesis of NiO Nanoparticles

Metal salt solution was mixed in double distilled water. In another beaker citric acid solution was prepared in double distilled water and then two solutions prepared separately were mixed and continuously stirred for 15 minutes. Ethylene glycol was then mixed into it drop wise with continuous stirring for three hours. The resultant precipitates thus obtained were washed with double distilled water and then dried at 100.0 °C in oven for 2.0 hours. Finally, these metal nanoparticles were put into the muffle furnace maintained at a constant temperature of 600.0°C for 2.0 hours. Green coloured NiO nanoparticles were thus obtained.

2.3. Characterization Techniques

The size, structure and morphology of metal oxide nanoparticles were characterised by FTIR (Thermo-USA, FTIR-380) in the wavelength range 400-4000 cm^{-1}, UV-Visible spectroscopy (Shimadzu 1800) in the wavelength range 200-1000 cm^{-1} and XRD (Rikagu mini-2 using Cuα1, λ=0.15406 nm radiations).

III. RESULTS AND DISCUSSIONS

3.1 X-Ray Diffraction Study

“Fig.1” represents X-ray diffraction pattern of metal oxide nanoparticles. XRD shows three characteristic peaks, indexed as the reflections from {110}, {200} and {220} planes (JCPDS card No. 87-0712) representing a typical face-centered cubic (fcc) structure of Nickle oxide nanoparticles.

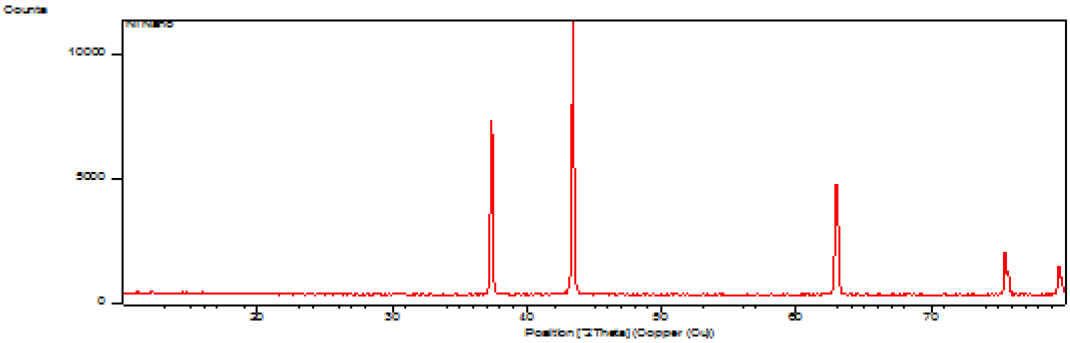

Figure1. XRD Spectra of Nickle Oxide Nanoparticles

3.2 FTIR Spectroscopy

"Fig 2" presents the FTIR spectra in the range 4000-400 cm^{-1}. The broad absorption band centred 1725 cm^{-1} is attributed to bending mode (H–O–H). FT-IR spectrum of NiO nanoparticles showed significant absorption peaks at 450 cm^{-1} is due to Co-O stretching vibration mode. The absorption peak at 2926.01 cm^{-1} may be due to $–CH_3$ stretching vibrations. The absorption peaks at 2856.58 cm^{-1} may be due to $–CH_2$ stretching vibrations.

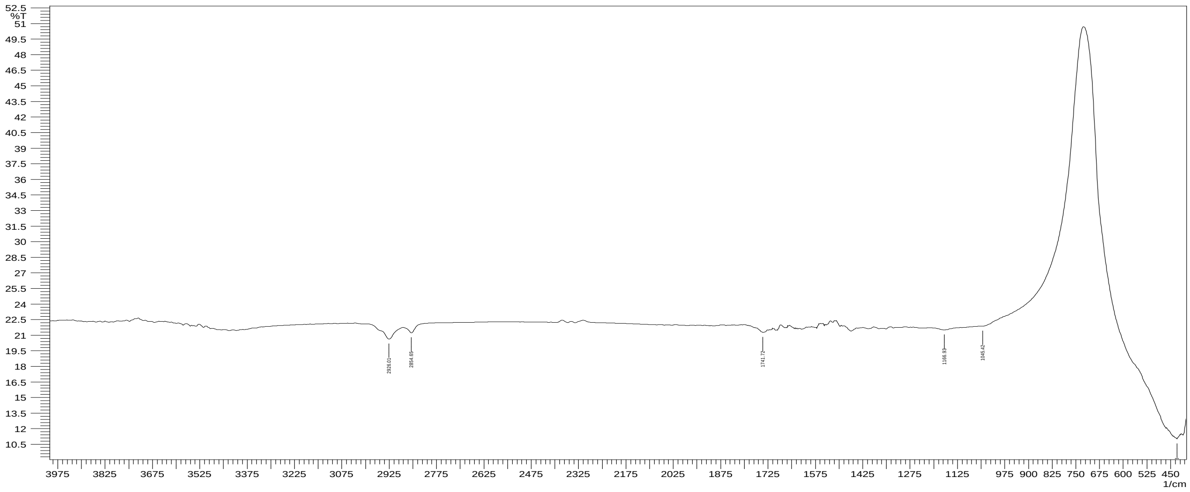

Figure2. FTIR Spectra of Nickle oxide nanoparticles

3.3 UV-Visible Spectroscopy

"Fig.3" represents the absorbance spectra of the NiO nanoparticles. The UV absorption spectra of NiO nanoparticles show a characteristics peak at a wavelength of 310 nm. The peak corresponds to the formation of Nickel oxide nanoparticles.

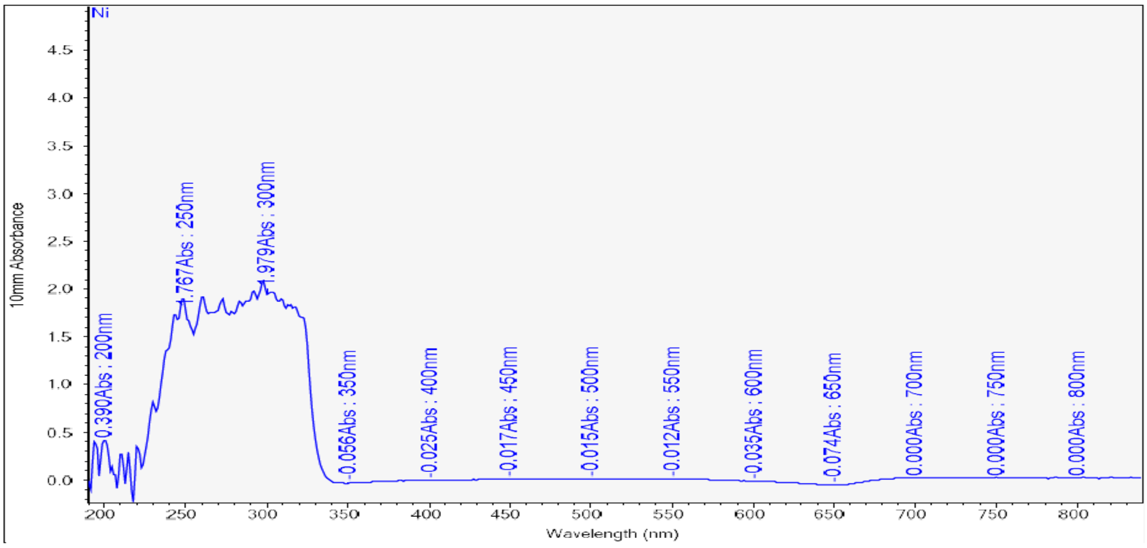

Figure3. UV-Visible spectra of Nickle-oxide nanoparticles

IV. CONCLUSIONS

NiO metal nanoparticles synthesized by modified sol-gel technique are typical fcc in structure. The results of UV-VIS, FTIR and XRD, indicates the formation of NiO nanoparticles. The optical absorption spectrum of Nickle oxide nanoparticles was studied by UV-Visible spectroscopy. The absorption band in finger print region of FTIR spectra i.e. 450cm^{-1} indicated metal oxide stretching vibrations. This modified sol-gel method is one of the simplest, environment friendly, cost effective and less time consuming method of synthesis of nanoparticles.

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