

Study Magnetic Properties And Synthesis With Characterization Of Nickel Oxide (NiO) Nanoparticles

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Abstract: Nickel Oxide (NiO) nanopowder was obtained during a chemical method, which is a bottom up approach of synthesis. It was initially prepared via chemical synthesis of main materials were nickel acetate, sodium hydroxide (NaOH) and cety trimethyl ammonium bromide(CTAB), and extremely stirring until the pH becomes 7.5, and nanoparticles of (NiO) are prepared by thermal decomposition of freshly prepared nickel hydroxide by a sol gel and followed by heat treatment at 350oC. Nickel oxide, a kind of soft magnetic materials is one of the most attracting class of materials due to its interesting and important properties and has many technical applications, such as in catalysis, sensors and so on. The characterization of (NiO) nanoparticles for structural properties were investigated by X-ray diffraction (XRD), and transmission electron microscopy (TEM). The surface morphology of the prepared sample was carried out by scanning electron microscopy (SEM), magnetization measurements were carried out on an Alternative Gradient Force Magnetometer (AGFM), which revealed saturation magnetization of the samples were strongly dependent on the calcinations temperature and particle size of the sample. The saturation magnetization values of the samples increased as a function of the calcinations temperature. Finally our results showed that the chemical synthesis method leads to obtain nickel oxide nanoparticles with good magnetic behavior.

Keywords: NiO nanoparticles, X-ray Diffraction, Transmission electron microscopic (TEM), vibrating sample magnetometer (VSM),chemical synthesis.

1 - Introduction

Nanotechnology (sometimes shortened to "**nanotech**") : Is the manipulation of matter on an atomic and molecular scale. Generally, nanotechnology works with materials, devices, and other structures with at least one dimension sized from 1 to 100 nanometers. The design, characterization, production and application of materials, devices and systems by controlling shape and size of the nanoscale ^[1], means the full and precise control in the production of materials. This is happening by controlling the interaction of molecules involved in the interaction, this type of interaction known as molecular manufacturing. And control is better in the article on the molecular level. The development of the atoms during the interaction in the right place or manner. For example, if the guide development of carbon atoms in coal at an interaction, it can produce diamonds. And also if it is to guide the development atoms of sand when you make the interaction can produce materials used in the production of computer chips is known that the traditional way in the manufacture of chemicals, different place by mixing the components interact together without taking into account the direction of the atoms involved in the interaction and therefore the chemical resulting from the mixture of several materials. By the use of nanotechnology it is possible to guide the development of the atoms involved in the interaction under the specific guidance and thus the resulting material will be more accurate and more purity of traditional methods of manufacturing and then unify the quality of the product and also reduce the production cost and reducing energy consumption. (nanodevice) there are devices on the nanoscale level is able to guide the atoms and put them in place during the process of interaction. As the design and fabrication of materials devices and systems with control at nanometer dimension ^[2].

The essence of nanotechnology is therefore size and control because of the diversity of applications the plural term nanotechnology is preferred by some nevertheless they all share the common feature of control at the nanometer scale the latter focusing on the observation and study of phenomena at the nanometer scale and ways of manipulating matter at that scale at which many properties of matter differ from those familiar at larger scale ^[3], is the manipulation of matter on a atomic and molecular scale. Generally, nanotechnology works with materials, devices, and other structures with at least one dimension sized from 1 to 100 nanometers. Nanotechnology is very diverse, ranging from

extensions of conventional device physics to completely new approaches based upon molecular self assembly from developing new materials with dimensions on the nanoscale to direct control of matter on the atomic scale. Nanotechnology entails the application of fields of science as diverse as surface science, organic chemistry, biology, microfabrication etc. Scientists debate the future implication of nanotechnology^[4]. Nanotechnology may be able to create many new materials and devices with a vast range of applications, such as in medicine, electronics, biomaterials and energy production. On the other hand, nanotechnology raises many of the same issues as any new technology, including concerns about the toxicity and environmental impact of nonmaterials, and their potential effects on global economics, as well as speculation about various doomsday scenarios. These concerns have led to a debate among advocacy groups and governments on whether special regulation of nanotechnology is warranted.

1.1 One-dimensional nanomaterials:- Fall under this category all materials that at least one of the measures to keep it away from 311 nm. And named this category mono-dimensional nanomaterials (i.e. after only one nanometer). Examples of such Material chips or Thin Layers membranes such as nanomaterials in the works employee coating Surface Nanocoating like surfaces which are used in coating surfaces of metal products Imposing rust protection from corrosion, or those thin films Thin Films thin used in Packing of food products in order of protection against pollution and damage. Also manufactures semiconductor materials various conductors such as silicon wafers to be employed in the manufacture of solar cells.

1.2 Two-dimensional nanomaterials: - Required in this class group of nanomaterials that at least scale dimensions 311 Nanometers. The nano-tubes, cylinders (Nanotubes), carbon nanotubes and The nano-fiber as well as nanowires (Nanowires) models value to that class of materials. It was no surprise that the candidate nomination carbon nanotubes because employ as supportive and reinforcing materials for molds Metals to raise the values of hardness and improve the mechanical properties, most notably raising resistance to collapse It is also gathered other unique properties, such as high-capacity electrical and thermal conductivity. Furthermore distinct chemical properties. It is expected to use the pipe and wire nanoparticles component manufacturing solar cells and electronic slides, sensors and electronic devices accurate^[8].

1.3 Three-dimensional nanomaterials:- Represent pellets Spheres nanoscale dimensions, such as nano-grained as well as powders of metals The ultra-soft ceramic material, examples of this class of materials technological value that qualify as a trilogy. Due to the measures taken away on three axes X, Y, Z less than about 311 nm. It is worth mentioning that this class of three-dimensional nanomaterials, whether in the form of granules or powders ultra-soft tops the list of world production of nanomaterials. Where large intervention metal oxides such as silicon dioxide 2SiO, titanium oxides 2TiO, Aluminum oxide Al₂O₃ as well as iron oxides Fe₃O₄ industry electrons and materials. Nickel is a silvery white color metallic, belongs to the transition metals is one of the four magnetic materials in temperature^[11,12] and pressure normal. Nickel metal and is subject to harsh methods. Nickel element chemically active form of free oxygen reacts with the air slowly in temperature and pressure, forming a regular layer of insulating oxide on the surface reduce the extent of chemical activity as is the case for the elements chromium, aluminum and titanium.

Magnetism: All matters consist of atoms and the atom consists of positively charged nucleus surrounded by negatively charged electrons. In atom the electron has two types of motions i.e. the orbital motion and the spin. These two types of motions are responsible for the magnetic moment of the electron. The magnetic behavior of any material is decided by the relative arrangement of atomic magnetic moments inside the material^[6].

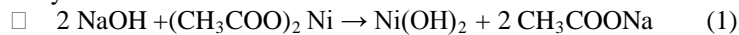
Diamagnetism: In diamagnetic materials all the electrons are paired and so the net electronic spin magnetic moment is equal to zero. Magnetization of diamagnetic material is always opposite to the applied magnetic field direction. In other words the susceptibility of the diamagnetic material is always negative. Also the susceptibility of the diamagnetic material is independent of temperature^[9].

- **Objective:** To synthesize Nickel Oxide nanomaterial (NiO) in the presence of sodium hydroxide by the chemical Method and to characterized the magnetic properties of Nickel Oxide nanomaterial (NiO).

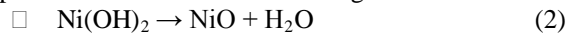
□ II- Practical part

- There are two basic method physical and chemical for the preparation of nanoparticles materials. In the present work nanoparticles of NiO were synthesized by chemical road. The main materials were nickel acetate, sodium hydroxide (NaOH) and cety trimethy ammonium bromide (CTAB) were procured from Merk (India) Ltd India, and were used without any purification. First, we prepared two separate solutions, one of them solution of 100 mM of nickel acetate in 100 ml of deionized water and the other solution contains 200 mM sodium hydroxide in 100 ml of deionized water. An amount of 0.3 mM of (CTAB) in 50 ml was added latter to the solution. For this NaOH solution added drop wise into the later solution. The mixed solution was stirred by magnetic stirring at room temperature naturally. And second way used same procedure for second solution but in step magnetic stirring with heating and until the pH of the system reaches to 7.5, at room temperature also. In this chemical method high frequency

ultrasounds waves used for exciting nucleation and then to remove byproducts, precursor was filtered and the resultant green gel washed repeatedly with distilled water for four times.



□ The resulting green gel is washed several times with distilled water. Finally the gel is dried by heating up to 70 °C for 21 hours. The surfactants were removed after the mentioned processes. After determining the reaction temperature of conversion nickel hydroxide to nickel oxide by heating in furnace in air, the oven dried cake was heated at 350°C for 3h to form NiO nanoparticle. After the process of developing the powder in the furnace becomes a Calcified Black color Nickel hydroxide decomposes into nickel oxide on heating as follows.



In this work nanocrystalline NiO sample is prepared by heating the nickel hydroxide in air for 3 hours at 350 °C. To identify the structure and phase purity of the prepared sample, powder X-ray diffraction (XRD) with CuK α radiation ($\lambda=1.540598\text{\AA}$) at room temperature were performed. The high resolution (TEM) images were recorded at Technai G230S model. Magnetization measurement (M–H characteristics) of the sample was recorded from a vibrating sample magnetometer (VSM) where magnetic field could be varied up to 1.8 Tesla.

III- The Result

In the result structural characterization of the prepared sample is done using a x-ray diffractometer and Cu K α radiation (wavelength $\lambda= 1.5418 \text{ \AA}$) at room temperature. Intensity of the diffracted x-ray beam is recorded as a function of the angle 2θ . The X-ray diffraction pattern of the prepared green colored powder sample at room temperature is shown in Figure 3.1. From this pattern it is found that the prepared green colored powder sample is nickel hydroxide. The nickel hydroxide decomposes into nickel oxide on heating. Details of this are discussed in Section 2.2. Keeping it in mind since the synthesized green colored powder is heated in an oven (furnace) at 350 °C for 3 hours. And due to this heating the color of the sample changes from green to black. The x-ray diffraction pattern of this sample at room temperature is shown in figure.

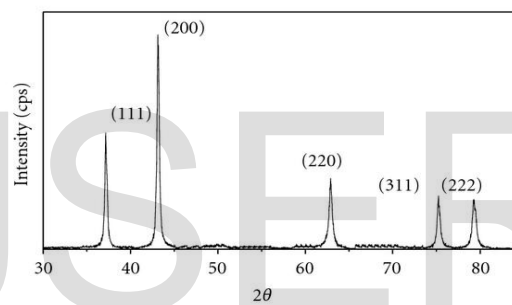


Figure 1: Room temperature x-ray diffraction pattern of NiO nanoparticles.

Magnetization measurements: Magnetization as a function of magnetic field measurements is done for nanocrystalline and bulk NiO samples using a vibrating sample magnetometer at room temperature. These measurements are shown in Figures 4.4 and 4.5 respectively.

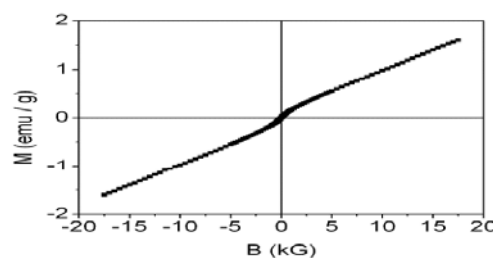


Figure 2: Magnetization M as a function of applied magnetic field B at room temperature for NiO nanoparticles.

From Fig 2. It is found that there is no hysteresis in all the M vs. B curves. The magnetizations of the two samples increase with increasing magnetic field strength. It is also observed that at smaller magnetic fields the magnetization increases with magnetic field nonlinearly whereas at relatively higher magnetic fields the magnetization increases with magnetic field almost linearly. These are characteristics of antiferromagnetic materials.

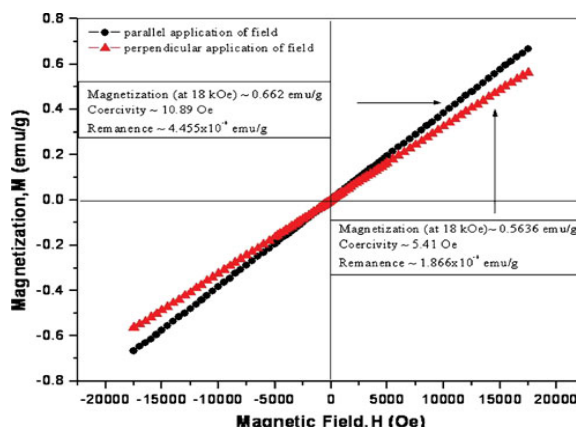


Figure 3: M- H characteristics of NiO nanoparticles.

Magnetization and Magnetic Field (M–H) behavior, for in plane parallel and out of plane perpendicular applied magnetic fields, of the prepared NiO nanoparticles is shown in figure 3. The magnetization has been observed not to saturate up to a maximum applied field of 18 ke. The M–H characteristics do not show any significant hysteresis, coercively, and retentively and thus it clearly shows the feature of superantiferromagnetic/superparamagnetic behavior. The magnetic behaviour of the particle surface differs from that of core.

IV- Conclusions

In summary, a simple and economical method to synthesize NiO nanoparticles by NiO chemical road. Nanoparticles have been prepared by the thermal decomposition of Ni(OH)₂ green colored powder sample nickel hydroxide by heating at 350°C. The color of the sample changes from green to black color. Nanoparticles of NiO are prepared by chemical way. The precursor materials were nickel acetate, sodium hydroxide (NaOH) and cety trimethy ammonium bromide (CTAB). The sample is characterized by X-Ray Diffraction, Vibrating Sample Magnetometer (VSM), scanning electron microscopy (SEM) and Transmission Electron Microscope(TEM). The magnetization of NiO nickel oxide nanoparticles is compared with that of bulk NiO. In this study the NiO nanoparticles are found to be antiferromagnetic at room temperature. The magnetization of NiO is also found to increase with decreasing crystallite size. Finally i got Nickel Oxide nanopowder black color.

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