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Preparation Methods of NiO Nanoparticles – An Overview

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Abstract: *The synthesis of Nickel oxide in the nano range has considerable attention, nowadays, due to their potential applications in various fields. Along with various methods the solution-phase precursor route method have been reported for the synthesis of Nickel oxide nanoparticles. This review article mainly focuses on the synthesis of NiO nanoparticles by various methods.*

Keywords: *Nickel oxide, solution-phase precursor route method*

INTRODUCTION

The synthesis of metal oxide materials at nano dimension integrates the materials science and technology, which leads more and more applications in Science and Technology. Various methods have been reported in the literature for the synthesis of nano crystalline NiO from different precursor materials. Along with the simple methods such as sol-gel processes, thermal decomposition, chemical routes, precipitation methods, solution-phase precursor route have also been reported. This review focused mainly on the synthesis of NiO nanoparticles by various methods, because the nano crystalline NiO have many potential applications in various fields like nano scale optoelectronic devices such as electro chromic display [1], sensors [2,3], environmental remediation [4], magnetic carriers for drug targeting and catalysis [5,6]. Moreover, the nano crystalline NiO exhibit novel and significant mechanical, electronic, magnetic and optical properties in comparison with their bulk counterparts [7]. Further nano crystalline NiO possesses peculiar magnetic properties related to the size and surface effects [8-11]. Therefore NiO in the nano range has been received considerable attention during the past decades.

Preparation Methods Discussion

Timothy et al., [12] reported that the citrate collaborate with a Guanidinium ion, as a generator of cubane – like complexes with the range of metal cations (Mg^{2+} , Mn^{2+} , Fe^{2+} , Co^{2+} , Ni^{2+} & Zn^{2+}) at room temperature, give crystalline products of composition $[C(NH_2)_3]_8[(M^{11})_4(cit)_4] \cdot 8H_2O$ with pH = 5, and study its structural and magnetic properties. Their structural study reveals that the compounds are iso-structural.

Hongxia Qiao et al., [13] synthesized NiO with particle size of 25nm by anodic arc plasma method. They found that NiO nanoparticle is in bcc structure with spherical shape and also have blue shift in IR absorption band and the result is compared with bulk NiO. The specific surface area of the sample is $33 \text{ m}^2/\text{g}$.

Subhash Thota et al., [14] synthesized NiO nanoparticle via sol-gel method. They reported the anomalies magnetic behavior at low and high temperature and the non-existence of spin glass behavior of NiO nanoparticle. They observed the blocking temperature (T_B)

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and band gap energy (E_g) increased with decreasing particle size by size effect.

Y. Bahari Molla Mahahleh et al., [15] prepared NiO nanoparticles by chemical precipitation method and studied the effect of applied surfactant (PEG, PVP and CTAB) on distribution of particle size. They proved PEG and PVP were comparatively more useful surfactants to reduce the size of the particles. The properties are identified by TG/DTA, IR, XRD and SEM.

C. T. Meneses et al., [16] synthesized high-quality NiO nanoparticles by simple method using organic precursor and Ni source. The particle size ranged from 3.2 to 79nm and it also depends on the synthesis time. This NiO nanoparticles have fcc structure and also proved the possibility to control the particle dispersion.

L. Xiang et al., [17] prepared NiO nanoparticles with 10-15nm diameter by air-calcinations precipitation method. They proved that a moderate alkaline environment is preferential for the dispersion of NiO nanoparticle from the zeta potential analysis.

D. Mohammadyani et al., [18] prepared highly crystalline pure NiO nanoparticles with average crystalline size of ~ 30 nm by a microwave assisted approach. The prepared NiO was black in color. They proved, it is due to non-stoichiometry of the nanoparticle.

Yu. A. Kotov et al., [19] synthesized NiO nanopowder by electrical explosion of a wire. The particle size varied from 15 to 50nm depending on the explosion condition these particle having different in shape and have both single and polycrystalline structure.

M. Abdul khaddar et al., [20] prepared nanostructured NiO with different particle size through a wet chemical method. They were found the magnetic hysteresis of the sample at room temperature using vibrating sample magnetometer. From the report, they proved the NiO with 2 to 5nm of average particle size exhibits superparamagnetic properties and NiO with 13 to 18nm nanoparticles exhibits super antiferromagnetic properties.

J. Estelle et al., [21] reported the NiO prepared from the different precursor. They were characterized the sample using BET, XRD, SEM. They proved the size of the particles varied with calcination temperatures. They reported, the NiO obtained from Nickel nitrate hexahydrate is heterogeneous distribution of octahedral particles. From nickel hydroxide it is more amorphous with high porosity of sponge like aspect, from Nickel acetate it is cubic crystallites.

Salah A. Mahloul et al., [22] measured zero field cooled and cooled magnetization for 5-55nm particle size NiO nanoparticles. Variation with particle size (d) and the temperature of the coercivity (H_c), exchange bias field (H_E), coercivity enhancement are discussed. The interfacial exchange energy is calculated as ~ 0.03 erg/cm².

Teressa Nathan et al., [23] prepared a single phase nanostructured NiO crystalline product was synthesized via a simple solvothermal synthesis protocol by using nitrate-citrate precursor having Ni(NO₃)₂ as starting material. Thermal and structural properties were characterized by TG/DTA and XRD studies. The porosity is confirmed by FE-SEM. Cyclic voltammeter reveals the pseudo capacitive behavior of the product when employed as working electrode in a three electrodes electrochemical cell containing 1M KOH aqueous electrolyte with Platinum (Pt) and saturated Calomel electrode as counter and reference electrodes, respectively, yielding a capacitance of ~ 200 F/g.

Solution precursor method was used to prepare the stoichiometry Nickel Oxide nanopowder with different calcination temperatures at different calcination time and it was characterized by TG/DTA, FTIR, UV-Visible spectroscopy, powder X – ray diffraction, Scanning Electron Microscope and FESEM. The metal precursors were prepared on the water bath at temperature of 90 °C. The metal complex was rehabilitated into Nickel Oxide by calcinating with different temperatures. The average crystallite size increased with increasing the calcination temperatures and the strain was decreased. The range of crystallite size varied from 30 to 40 nm. The structural properties were analyzed by both Scherrer formula and the William and Hall methods. The surface morphology of the Nickel Oxide nanopowders were analyzed by SEM and FESEM. The SEM image shows that the porosity increased with increasing the calcination temperatures. The FESEM showed that the different morphology of NiO nanopowders.

Conclusion

The research in the synthesis of nickel oxide nanoparticles is increased recently due to the novel characteristics and properties. Further the nickel oxide in the nano scale has a wide variety of applications in various fields. Although a number of publications are witnessing the synthesis of nano crystalline nickel oxide by different methods, new methods and/or simplified methods are needed for the synthesis. Based on this review, further research efforts have to be made, in future, for the synthesis of Nickel oxide nanoparticles.

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