

A Study and Characterization of Zn-DOPED NiO nanoparticles using Wet chemical method

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Abstract

In present study, the synthesis of illustrated that wet chemical reduction method is an applicable way for synthesis of Zn doped NiO nanoparticles. X-ray diffraction patterns of the nickel nanoparticles prepared with water , propanaol and ethanol on different concentrations of hydrazine confirm that the peaks are well defined and agree well with the JCPDS data of cubic structure.. SEM images of the zinc doped nickeloxide nanoparticles shows that shape of the particles is nearly spherical with homogeneous size distribution. It is observed from the EDAX analysis that the average atomic and weight percentage of Nickel oxide nanoparticles exhibits nearly the composition without inclusion of any other impurities in each case. The FT-IR spectra indicated the formation of Zinc doped Nickel Oxide nanoparticles. The chemical structure information of the products is studied by FTIR spectra. An absorption spectra of ethanol and ethanol assisted Zn-doped NiO samples with the strong absorption edges in obtained from the UV region at 350 and 310 nm, respectively.

Key words: FTIR, UV , Nickel oxide, wet-chemical method etc.,

INTRODUCTION

Nanoscience is one of the most promising areas of research in modern science with incredible applications in physics, chemistry, biology, medicine and material science. The major thrust has been given in developing new nanomaterials and examining their properties by the modification of particle size, shape and distribution. Nanotechnology can be defined as

the design synthesis, and application of materials and devices whose size and shape have been engineered at the nanoscale. It exploits unique chemical, physical, electrical, and mechanical properties that emerge when material is structured at the nanoscale. Nanomaterials have a long list of applications in improving human life and its environment. The first relation between human life and nanoscale was developed naturally in ayurveda, which is 5000 years old Indian system of medicine. It had some knowledge of nanoscience and nanotechnology before the term „Nano“ was even formed [1-2]. Research on semiconductor nanomaterials provide an improved physical, chemical and biological properties, which might be manipulated by the elective compounds with proper stoichiometry ratio of the assemble units (Coey et al 2004). It since the Nobel Laureate and the father of nanotechnology Dr. Richard Feynman lecture is challenged the science community to think over small and seeds of a new era in science and technology [3]. Among them, the main research of nanomaterials focuses on the creation and exploitation of materials which have size and morphological characteristics from atom to bulk materials with at least one dimension in the nanoscale range because of these nanoscale materials properties can be vary from those at a large scale [4].

The properties of the materials are different at nanoscale region due to two main reasons such as (i) increased surface area and (ii) quantum confinement effect [5]. The above explanation of this confinement within the physical boundaries of the semiconductor materials is given by quantum effect [6]. In quantum dot (0-D), the extreme case of this process of size reduction in which all three dimensions reaches at the nano range, it has been divided in possible morphologies like in spherical, spheres, plates and cubes. Quantum dimensional materials are very useful in the future development of optoelectronics devices [7]. The matter in nanometer regime has an inherent tendency to form bigger aggregates and the materials need to be stabilized kinetically in their nano regime such as, electrostatic stabilization and steric stabilization [8]. Metal oxide nanoparticles are the most common and widespread nanomaterials that are opening the doors to new innovations. Advances in this area have been progressing sharply over the past decades. They represent a field of material chemistry which attracts considerable interest due to their potential technological applications [18]. Inorganic nanostructures are becoming the ultimate systems for bringing about innovative phenomena at the nano range, leading towards a broad spectrum of applications. Different techniques are feasible for the preparation of metal oxides nanoparticles; among the many known synthesis methods, the hydrothermal method is the most preferred, as it offers good flexibility in controlling the morphology, size, concentration and the distribution of the synthesized metal

oxide nanoparticles [19]. It is also extensively desirable because of its ease of use, high efficiency and economic viability. In this technique the experimental parameters play an important role and influence the crystal structure and morphology of the metal oxide nanomaterials using solvents and dopant. Recently, II-VI semiconductors have been focus of intense research in nanomaterials [20].

Each of the semiconductors demonstrates some unique properties making them useful for unique applications with typically wide bandgap materials serving as efficient light emitters and it's a strong candidate for optoelectronics devices. The synthesis of inorganic nanoparticles has attracted much more interest due to their strong size dependent, electronic properties, optical properties and potential applications such as, NLO, LED, solar cells, biological labeling, electronic devices, optical recording materials and etc [21]. NiO nanoparticles showed size dependent property appears when the radius of the particles is comparable to the Bohr radius of the excitons in the bulk materials. By controlling the particle size, the forbidden gap in the semiconductor can be tuned [22].

Materials and Methods

Analytical grade reagents chemicals Nickel acetate and zinc acetate, ethanol, propanol deionized water obtained from M/s/ Sigma Aldrich company India.

All the chemical reagents were used without further purification; and double distilled water was used throughout the experiment. NiO nanoparticles were prepared by taking of 1.85g of Nickel acetate, 0.43g of NaOH were dissolved 80 mL of water, propanol or ethanol as solvent under stirring for 2 hrs. The mixed solution was transferred into a 100 mL of Teflon-lined stainless steel autoclave that was maintained at 180 °C for 12 hrs. Resultant product was filtered and washed with the distilled water repeatedly to remove impurities and dried vacuum at 80 °C for 6 hrs. The same procedure was followed for the preparation of ethanol assisted Zn-doped NiO nanoparticles using zinc acetate as dopant.

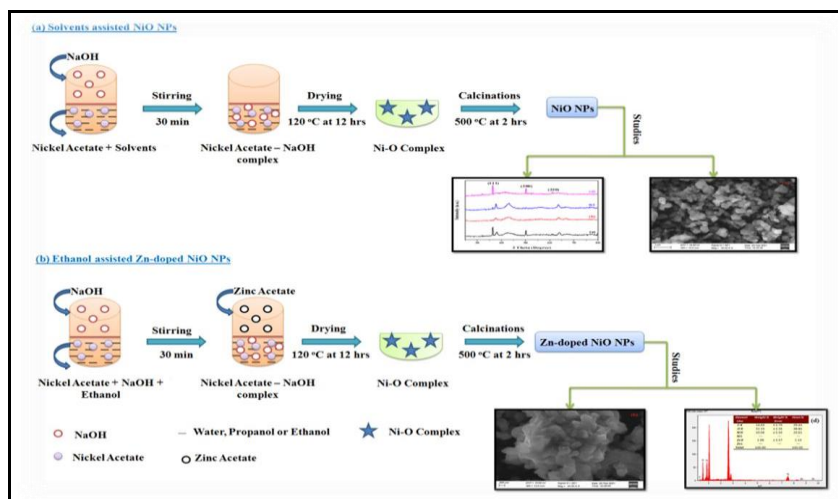


Figure 1 - of synthesis of Zn-doped Nickle Oxide nanoparticles -

RESULTS AND DISCUSSION

FT-IR Analyses

Figure .2 (a-b) shows FT-IR of ethanol and ethanol assisted Zn-doped NiO. The broad absorption peak centered at 3435cm^{-1} corresponds to the O-H stretching vibration of residual H_2O and OH groups. The absorption band located between $\sim (2800-3100)\text{cm}^{-1}$ corresponds to stretching and bending vibrations of O-H groups [39]. The absorption band centered at 1000 to 1500 is assigned to the ν_3 anti-symmetric stretching vibrations. Further, the strong absorption peak appears at 625cm^{-1} is assigned to the stretching vibration of Ni-O, which confirms the formation of the cubic structure of the NiO sample [40]. Since, there was no extra peak observed in the FT-IR spectra with addition of Zn ions, indicating its homogeneous dispersion in the prepared material, which is in good agreement with the XRD.

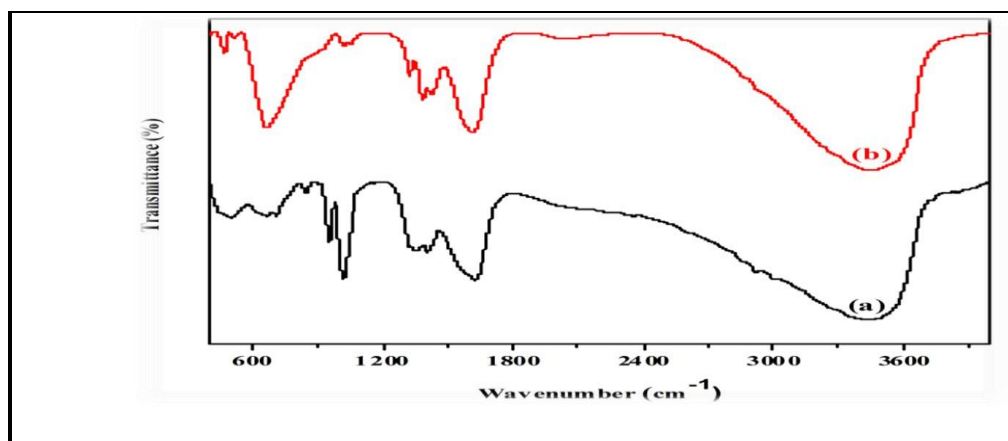
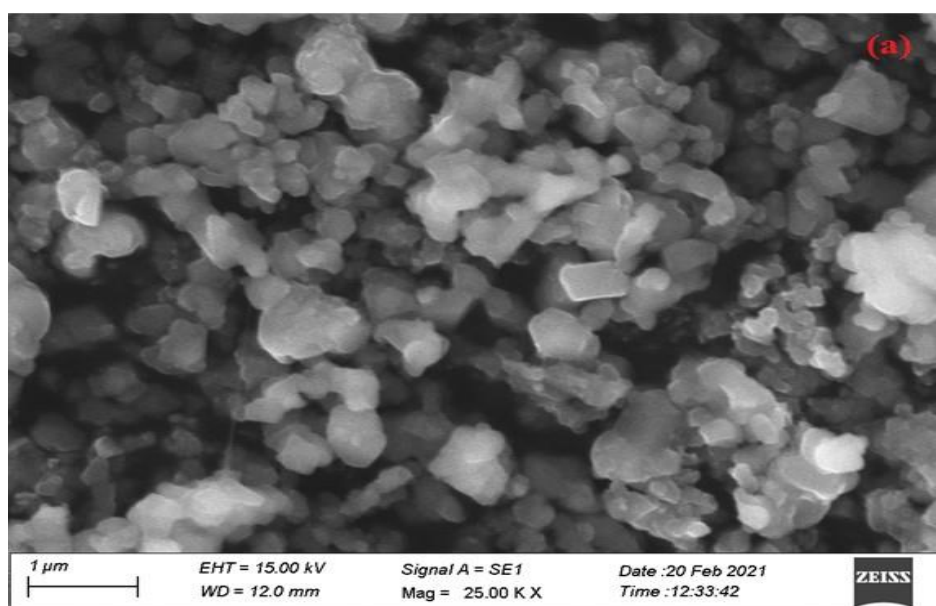
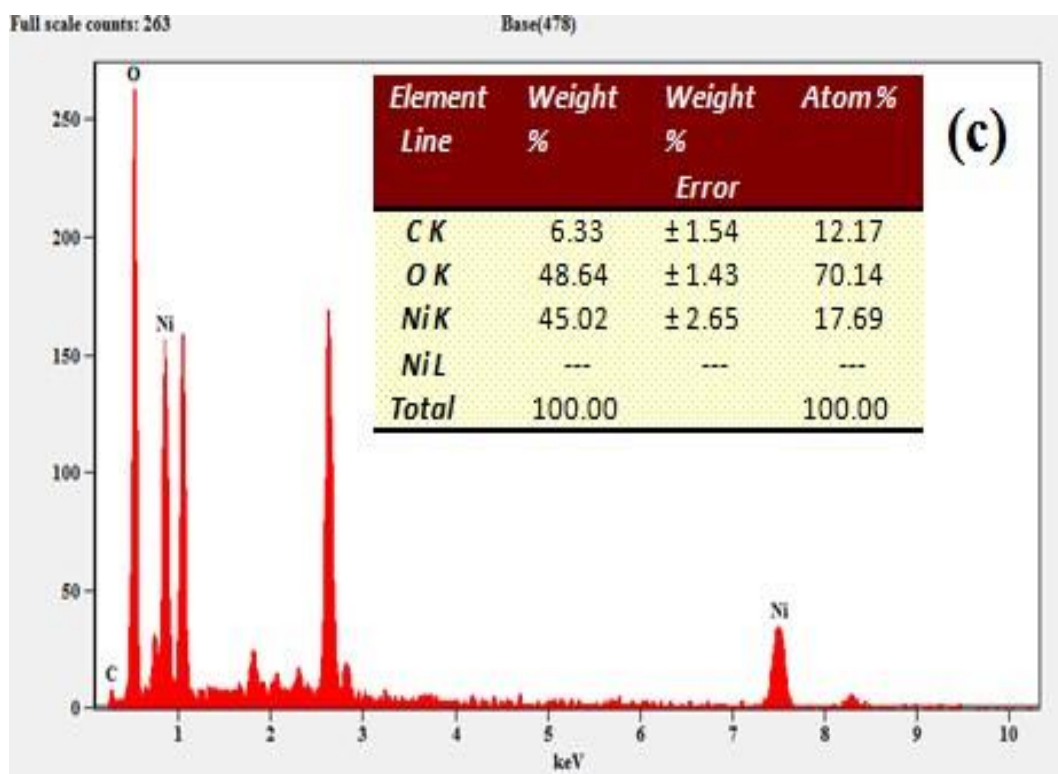
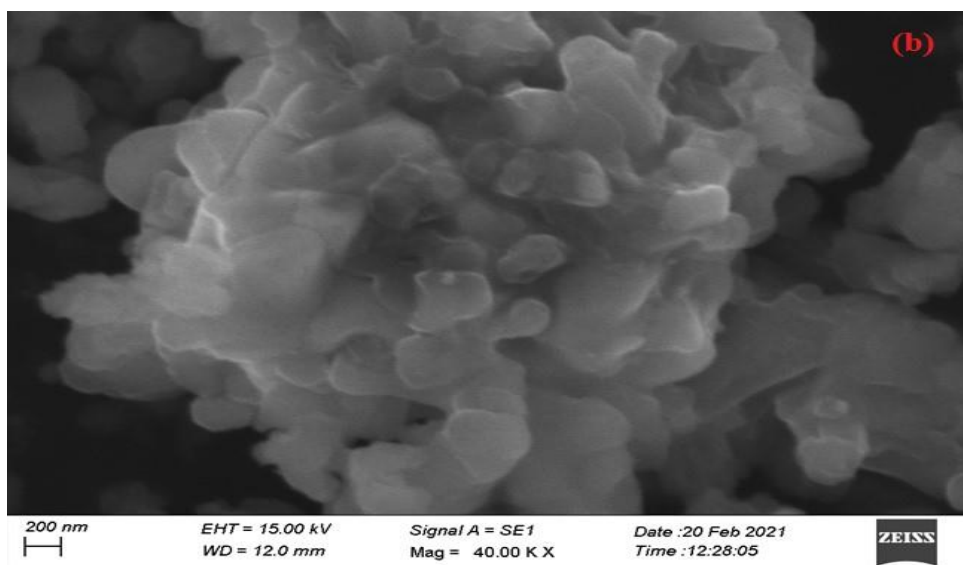


Figure 2-FT-IR of (a) Ethanol and (b) Ethanol assisted Zn-doped NiO nanoparticles

SEM Analysis

Figure 3 (a-d) shows SEM-EDX of ethanol and ethanol assisted Zn-doped NiO. As shown in the SEM images, aggregated and uniformed spherical-like morphologies were observed. Whereas, ethanol assisted Zn-doped NiO sample shows a uniform spherical-like morphology with smaller particle size. Figure 3 (c-d) shows EDX spectrum of ethanol assisted Zn-doped NiO samples with the presence of compositional elements such as nickel, oxygen and zinc. No extra peaks were present in the spectrum due to other element and zinc ions were equally distributed in the host matrix [41].





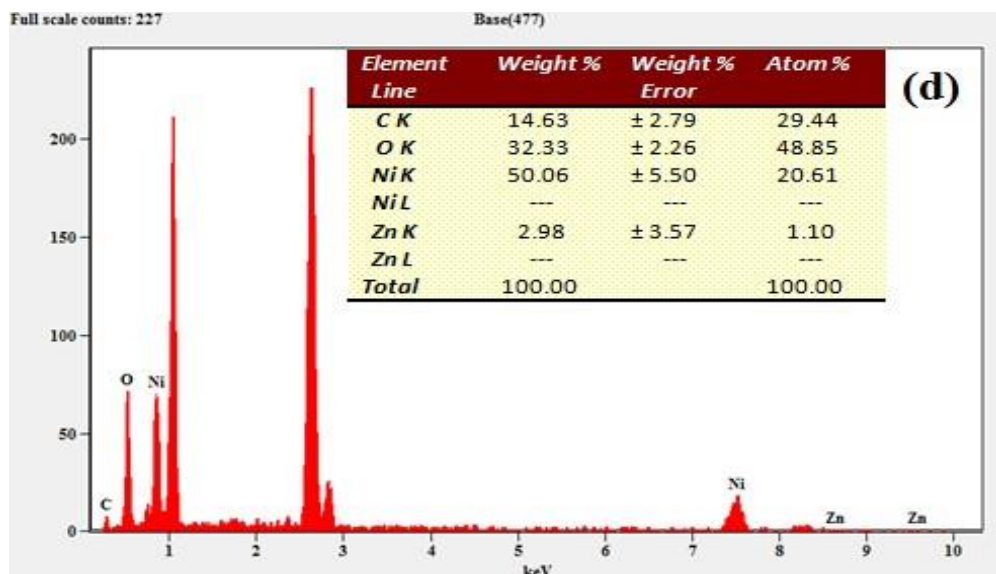


Figure 3 SEM-EDX (a, c) Ethanol and (b, d) Ethanol assisted Zn-doped NiO

UV-Visible Analysis

Figure 4 (a-b) shows absorption spectra of ethanol and ethanol assisted Zn-doped NiO samples with the strong absorption edges in the UV region at 350 and 310 nm, respectively.. In addition, the band gap values were estimated by plotting $(\alpha h\nu)^2$ as a function of photon energy ($h\nu$). The band gap values of the synthesized samples were estimated at 3.54 and 4.05 eV, respectively which were higher value than that of the bulk NiO 3.65 eV [42].

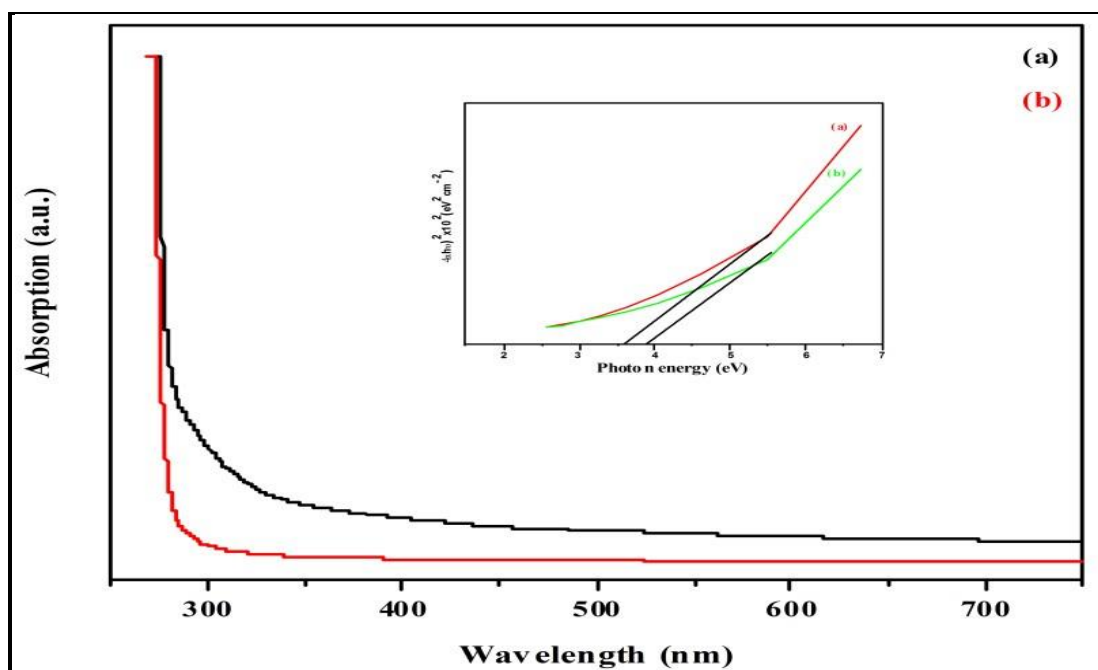


Figure.4 UV-visible of (a) Ethanol and (b) Ethanol assisted Zn-doped NiO nanoparticles

Conclusion

NiO nanoparticles were comparatively investigated using different solvents and dopant by the wet-chemical method. The bandgap of Zn-NiO is engineered by the control of the crystal size that leads to tunable band-edge emission. However, it is a challenge to find a prepared sample with particle sizes about few nanometres through this method using solvents and dopant. The main aim of the present works to study the effect of solvents and dopant on the size, shape, physical and chemical properties, so as to be applicable for various applications. Zn-doped NiO nanoparticles have been successfully synthesized with the particle size of Zn-doped about 38, and 18 nm by using the simple wet chemical method. The structure of the samples was confirmed by FTIR analyses. Spherical-like morphology morphologies were obtained for the synthesized samples. Among them results, the ethanol assisted Zn-doped NiO nanoparticles were found to be best.

REFERENCES

- 1) Nishizaki T, Okui M, Kurosaki K, Uno M, Yamanaka S, Takeda K, Anada H, *J. Alloy and Compd.*, Vol. 330, p. 307, 2002.
- 2) Nozik AJ, Memming R, *J. Phys. Chem.*, Vol. 100, p. 13061, 1996.
- 3) O'Toole GA, Pratt LA, Watnick, PI, Newman DK, Weaver VB, Kolter R, *Met. Enz.*, Vol. 310, p. 91, 1999.
- 4) Oura K, Lifshits VG, Saranin AA, Zotov AV, Katayama M, *Surf. Sci., An Introduction Springer-Verlag Berlin Heidelberg, Germany*, 2003.
- 5) Pan TM, Changn WT, Chiu FC, *Appl. Surf. Sci.*, Vol. 257, p. 3968, 2011.
- 6) Pan ZW, Dai ZR, Wang ZL, *Sci.*, Vol. 291, p. 1947, 2001.
- 7) Panagiotou T, Fishcer RJ, *Reac. and Sep.*, p. 33, 2008.

Research Paper

- 8) Park J, Joo J, Kwon SG, Jang Y, Hyeon T, *Angew. Chemie. Int. Ed.*, Vol. 46, p. 4630, 2007.
- 9) Paunovic V, Zivkovic L, Mitic V, *Sci. of Sint.*, vol. 42, p.79, 2010.
- 10) Pinna N, Niederberger M, *Chem. Int. Ed.*, Vol. 47, p. 5292, 2008.
- 11) Pinto RJB, Marques PAAP, Neto CP, Trindade T, Daina S, Sadocco P, *Acta. Biomater.*, Vol. 5, p. 2279, 2009.
- 12) Poole CP, Owens FJ, Introduction to Nanotechnology, *John Wiley and Sons, Inc., New Jersey*, 2003.
- 13) Prabhawathi V, Sivakumar PM, Doble M, *Ind. Eng. Chem. Res.*, Vol. 51, p. 5230, 2012.
- 14) Prakash Babu D, Hari Krishna R, Nagabhushana BM, Nagabhushana H, Shivakumara C, Chakradar RPS, Ramalingam HB, Sharma SC, Chandramohan R, *Spectrochi. Acta Part A: Mol. And Biomol. Spectro.*, Vol. 122, p. 216, 2014.
- 15) Puentes VF, Krishnan KM, Alivisatos AP, *Sci.*, Vol. 291, p. 2115, 2001.
- 16) Qiu M, Zhu L, Zhang T, Li H, Sun Y, Liu K, *Mater. Res. Bull.*, Vol. 47, p. 2437, 2012.
- 17) Qu LH, Peng XG, *J. Am. Chem. Soc.*, Vol. 124, p. 2049, 2002.
- 18) Rabani J, *J. Phys. Chem.*, Vol. 93, p. 7707, 1989.
- 19) Raghupathi KR, Koodali RT, Manna AC, *Lang.*, Vol. 27, p. 4020, 2011.
- 20) Rajendran V, Mekala R, *J. of All. And Comp.*, Vol. 741, p. 1055, 2018.
- 21) Ramamurthy CH, Padma M, Samadanam ID, Mareeswaran R, Suyavaran A, Kumar MS, Premkumar K, Thirunavukkarasu C, *Coll. and Surf. B: Bioint.*, Vol. 102, p. 808, 2013.
- 22) Ramsden JJ, *Nanotech. Percep.*, Vol.1, p. 3, 2005.

Research Paper

- 23) Rao CNR, Muller A, Cheetham AK, *The Chemistry of Nanomaterials Synthesis, Properties and Applications, Wiley-VCH Berlin, 2004.*
- 24) Rao KV, Sunandana CS, *Mat. Sci.*, Vol. 43, p. 154, 2008.
- 25) Raveendran TV, Limna Mol VP, *Curr. Sci.*, Vol. 97, p. 508, 2009.
- 26) Reeve KE, Undergraduate Honors Thesis. School of Allied Medical Professions, The Ohio State University, 2010.
- 27) Reza A, Soheila S, Lotf Ali S, *Chem. Eng. J.*, Vol. 236, p. 82, 2014.
- 28) Rifki S, Bamhang SP, Suhanda S, *J. of the Aus. Cer. Soc.*, Vol. 49, p. 101, 2013.
- 29) Rodrigues V, Bettini J, Rocha AR, Rego LGC, Ugarte D, *Phys. Rev. B.*, Vol. 65, p. 153402, 2002.
- 30) Rodrigues V, Fuhrer T, Ugarte D, *Phys. Rev. Lett.*, Vol. 85, p. 4124, 2000.
- 31) Rodriguez JA, Fernandez-Garcia M, *Synthesis, Properties and Applications of Oxide Nanoparticles, Wiley: New Jersey, 2007.*
- 32) Roe D, Karandikar B, Bonn-Savage N, Gibbins B, Rouillet JB, *J. Antimic. Chemother.*, Vol. 61, p. 869, 2008.
- 33) Salavati-Niasari M, Khansari A, Davar F, *Inorg. Chim. Acta.*, Vol. 362, p. 4937, 2009.
- 34) alavati-Niasari M, Javidi J, Davar F, *Sonochem.*, Vol. 17, p. 870, 2010.
- 35) Sanchez C, Julian B, Bellevielle P, Popall M, *J. Mater. Chem.*, Vol. 15, p. 3559, 2005.
- 36) Sato S, Takahashi R, Kobune M, Gotoh H, *Appl. Catal. A: Gen.*, Vol. 356, p. 57, 2009.
- 37) Sattler KD, *Handbook of Nanophysics: Nanoparticles and Quantum Dots, CRC Press, New York, 2011.*
- 38) Sawai J, *J. Microbiol. Met.*, Vol. 54, p. 177, 2003.

Research Paper

- 39) Schmids G, Nanoparticles: From Theory to Application, 2nd Edition, Wiley- VCH, Weinheim, 2010.
- 40) Sediri F, Gharbi N, *J. of Phy. and Chem. of Sol.*, Vol. 68, p. 1821, 2007.
- 41) Senthil Kumar N, Sethu Raman M, Chandrasekaran J, Priya R, Chavali M, Suresh R, *Mat. Sci. in Semi. Proc.*, Vol. 41, p. 497, 2016.
- 42) Shaffer BT, Lighthart B, *Microbiol. Ecol.*, Vol. 34, p. 167, 1997.