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Bismuth Oxide (Bio) Nanoparticles Prepared by Co – Precipitation Method

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ABSTRACT

The bismuth oxide (BiO) nanoparticles have been successfully prepared by co-precipitation method. The crystallite size and morphology of bismuth oxide have been investigated by X-Ray diffraction (XRD), scanning electron microscopy (SEM), energy dispersive spectrum (EDS), and transmission electron microscopy (TEM) techniques. The calculated average crystallite sizes of BiO in 34 nm. Furthermore, bismuth oxide nanoparticles have the crystallite size in the range ~24-38 nm, as confirmed by TEM. Results obtained indicate that the co-precipitation method is a promising low temperature, cheap, and fast method for the production of bismuth oxide nanostructures.

Keywords: XRD; Co-precipitation method; SEM; EDS; TEM.

INTRODUCTION

It is non flammable, stable and insoluble in water, II-VI semiconductor with wide band gap energy that is 3.3ev and high excitation energy that is 60 eV [1]. Bismuth oxide is the topic of interest in these days due to its presence much unique and important morphology likes nanorods, nanoflowers, nanowires, nano dendrites and nanoparticles bismuth oxide (BiO) is a white solid inorganic powder. In recent years, noble metal oxide nanoparticles have been the subject of focused research due to their unique electronic optical, mechanical, magnetic and chemical properties. This semiconductor has several favorable properties including good transparency, high electron mobility, strong room temperature, low toxicity, luminescence and photo chemical stability and higher breakdown field strength.

General, BiO_2 crystallizes in two main form, hexagonal wurtzite and cubic zinc blende but the (B4 type) wurtzite structure is obtained only at optimum pressure and temperature [2-3]. Bismuth oxide (BiO) crystallizes in the typical wurtzite hexagonal structure where oxygen and zinc atoms are spatially arranged in a way that O atoms are arranged in a closed hexagonal structure, while the Bi atoms occupy the centre of the distorted tetrahedron structure [4]. The variety of structures of Nano metric zinc oxide means that ZnO_2 can be classified among new materials with potential applications in many fields of nano technology. Bismuth oxide (BiO) can occur in one - (ID), two - (2D), and three-dimensional (3D) structures. One dimensional structure make up the largest group, including nano rod -needles, - helixes, - springs and -rings, - ribbons, - tubes - belts - wires and -combs. BiO can be obtained in 2D structures, such as Nano plate/Nano sheet and Nano pellets. Examples of 3D structures of zinc oxide include flower, dandelion, snowflakes, coniferous urchin-like, BiO provides one of the greatest assortments of varied particle structures among all known materials [5-6]. The large specific surface area high pore volume, nano structured properties, low cost and low toxicity of nano BiO [7] make it a promising candidate, particularly in catalysts [8], photo catalysis, electrostatic dissipative coating, transparent UV protection films, and chemical sensors [9-12], gas sensor, solar cells. Moreover, BiO nanoparticles have a tremendous potential in biological applications like biological sensing, biological labeling, gene delivery, drug delivery and nano-medicine [13-16].

One of the most important environmental applications of nanotechnology is in the water sector. heterogeneous photocatalysts, one of the advanced oxidation process(AOPS),is a cost-effective treatment methods for the removal of toxic pollutants from industrial waste water sowing to its ability to convert these into safer and products such as CO_2 , H_2O and mineral acids [17-18]. Several conventional methods have been used for synthesis of ZnO_2 nanoparticles like chemical vapour synthesis [19-21], laser ablation [22-23], solvothermal [24], thermal decomposition [25], and sol-gel method [26]. In the present study was report the synthesis of BiO nanoparticles using co-precipitation method and the characterization of BiO nanoparticles using X-ray diffraction (XRD), transmission electron microscopy (TEM), selected area electron diffraction (SAED), scanning electron microscopy (SEM), fourier transform infrared

spectroscopy (FTIR) energy dispersive spectrum (EDS) are discussed. Here we present a simple co-precipitation method to synthesize uniform, spherically shaped and pure BiO and Aluminium doped Bismuth oxide is the topic of interest in these days due to its presence much unique and important morphology likes nanorods, nanoflowers, nanowires, nano dendrites and nanoparticles bismuth oxide (BiO) is a white solid inorganic powder.

EXPERIMENTAL PROCEDURE

Materials

Bismuth nitrate (Bi $(NO_3)_2.6H_2O$) and ammonia solution of analytical grade (SD fine chemicals, 98.5%) were used as such without further purification for synthesis process. Double distilled water was used throught the experiments.

Synthesis of pure BiO_2 nanopowder

Pure BiO samples have been prepared by using a starting solution of Bi nitrate with 0.1 M concentration diluted in deionized water salt used as dopant source is added with a small amount in the starting solution. Then, NH_3 was added, under constant stirring conditions, up to at the pH level of 8. The stirred mixture was irradiated by the microwave radiation of frequency 2.45GHZ, for 5 minutes continuously. The precipitates were collected and, washed with distilled water for several times until the extracts turns into a white product. The final product was annealed at 400 °C for 5 hours.

Characterization

The resulting powders were analyzed by X-ray diffraction (XRD) using a Bruker AXS D8 Advance instrument diffractometer with monochromatic CuKα1 wavelength of 1.5406 Å. The samples morphology was observed by scanning electron microscopy (SEM), using a JEOL 5600LV microscope at an accelerating voltage of 10 kV. The microstructure was studied by transmission electron microscopy (TEM) and selected-area electron diffraction (SAED) in a Tecnai G20-stwin operated at 200 kV. The Fourier transform infrared spectra (FT-IR) of the samples were recorded by using a Nicolet 5DX FTIR spectrometer.

RESULTS AND DISCUSSION

X-Ray Diffraction analysis

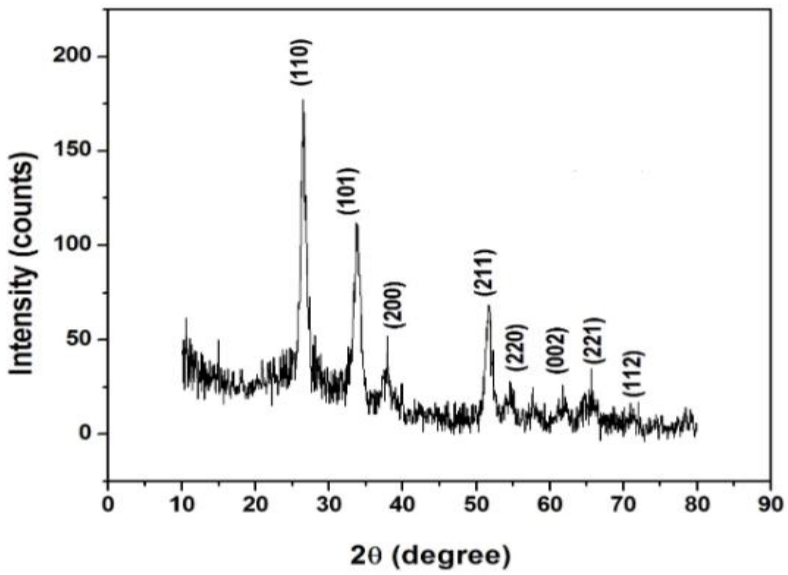

Fig .1 X-Ray diffraction pattern of BiO nanoparticles

The phase formation and purity of the as synthesized BiO nanoparticles were investigated by XRD as shown in Fig.1. All the diffractions peaks can be perfectly indexed the **tetragonal structure**. The average crystalline size of BiO_2 nanoparticles in found to be **28 nm.** The following miller indices **(110), (101), (200), (221), (220), (002), (221), (112)** with calculated lattice parameter of in the standard **JCPDS (# 41-1445)** data the average size of the nanoparticles were calculated based on using Debye-Scherrer formula,

$$D = K \lambda / \beta \cos \theta$$

D – Mean crystalline size
K- Shape factor
λ –wavelength of incident beam
β –full width at half maximum
θ- Bragg's angle

Scanning Electron Microscopy (Sem)

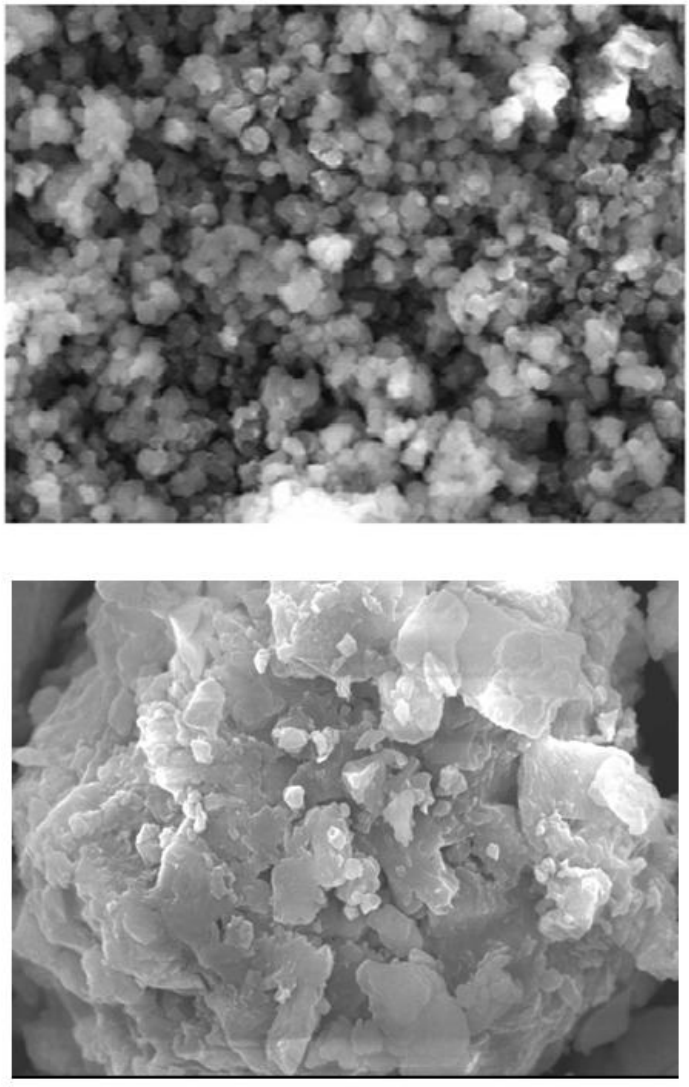

Fig.2 SEM analyzing images of BiO nanoparticles

In order to study the morphology and size distribution of the synthesized samples, scanning electron microscopy (SEM). SEM micrograph reveals that the obtained sample is the approximate spherical particles with a little agglomeration, and the particles sizes of them are in the range of **59-90 nm.** Which are larger compared with the results obtained from XRD analysis. The concentration is too high; the morphology of BiO particles becomes less uniform.

Energy dispersive spectrum (eds)

Fig.3 shows a typical energy dispersive of BiO nanoparticles synthesized by co - precipitation method. This spectrum is performed to investigate the elemental composition of BiO nanostructures. Energy dispersive spectrum analysis confirms the presence of BiO nanostructures. The table shows ratio of oxygen and Bi, which contains the weight 0.525 % and atomic 20.48% of oxygen and weight 2.042% and atomic 79.52% of Bi.

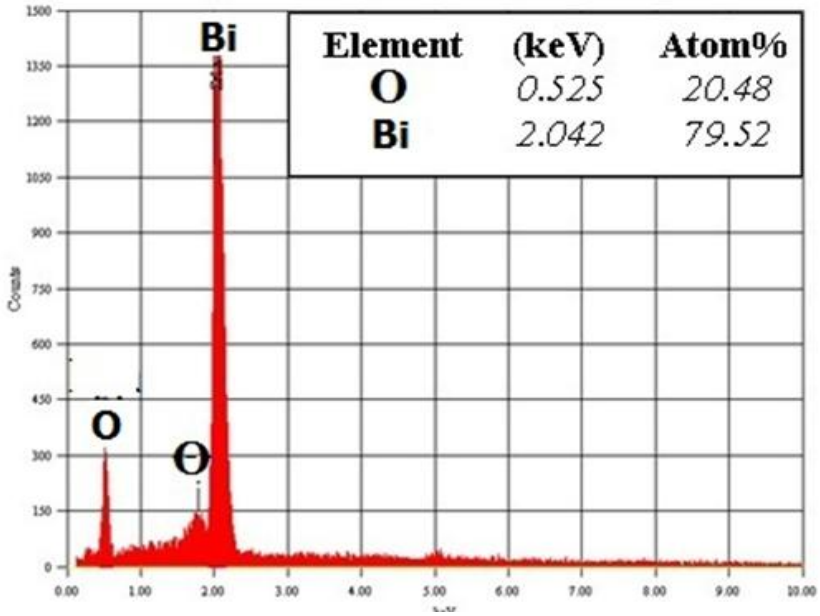

Fig.3 EDS analyzing image of BiO nanoparticles

Transmission electron microscopy (TEM)

The Particle size and nanostructure of BiO nanoparticles have been examined through transmission electron microscope (TEM) are shown in Fig 4. The particle sizes of the bismuth oxide samples are consistent with the results of XRD analysis. The pattern implies that the prepared BiO nanoparticles are some particles **spherical shape** in the range of about 18-36 nm. The SAED pattern of BiO_2 nanostructures further confirms the crystalline nature of the sample. Fig 4 shows an electron diffraction pattern representing well-defined quasicontinuous diffraction rings. It is visible that the (011), (021), (211) and (131) planes were clearly distinguished as observed in XRD patterns. The SAED pattern of the high resolution TEM image conformed the nanoparticles corresponds to tetragonal structure.

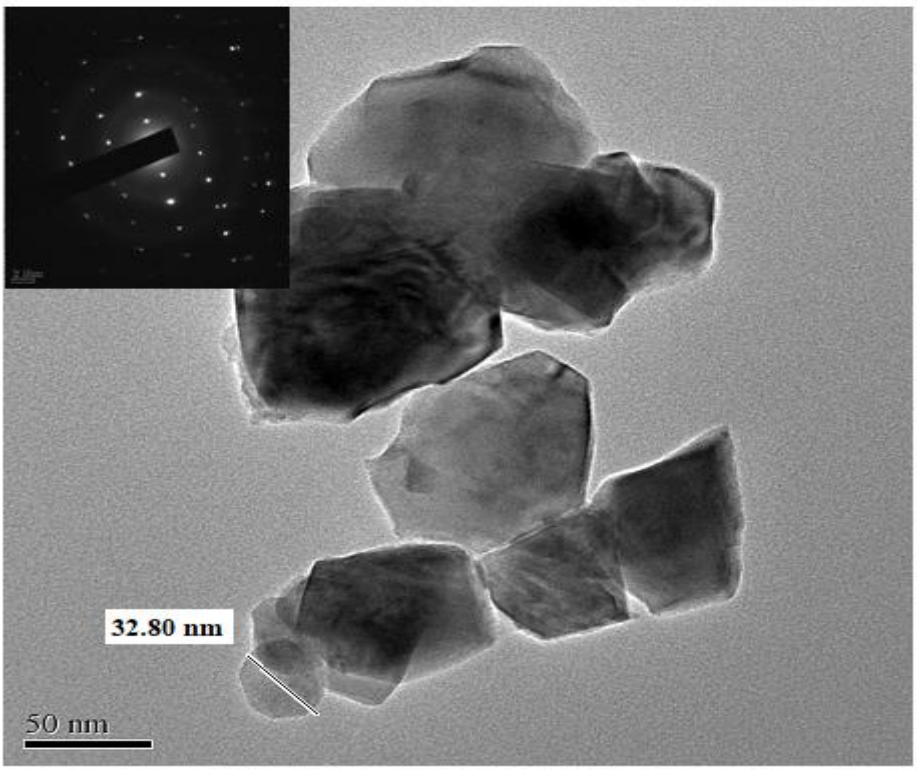

Fig.4 TEM analyzing images of BiO nanoparticles

CONCLUSION

The bismuth oxide (BiO) nano powders are successfully synthesized by co- precipitation method. The average crystalline size of BiO_2 nanoparticles in found to be **28 nm**. The following miller indices **(110), (101), (200), (221), (220), (002), (221), (112)** all the diffractions peaks can be perfectly indexed the **tetragonal structures**. The SEM images revels the approximate spherical particles with a little agglomeration and the particles sizes. The TEM pattern implies that the prepared BiO_2 nanoparticles are some particles **spherical shape** in the range of about 18-36 nm. The SAED pattern of BiO nanostructures further confirms the crystalline nature of the sample. EDS shows the chemical composition of Bi and O peaks. The total ratio of elements having atomic weight has been calculated. This is simple synthesized method it has used for ceramics and photovoltaic applications.

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