Effect of Calcination Temperature on Structural and Morphological Characterization of In_2O_3 nanoparticles synthesized using Aloe Vera Plant extract

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ABSTRACT

In this work In2O3 nanoparticles (NPs) has been synthesized with cubic structure by simple, cost effective and eco friendly route using Aloe Vera barbadensis Miller species available in our region. NPs formed after calcinations the dried precursor of In2O3 in air at 3500C, 4500C and 5500C for 2 h. The structural, morphological and compositional properties of synthesized NPs were characterized using XRD and SEM. The morphology and crystallite size of In2O3 material were affected by calcinations temperature.

Keywords: Indium oxide, Aloe Vera, Nanoparticles.

INTRODUCTION:

Indium oxide (In2O3) belongs to class of wide band gap metal oxides. It has attracted considerable attention because of it has interesting properties such as high transparency to visible light, high electron affinity and low electron effective mass.In2O3 has wide applications in flat panel display materials [1], fuel cells[2], gas sensors[3], nanoscale transistor [4] etc. In2O3 nanocrystals with different morphologies such as nanoparticles [5], nanowires [6], nanorods [7], nanoribbons/nanobelts [8-9], nanocrystals chains [10], nanotubes [11], nanotowers [12], hollow spheres [13] have been successfully prepared in past decades. In recent years, the development of efficient green chemistry methods for synthesis of metal nanoparticles has become a major focus of researchers. They have investigated in order to find an eco-friendly technique for production of well-characterized nanoparticles. NPs produced by plants are more stable and the rate of synthesis is faster. In2O3 have been synthesized by several techniques including hydrothermal [14], sol-gel techniques [15], gas phase deposition [16] etc. Among other established synthesis methods, simple and cost effective route to synthesize nanocrystalline In2O3 powder by using a novel synthesis method using Aloe Vera plant extract reported by Maensiri [17]. Among 400 different species of aloe, A. Vera barbadensis Miller is most popular and biologically most active. Aloe Vera (Aloe barbandesis Miller) is a perennial succulent belonging to the Liliaceal family, and it is a cactus like plant that grows in hot ,dry climates .Aloe Vera possess anti-inflammatory, UV protective, immunomodulatory, antiprotozoal and wound and burn healing promoting properties. The extract of Aloe Vera plant has been successfully used to synthesize single crystalline triangular gold nanoparticles (~50-350 nm size) and spherical silver nanoparticles (~15 nm size)[18].

Synthesis of nanocrystalline In_2O_3 powder:

The synthesis of nanocrystalline In2O3 powder is described in detail elsewhere [17].In typical synthesis Indium (III) acetyl acetonate (Alfa Aesar, 98%) was used as starting chemical material for In2O3. Aloe Vera leaves of Aloe barbadensis Miller species were collected and thoroughly washed with tap water. The pulp of leaves were finely cut and boiled in 100 ml of de-ionized water. 5g of Indium (III) acetyl acetonate was first dissolved in 50 ml Aloe Vera extract solution under vigorous stir at 600C for several hours, until dried using constant temperature magnetic stirrer cum heater. The dried precursor (brownish color) was crushed using mortar and pestle and subsequently calcined in muffle furnace at 3500C, 4500C and 5500C for 2 h in air. The dried precursor turns into yellowish powder.

Structural and morphological Studies:

The surface morphology and chemical composition of the films were analyzed using scanning electron microscope [SEM model JEOL 6300(LA) Germany] coupled with an energy dispersive spectrometer (EDS JEOL, JED-2300, Germany). The phases of the calcined powder was obtained using X-ray diffraction (XRD, Bruker D8, Advance) spectroscopy with Cu-Kα Radiation (λ=1.542Å) for the Bragg angle ranging from 20 to 80º.The grain size was determined using Scherrer formula.

RESULTS AND DISCUSSION:

Structural Characterization:

Fig. 1 shows the XRD pattern of In2O3 NPs calcined at 350,450 and 5500C respectively. All XRD reflection can be indexed to cubic In2O3 (JCPDS card number 06-0416), no other peaks can be observed, revealing their phase-pure cubic structures. Indium Oxide is grown in body centred cubic (bcc) phase with (222) plane orientation. The intensities of the diffraction peaks increased after calcination temperature indicating better crystallinity. This confirms that synthesis is viable and complete, producing quality In2O3 NPs (impurity free, with X-ray detection limits). The XRD patterns, shown in Fig. 1 indicates formation of crystalline In2O3 NPs with cubic structure with average crystallite size of 9 nm,10 nm and 12 nm (estimated from Scherrer formula) for calcination temperature 3500C,4500C,5500C respectively. From fig.1 It has been observed that structural planes of XRD pattern more disturbed at calcination temperature 3500C.

Fig.1: XRD patterns of nanocrystalline In2O3 samples calcined at (a) 3500C (b) 4500C(c) 5500C

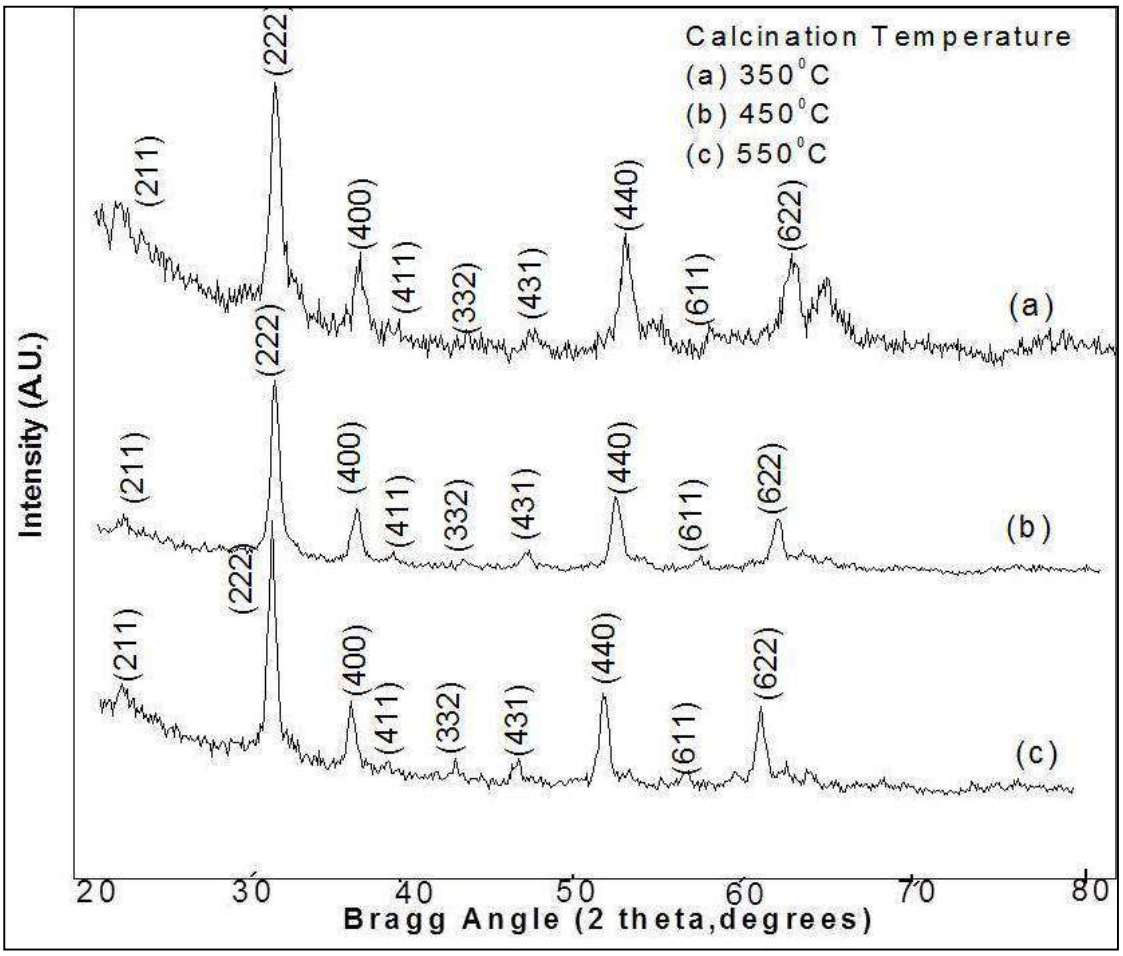
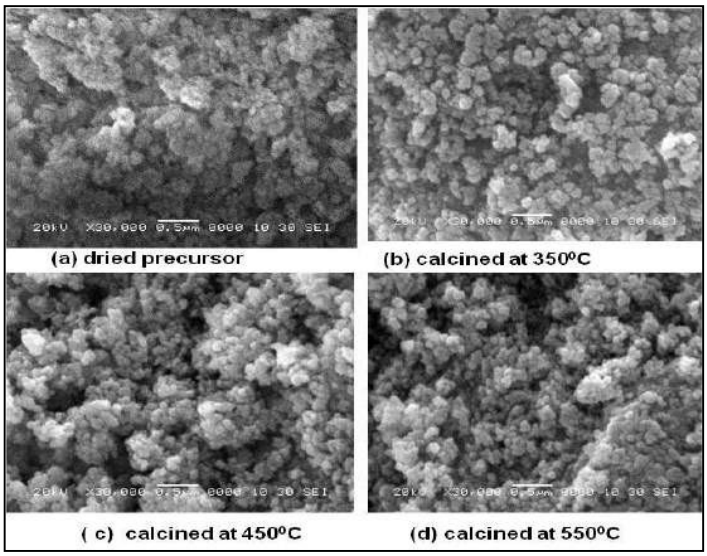


Fig.2 shows typical SEM images of dried precursor of In2O3 and calcined at 3500C, 4500C, 5500C . A uniform distribution of spherical particles can be seen. The SEM images of In2O3 sample calcined at 450 0C shows cauliflower like structure.

Fig.2: SEM images of dried precursor and calcined In2O3 at 3500C, 4500C, 5500C



CONCLUSIONS:

In2O3 Nps synthesized using simple, cost effective and environmental friendly route. X-ray diffraction (XRD) shows cubic BCC structure. The crystallite size increases with increase in calcination temperature. Scanning Electron Microscopy (SEM) analysis showed agglomeration of NPs with spherical shape. The calcined samples have cauliflower like structure. The morphology and size were affected by calcination temperature. The synthesized Indium Oxide NPs r can be used for gas sensors and biosensors applications.

REFERENCES:

J.Cui, A.Wang, N. L.Edleman, J.Ni, P.Lee, N. R.Armstrong, T. J.Marks, *Adv. Mater.*13(2001)1476-1480.

J. Parrondo, R. Santhanam, F. Mijangos, B. Rambabu, *Int. J. Electrochem. Sci*., 5 (2010) 1342-1354.

S.C.Kulkarni ,R.Y. Borse,*journal of sensor and tranducer*.vol. 125,issue2,Feb 2011,pp194-204

P. Nguyen, H. T.Ng, T.Yamada, M. K.Smith, J.Li, J.Han, M.Meyyappan, *Nano Lett*. 4(2004)651- 657

C.Liang, G.Meng, Y.Lei, F. Phillipp, L. Zhang, *Adv. Mater*. 13(2001) 1330-1333.

Z.Pan, Z.Dai, Z. Wang, *Science* 291(2001) 1947-1949

Jae Myung Kim, Joung Kyu Park,Kyung Nam Kim, Chang Hae Kim,Ho Gyeom jang ,*current Applied physics* 651 (2006) e198-e201

Xiang Yang Kong, Zhong Lin Wang, *solid state communications* 128 (2003) 1-4

J.Jeong, J.Lee, C. Lee, S.An, G. Yi, *Chem. Phys. Lett*. 384(2004)246

Ahsanulhaq Qurashi, E.M.EI-Maghraby,Toshinari Yamazaki,Toshio Kikuta, *Sensors and Actuators B* 147 (2010)48-54

C.Chen, D.Chen, X.Jiao, C.Wang, *Chem. Commun*. (2006) 4632.

Y.Yan, Y.Zhang, H.Zeng, L.Zhang *Cryst. Growth & Des.* 7 (2007) 940-943.

P. Zhao, T.Huang, K.Huang, *J. Phys. Chem*. C 111(2007) 12890-12897.

Jiaqiang Xu, Xiaohua Wang, Jianian Shen, *sensors and Actuators* B115 (2006) 642-646.

S.C. Kulkarni, C.S.Aher,B.G. Bharate, R.Y.Borse,S.A.Ansari,P.K.Khanna,*Advanced science Letter,* Vol.4,1-5 2011.

E. Gagaouakis, M. Bender, E. Doulouufakis, N. Katsarakis, E. Natsakou,V. Cimalla, G. Kiriakidis, Sens. Actuators B 80, 155-161, (2001).

S.Maenseri, P. Laokul etal, journal of optoelectronics and Materials ,vol.10,No.3.March 2008,p 161-165

Amit Kumar Mittal, Yusuf Chisti , Uttam Chand Banerjee, Biotechnology Advances 31 (2013) 346–356
