JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Solution Combustion Method (SCM) for the Formulation of $BiFe_{1-x+y}Ba_xCa_yO_3$ (x, y = 0.1, 0.15, 0.2, 0.25) Nanopowder Samples

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Abstract: This paper presents the formulation of nanopowders of multiferroic samples like $BiFe_{0.8}Ba_{0.1}Ca_{0.1}O_3$, $BiFe_{0.7}Ba_{0.15}Ca_{0.15}O_3$, $BiFe_{0.6}Ba_{0.2}Ca_{0.2}O_3$ and $BiFe_{0.5}Ba_{0.25}Ca_{0.25}O_3$ by solution combustion method (SCM). The nanopowders of $BiFe_{0.8}Ba_{0.1}Ca_{0.1}O_3$, $BiFe_{0.7}Ba_{0.15}Ca_{0.15}O_3$, $BiFe_{0.6}Ba_{0.2}Ca_{0.2}O_3$ and $BiFe_{0.5}Ba_{0.25}Ca_{0.25}O_3$ samples were prepared using metal nitrates and glycine fuel as initial starting materials. These nanopowder samples were processed by grinding them in an acetone medium, calcining them at various temperatures, and finally producing pellets.

Keywords: Multiferroics, Nanopowder, $BiFeO_3$, Ca and Ba dopants, SCM, applications.

I. INTRODUCTION

Ferroelectricity and ferromagnetism coexisting and interacting simultaneously in multiferroic materials [1]. At room temperature, $BiFeO_3$ manifests a ferroelectric Curie temperature T_C = 1103 K and G-type antiferromagnetic Neel temperature T_N = 643K [2].

The multiferroic $BiFeO_3$ have number of key applications in spintronics [3], photovoltaics, optical filters [4], sensors [5], catalytic [6], piezoelectric devices, photosensitizers [7], multistate storage [8] and high density microactuators [9]. The number of formulation routes have been used for the synthesis of $BiFeO_3$ multiferroic ceramics like solid state reaction technique [10], combustion technique [11], auto-combustion method [12] and sol-gel auto combustion method [13].

In this article, we have synthesized the $BiFe_{0.8}Ba_{0.1}Ca_{0.1}O_3$, $BiFe_{0.7}Ba_{0.15}Ca_{0.15}O_3$, $BiFe_{0.6}Ba_{0.2}Ca_{0.2}O_3$ and $BiFe_{0.5}Ba_{0.25}Ca_{0.25}O_3$ multiferroic nanopowder samples through solution combustion method.

II. Experimental Procedure:

Initial Materials:

The bismuth nitrate, ferric nitrate, barium nitrate, calcium nitrate and glycine were used as initial starting materials.

Synthesis Process:

The preparation of $BiFe_{0.8}Ba_{0.1}Ca_{0.1}O_3$, $BiFe_{0.7}Ba_{0.15}Ca_{0.15}O_3$, $BiFe_{0.6}Ba_{0.2}Ca_{0.2}O_3$ and $BiFe_{0.5}Ba_{0.25}Ca_{0.25}O_3$ ceramic samples were carried out using the precursors such as bismuth nitrate, ferric nitrate, barium nitrate, calcium nitrate as an oxidizers while glycine was used as a fuel. The oxidizer (O) to fuel (F) ratio was measured accurately to form the sample mixture by measuring the oxidizing and reducing valences of the fuel [14].

The bismuth nitrate, ferric nitrate, barium nitrate, calcium nitrate and glycine taken in a stoichiometric extent and were dissolved in a distilled water in a separate beakers thereafter, The mixture of these solutions was transferred to a Pyrex dish and heated on a gas burner. Afterwards the continuous heating, the water gets evaporated and finally a combustion takes place with formation of $BiFe_{0.8}Ba_{0.1}Ca_{0.1}O_3$, $BiFe_{0.7}Ba_{0.15}Ca_{0.15}O_3$, $BiFe_{0.6}Ba_{0.2}Ca_{0.2}O_3$ and $BiFe_{0.5}Ba_{0.25}Ca_{0.25}O_3$ nanopowder samples. The experimental process was given by Chaudhari et.al. [15], these powders were grinded in an acetone medium and finally calcined at 200^oC, 210^oC, 220^oC, 230^oC for 1 hour in a furnace and finally carried out for pellet formation. The following flowchart in Fig.1. shows the entire experimental procedure for the formulation of these powder samples and Fig. 2. describes the complete experimental route for the formulation of the powder samples.

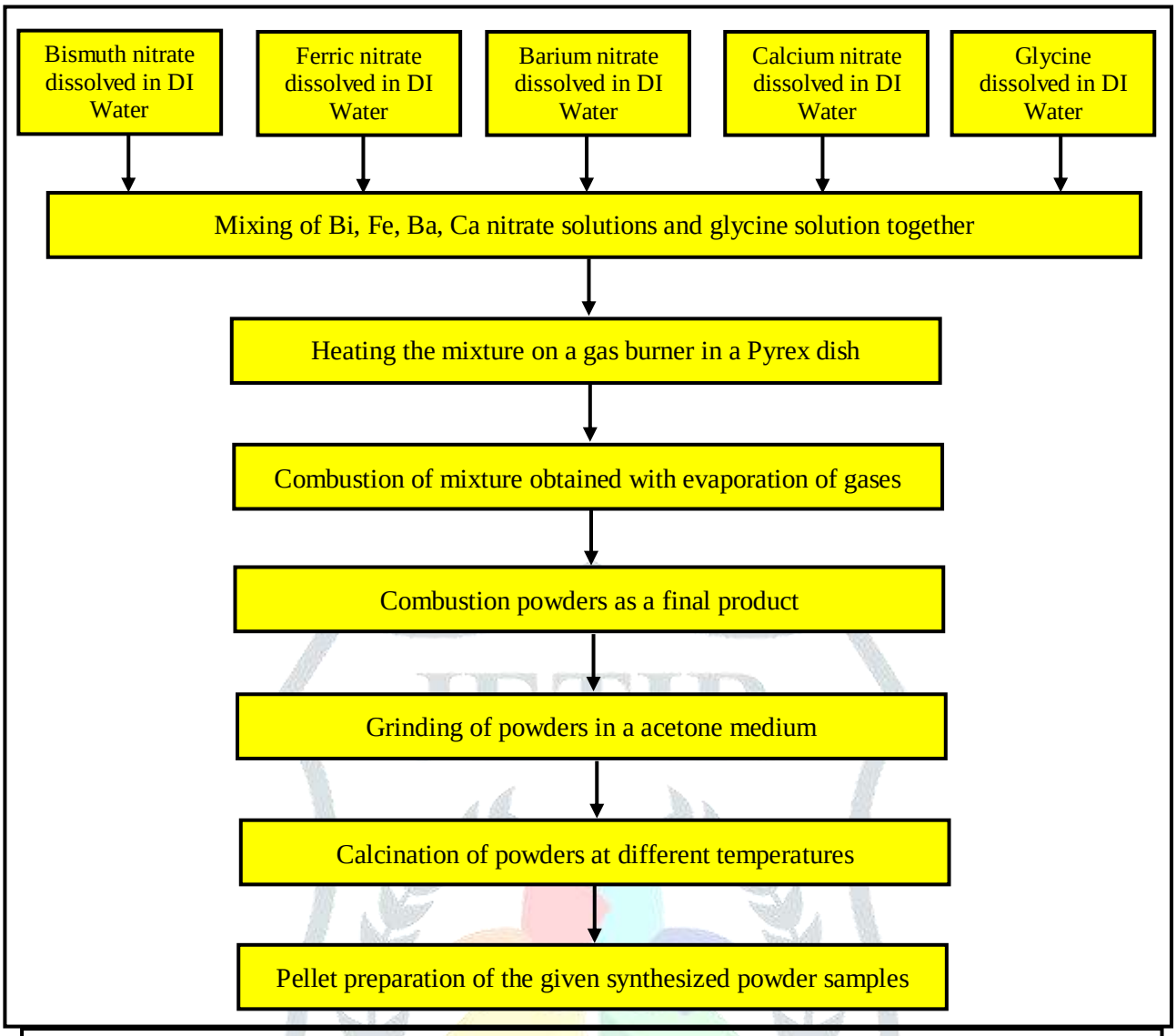

Fig.1. Flowchart of preparation of $BiFe_{0.8}Ba_{0.1}Ca_{0.1}O_3$, $BiFe_{0.7}Ba_{0.15}Ca_{0.15}O_3$, $BiFe_{0.6}Ba_{0.2}Ca_{0.2}O_3$ and $BiFe_{0.5}Ba_{0.25}Ca_{0.25}O_3$ multiferroic samples by SCM.

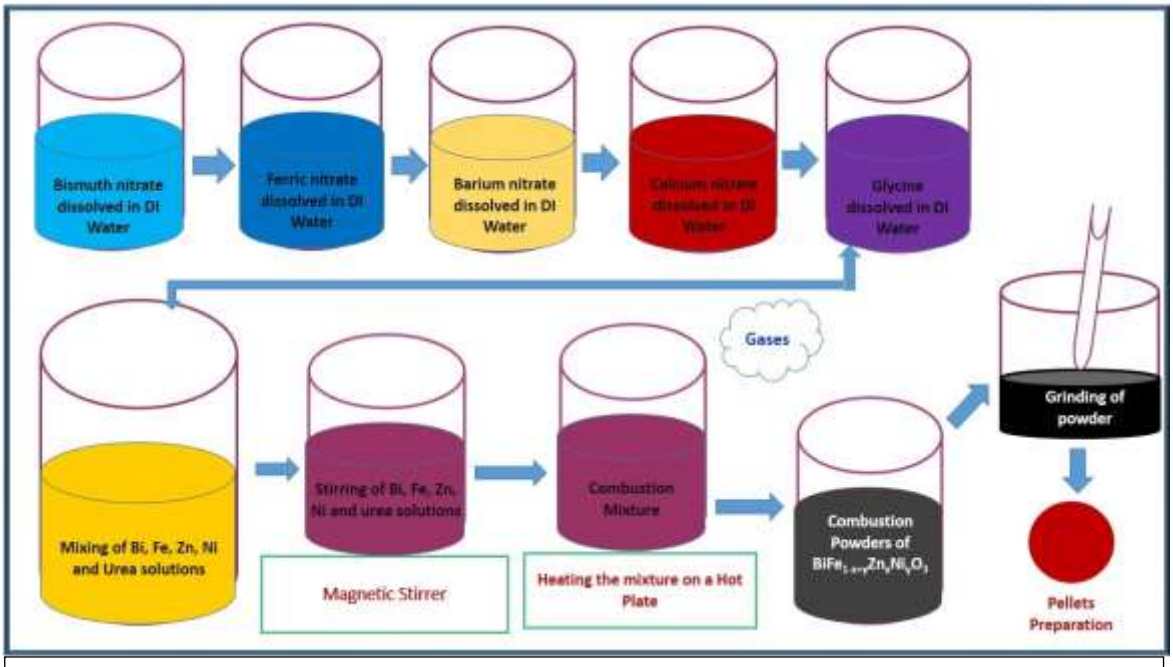

Fig.2 Experimental process of synthesis of $BiFe_{0.8}Ba_{0.1}Ca_{0.1}O_3$, $BiFe_{0.7}Ba_{0.15}Ca_{0.15}O_3$, $BiFe_{0.6}Ba_{0.2}Ca_{0.2}O_3$ and $BiFe_{0.5}Ba_{0.25}Ca_{0.25}O_3$ samples.

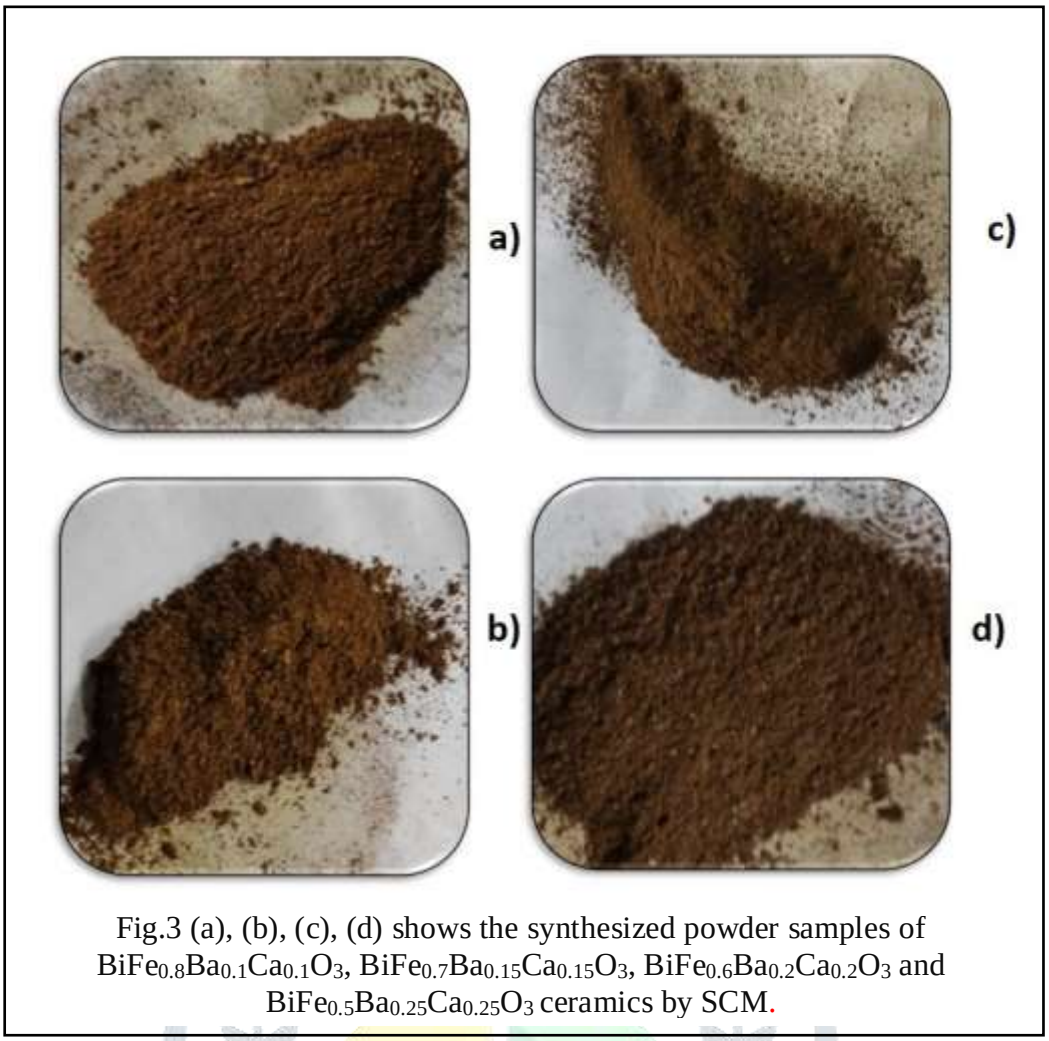

Fig.3 (a), (b), (c), (d) shows the synthesized powder samples of $BiFe_{0.8}Ba_{0.1}Ca_{0.1}O_3$, $BiFe_{0.7}Ba_{0.15}Ca_{0.15}O_3$, $BiFe_{0.6}Ba_{0.2}Ca_{0.2}O_3$ and $BiFe_{0.5}Ba_{0.25}Ca_{0.25}O_3$ ceramics by SCM.

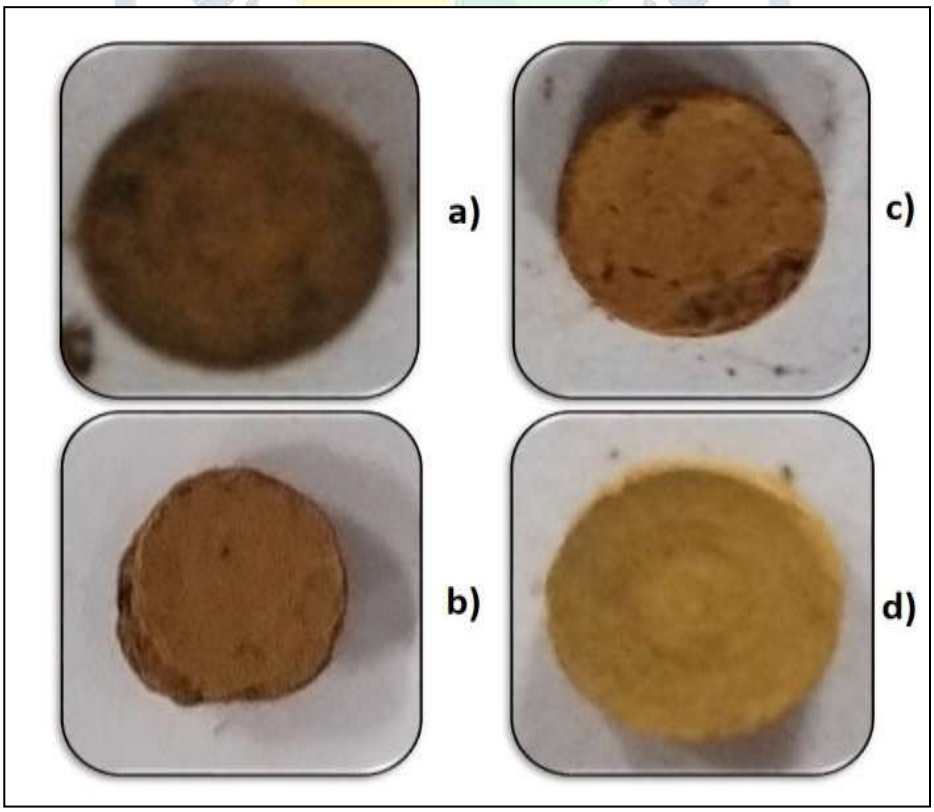

Fig. 4 (a), (b), (c), (d) shows the pellets of the formulated samples of $BiFe_{0.8}Ba_{0.1}Ca_{0.1}O_3$, $BiFe_{0.7}Ba_{0.15}Ca_{0.15}O_3$, $BiFe_{0.6}Ba_{0.2}Ca_{0.2}O_3$ and $BiFe_{0.5}Ba_{0.25}Ca_{0.25}O_3$ ceramics by SCM.

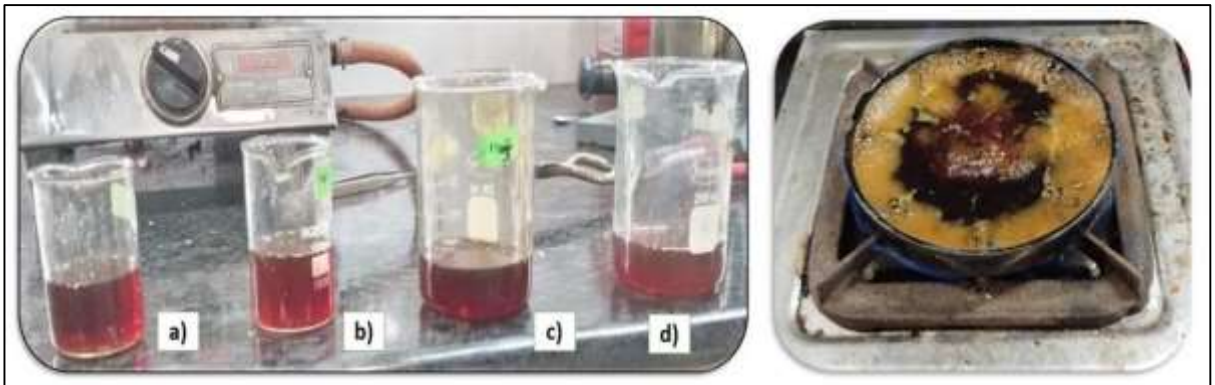

Fig. 5 (a), (b), (c), (d) shows the solutions of $BiFe_{0.8}Ba_{0.1}Ca_{0.1}O_3$, $BiFe_{0.7}Ba_{0.15}Ca_{0.15}O_3$, $BiFe_{0.6}Ba_{0.2}Ca_{0.2}O_3$ and $BiFe_{0.5}Ba_{0.25}Ca_{0.25}O_3$ samples and a combustion reaction on a gas burner.

III. Results and Discussion:

Fig.1. shows the flowchart of sample preparation of $BiFe_{0.8}Ba_{0.1}Ca_{0.1}O_3$, $BiFe_{0.7}Ba_{0.15}Ca_{0.15}O_3$, $BiFe_{0.6}Ba_{0.2}Ca_{0.2}O_3$ and $BiFe_{0.5}Ba_{0.25}Ca_{0.25}O_3$ materials and Fig.2. presents the whole experimental scheme of synthesis of the nanopowder samples. Fig.3 (a), (b), (c), (d) shows the synthesized $BiFe_{0.8}Ba_{0.1}Ca_{0.1}O_3$, $BiFe_{0.7}Ba_{0.15}Ca_{0.15}O_3$, $BiFe_{0.6}Ba_{0.2}Ca_{0.2}O_3$ and $BiFe_{0.5}Ba_{0.25}Ca_{0.25}O_3$ powder samples. Fig. 4 (a), (b), (c), (d) shows the pellets of the prepared $BiFe_{0.8}Ba_{0.1}Ca_{0.1}O_3$, $BiFe_{0.7}Ba_{0.15}Ca_{0.15}O_3$, $BiFe_{0.6}Ba_{0.2}Ca_{0.2}O_3$ and $BiFe_{0.5}Ba_{0.25}Ca_{0.25}O_3$ samples. These formulated powder samples were grinded in an acetone medium, calcined carried out at temperatures of 200°C, 210°C, 220°C, 230°C for 1 hour in a furnace. Fig. 5 (a), (b), (c), (d) shows $BiFe_{0.8}Ba_{0.1}Ca_{0.1}O_3$, $BiFe_{0.7}Ba_{0.15}Ca_{0.15}O_3$, $BiFe_{0.6}Ba_{0.2}Ca_{0.2}O_3$ and $BiFe_{0.5}Ba_{0.25}Ca_{0.25}O_3$ samples solutions and the combustion reaction carried out on a gas burner.

IV. Conclusion:

In the present article, we have effectively synthesized the multiferroic $BiFe_{0.8}Ba_{0.1}Ca_{0.1}O_3$, $BiFe_{0.7}Ba_{0.15}Ca_{0.15}O_3$, $BiFe_{0.6}Ba_{0.2}Ca_{0.2}O_3$ and $BiFe_{0.5}Ba_{0.25}Ca_{0.25}O_3$ powder samples and finally pellets formation. At different temperatures, these powder samples were calcined.

References

1. Senbeto Kena Etana, P. Vijarya Bhaskar Rao, Structural, Dielectric and magneto-electric properties of La and Co Co-Substituted $BiFeO_3$ Ceramics, International Journal of ChemTech Research, 12 (02), 299-309 (2019).
2. Weiwei Mao, Xingfu Wang, Liang Chu, Yiyi Zhu, Qi Wang, Jian Zhang, Jianping Yang, Xing'ao Li, Wei Huang, Simultaneous enhancement of magnetic and ferroelectric properties in Dy and Cr co-doped $BiFeO_3$ nanoparticles, Phys. Chem. Chem. Phys., 18, 6399 - 6405 (2016).
3. Ghanshyam Arya, Ashwani Kumar, Mast Ram, Nainjeet Singh Negi, Structural, Dielectric, Ferroelectric and Magnetic Properties of Mn-Doped $BiFeO_3$ Nanoparticles Synthesized by Sol-Gel Method, International Journal of Advances in Engineering & Technology, 5 (2), 245-252 (2013).
4. E. Mostafavi, A. Ataie, Fabrication and characterization of nanostructured Ba-doped $BiFeO_3$ porous ceramics, Materials Science-Poland, 34 (1), 148-156 (2016).

5. V. Sesha Sai Kumar, K. Venkateswara Rao, Ch. Shilpa Chakra, A. Shiva Kishore Goud, T. Krishnaveni, Synthesis of Nanocrystalline Bismuth Ferrite by Solution Combustion Synthesis Method, Journal of NanoScience, Nanoengineering & Applications, 1 (2), 52-58 (2011).
6. H. Sangian, O. Mirzaee, M. Tajally, Reverse Chemical Co-Precipitation: An Effective Method for Synthesis of $BiFeO_3$ Nanoparticles, ACERP, 3 (1), 31-36 (2017).
7. A. Haruna, I. Abdulkadir, S. O. Idris, Photocatalytic activity and doping effects of $BiFeO_3$ nanoparticles in model organic dyes, Heliyon, 6, e03237 (2020).
8. Heng Wu, Jun Zhou, Lizhi Liang, Lei Li, Xinhua Zhu, Fabrication, Characterization, Properties, and Applications of Low-Dimensional $BiFeO_3$ Nanostructures, Journal of Nanomaterials, Volume 2014, Article ID 471485, 14 pages.
9. V. Srinivas, A. T. Raghavender, K. Vijaya Kumar, Structural and Magnetic Properties of Mn Doped $BiFeO_3$ Nanomaterials, Physics Research International, Volume 2016, Article ID 4835328, 5 pages.
10. S. S. Arafat, S. Ibrahim, Study of the Structural and Electrical Properties of Cr-Doped $BiFeO_3$ Ceramic, Materials Sciences and Applications, 8, 716-725 (2017).
11. Baljinder Kaur, Lakhbir Singh, V. Annapu Reddy, Dae-Yong Jeong, Navneet Dabra, Jasbir S. Hundal, AC Impedance Spectroscopy, Conductivity and Optical Studies of Sr doped Bismuth Ferrite Nanocomposites, Int. J. Electrochem. Sci., 11, 4120 – 4135 (2016).
12. J. A. Bhalodia, P. V. Kanjariya, S. R. Mankadia, G. D. Jadav, Structural and Magnetic Characterization of $BiFeO_3$ Nano-particles Synthesized Using Auto-combustion Technique, International Journal of ChemTech Research, 6 (3), 2144-2146 (2014).
13. V. B. Sherkar, A. V. Mancharkar, Synthesis and Characterization of Bismuth Ferrite Nanoparticles by Sol-Gel Auto Combustion Technique, JASC: Journal of Applied Science and Computations, VI (I), 900-902 (2019).
14. S. Saha, S. J. Ghanawat, R. D. Purohit, Solution combustion synthesis of nano particle $La_{0.9}Sr_{0.1}MnO_3$ powder by a unique oxidant-fuel combination and its characterization, J. Mater. Sci., 41, 1939-1943 (2006).
15. Yogesh A. Chaudhari, Chandrashekhar M. Mahajan, Ebrahim M. Abuassaj, Prashant P. Jagtap, Pramod B. Patil, Subhash T. Bendre, Ferroelectric and dielectric properties of nanocrystalline $BiFeO_3$ multiferroic ceramics synthesized by solution combustion method (SCM), Materials Science-Poland, 31(2), 221-225 (2013).