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Solution Combustion Method (SCM) For The Preparation Of $Bi_{1-X+Y}ba_xca_yfeo_3$ (X, Y = 0.1, 0.15, 0.2, 0.25) Nanopowder Samples

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Abstract: This paper describes the synthesis of nanopowder multiferroic ceramics samples such as $Bi_{0.8}Ba_{0.1}Ca_{0.1}FeO_3$, $Bi_{0.7}Ba_{0.15}Ca_{0.15}FeO_3$, $Bi_{0.6}Ba_{0.2}Ca_{0.2}FeO_3$ and $Bi_{0.5}Ba_{0.25}Ca_{0.25}FeO_3$ samples using solution combustion method. These nanopowder samples of $Bi_{0.8}Ba_{0.1}Ca_{0.1}FeO_3$, $Bi_{0.7}Ba_{0.15}Ca_{0.15}FeO_3$, $Bi_{0.6}Ba_{0.2}Ca_{0.2}FeO_3$ and $Bi_{0.5}Ba_{0.25}Ca_{0.25}FeO_3$ were prepared using metal nitrates and glycine fuel as preliminary precursors. These nanopowder ceramics were grinded finally in an acetone medium, calcined at different optimized temperatures and finally pelletized in the form of pellets.

Keywords: Multiferroic, Nanopowders, $BiFeO_3$, Ba and Ca dopants, SCM, applications.

I. Introduction

Several ferroic properties are displayed by multiferroic materials like ferroelectricity, ferroelasticity, and ferromagnetism in a single phase [1]. At room temperature, $BiFeO_3$ has ferroelectric Curie temperature (T_C = 1103 K) and G-type antiferromagnetic Neel temperature (T_N = 643 K) [2]. The multiferroic bismuth ferrite ($BiFeO_3$) have number of important applications such as nanoelectronics [3], memory devices [4], optical filters [5], piezoelectric devices [6] and microelectronic devices [7].

The number of synthesis routes have been used for the preparation of $BiFeO_3$ ceramics such as solid state reaction route [8], mechanochemical synthesis technique [9], Sol gel method [10], hydrothermal method [11], citrate gel technique [12], Co-precipitation technique [13] and liquid phase precipitation route [14]. In this article, we have synthesized the $Bi_{0.8}Ba_{0.1}Ca_{0.1}FeO_3$, $Bi_{0.7}Ba_{0.15}Ca_{0.15}FeO_3$, $Bi_{0.6}Ba_{0.2}Ca_{0.2}FeO_3$ and $Bi_{0.5}Ba_{0.25}Ca_{0.25}FeO_3$ multiferroic ceramics via solution combustion method.

II. EXPERIMENTAL PROCEDURE:

Initial Materials:

The bismuth nitrate, barium nitrate, calcium nitrate, ferric nitrate and glycine were used as primary starting materials for the formulation of Bi site codoping of Ba and Ca in $BiFeO_3$.

Synthesis Process:

The preparation of $Bi_{0.8}Ba_{0.1}Ca_{0.1}FeO_3$, $Bi_{0.7}Ba_{0.15}Ca_{0.15}FeO_3$, $Bi_{0.6}Ba_{0.2}Ca_{0.2}FeO_3$ and $Bi_{0.5}Ba_{0.25}Ca_{0.25}FeO_3$ ceramic samples were carried out using the precursors such as bismuth nitrate, barium nitrate, calcium nitrate, ferric nitrate as an oxidizers while glycine was used as a fuel. In order to prepare the mixture of samples, the oxidizer (O) to fuel (F) ratio was properly considered using the oxidizing and reducing valences of the metal nitrates and fuel [15].

The bismuth nitrate, barium nitrate, calcium nitrate, ferric nitrate and glycine taken in a stoichiometric quantity and were dissolved in a distilled water in a separate beakers after that, these solution were mixed together and conveyed in a pyrex dish for heating on a gas burner. Afterwards the continuous heating, the water gets evaporated and finally a combustion takes place with formation of $Bi_{0.8}Ba_{0.1}Ca_{0.1}FeO_3$, $Bi_{0.7}Ba_{0.15}Ca_{0.15}FeO_3$, $Bi_{0.6}Ba_{0.2}Ca_{0.2}FeO_3$ and $Bi_{0.5}Ba_{0.25}Ca_{0.25}FeO_3$ powders. The experimental procedure was given by Chaudhari et.al. [16], these powders were grinded in an acetone medium and finally calcined at 210^oC, 220^oC, 230^oC, 240^oC for 2 hours 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. depicts the detailed experimental process of formulation of the powder samples.

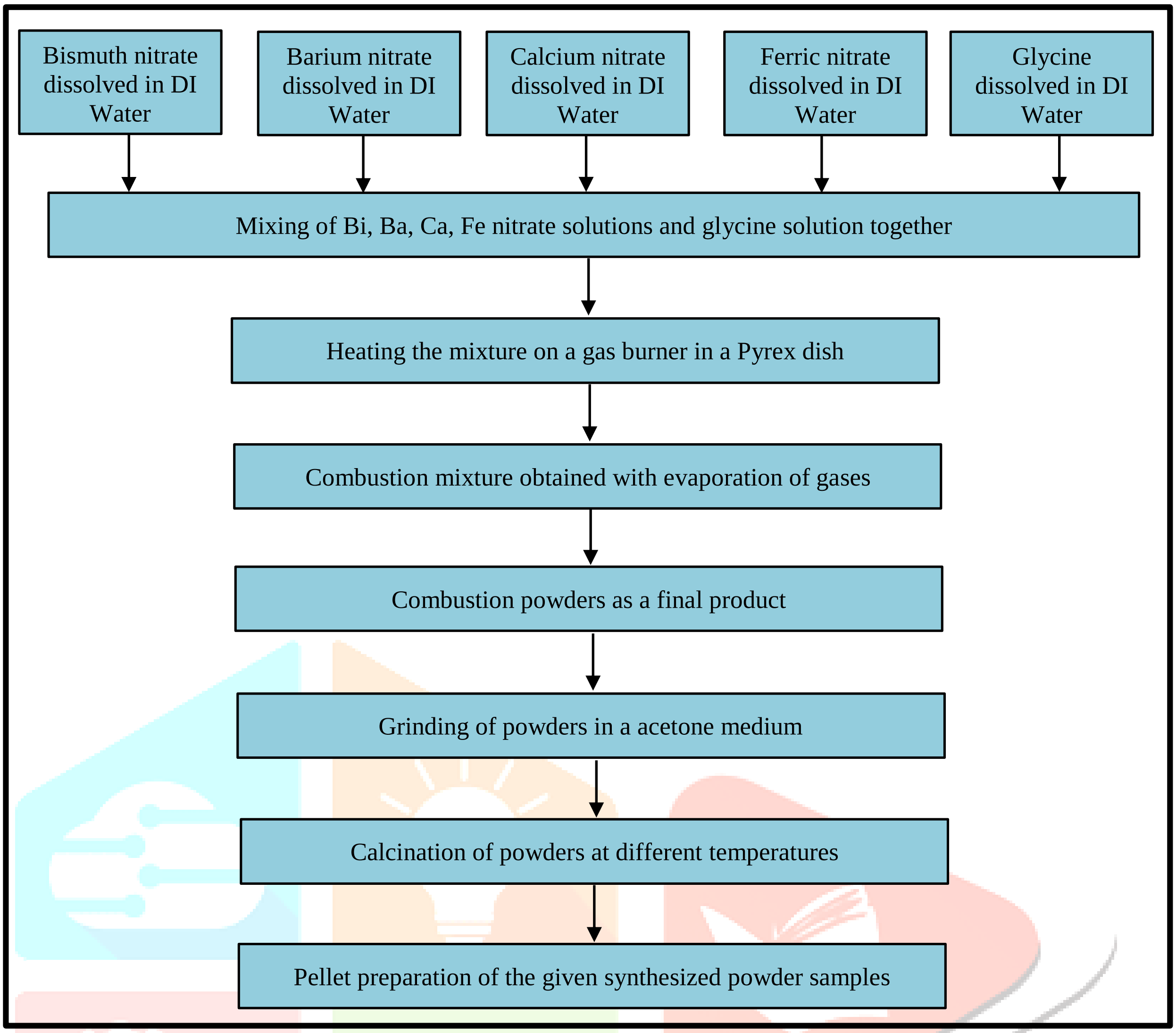

Fig.1. Flowchart of preparation of $Bi_{0.8}Ba_{0.1}Ca_{0.1}FeO_3$, $Bi_{0.7}Ba_{0.15}Ca_{0.15}FeO_3$, $Bi_{0.6}Ba_{0.2}Ca_{0.2}FeO_3$ and $Bi_{0.5}Ba_{0.25}Ca_{0.25}FeO_3$ multiferroic samples by SCM.

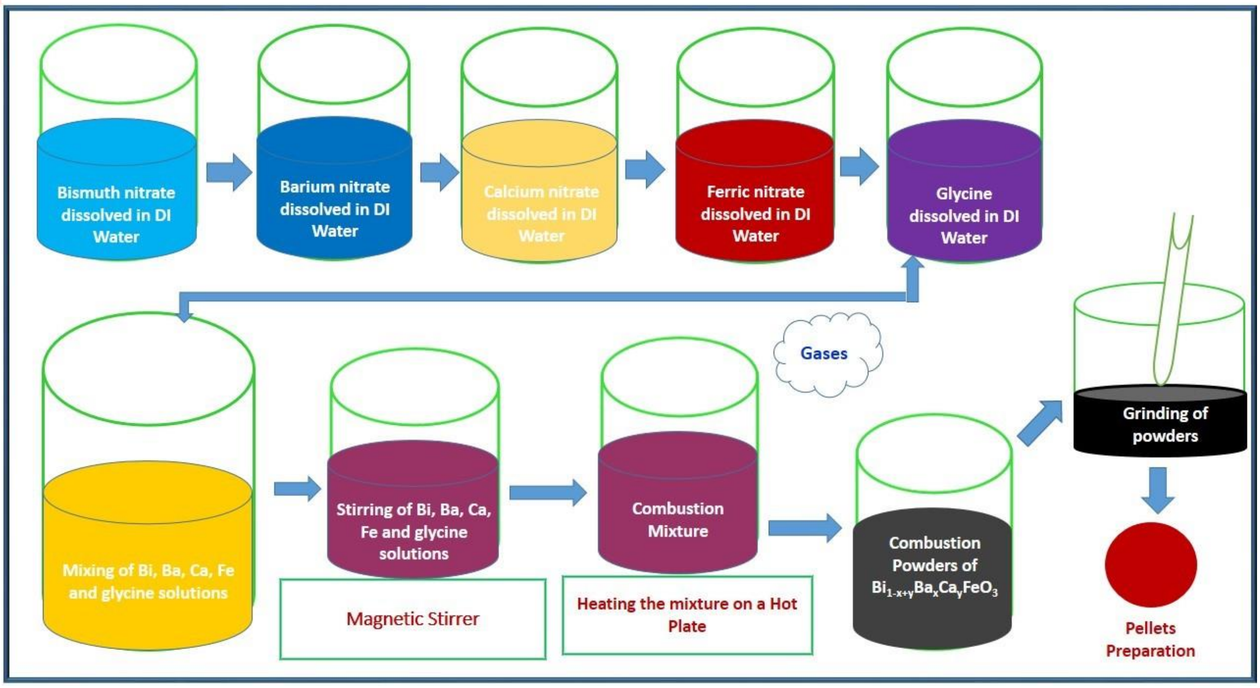

Fig.2. Experimental process of formulation of $Bi_{0.8}Ba_{0.1}Ca_{0.1}FeO_3$, $Bi_{0.7}Ba_{0.15}Ca_{0.15}FeO_3$, $Bi_{0.6}Ba_{0.2}Ca_{0.2}FeO_3$ and $Bi_{0.5}Ba_{0.25}Ca_{0.25}FeO_3$ powder samples.

Fig.3 (a), (b), (c), (d) shows the synthesized powder samples of $Bi_{0.8}Ba_{0.1}Ca_{0.1}FeO_3$, $Bi_{0.7}Ba_{0.15}Ca_{0.15}FeO_3$, $Bi_{0.6}Ba_{0.2}Ca_{0.2}FeO_3$ and $Bi_{0.5}Ba_{0.25}Ca_{0.25}FeO_3$ ceramics.

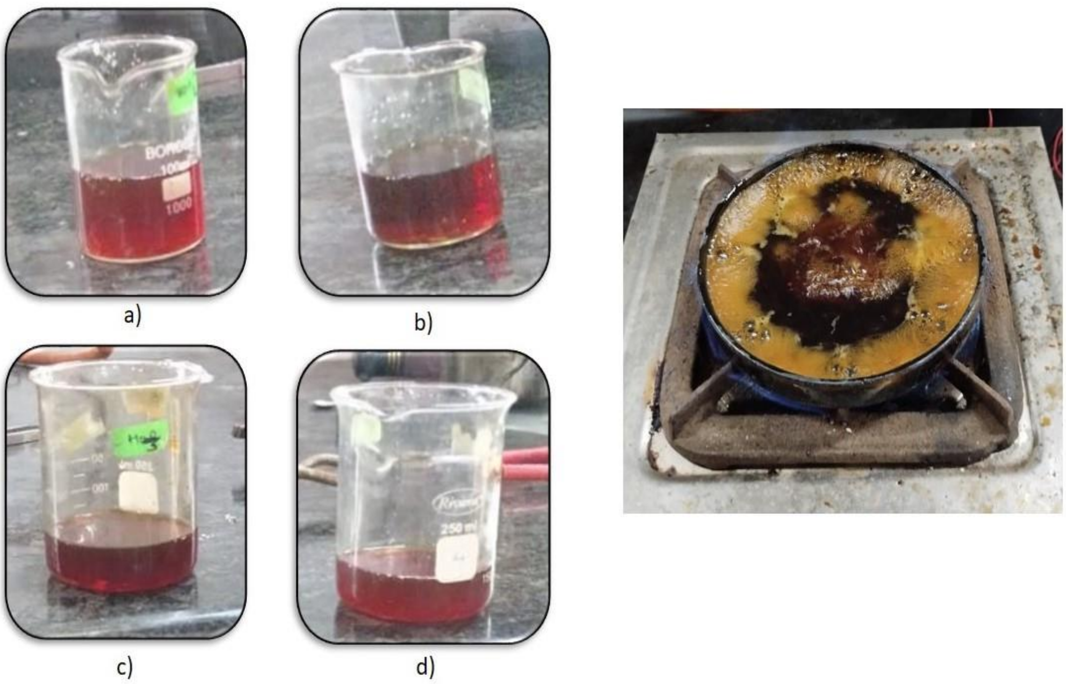

Fig.5 (a), (b), (c), (d) shows the prepared solutions of $Bi_{0.8}Ba_{0.1}Ca_{0.1}FeO_3$, $Bi_{0.7}Ba_{0.15}Ca_{0.15}FeO_3$, $Bi_{0.6}Ba_{0.2}Ca_{0.2}FeO_3$ and $Bi_{0.5}Ba_{0.25}Ca_{0.25}FeO_3$ samples and a combustion reaction on a gas burner.

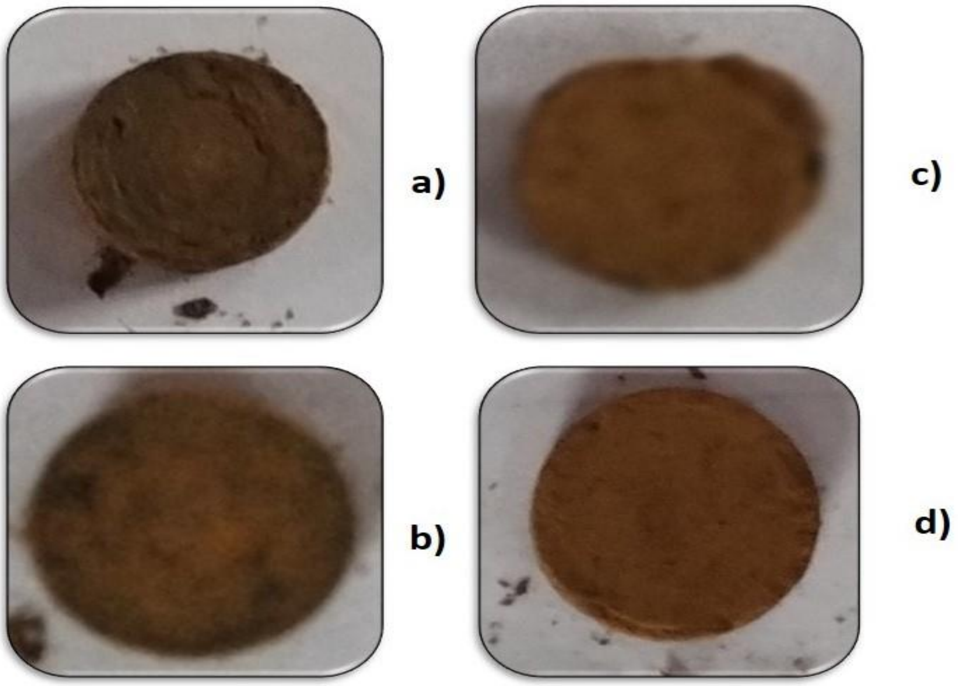

Fig. 4 (a), (b), (c), (d) shows the pellets of the formulated samples of $Bi_{0.8}Ba_{0.1}Ca_{0.1}FeO_3$, $Bi_{0.7}Ba_{0.15}Ca_{0.15}FeO_3$, $Bi_{0.6}Ba_{0.2}Ca_{0.2}FeO_3$ and $Bi_{0.5}Ba_{0.25}Ca_{0.25}FeO_3$ ceramics.

III. Results and discussion:

Fig.1. shows the flowchart of sample preparation of $Bi_{0.8}Ba_{0.1}Ca_{0.1}FeO_3$, $Bi_{0.7}Ba_{0.15}Ca_{0.15}FeO_3$, $Bi_{0.6}Ba_{0.2}Ca_{0.2}FeO_3$ and $Bi_{0.5}Ba_{0.25}Ca_{0.25}FeO_3$ materials in powder form and Fig 2. illustrates the full experimental process of formulation of the powder samples.

Fig.3 (a), (b), (c), (d) shows the synthesized $Bi_{0.8}Ba_{0.1}Ca_{0.1}FeO_3$, $Bi_{0.7}Ba_{0.15}Ca_{0.15}FeO_3$, $Bi_{0.6}Ba_{0.2}Ca_{0.2}FeO_3$ and $Bi_{0.5}Ba_{0.25}Ca_{0.25}FeO_3$ nanopowder samples. Fig. 4 (a), (b), (c), (d) shows the pellets of the prepared $Bi_{0.8}Ba_{0.1}Ca_{0.1}FeO_3$, $Bi_{0.7}Ba_{0.15}Ca_{0.15}FeO_3$, $Bi_{0.6}Ba_{0.2}Ca_{0.2}FeO_3$ and $Bi_{0.5}Ba_{0.25}Ca_{0.25}FeO_3$ samples. These formulated powder samples were grinded in an acetone medium, calcined carried out at temperatures of 210°C, 220°C, 230°C, 240°C for 2 hours in a furnace. Fig. 5 (a), (b), (c), (d) shows the prepared solutions of $Bi_{0.8}Ba_{0.1}Ca_{0.1}FeO_3$, $Bi_{0.7}Ba_{0.15}Ca_{0.15}FeO_3$, $Bi_{0.6}Ba_{0.2}Ca_{0.2}FeO_3$ and $Bi_{0.5}Ba_{0.25}Ca_{0.25}FeO_3$ samples and a combustion reaction on a gas burner.

IV. Conclusion:

In the present article, we have effectively produced the multiferroic $Bi_{0.8}Ba_{0.1}Ca_{0.1}FeO_3$, $Bi_{0.7}Ba_{0.15}Ca_{0.15}FeO_3$, $Bi_{0.6}Ba_{0.2}Ca_{0.2}FeO_3$ and $Bi_{0.5}Ba_{0.25}Ca_{0.25}FeO_3$ nanopowder samples using solution combustion method (SCM).

REFERENCES:

1. Harish Kumar Meena, Khushbu Meena, Sushil Kumar Jain, Garima Agarwal, Balram Tripathi, Ultrasound assisted synthesis of $BiFeO_3$ nanoparticles for enhanced photovoltaic applications, International Journal of Current Science (IJCSPUB), 12 (3), 776-784 (2022).
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. Md. Masud Parvez, Synthesis of Yttrium Doped Bismuth Feraites Nanoparticles by Modified Pechini Sol-Gel Method, SEU Journal of Science and Engineering, 11(2), 41-48 (2017).
4. 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).
5. E. Mostafavi, A. Ataie, Fabrication and characterization of nanostructured Ba-doped $BiFeO_3$ porous ceramics, Materials Science-Poland, 34 (1), 148-156 (2016).
6. A. Haruna, I. Abdulkadir, S.O. Idris, Photocatalytic activity and doping effects of $BiFeO_3$ nanoparticles in model organic dyes, Heliyon, 6, e03237 (2020).
7. 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).
8. J D Suarez Londono, S Segura Pena, E H Sachica, A F Cruz Pacheco, A Sarmiento Santos, C A Parra Vargas, Structural and magnetic analysis of the $Bi_{x-1}Sm_{0x}FeO_3$ (x=0.04 and 0.07) system, Journal of Physics: Conf. Series, 935, 012007 (2017).
9. M. Polomska, B. Hilczer, I. Szafraniak-Wiza, A. Pietraszko, B. Andrzejewski, XRD, Raman and magnetic studies of $Bi_{1-x}La_xFeO_3$ solid solution obtained by mechanochemical synthesis, Phase Transitions, 90 (1), 24-33 (2017).
10. Manjusha Eledath, Shalini Vishwanathan, Maneesh Chandran, Sol-Gel Synthesis of Multifunctional Bismuth Ferrite Nanostructures: Effect of Heating Conditions on their Photocatalytic Activity, IOP Conf. Series: Materials Science and Engineering, 1221, 012044 (2022).
11. M. Hojamberdiev, Y. Xu, F. Wang, W. Liu, J. Wang, La-Modification of Multiferroic $BiFeO_3$ by Hydrothermal Method at Low Temperature, Inorganic Materials, 45 (10), 1183–1187 (2009).
12. M. B. Bellakki, V. Manivannan, Citrate-gel synthesis and characterization of yttrium-doped multiferroic $BiFeO_3$, J Sol-Gel Sci. Technol., 53, 184–192 (2010).
13. M. Muneeswaran, P. Jegatheesan, N. V. Giridharan, Synthesis of nanosized $BiFeO_3$ powders by co-precipitation method, Journal of Experimental Nanoscience, 8 (3), 341–346 (2013).
14. Xinxin Wang, Yifa Dong, Studies on the Preparation and Photocatalytic Performance of Bismuth Ferrite, E3S Web of Conferences, 245, 03078 (2021).

15. 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).
16. 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).