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Synthesis of $\text{Bi}_{1-x}\text{Zn}_x\text{Fe}_{1-y}\text{Ni}_y\text{O}_3$ and $\text{Bi}_{1-x}\text{Ni}_x\text{Fe}_{1-y}\text{Zn}_y\text{O}_3$ ($x, y = 0.05, 0.1, 0.15, 0.2$) Multiferroics through Effective Solution Combustion Method

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ABSTRACT; This paper presents the synthesis of nanopowders of $\text{Bi}_{0.95}\text{Zn}_{0.05}\text{Fe}_{0.95}\text{Ni}_{0.05}\text{O}_3$, $\text{Bi}_{0.9}\text{Zn}_{0.1}\text{Fe}_{0.9}\text{Ni}_{0.1}\text{O}_3$, $\text{Bi}_{0.85}\text{Zn}_{0.15}\text{Fe}_{0.85}\text{Ni}_{0.15}\text{O}_3$, $\text{Bi}_{0.8}\text{Zn}_{0.2}\text{Fe}_{0.8}\text{Ni}_{0.2}\text{O}_3$, $\text{Bi}_{0.95}\text{Ni}_{0.05}\text{Fe}_{0.95}\text{Zn}_{0.05}\text{O}_3$, $\text{Bi}_{0.9}\text{Ni}_{0.1}\text{Fe}_{0.9}\text{Zn}_{0.1}\text{O}_3$, $\text{Bi}_{0.85}\text{Ni}_{0.15}\text{Fe}_{0.85}\text{Zn}_{0.15}\text{O}_3$ and $\text{Bi}_{0.8}\text{Ni}_{0.2}\text{Fe}_{0.8}\text{Zn}_{0.2}\text{O}_3$ ceramics using solution combustion method (SCM). These samples $\text{Bi}_{0.95}\text{Zn}_{0.05}\text{Fe}_{0.95}\text{Ni}_{0.05}\text{O}_3$, $\text{Bi}_{0.9}\text{Zn}_{0.1}\text{Fe}_{0.9}\text{Ni}_{0.1}\text{O}_3$, $\text{Bi}_{0.85}\text{Zn}_{0.15}\text{Fe}_{0.85}\text{Ni}_{0.15}\text{O}_3$, $\text{Bi}_{0.8}\text{Zn}_{0.2}\text{Fe}_{0.8}\text{Ni}_{0.2}\text{O}_3$, $\text{Bi}_{0.95}\text{Ni}_{0.05}\text{Fe}_{0.95}\text{Zn}_{0.05}\text{O}_3$, $\text{Bi}_{0.9}\text{Ni}_{0.1}\text{Fe}_{0.9}\text{Zn}_{0.1}\text{O}_3$, $\text{Bi}_{0.85}\text{Ni}_{0.15}\text{Fe}_{0.85}\text{Zn}_{0.15}\text{O}_3$, $\text{Bi}_{0.8}\text{Ni}_{0.2}\text{Fe}_{0.8}\text{Zn}_{0.2}\text{O}_3$ ceramics were prepared using metal nitrates and glycine fuel as a crucial preliminary material. These nanopowder samples were ground, calcined at various high temperatures, and then pelletized to make pellets.

KEYWORDS: Multiferroics, Nanopowders, Zn-Ni substituted BiFeO_3 , Glycine fuel, SCM, applications.

I. INTRODUCTION

One type of ferrite that combines electrical and magnetic features is bismuth ferrite, or BiFeO_3 (BFO) [1]. Ferroelectric ($T_C \sim 1103\text{K}$) and antiferromagnetic ($T_N \sim 643\text{K}$) orders occur simultaneously in bismuth ferrite, one of the extremely rare multiferroic materials [2]. The multiferroic BiFeO_3 has variety of applications like low power consumption, environmental friendly devices [3], capacitors, nonvolatile logic [4], spintronics, stable nano-scale memory element [5], infrared detector [6], photocatalytic field [7], microelectronics [8], non-linear optics, photo-electrochemical cells [9], transducers, actuators [10]. The number of synthesis techniques have been used for the preparation of pure, doped and codoped BiFeO_3 ceramics like citrate method [11], Co-precipitation technique [12], Sol gel method [13], Sol-gel auto combustions method [14] and solid state reaction route [15]. In this paper, we have prepared our $\text{Bi}_{1-x}\text{Zn}_x\text{Fe}_{1-y}\text{Ni}_y\text{O}_3$ and $\text{Bi}_{1-x}\text{Ni}_x\text{Fe}_{1-y}\text{Zn}_y\text{O}_3$ nanopowder samples at different doping concentrations using solution combustion method.

II. METHODOLOGY

Experimental Process of Preparation of $\text{Bi}_{1-x}\text{Zn}_x\text{Fe}_{1-y}\text{Ni}_y\text{O}_3$ ($x = y = 0.05, 0.1, 0.15, 0.2$):

Initial Materials: Zinc, ferric, nickel, and bismuth nitrates, as well as glycine, are the main starting ingredients.

Synthesis Process:

The preparation of $\text{Bi}_{0.95}\text{Zn}_{0.05}\text{Fe}_{0.95}\text{Ni}_{0.05}\text{O}_3$, $\text{Bi}_{0.9}\text{Zn}_{0.1}\text{Fe}_{0.9}\text{Ni}_{0.1}\text{O}_3$, $\text{Bi}_{0.85}\text{Zn}_{0.15}\text{Fe}_{0.85}\text{Ni}_{0.15}\text{O}_3$, $\text{Bi}_{0.8}\text{Zn}_{0.2}\text{Fe}_{0.8}\text{Ni}_{0.2}\text{O}_3$ ceramic samples were carried out using the precursors such as bismuth nitrate, zinc nitrate, ferric nitrate, nickel nitrate as an oxidizers while glycine was used as a fuel. Using the oxidizing and reducing valences of the metal nitrates and fuel, the oxidizer (O) to fuel (F) ratio was exactly taken consideration when generating the sample mixture [16].

The bismuth nitrate, zinc nitrate, ferric nitrate, nickel nitrate and glycine taken in a stoichiometric quantity and were dissolved in a distilled water in a separate beakers after that, these solutions were combined and heated on a gas burner in a Pyrex dish. Subsequently the constant heating, the water gets evaporated and lastly a combustion takes place with formation of $\text{Bi}_{0.95}\text{Zn}_{0.05}\text{Fe}_{0.95}\text{Ni}_{0.05}\text{O}_3$, $\text{Bi}_{0.9}\text{Zn}_{0.1}\text{Fe}_{0.9}\text{Ni}_{0.1}\text{O}_3$, $\text{Bi}_{0.85}\text{Zn}_{0.15}\text{Fe}_{0.85}\text{Ni}_{0.15}\text{O}_3$, $\text{Bi}_{0.8}\text{Zn}_{0.2}\text{Fe}_{0.8}\text{Ni}_{0.2}\text{O}_3$ nanopowder samples. The experimental procedure was given by Chaudhari et.al. [17], these powders were grinded in an acetone medium and finally calcined at 375°C , 380°C , 385°C , 390°C for 1 hour in a furnace and finally carried out for pelletization. Fig. 1 (a) depicts the flowchart used to prepare these samples, while Fig. 1 (b) details the entire experimental procedure used to produce these nanopowder samples. Fig. 2 (a), (b), (c), (d) shows the synthesized nanopowders of $\text{Bi}_{0.95}\text{Zn}_{0.05}\text{Fe}_{0.95}\text{Ni}_{0.05}\text{O}_3$, $\text{Bi}_{0.9}\text{Zn}_{0.1}\text{Fe}_{0.9}\text{Ni}_{0.1}\text{O}_3$, $\text{Bi}_{0.85}\text{Zn}_{0.15}\text{Fe}_{0.85}\text{Ni}_{0.15}\text{O}_3$, $\text{Bi}_{0.8}\text{Zn}_{0.2}\text{Fe}_{0.8}\text{Ni}_{0.2}\text{O}_3$ samples

and Fig.3 (a), (b), (c), (d) shows the prepared pellets of $\text{Bi}_{0.95}\text{Zn}_{0.05}\text{Fe}_{0.95}\text{Ni}_{0.05}\text{O}_3$, $\text{Bi}_{0.9}\text{Zn}_{0.1}\text{Fe}_{0.9}\text{Ni}_{0.1}\text{O}_3$, $\text{Bi}_{0.85}\text{Zn}_{0.15}\text{Fe}_{0.85}\text{Ni}_{0.15}\text{O}_3$, $\text{Bi}_{0.8}\text{Zn}_{0.2}\text{Fe}_{0.8}\text{Ni}_{0.2}\text{O}_3$ powder samples.

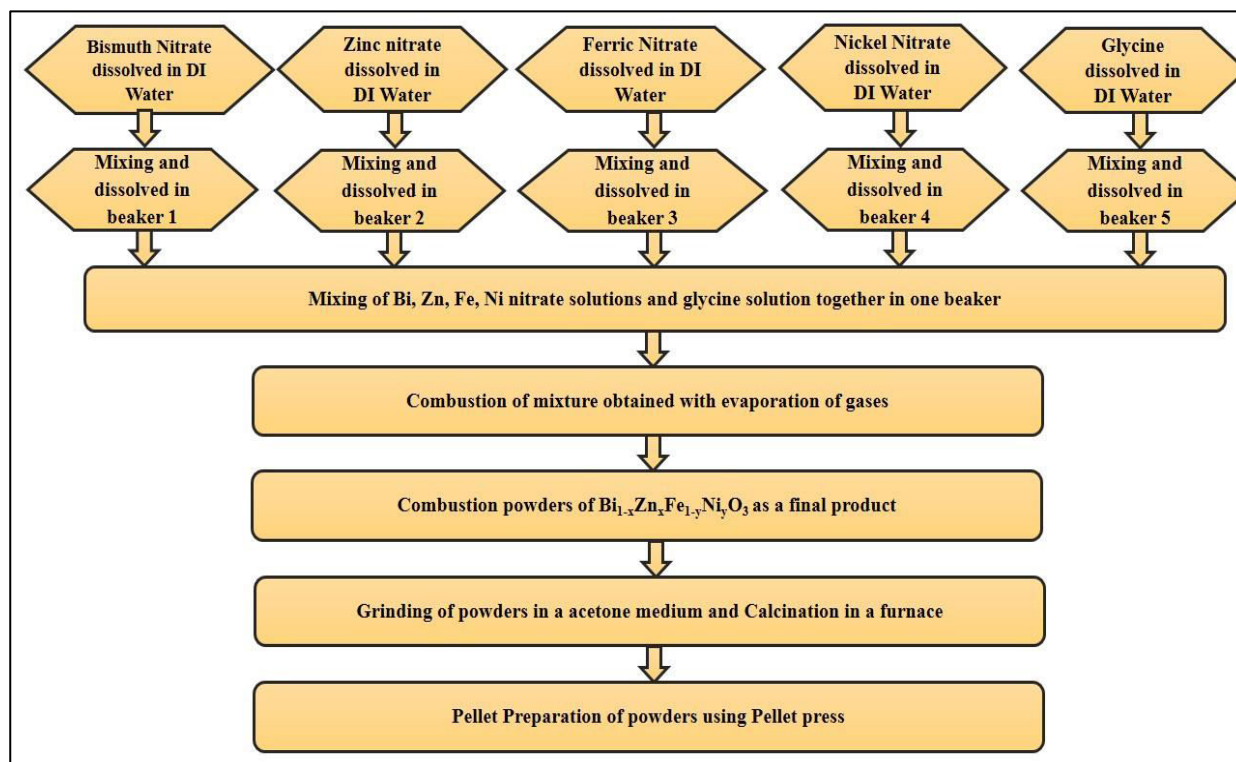


Fig.1 (a). Flowchart of synthesis of $\text{Bi}_{0.95}\text{Zn}_{0.05}\text{Fe}_{0.95}\text{Ni}_{0.05}\text{O}_3$, $\text{Bi}_{0.9}\text{Zn}_{0.1}\text{Fe}_{0.9}\text{Ni}_{0.1}\text{O}_3$, $\text{Bi}_{0.85}\text{Zn}_{0.15}\text{Fe}_{0.85}\text{Ni}_{0.15}\text{O}_3$, $\text{Bi}_{0.8}\text{Zn}_{0.2}\text{Fe}_{0.8}\text{Ni}_{0.2}\text{O}_3$ ceramic samples by SCM.

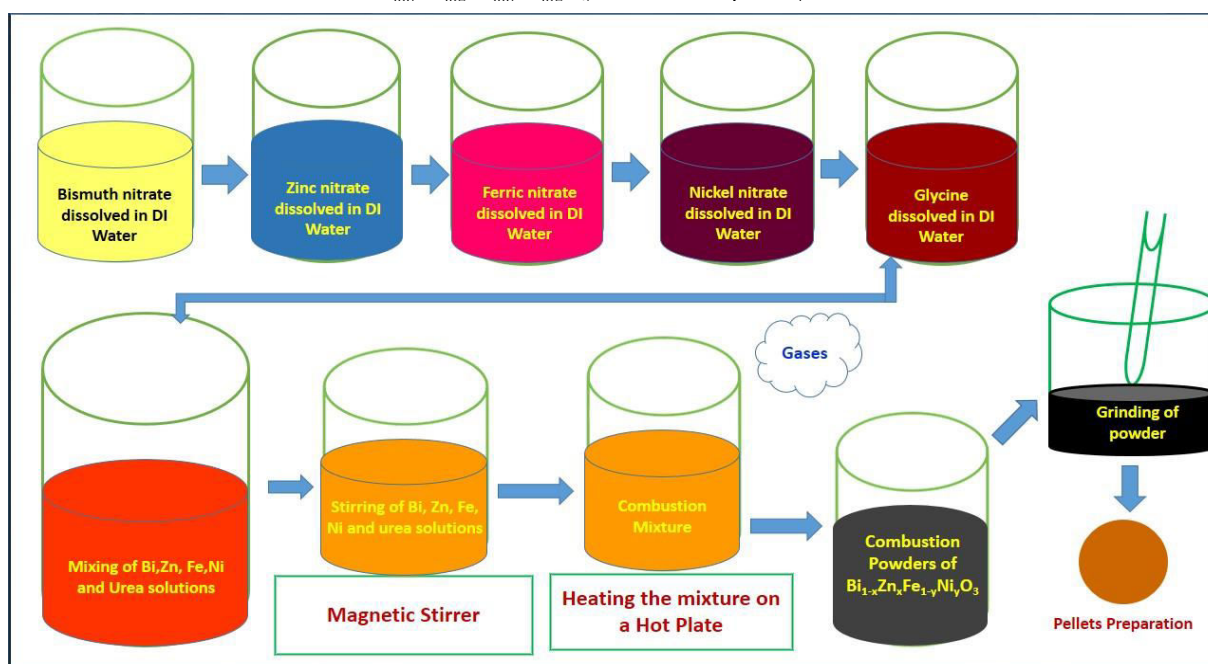


Fig.1 (b). Experimental methodology



Fig. 2 (a), (b), (c), (d) shows the synthesized powders of $\text{Bi}_{0.95}\text{Zn}_{0.05}\text{Fe}_{0.95}\text{Ni}_{0.05}\text{O}_3$, $\text{Bi}_{0.9}\text{Zn}_{0.1}\text{Fe}_{0.9}\text{Ni}_{0.1}\text{O}_3$, $\text{Bi}_{0.85}\text{Zn}_{0.15}\text{Fe}_{0.85}\text{Ni}_{0.15}\text{O}_3$ and $\text{Bi}_{0.8}\text{Zn}_{0.2}\text{Fe}_{0.8}\text{Ni}_{0.2}\text{O}_3$ ceramic samples.

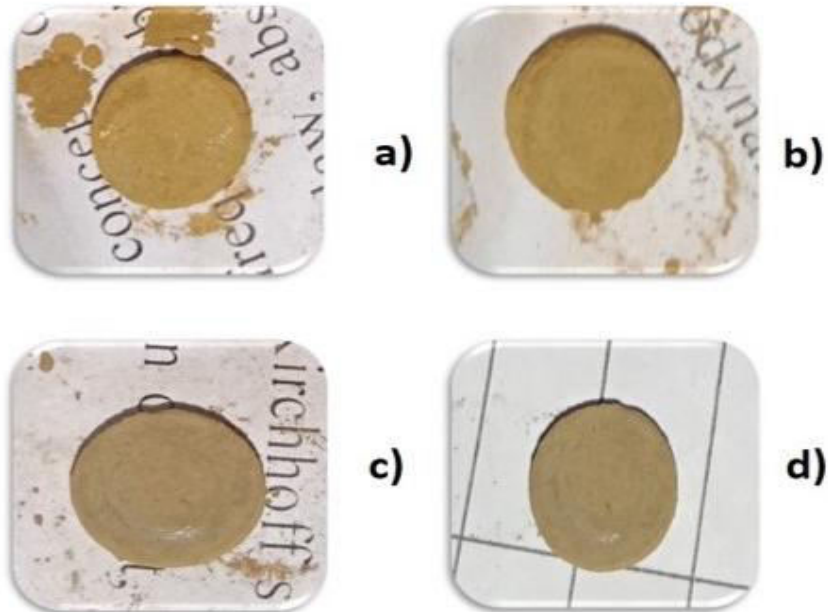


Fig. 3 (a), (b), (c), (d) shows the pellets of synthesized powders samples of $\text{Bi}_{0.95}\text{Zn}_{0.05}\text{Fe}_{0.95}\text{Ni}_{0.05}\text{O}_3$, $\text{Bi}_{0.9}\text{Zn}_{0.1}\text{Fe}_{0.9}\text{Ni}_{0.1}\text{O}_3$, $\text{Bi}_{0.85}\text{Zn}_{0.15}\text{Fe}_{0.85}\text{Ni}_{0.15}\text{O}_3$ and $\text{Bi}_{0.8}\text{Zn}_{0.2}\text{Fe}_{0.8}\text{Ni}_{0.2}\text{O}_3$ samples.

Experimental Process of Preparation of $\text{Bi}_{1-x}\text{Ni}_x\text{Fe}_{1-y}\text{Zn}_y\text{O}_3$ ($x = y = 0.05, 0.1, 0.15, 0.2$):

Initial Materials:

Bismuth nitrate, nickel nitrate, ferric nitrate, zinc nitrate, and glycine are the main beginning components.

Synthesis Process:

The preparation of $\text{Bi}_{0.95}\text{Ni}_{0.05}\text{Fe}_{0.95}\text{Zn}_{0.05}\text{O}_3$, $\text{Bi}_{0.9}\text{Ni}_{0.1}\text{Fe}_{0.9}\text{Zn}_{0.1}\text{O}_3$, $\text{Bi}_{0.85}\text{Ni}_{0.15}\text{Fe}_{0.85}\text{Zn}_{0.15}\text{O}_3$, $\text{Bi}_{0.8}\text{Ni}_{0.2}\text{Fe}_{0.8}\text{Zn}_{0.2}\text{O}_3$ ceramic samples were carried out by the precursors such as bismuth nitrate, nickel nitrate, ferric nitrate, zinc nitrate as oxidizers whereas glycine was used as a fuel. Using the oxidizing and reducing valences of the metal nitrates and fuel, the oxidizer (O) to fuel (F) ratio was precisely taken into account when preparing the sample combination [16].

In separate beakers, distilled water was used to dissolve the stoichiometric amounts of bismuth nitrate, nickel nitrate, ferric nitrate, zinc nitrate, and glycine. These solutions were combined, then put in a Pyrex dish and heated using a gas burner. Afterwards the continuous heating, the water gets evaporated and finally a combustion takes place with formation of $\text{Bi}_{0.95}\text{Ni}_{0.05}\text{Fe}_{0.95}\text{Zn}_{0.05}\text{O}_3$, $\text{Bi}_{0.9}\text{Ni}_{0.1}\text{Fe}_{0.9}\text{Zn}_{0.1}\text{O}_3$, $\text{Bi}_{0.85}\text{Ni}_{0.15}\text{Fe}_{0.85}\text{Zn}_{0.15}\text{O}_3$, $\text{Bi}_{0.8}\text{Ni}_{0.2}\text{Fe}_{0.8}\text{Zn}_{0.2}\text{O}_3$ ceramic nanopowder samples. The experimental route was stated by Chaudhari et.al. [17], these powders were grinded in an acetone medium and lastly calcined at 410°C , 430°C , 450°C , 470°C for 2 hours in a furnace and finally carried out for pelletization. The procedure for the production of these nanopowder samples is shown in the flowchart in Figure 4(a) and Fig. 4 (b) describes the experimental methodology of preparation of these samples. Fig.5 a), (b), (c), (d) shows the synthesized powder samples of $\text{Bi}_{0.95}\text{Ni}_{0.05}\text{Fe}_{0.95}\text{Zn}_{0.05}\text{O}_3$, $\text{Bi}_{0.9}\text{Ni}_{0.1}\text{Fe}_{0.9}\text{Zn}_{0.1}\text{O}_3$, $\text{Bi}_{0.85}\text{Ni}_{0.15}\text{Fe}_{0.85}\text{Zn}_{0.15}\text{O}_3$, $\text{Bi}_{0.8}\text{Ni}_{0.2}\text{Fe}_{0.8}\text{Zn}_{0.2}\text{O}_3$ ceramics and Fig.6 a), (b), (c), (d) shows the prepared pellets of the $\text{Bi}_{0.95}\text{Ni}_{0.05}\text{Fe}_{0.95}\text{Zn}_{0.05}\text{O}_3$, $\text{Bi}_{0.9}\text{Ni}_{0.1}\text{Fe}_{0.9}\text{Zn}_{0.1}\text{O}_3$, $\text{Bi}_{0.85}\text{Ni}_{0.15}\text{Fe}_{0.85}\text{Zn}_{0.15}\text{O}_3$, $\text{Bi}_{0.8}\text{Ni}_{0.2}\text{Fe}_{0.8}\text{Zn}_{0.2}\text{O}_3$ powder samples.

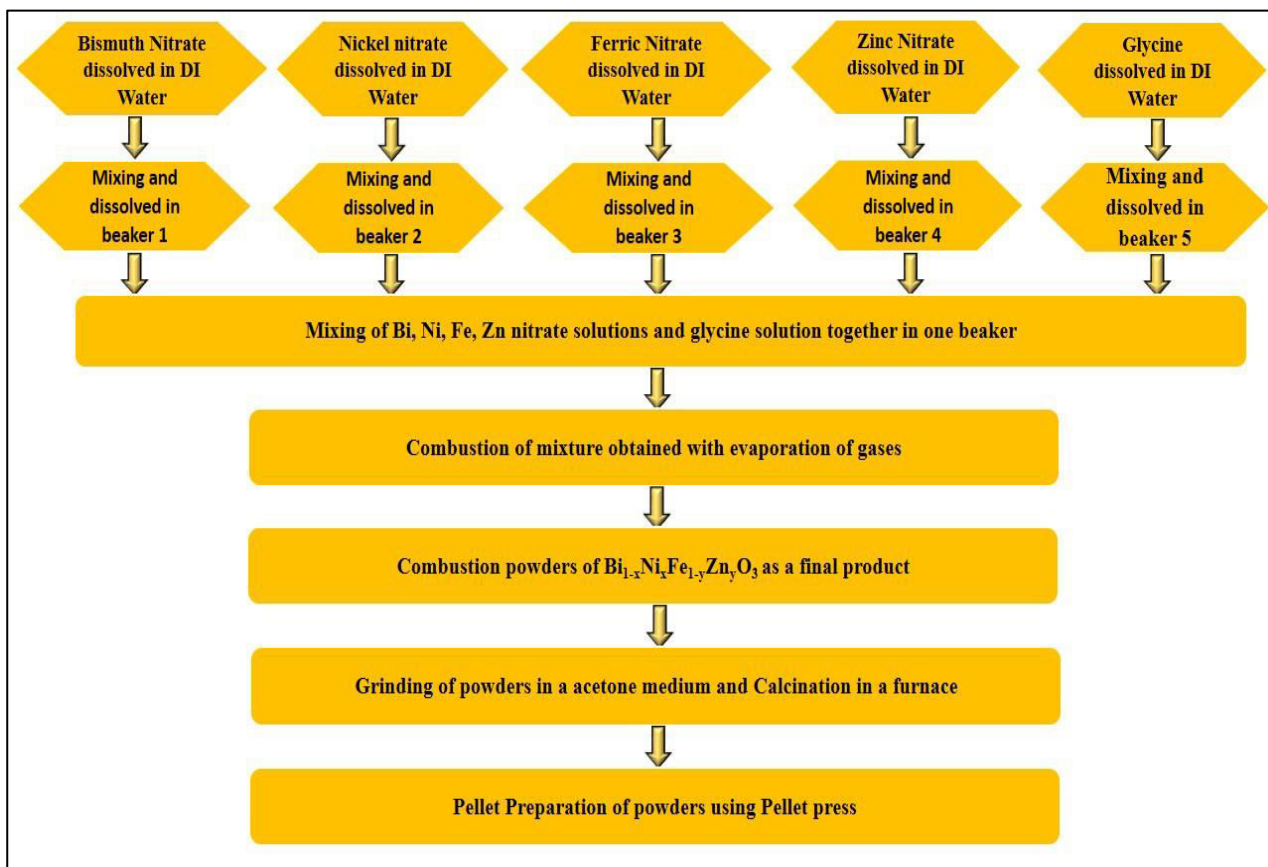


Fig. 4 (a). Flowchart of synthesis of $\text{Bi}_{0.95}\text{Ni}_{0.05}\text{Fe}_{0.95}\text{Zn}_{0.05}\text{O}_3$, $\text{Bi}_{0.9}\text{Ni}_{0.1}\text{Fe}_{0.9}\text{Zn}_{0.1}\text{O}_3$, $\text{Bi}_{0.85}\text{Ni}_{0.15}\text{Fe}_{0.85}\text{Zn}_{0.15}\text{O}_3$, $\text{Bi}_{0.8}\text{Ni}_{0.2}\text{Fe}_{0.8}\text{Zn}_{0.2}\text{O}_3$ ceramic samples by SCM.

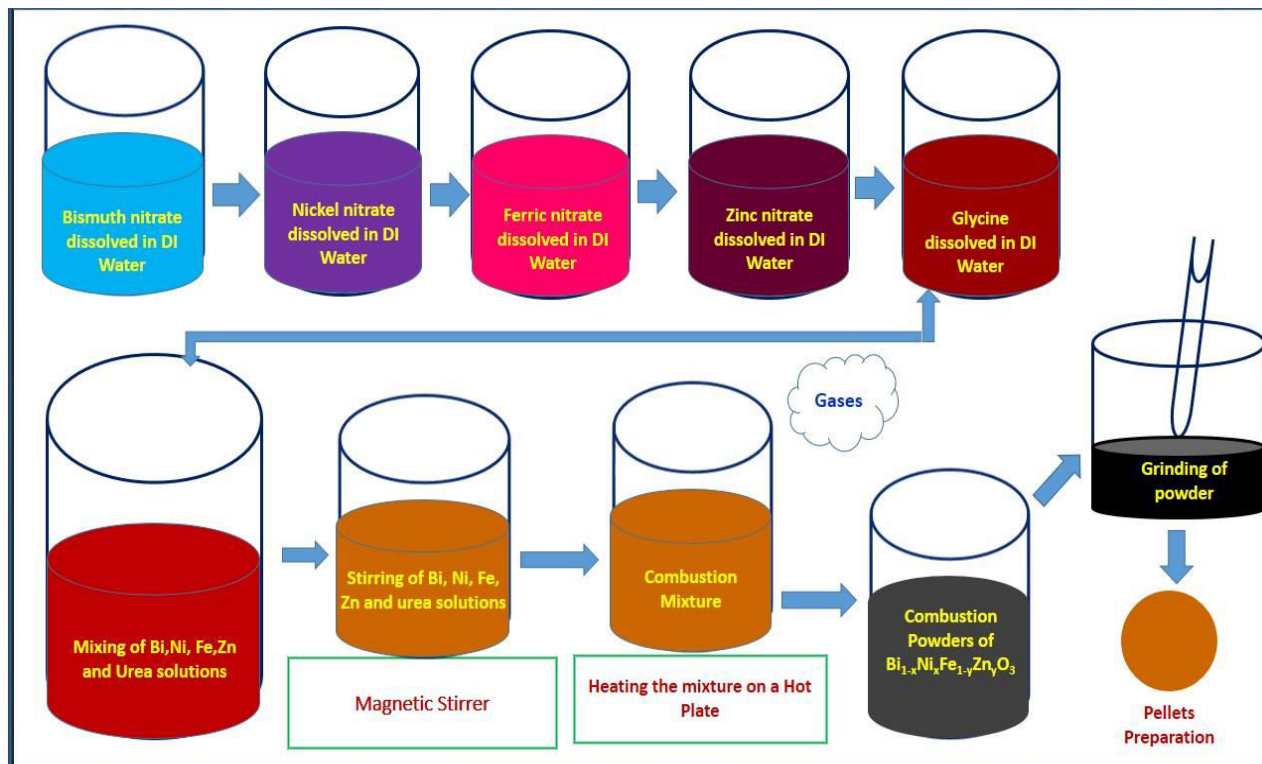
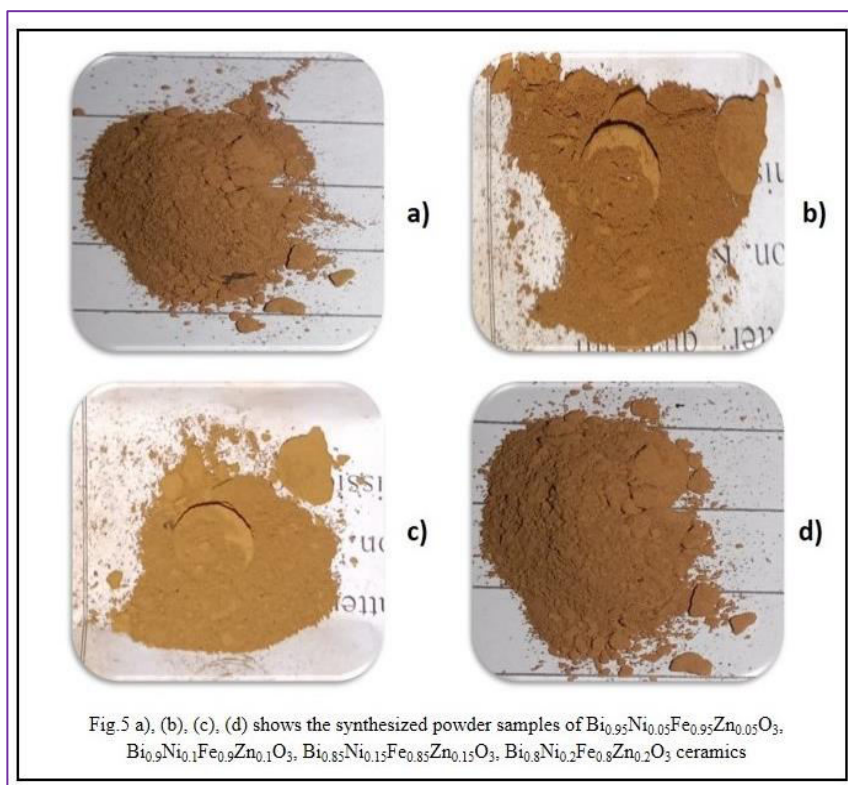
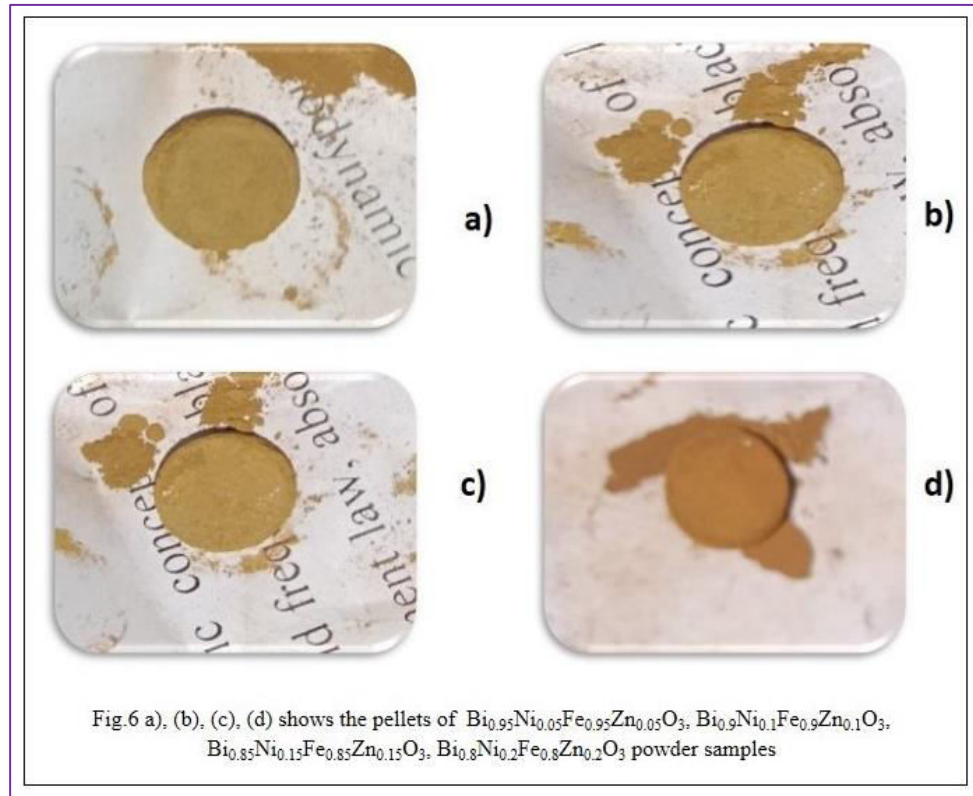


Fig. 4 (b). Experimental methodology process





III. RESULTS AND DISCUSSION:

Fig.1 (a) presents the flowchart of preparation of the $\text{Bi}_{1-x}\text{Zn}_x\text{Fe}_{1-y}\text{Ni}_y\text{O}_3$ samples and Fig.1 (b) shows the brief experimental methodology of formulation of $\text{Bi}_{1-x}\text{Zn}_x\text{Fe}_{1-y}\text{Ni}_y\text{O}_3$ nanopowder samples. Fig. 2 (a), (b), (c), (d) shows the synthesized nanopowders of $\text{Bi}_{0.95}\text{Zn}_{0.05}\text{Fe}_{0.95}\text{Ni}_{0.05}\text{O}_3$, $\text{Bi}_{0.9}\text{Zn}_{0.1}\text{Fe}_{0.9}\text{Ni}_{0.1}\text{O}_3$, $\text{Bi}_{0.85}\text{Zn}_{0.15}\text{Fe}_{0.85}\text{Ni}_{0.15}\text{O}_3$, $\text{Bi}_{0.8}\text{Zn}_{0.2}\text{Fe}_{0.8}\text{Ni}_{0.2}\text{O}_3$ samples and Fig.3 (a), (b), (c), (d) shows the pellets of formulated $\text{Bi}_{0.95}\text{Zn}_{0.05}\text{Fe}_{0.95}\text{Ni}_{0.05}\text{O}_3$, $\text{Bi}_{0.9}\text{Zn}_{0.1}\text{Fe}_{0.9}\text{Ni}_{0.1}\text{O}_3$, $\text{Bi}_{0.85}\text{Zn}_{0.15}\text{Fe}_{0.85}\text{Ni}_{0.15}\text{O}_3$, $\text{Bi}_{0.8}\text{Zn}_{0.2}\text{Fe}_{0.8}\text{Ni}_{0.2}\text{O}_3$ powder samples.

In Figure 4(a), the flowchart for the preparation of the $\text{Bi}_{1-x}\text{Ni}_x\text{Fe}_{1-y}\text{Zn}_y\text{O}_3$ samples is shown and Fig.4 (b) shows the brief experimental methodology of formulation of $\text{Bi}_{1-x}\text{Ni}_x\text{Fe}_{1-y}\text{Zn}_y\text{O}_3$ nanopowder samples. Fig.5 a), (b), (c), (d) shows the synthesized nanopowders of $\text{Bi}_{0.95}\text{Ni}_{0.05}\text{Fe}_{0.95}\text{Zn}_{0.05}\text{O}_3$, $\text{Bi}_{0.9}\text{Ni}_{0.1}\text{Fe}_{0.9}\text{Zn}_{0.1}\text{O}_3$, $\text{Bi}_{0.85}\text{Ni}_{0.15}\text{Fe}_{0.85}\text{Zn}_{0.15}\text{O}_3$, $\text{Bi}_{0.8}\text{Ni}_{0.2}\text{Fe}_{0.8}\text{Zn}_{0.2}\text{O}_3$ samples and Fig.6 a), (b), (c), (d) shows the pellets of the prepared $\text{Bi}_{0.95}\text{Ni}_{0.05}\text{Fe}_{0.95}\text{Zn}_{0.05}\text{O}_3$, $\text{Bi}_{0.9}\text{Ni}_{0.1}\text{Fe}_{0.9}\text{Zn}_{0.1}\text{O}_3$, $\text{Bi}_{0.85}\text{Ni}_{0.15}\text{Fe}_{0.85}\text{Zn}_{0.15}\text{O}_3$, $\text{Bi}_{0.8}\text{Ni}_{0.2}\text{Fe}_{0.8}\text{Zn}_{0.2}\text{O}_3$ powder samples.

IV. CONCLUSION

In the present paper, we have successfully produced the nanopowders of the $\text{Bi}_{0.95}\text{Zn}_{0.05}\text{Fe}_{0.95}\text{Ni}_{0.05}\text{O}_3$, $\text{Bi}_{0.9}\text{Zn}_{0.1}\text{Fe}_{0.9}\text{Ni}_{0.1}\text{O}_3$, $\text{Bi}_{0.85}\text{Zn}_{0.15}\text{Fe}_{0.85}\text{Ni}_{0.15}\text{O}_3$, $\text{Bi}_{0.8}\text{Zn}_{0.2}\text{Fe}_{0.8}\text{Ni}_{0.2}\text{O}_3$, $\text{Bi}_{0.95}\text{Ni}_{0.05}\text{Fe}_{0.95}\text{Zn}_{0.05}\text{O}_3$, $\text{Bi}_{0.9}\text{Ni}_{0.1}\text{Fe}_{0.9}\text{Zn}_{0.1}\text{O}_3$, $\text{Bi}_{0.85}\text{Ni}_{0.15}\text{Fe}_{0.85}\text{Zn}_{0.15}\text{O}_3$, $\text{Bi}_{0.8}\text{Ni}_{0.2}\text{Fe}_{0.8}\text{Zn}_{0.2}\text{O}_3$ samples through solution combustion method.

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