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Solution Combustion Method: An Effective Pathway for the Preparation of $BiFe_{1-x+y}Na_xK_yO_3$ (x = y = 0.1, 0.2, 0.3, 0.4) Codoped Multiferroic Ceramics

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ABSTRACT

This paper presents the synthesis of Fe site Na and K codoped $BiFeO_3$ ceramic samples using solution combustion method. The Na and K codoped $BiFeO_3$ samples such as $BiFe_{0.8}Na_{0.1}K_{0.1}O_3$, $BiFe_{0.6}Na_{0.2}K_{0.2}O_3$, $BiFe_{0.4}Na_{0.3}K_{0.3}O_3$ and $BiFe_{0.2}Na_{0.4}K_{0.4}O_3$ multiferroic ceramic samples were formulated using metal nitrates and glycine as a key precursors. All these $BiFe_{0.8}Na_{0.1}K_{0.1}O_3$, $BiFe_{0.6}Na_{0.2}K_{0.2}O_3$, $BiFe_{0.4}Na_{0.3}K_{0.3}O_3$ and $BiFe_{0.2}Na_{0.4}K_{0.4}O_3$ multiferroic samples were grinded in acetone medium, calcined at different temperatures and lastly pelletized in the form of pellets.

KEYWORDS: *Multiferroics, BiFeO3, Na and K dopants, SCM, applications*

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INTRODUCTION

The coexistence of ferromagnetic and ferroelectric characteristics makes multiferroic materials particularly interesting [1]. The bismuth ferrite ($BiFeO_3$) has ferroelectric Curie temperature T_C = 1103 K and antiferromagnetic Neel temperature T_N = 643 K [2]. The multiferroic $BiFeO_3$ have number of prime applications in different fields like energy storage systems, supercapacitor [3], photo-degradation of organic dyes, wastewater treatments, air purification process [4], electromagnetic sensors, electric energy harvesting [5], next-generation spintronic applications [6] and photovoltaics, optical filters [7].

The number of synthesis routes are used for the preparation of pure, doped and codoped $BiFeO_3$ multiferroic ceramic samples like Citrate method [8], polymeric precursor method [9], citrate-gel method [10], sol gel method [11] and solution combustion synthesis [12].

The present article describes the synthesis of $BiFe_{0.8}Na_{0.1}K_{0.1}O_3$, $BiFe_{0.6}Na_{0.2}K_{0.2}O_3$, $BiFe_{0.4}Na_{0.3}K_{0.3}O_3$ and $BiFe_{0.2}Na_{0.4}K_{0.4}O_3$ multiferroic ceramic samples via solution combustion method.

Experimental Process:

The formulation of $BiFe_{0.8}Na_{0.1}K_{0.1}O_3$, $BiFe_{0.6}Na_{0.2}K_{0.2}O_3$, $BiFe_{0.4}Na_{0.3}K_{0.3}O_3$ and $BiFe_{0.2}Na_{0.4}K_{0.4}O_3$ ceramic samples were carried out by solution combustion method (SCM).

Materials:

The preliminary materials used are bismuth nitrate, sodium nitrate, Potassium nitrate, ferric nitrate and glycine.

Synthesis Process:

The preparation of $BiFe_{0.8}Na_{0.1}K_{0.1}O_3$, $BiFe_{0.6}Na_{0.2}K_{0.2}O_3$, $BiFe_{0.4}Na_{0.3}K_{0.3}O_3$ and $BiFe_{0.2}Na_{0.4}K_{0.4}O_3$ ceramic samples were carried out using the precursors such as bismuth nitrate, ferric

nitrate, sodium nitrate, potassium nitrate as 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 [13].

The bismuth nitrate, ferric nitrate, sodium nitrate, potassium 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. Subsequently the constant heating, the water gets evaporated and lastly a combustion takes place with formation of $BiFe_{0.8}Na_{0.1}K_{0.1}O_3$, $BiFe_{0.6}Na_{0.2}K_{0.2}O_3$, $BiFe_{0.4}Na_{0.3}K_{0.3}O_3$ and $BiFe_{0.2}Na_{0.4}K_{0.4}O_3$ powder ceramic samples. The experimental procedure was given by Chaudhari et.al. [14], these powders were grinded in an acetone medium and finally calcined at 450°C, 480°C, 510°C, 540°C for 2 hours in a furnace and finally carried out for pelletization. The Fig.1 presents the flowchart of entire experimental process of preparation of these samples and Fig.2 describes the experimental methodology process for the formulation of these ceramic samples. Fig. 3 (a), (b), (c), (d) shows the synthesized powders of $BiFe_{0.8}Na_{0.1}K_{0.1}O_3$, $BiFe_{0.6}Na_{0.2}K_{0.2}O_3$, $BiFe_{0.4}Na_{0.3}K_{0.3}O_3$ and $BiFe_{0.2}Na_{0.4}K_{0.4}O_3$ ceramic samples and Fig.4 (a), (b), (c), (d) shows the pellets of $BiFe_{0.8}Na_{0.1}K_{0.1}O_3$, $BiFe_{0.6}Na_{0.2}K_{0.2}O_3$, $BiFe_{0.4}Na_{0.3}K_{0.3}O_3$ and $BiFe_{0.2}Na_{0.4}K_{0.4}O_3$ ceramic samples.

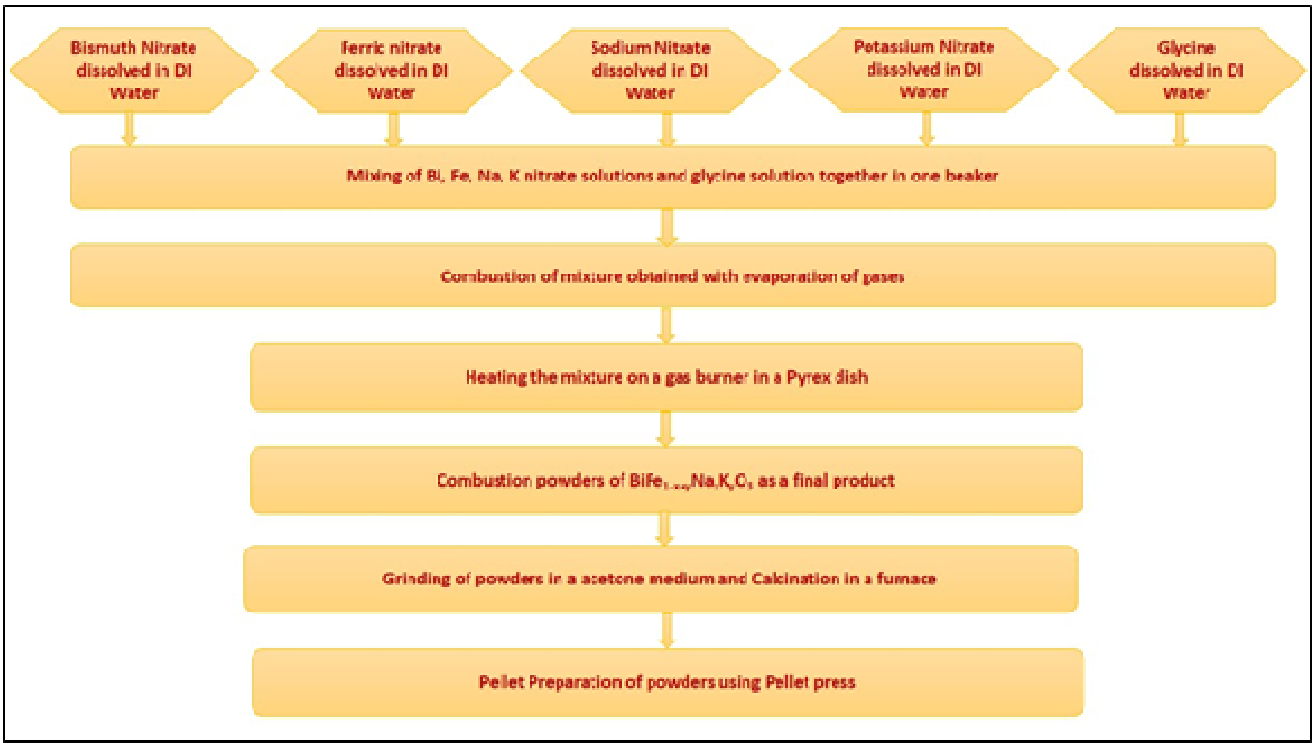

Fig.1. Flowchart of synthesis of $BiFe_{0.8}Na_{0.1}K_{0.1}O_3$, $BiFe_{0.6}Na_{0.2}K_{0.2}O_3$, $BiFe_{0.4}Na_{0.3}K_{0.3}O_3$ and $BiFe_{0.2}Na_{0.4}K_{0.4}O_3$ nanoceramics samples.

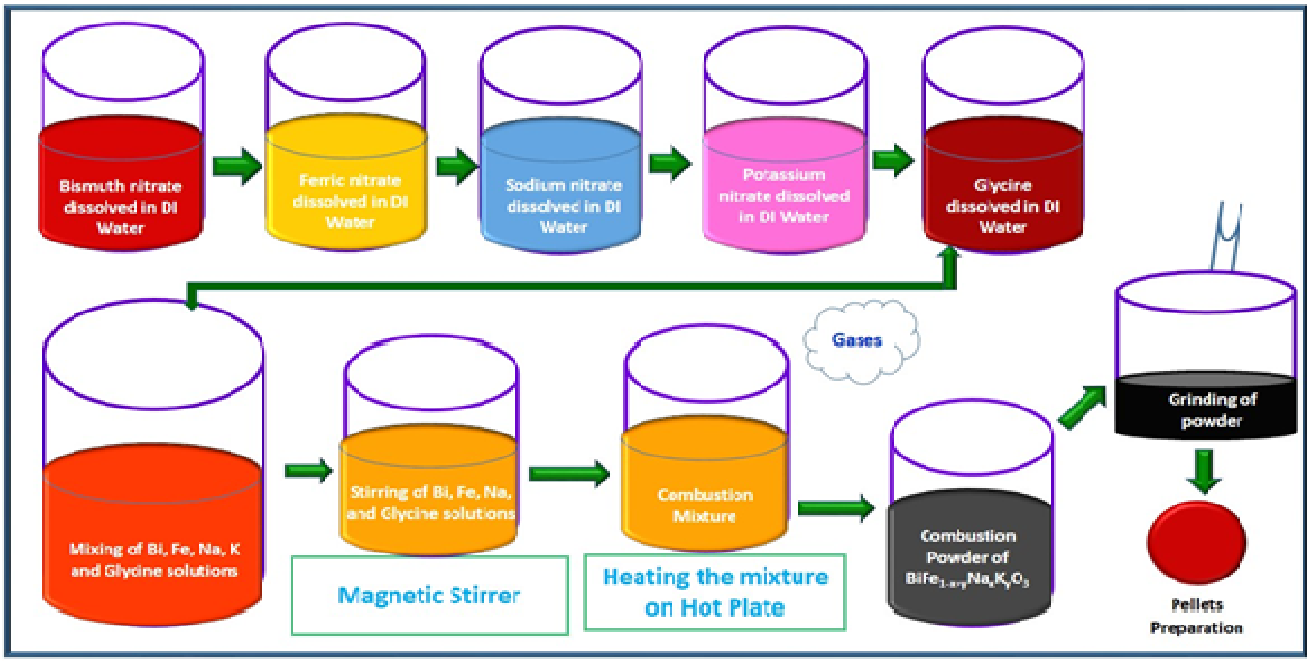

Fig.2. Experimental procedure for the formulation of $BiFe_{0.8}Na_{0.1}K_{0.1}O_3$, $BiFe_{0.6}Na_{0.2}K_{0.2}O_3$, $BiFe_{0.4}Na_{0.3}K_{0.3}O_3$ and $BiFe_{0.2}Na_{0.4}K_{0.4}O_3$ nanoceramics samples.

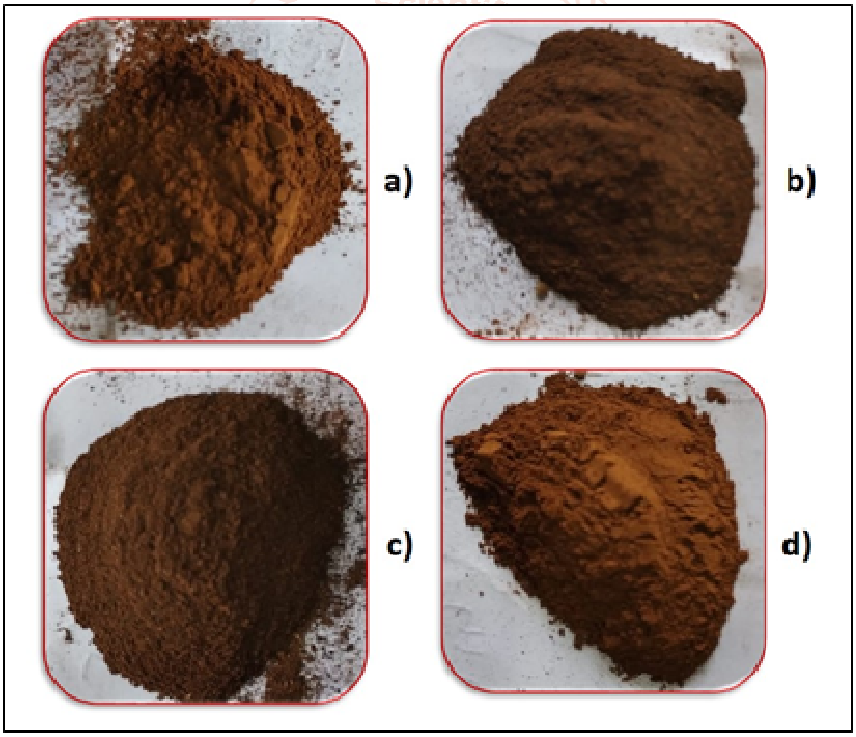

Fig.3. Synthesized powder samples of a) $BiFe_{0.8}Na_{0.1}K_{0.1}O_3$ b) $BiFe_{0.6}Na_{0.2}K_{0.2}O_3$ c) $BiFe_{0.4}Na_{0.3}K_{0.3}O_3$ and d) $BiFe_{0.2}Na_{0.4}K_{0.4}O_3$ nanoceramics samples.

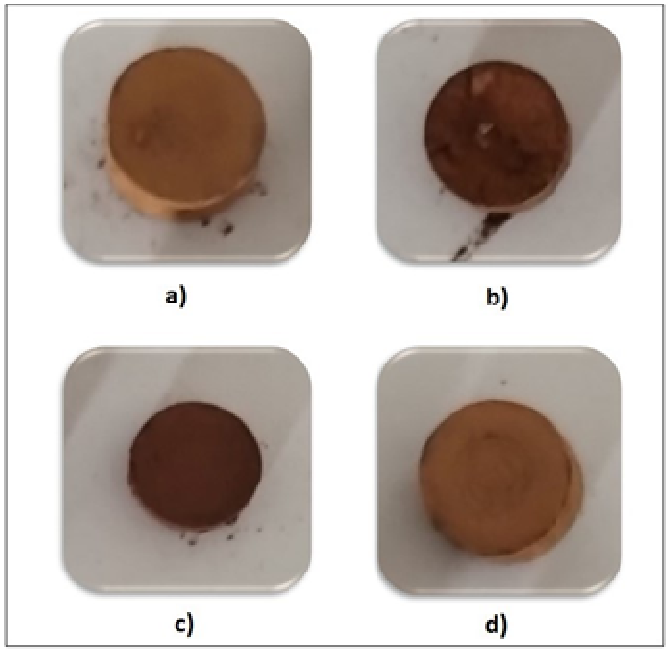

Fig.4. Pellets of synthesized powder samples of a) $BiFe_{0.8}Na_{0.1}K_{0.1}O_3$ b) $BiFe_{0.6}Na_{0.2}K_{0.2}O_3$ c) $BiFe_{0.4}Na_{0.3}K_{0.3}O_3$ and d) $BiFe_{0.2}Na_{0.4}K_{0.4}O_3$ samples.

Results and discussion:

Fig.1 presents flowchart of preparation of $BiFe_{0.8}Na_{0.1}K_{0.1}O_3$, $BiFe_{0.6}Na_{0.2}K_{0.2}O_3$, $BiFe_{0.4}Na_{0.3}K_{0.3}O_3$ and $BiFe_{0.2}Na_{0.4}K_{0.4}O_3$ samples and Fig.2 describes the experimental methodology for the formulation of $BiFe_{0.8}Na_{0.1}K_{0.1}O_3$, $BiFe_{0.6}Na_{0.2}K_{0.2}O_3$, $BiFe_{0.4}Na_{0.3}K_{0.3}O_3$ and $BiFe_{0.2}Na_{0.4}K_{0.4}O_3$ ceramic samples. Fig. 3 (a), (b), (c), (d) shows the synthesized powders of $BiFe_{0.8}Na_{0.1}K_{0.1}O_3$, $BiFe_{0.6}Na_{0.2}K_{0.2}O_3$, $BiFe_{0.4}Na_{0.3}K_{0.3}O_3$ and $BiFe_{0.2}Na_{0.4}K_{0.4}O_3$ samples and Fig.4 (a), (b), (c), (d) shows the prepared pellets of $BiFe_{0.8}Na_{0.1}K_{0.1}O_3$, $BiFe_{0.6}Na_{0.2}K_{0.2}O_3$, $BiFe_{0.4}Na_{0.3}K_{0.3}O_3$ and $BiFe_{0.2}Na_{0.4}K_{0.4}O_3$ ceramic samples.

Conclusions:

In this article, we have successfully formulated the codoped samples such as $BiFe_{0.8}Na_{0.1}K_{0.1}O_3$, $BiFe_{0.6}Na_{0.2}K_{0.2}O_3$, $BiFe_{0.4}Na_{0.3}K_{0.3}O_3$ and $BiFe_{0.2}Na_{0.4}K_{0.4}O_3$ ceramics through solution combustion method.

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