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# **An Effective Pathway for the Preparation of Na and K codoped BiFeO<sub>3</sub> Multiferroic Ceramics using Nitrates and Urea Fuel**

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**ABSTRACT:** The synthesis of Fe site Na and K codoped BiFeO<sub>3</sub> ceramic samples using the solution combustion process is presented in this research. The BiFe<sub>0.8</sub>Na<sub>0.1</sub>K<sub>0.1</sub>O<sub>3</sub>, BiFe<sub>0.6</sub>Na<sub>0.2</sub>K<sub>0.2</sub>O<sub>3</sub>, BiFe<sub>0.4</sub>Na<sub>0.3</sub>K<sub>0.3</sub>O<sub>3</sub> and BiFe<sub>0.2</sub>Na<sub>0.4</sub>K<sub>0.4</sub>O<sub>3</sub> multiferroic ceramic samples were made utilizing metal nitrates and urea as essential precursors. The codoped BiFeO<sub>3</sub> samples were made at various doping levels. The multiferroic samples BiFe<sub>0.8</sub>Na<sub>0.1</sub>K<sub>0.1</sub>O<sub>3</sub>, BiFe<sub>0.6</sub>Na<sub>0.2</sub>K<sub>0.2</sub>O<sub>3</sub>, BiFe<sub>0.4</sub>Na<sub>0.3</sub>K<sub>0.3</sub>O<sub>3</sub> and BiFe<sub>0.2</sub>Na<sub>0.4</sub>K<sub>0.4</sub>O<sub>3</sub> were all ground in acetone medium, calcined at various temperatures, and then pelletized.

**KEYWORDS:** Multiferroics, BiFeO<sub>3</sub>, Na, K dopants, Combustion, applications.

## **I. INTRODUCTION**

Multiferroic materials attract significant attention because they exhibit both ferromagnetic and ferroelectric properties [1]. The ferroelectric Curie temperature of bismuth ferrite (BiFeO<sub>3</sub>) is 1103 K as well as the antiferromagnetic Neel temperature is 643 K [2]. The multiferroic BiFeO<sub>3</sub> have number of prime applications in different fields like supercapacitor, photocatalysis [3], photo-degradation of organic dyes, wastewater treatments, air purification process [4], electromagnetic sensors, electric energy harvesting [5], next-generation spintronic and photocatalytic applications [6] and photovoltaics, optical filters [7]. A variety of synthesis methods are utilized for producing pure, doped, and codoped BiFeO<sub>3</sub> multiferroic ceramic samples, including Citrate method [8], polymeric precursor method [9], citrate-gel method [10], sol gel method [11] and solution combustion synthesis [12].

The solution combustion process is used in this paper for the production of multiferroic samples BiFe<sub>0.8</sub>Na<sub>0.1</sub>K<sub>0.1</sub>O<sub>3</sub>, BiFe<sub>0.6</sub>Na<sub>0.2</sub>K<sub>0.2</sub>O<sub>3</sub>, BiFe<sub>0.4</sub>Na<sub>0.3</sub>K<sub>0.3</sub>O<sub>3</sub> and BiFe<sub>0.2</sub>Na<sub>0.4</sub>K<sub>0.4</sub>O<sub>3</sub>.

## **II. METHODOLOGY**

The solution combustion method (SCM) was used to formulate the ceramic samples of BiFe<sub>0.8</sub>Na<sub>0.1</sub>K<sub>0.1</sub>O<sub>3</sub>, BiFe<sub>0.6</sub>Na<sub>0.2</sub>K<sub>0.2</sub>O<sub>3</sub>, BiFe<sub>0.4</sub>Na<sub>0.3</sub>K<sub>0.3</sub>O<sub>3</sub> and BiFe<sub>0.2</sub>Na<sub>0.4</sub>K<sub>0.4</sub>O<sub>3</sub> materials.

### **Materials:**

Urea, sodium nitrate, potassium nitrate, ferric nitrate, and bismuth nitrate are the precursors that are utilized.

### **Synthesis Process:**

The preparation of BiFe<sub>0.8</sub>Na<sub>0.1</sub>K<sub>0.1</sub>O<sub>3</sub>, BiFe<sub>0.6</sub>Na<sub>0.2</sub>K<sub>0.2</sub>O<sub>3</sub>, BiFe<sub>0.4</sub>Na<sub>0.3</sub>K<sub>0.3</sub>O<sub>3</sub> and BiFe<sub>0.2</sub>Na<sub>0.4</sub>K<sub>0.4</sub>O<sub>3</sub> ceramic samples were carried out using the precursors such as bismuth nitrate, ferric nitrate, sodium nitrate, potassium nitrate as oxidizers while urea 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, After mixing these solutions, they were transferred to a Pyrex dish and heated using a gas burner. Following continuous heating, the water evaporates, and finally, a combustion occurs, forming powdered ceramic samples of BiFe<sub>0.8</sub>Na<sub>0.1</sub>K<sub>0.1</sub>O<sub>3</sub>, BiFe<sub>0.6</sub>Na<sub>0.2</sub>K<sub>0.2</sub>O<sub>3</sub>,



$\text{BiFe}_{0.4}\text{Na}_{0.3}\text{K}_{0.3}\text{O}_3$  and  $\text{BiFe}_{0.2}\text{Na}_{0.4}\text{K}_{0.4}\text{O}_3$  powder ceramic samples. The experimental procedure was given by Chaudhari et.al. [14], These powders were ground in an acetone medium, then calcined in a furnace for two hours at 450, 480, 510 ° C before being pelletized. The Fig.1 presents the flowchart of preparation of these samples and Fig.2 describes the experimental methodology for the formulation of these ceramic samples. Fig. 3 (a), (b), (c), (d) shows the synthesized powders of  $\text{BiFe}_{0.8}\text{Na}_{0.1}\text{K}_{0.1}\text{O}_3$ ,  $\text{BiFe}_{0.6}\text{Na}_{0.2}\text{K}_{0.2}\text{O}_3$ ,  $\text{BiFe}_{0.4}\text{Na}_{0.3}\text{K}_{0.3}\text{O}_3$  and  $\text{BiFe}_{0.2}\text{Na}_{0.4}\text{K}_{0.4}\text{O}_3$  ceramic samples and Fig.4 (a), (b), (c), (d) shows the pellets of  $\text{BiFe}_{0.8}\text{Na}_{0.1}\text{K}_{0.1}\text{O}_3$ ,  $\text{BiFe}_{0.6}\text{Na}_{0.2}\text{K}_{0.2}\text{O}_3$ ,  $\text{BiFe}_{0.4}\text{Na}_{0.3}\text{K}_{0.3}\text{O}_3$  and  $\text{BiFe}_{0.2}\text{Na}_{0.4}\text{K}_{0.4}\text{O}_3$  ceramic samples.

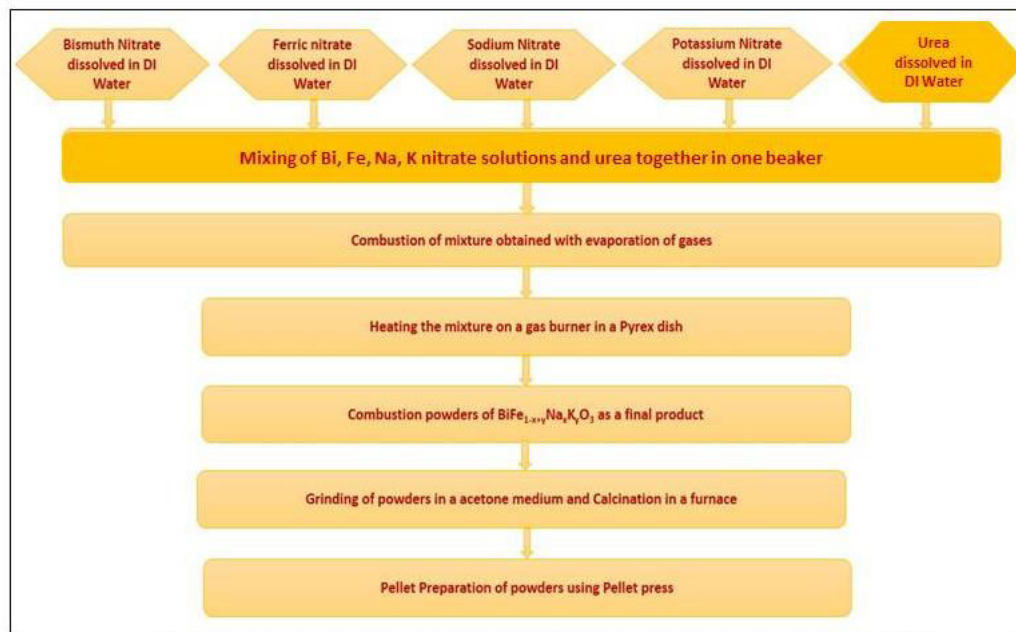


Fig.1. Flowchart of synthesis of  $\text{BiFe}_{0.8}\text{Na}_{0.1}\text{K}_{0.1}\text{O}_3$ ,  $\text{BiFe}_{0.6}\text{Na}_{0.2}\text{K}_{0.2}\text{O}_3$ ,  $\text{BiFe}_{0.4}\text{Na}_{0.3}\text{K}_{0.3}\text{O}_3$  and  $\text{BiFe}_{0.2}\text{Na}_{0.4}\text{K}_{0.4}\text{O}_3$  nanoceramics samples.

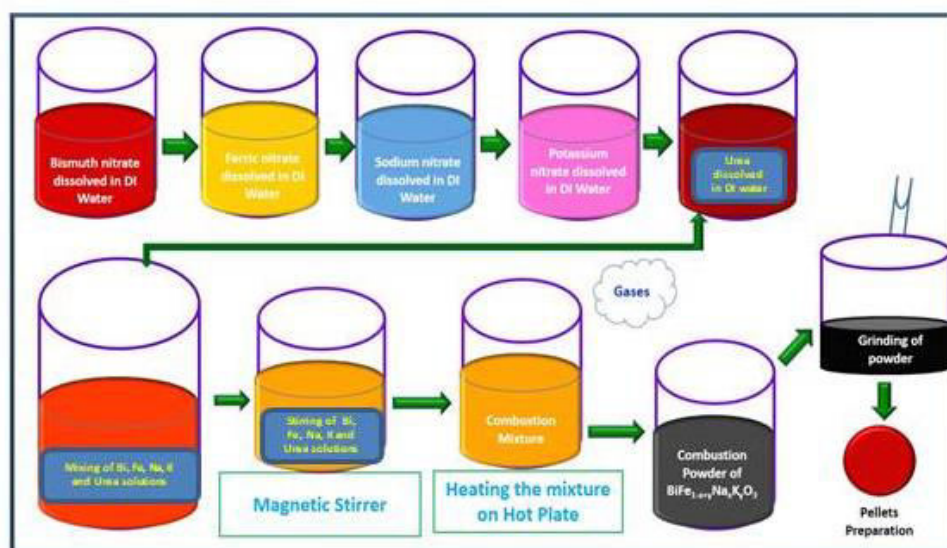


Fig.2. Experimental procedure for the formulation of  $\text{BiFe}_{0.8}\text{Na}_{0.1}\text{K}_{0.1}\text{O}_3$ ,  $\text{BiFe}_{0.6}\text{Na}_{0.2}\text{K}_{0.2}\text{O}_3$ ,  $\text{BiFe}_{0.4}\text{Na}_{0.3}\text{K}_{0.3}\text{O}_3$  and  $\text{BiFe}_{0.2}\text{Na}_{0.4}\text{K}_{0.4}\text{O}_3$  nanoceramics samples.

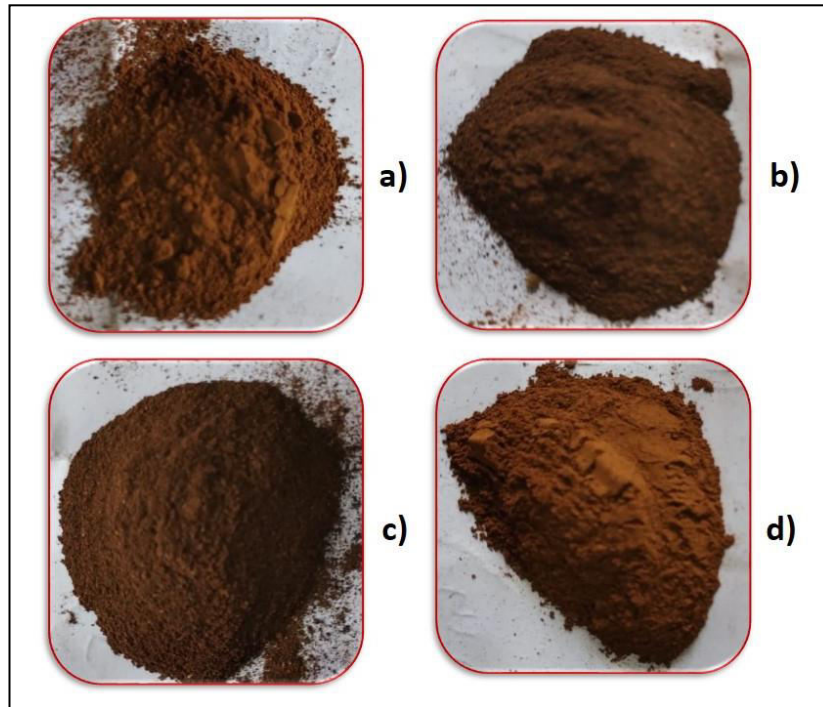


Fig.3. Synthesized powder samples of a)  $\text{BiFe}_{0.8}\text{Na}_{0.1}\text{K}_{0.1}\text{O}_3$  b)  $\text{BiFe}_{0.6}\text{Na}_{0.2}\text{K}_{0.2}\text{O}_3$  c)  $\text{BiFe}_{0.4}\text{Na}_{0.3}\text{K}_{0.3}\text{O}_3$  and d)  $\text{BiFe}_{0.2}\text{Na}_{0.4}\text{K}_{0.4}\text{O}_3$  nanoceramics samples.

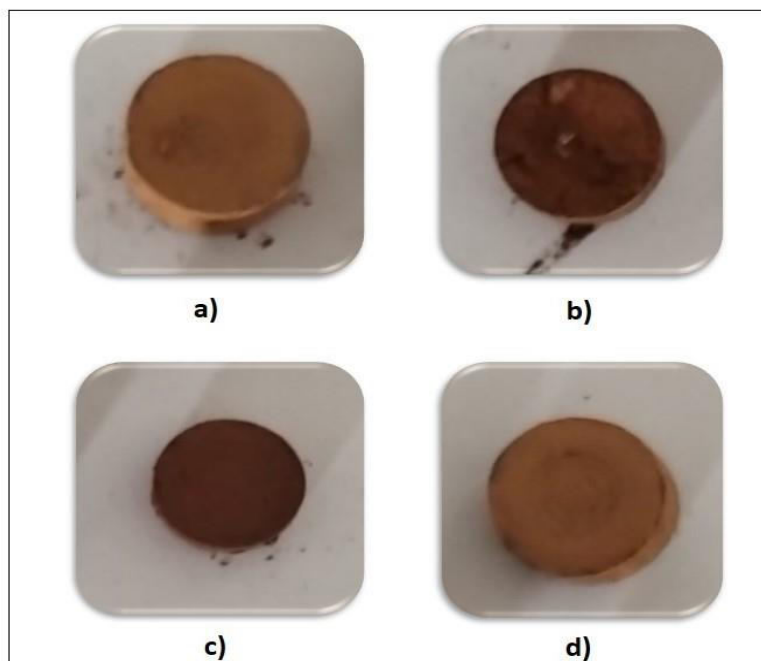


Fig.4. Pellets of synthesized powder samples of a)  $\text{BiFe}_{0.8}\text{Na}_{0.1}\text{K}_{0.1}\text{O}_3$  b)  $\text{BiFe}_{0.6}\text{Na}_{0.2}\text{K}_{0.2}\text{O}_3$  c)  $\text{BiFe}_{0.4}\text{Na}_{0.3}\text{K}_{0.3}\text{O}_3$  and d)  $\text{BiFe}_{0.2}\text{Na}_{0.4}\text{K}_{0.4}\text{O}_3$  samples.

### III. RESULTS AND DISCUSSION

Fig.1 presents flowchart of preparation of  $\text{BiFe}_{0.8}\text{Na}_{0.1}\text{K}_{0.1}\text{O}_3$ ,  $\text{BiFe}_{0.6}\text{Na}_{0.2}\text{K}_{0.2}\text{O}_3$ ,  $\text{BiFe}_{0.4}\text{Na}_{0.3}\text{K}_{0.3}\text{O}_3$  and  $\text{BiFe}_{0.2}\text{Na}_{0.4}\text{K}_{0.4}\text{O}_3$  samples and Fig.2 describes the experimental methodology for the formulation of  $\text{BiFe}_{0.8}\text{Na}_{0.1}\text{K}_{0.1}\text{O}_3$ ,  $\text{BiFe}_{0.6}\text{Na}_{0.2}\text{K}_{0.2}\text{O}_3$ ,  $\text{BiFe}_{0.4}\text{Na}_{0.3}\text{K}_{0.3}\text{O}_3$  and  $\text{BiFe}_{0.2}\text{Na}_{0.4}\text{K}_{0.4}\text{O}_3$  ceramic samples. Fig. 3 (a), (b), (c), (d) shows the synthesized powders of  $\text{BiFe}_{0.8}\text{Na}_{0.1}\text{K}_{0.1}\text{O}_3$ ,  $\text{BiFe}_{0.6}\text{Na}_{0.2}\text{K}_{0.2}\text{O}_3$ ,  $\text{BiFe}_{0.4}\text{Na}_{0.3}\text{K}_{0.3}\text{O}_3$  and  $\text{BiFe}_{0.2}\text{Na}_{0.4}\text{K}_{0.4}\text{O}_3$  samples and Fig.4 (a), (b), (c), (d) shows the prepared pellets of  $\text{BiFe}_{0.8}\text{Na}_{0.1}\text{K}_{0.1}\text{O}_3$ ,  $\text{BiFe}_{0.6}\text{Na}_{0.2}\text{K}_{0.2}\text{O}_3$ ,  $\text{BiFe}_{0.4}\text{Na}_{0.3}\text{K}_{0.3}\text{O}_3$  and  $\text{BiFe}_{0.2}\text{Na}_{0.4}\text{K}_{0.4}\text{O}_3$  ceramic samples.

### IV. CONCLUSIONS

In this article, we have successfully formulated the codoped samples such as  $\text{BiFe}_{0.8}\text{Na}_{0.1}\text{K}_{0.1}\text{O}_3$ ,  $\text{BiFe}_{0.6}\text{Na}_{0.2}\text{K}_{0.2}\text{O}_3$ ,  $\text{BiFe}_{0.4}\text{Na}_{0.3}\text{K}_{0.3}\text{O}_3$  and  $\text{BiFe}_{0.2}\text{Na}_{0.4}\text{K}_{0.4}\text{O}_3$  ceramics through solution combustion method.

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