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STRUCTURAL AND ELECTRICAL PROPERTIES OF PURE AND ZINC DOPED BA_2TIO_4 NANOPARTICLES

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Abstract :

Nanotechnology is the art and science of manipulating matter at the nanoscale to create. It includes making products such as electronic devices, catalysts, sensors, etc. Microwave heating which allows a considerable reduction of the time, as been used in organic chemistry for several decades. In this work, microwave assisted solvothermal method of successfully used for synthesis of Ba_2TiO_4 nanoparticles. Here we have to prepare pure and 5 and 10wt% Zn doped Ba_2TiO_4 nanoparticles by microwave assisted solvothermal method. The grain size of pure, 5 and 10wt% Zinc doped Ba_2TiO_4 nanoparticles were determined by PXRD measurements. The electrical properties of Ba_2TiO_4 nanoparticles were determined from AC conductivity analysis.

Keywords : Ba_2TiO_4, nanoparticles, solvothermal, PXRD, AC Electrical parameters,

I. Introduction :

Nanotechnology is defined as fabrication of devices with atomic or molecular scale precision. Devices with minimum feature sizes less than 100 nm are considered to be products of nanotechnology. Fabrication of nano machines, nano electronics and other nano devices will undoubtedly solve an enormous amount of the problems faced by mankind today [1]. Nanotechnology applications in space development sand systems, high performance textile, the agricultural and food, energy [2]. Nanomaterials with fast ion transport are related also to nano ionic's, nano electronics. [3]. The nanomaterials field includes subfields which develop (or) study materials having unique properties arising from their nano scale dimensions.

Interface and colloidal science has given rise to many materials which may be useful in nanotechnology, such as carbon nano tubes and other fullerenes, and various nanoparticles and nano rods. Nanomaterials with fast ion transport are related also to nano ionic's, nano electronics. [4]. Development of applications incorporating semiconductor nanoparticles to be used in the next generation of products, such as display technology, lighting, solar cells and biological imaging; see quantum dots. [5,6]. Barium titanium oxide is the white colour precipitate. It has two phases: a low-temperature phase with p21/n symmetry and a high temperature (α) phase with p21nb symmetry [7]. The structure of Ba_2TiO_4 is usually among the titanates because its titanium atoms sit in a four-oxygen tetrahedron rather than a six – oxygen octahedran [8]. Barium Titanium Oxides is highly insoluble thermally barium source suitable for glass, optic and ceramic application. However, certain perovskite structured oxides are electronically conductive finding application in the cathode of solid fuel cells and oxygen generation systems. Barium titanium oxide is available in nano powder. Barium Titanium Oxide is a common electronic ceramic material which shows high dielectric and ferroelectric properties [10]. Due to its high dielectric constant, low dielectric loss and excellent ferroelectric property, it is used in multilayer ceramic capacitors, positive temperature coefficient of resistivity thermistors, dynamic random-access memory. It has been know that high dielectric constant with low dielectric loss and good temperature stability can be attained by the addition of dopants [11]. In this paper, we have made an attempt to prepare pure and zinc doped Ba_2TiO_4 nanoparticles by microwave assisted solvothermal method. The prepared samples were annealed (pure, 5wt% and 10wt% Zn doped) at 600^0C and characterized by PXRD and Electrical studies. The results obtained were reported and discussed herein.

II. MATERIALS AND METHODS

A. Material

The precursors used for synthesis were Barium accetate [12], Titanium tetrachloride[13], Zinc acetate and Urea. All the reagents were of analytical grade and were used without further purification. Doubly distilled water is used as a solvent.

B. Preparation of sample

In a typical process of pure Ba_2TiO_4 nanoparticles, barium acetate titanium tetrachloride and urea were taken in 1:3 molecular ratio and dissolved separately in doubly distilled water using a magnetic stirrer. Under stirring condition of barium acetate, titanium tetrachloride, urea solution were added and the resultant solution were kept in a domestic microwave oven. The microwave irradiation were carried out until the solvent get evaporated completely and colloidal precipitate were formed. The colloidal form of precipitate were formed and product were washed several time with doubly distilled water and then with acetone to remove the organic impurities if any. Similar procedure were carried out for the Zinc doped (5 and 10 wt%) Barium titanium oxide nanoparticles. The as-prepared samples were annealed at 600°C for 1hr. The annealed samples were used for characterization studies. The required amount of the substance (A) was estimated by using the formula.

$$A = MXV/1000$$

Where,

M is the molecular weight of the substance
X is the concentration in molar units.
V is the volume of the solvent 100ml in the present work.

The reactions were found to be fast in the three samples and highly yielding with microwave the mass of the product nano powders prepared were measured accurately.

III. RESULT AND DISCUSSION

COLOR AND PHOTOGRAPH OF PREPARED NANOPARTICLES

There are number of methods available for the synthesis of nanomaterials suchas sol - gel, solid state reaction, precipitation, and microwave assisted solvothermalmethod. Among these methods, microwave assisted solvothermal technique is a simple, rapid and versatile method for the synthesis of nanoparticles. The average time taken to prepare all the samples in the present study was observed to be 15 to 18 minutes. The reactions were found to be fast with the microwave. The colloidal form of samples were collected and washed with distilled water for five times and then with acetone. The photographs of prepared samples were shown in the Figure 1. The colors of the prepared samples were noted. By this method high quality, fine white color nano powder has been obtained. Then the prepared nanoparticles were annealed 600^{0}C temperature. There is a small change in the color of the proposed samples. Table 1 shows the colors for the prepared samples. Photograph of the prepared samples From left (i) Pure Ba_2TiO_4, (ii) 5wt% Zn^{2+}doped (iii) 10wt% Zn^{2+} doped Ba_2TiO_4 nanoparticles.

Table 1 : Reaction time, yield percentage and colour

Name of the sample	**Reaction time (min)**	**colour**	**Yield percentage**
Pure Ba_2TiO_4	17	white	12.34
5wt% Zn^{2+} doped Ba_2TiO_4	15	Pale brown	10.80
10wt% Zn^{2+} doped Ba_2TiO_4	10	Brown	10.91

Figure 1 Photographs of Pure, 5 and 10 wt% Zinc doped Ba_2TiO_4 nanoparticles

PXRD ANALYSIS

The PXRD pattern of pure Ba_2TiO_4, 5wt% and 10wt% Zinc doped nanoparticles are provided in figures 2 - 4. All the different peaks present in the PXRD pattern pure Ba_2TiO_4 nanoparticles can be indexed using the data available in the JCPDS file (50-0626). From the PXRD pattern, the average crystallite sizes were determined by the Scherer formula and the lattice parameter were determined. From the indexed PXRD pattern the structure of the prepared pure Ba_2TiO_4 nanoparticles were found to be monoclinic. The crystallite size of the prepared samples were 31.69nm, 55.61nm, 13.93nm for pure, 5wt% and 10wt% Zinc doped Ba_2TiO_4 nanoparticles respectively.

X-ray diffraction (XRD) is a powerful technique used to uniquely identify the crystalline phase present in materials and to measure the structural properties (strain state, grain size, pitaxy, phase composition, preferred orientationand defect structure) of these phases. XRD is also used to determine the thickness of thin films and multi layers and atomic arrangements in amorphous materials (including polymers) and at interfaces. The study of crystal structure by X-ray diffraction was discovered in the year 1912 by Bragg. X-ray diffraction method is widely used for characterization of composite materials.

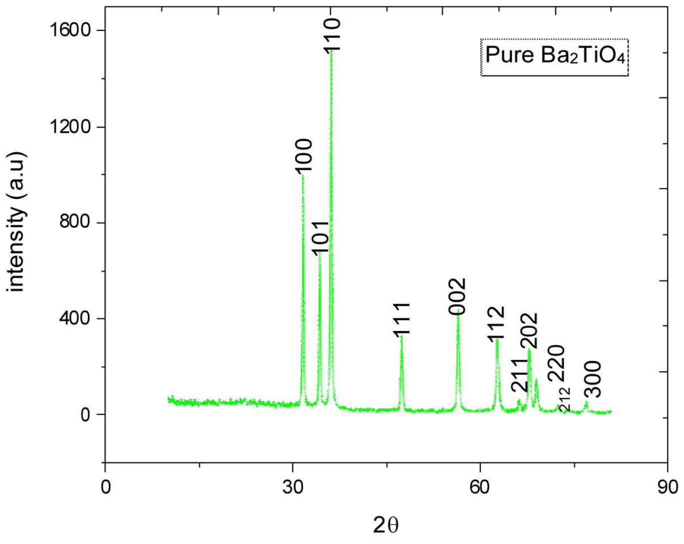

Figure 2: PXRD pattern of pure Ba_2TiO_4 nanoparticles.

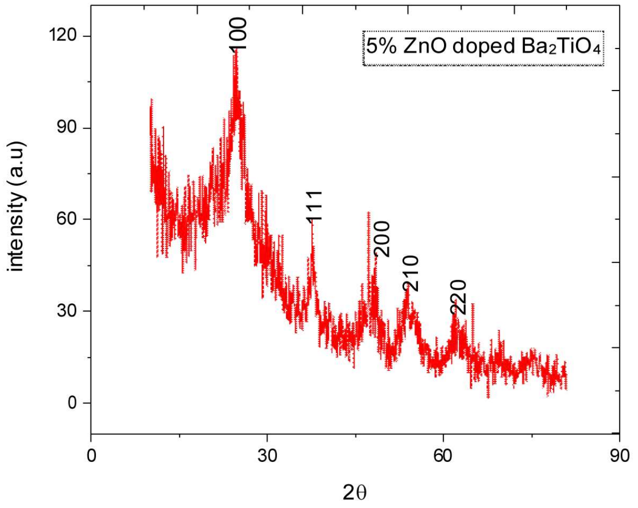

Figure 3: PXRD pattern of 5wt% Zinc doped Ba_2TiO_4 nanoparticles.

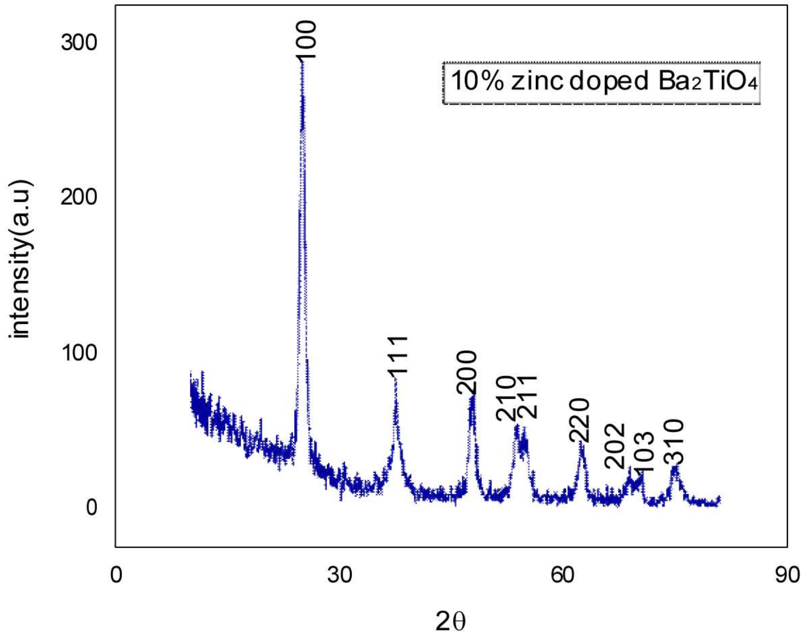

Figure 4: PXRD pattern of 10wt% Zinc doped Ba_2TiO_4 nanoparticles

AC CONDUCTIVITY MEASUREMENT

The behavior of electrical parameters such as dielectric constant, dielectric loss factor and AC electrical conductivity with respect to frequency and temperature is shown in figures 5 - 13. It was observed that for all the prepared samples, the AC conductivity increases with increase in temperature and decreases with increase in frequency. Here the AC electrical conductivity increases with frequency and hence the mechanism of conduction in the prepared samples is localized conduction mechanism. Also the conduction process was due to small polaron hopping since theconductivity increases with frequency. The conductivity of the material is low at low temperatures because the mobility of ion is very low at low temperatures.

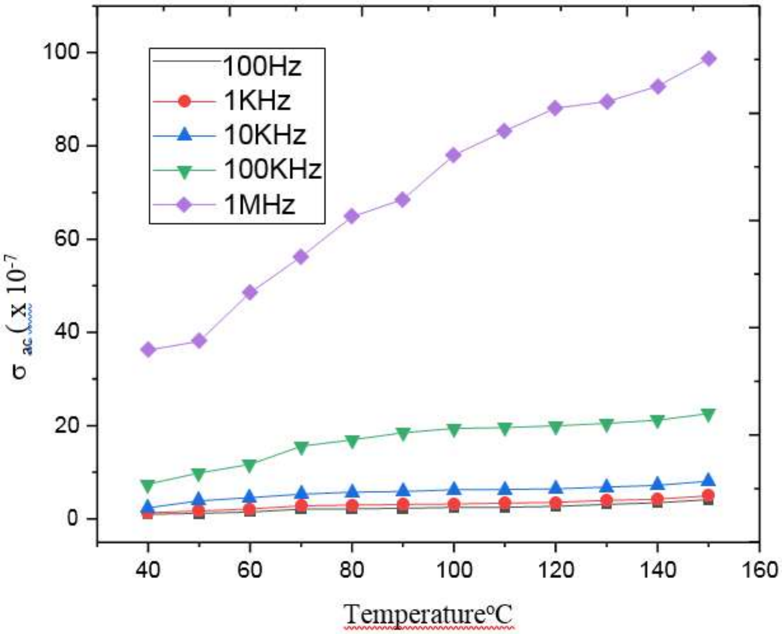

Figure 5: AC electrical conductivity for pure Ba_2TiO_4 nanoparticles

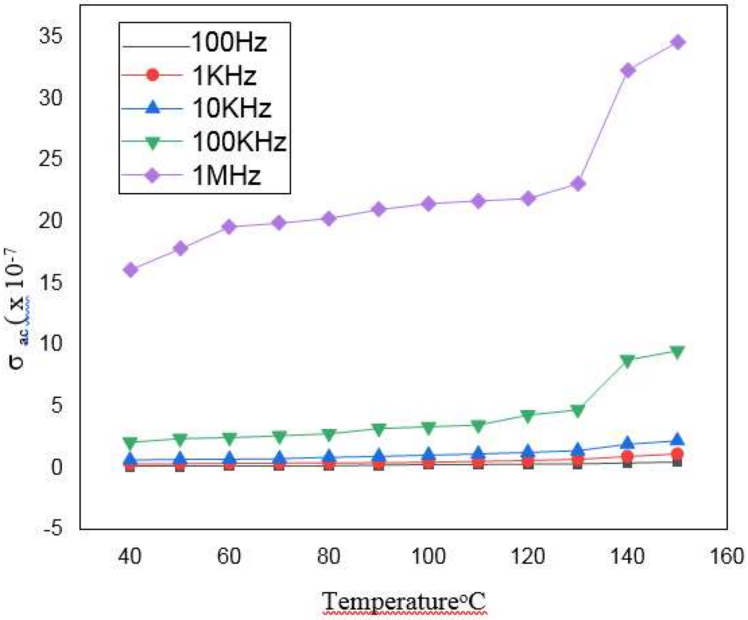

Figure 6: AC electrical conductivity for 5wt% of Zinc doped Ba_2TiO_4 nanoparticles

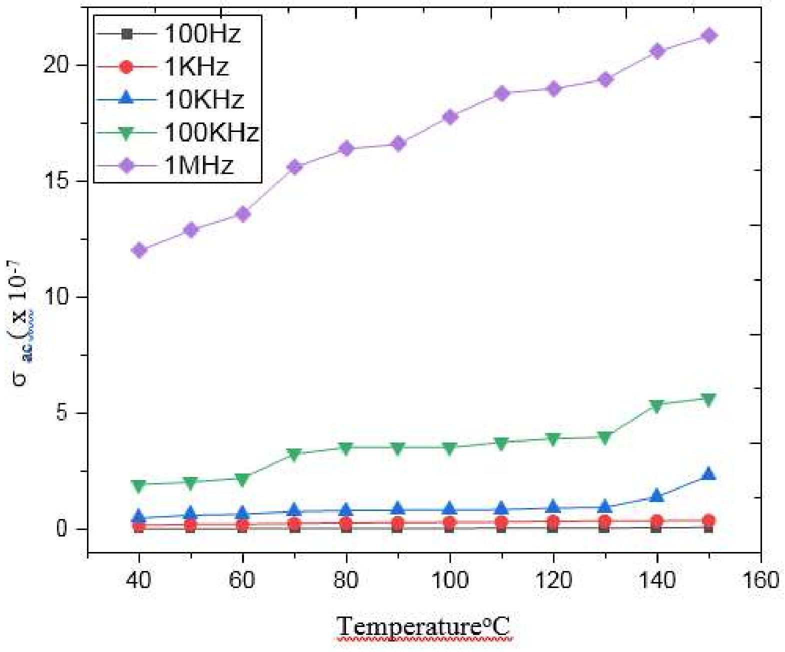

Figure 7: AC electrical conductivity for 10wt% of Zn^{2+} doped Ba_2TiO_4 nanoparticles

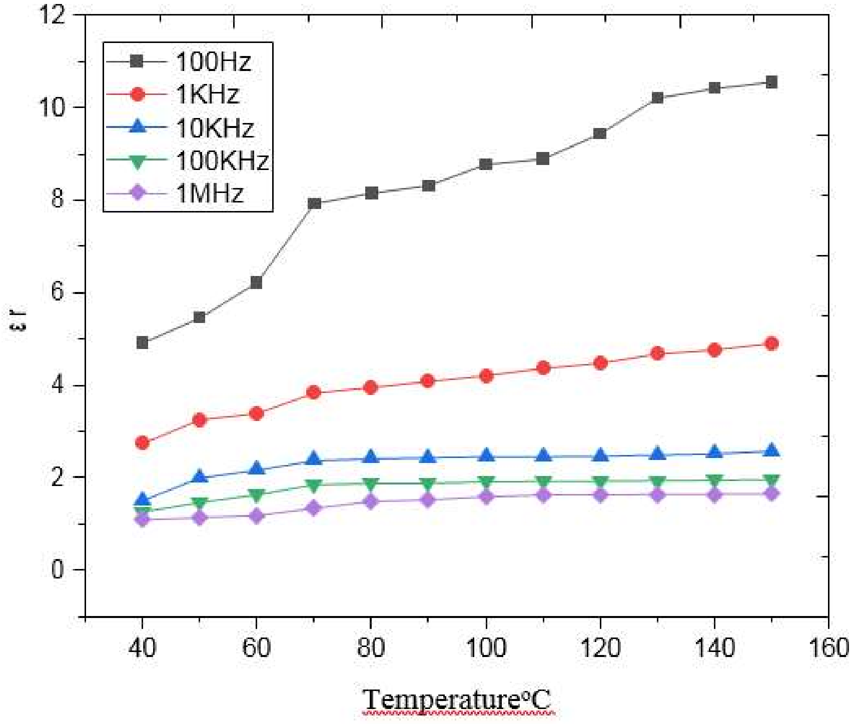

Figure 8 : Dielectric Constant of Pure Ba_2TiO_4 nanoparticles

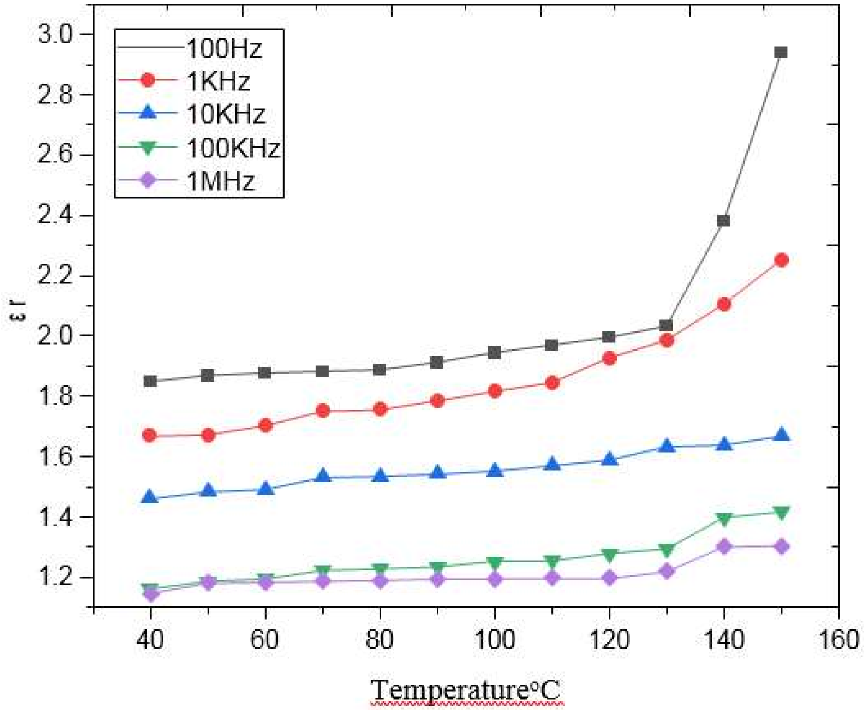

Figure 9: Dielectric Constant of 5wt% Zinc doped Ba_2TiO_4 nanoparticles

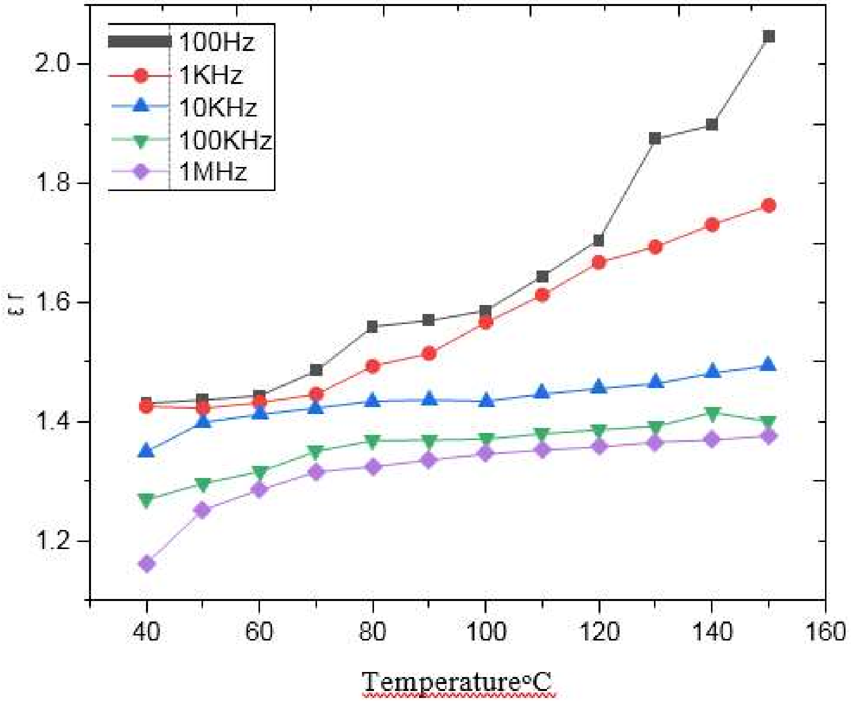

Figure 10: Dielectric Constant of 10wt% Zinc doped Ba_2TiO_4 nanoparticles

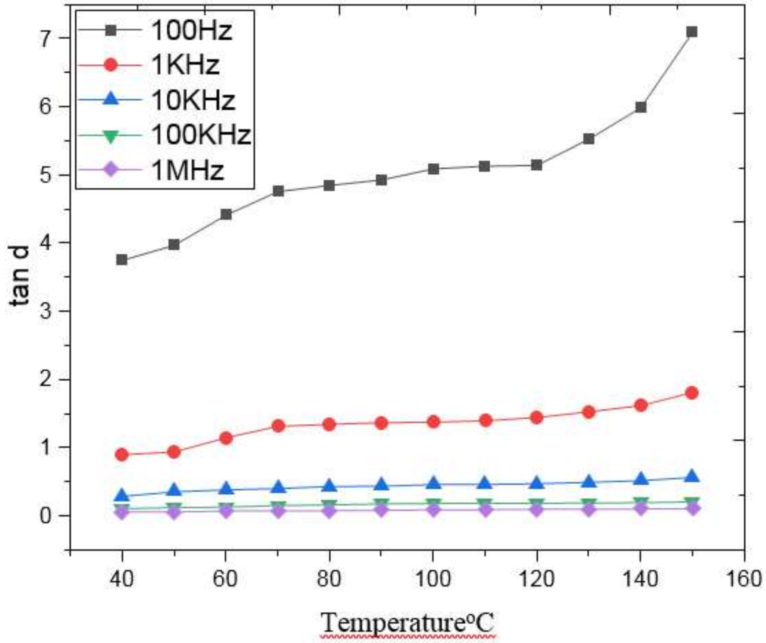

Figure 11: Dielectric loss pattern for Pure Ba_2TiO_4 nanoparticles

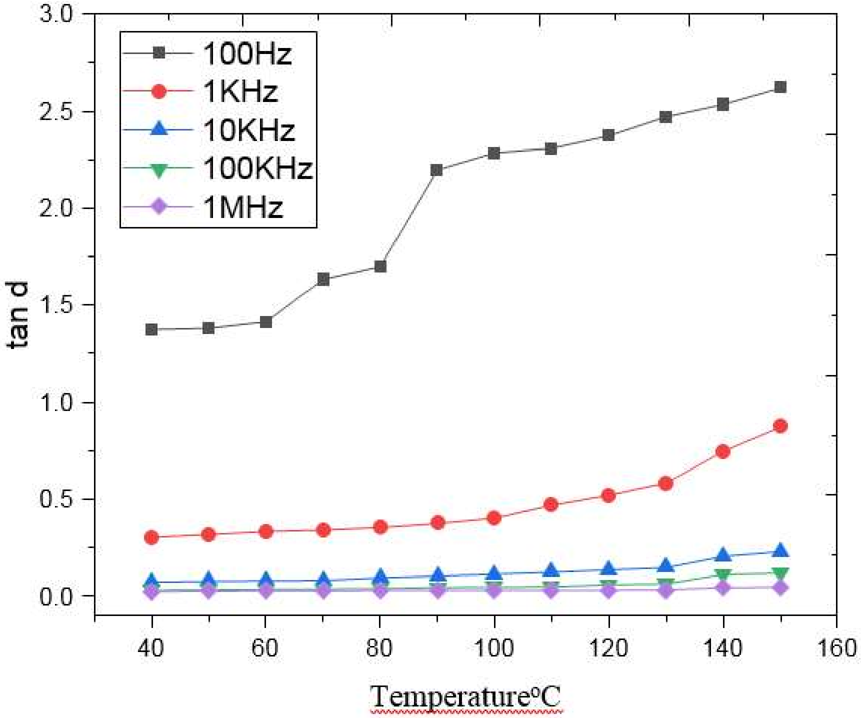

Figure.12. Dielectric loss for 5wt% Zinc doped Ba_2TiO_4 nanoparticles

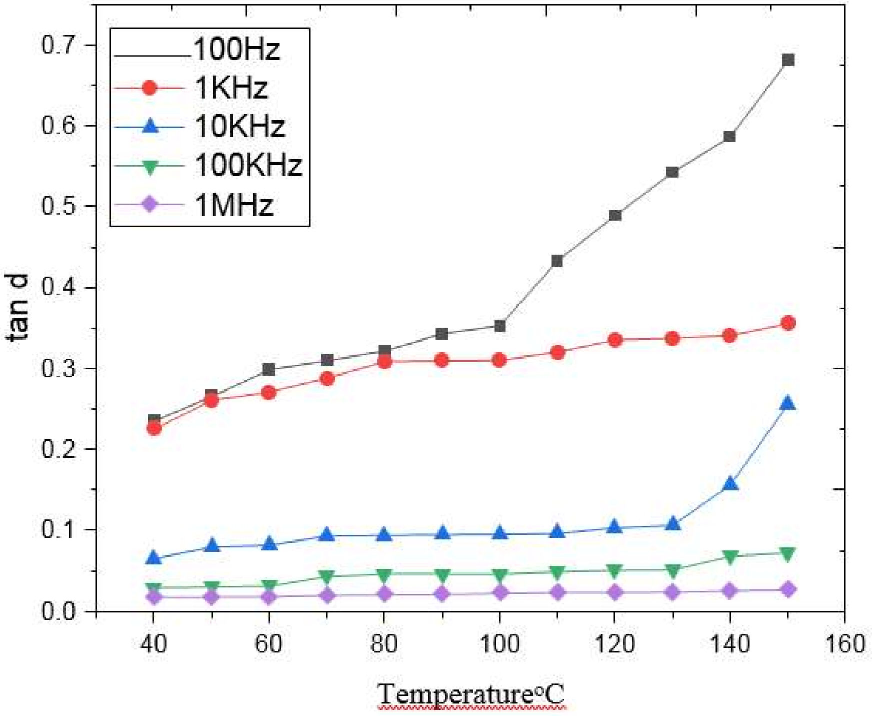

Figure 13 : Dielectric loss for 10wt% Zinc doped Ba_2TiO_4 nanoparticles

CONCLUSION

In the present study, pure Ba_2TiO_4, nanoparticles were prepared by simple solvothermal method with a domestic microwave oven. The prepared samples were characterized by making Powder x-ray diffraction (PXRD) and AC electrical measurements. The identity of the material was confirmed and the crystalline size was determined by using Debye - Scherer's formula. The PXRD patterns indicate the nano crystalline nature of the prepared samples also indicate that the prepared samples were monoclinic in structure. Particle size of 31.69nm, 55.61nm, 13.93nmfor pure, 5wt%,10wt% respectively.

The prepared samples were pelletized and dielectric measurements were carried out for various temperatures with various frequencies 100Hz, 1 KHz, 10 KHz, 100 KHz and 1 MHz. The dielectric parameter viz. Dielectric constant and dielectric loss factor increase with increase in temperature and decrease with increase in frequency. The AC electrical conductivity values have been found to be increase with increase in temperature and frequency. The major application of Zincdoped Ba_2TiO_4 nanoparticles are used in electro-optical devices, dielectric amplifiers, varistors, pyroelectric sensors, micro-capacitors, and piezoelectric devices are the included applications.

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