# TEMPERATURE DEPENDENT DIELECTRIC PROPERTIES OF Y (NI0.5ZN0.3CO0.2FE2O4) + (1-Y) BATIO3 ME COMPOSITES

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***ABSTRACT***

*Magnetoelectric Composites (ME) having chemical formula y(Ni0.5Zn0.3Co0.2Fe2O4)+(1-y)BaTiO3 with y = 0.1, 0.3 and 0.5 were prepared by standard double sintering ceramic method. The presences of both phases without any impurity were confirmed by X-ray diffraction pattern. Variation of dielectric constant (έ) and dielectric loss (tanδ) with temperature for fixed frequencies 1 kHz, 10 kHz, 100 kHz and 1 MHz were studied. Effects of variation of ferrite phase in ME composite on dielectric constant were also studied.*

***KEYWORDS:*** *XRD, Dielectric constant, loss tangent*

## I. INTRODUCTION

Magnetoelectric (ME) materials show the unique ME effect property which is not shown by their constituent phases. ME effect occurs due to coupling between two phases , results in induction of electric polarization by applying an external magnetic field or induction of magnetization by applying an external electric field [1-4]. These magnetoelectric materials are classified into two groups: single phase materials and two phase materials or composites. The single phase materials show weak ME effect due which its applications are limited. Whereas two phase magnetoelectric materials show larger ME effect than the single phase materials . In the recent years, many researchers are taking interest in the study of the magnetoelectric (ME) materials because of their potential for applications as multifunctional devices , magnetic field sensors, transducers, memory devices, electro-optic devices, electrically tunable microwave devices such as filters, oscillators and phase shifters etc. [5-13].

We have selected $Ni_{0.5}Zn_{0.3}Co_{0.2}Fe_2O_4$ as a ferrite phase and $BaTiO_3$ as a ferroelectric phase. To improve the productivity it is essential to revise the properties of these materials, due to this fact we have studied effect of change of ferrite phase on temperature dependent dielectric properties. We have planned to synthesize the individual ferrite and ferroelectric phases and their ME composites. Our aim is to study the XRD and dielectric properties of prepared ME composites. We except that mixing of ferrite and ferroelectric may influence the dielectric properties of ME composites.

## II. MATERIALS AND METHODS

The y($Ni_{0.5}Zn_{0.3}$ $Co_{0.2}Fe_2O_4$ )+ (1-y) ($BaTiO_3$ ) composite materials were prepared by standard double sintering ceramic method. Ferrite phase were prepared by using A.R. grade powders of $NiCO_3$, $ZnCO_3$, $CoCO_3$ and $Fe_2O_3$ and using A.R grade powders of $BaCO_3$ and $TiO_2$ ferroelectric phase were prepared by using. The individual phases were ground for 2-3 hr and mixed in proper molar proportions. The ferrite phase $Ni_{0.5}Zn_{0.3}Co_{0.2}Fe_2O_4$ and ferroelectric phase $BaTiO_3$ were presintered separately at $900^0$C and

$1000^0C$ respectively for 12 hr. The samples of ME composites were prepared by mixing ferrite and ferroelectric phase in the ratio of 10:90, 30:70 and 50:50. These composites were presented at $1100^0C$ for 12 hours. The pellets of ME composite were having thickness 2-3mm and diameter 10-15mm prepared by using hydraulic press. The remaining powder and pellets were final sintered at $1200^0C$ for 12 hours.
Prepared samples was characterized by X-Ray Diffractometer (Brucker D8 Advance) using Cu–Kα radiation (□=1.5418 Å) within the 2θ range $20^0$-$80^0$. The lattice parameters were determined by X'pert High Score Plus software. Capacitance (Cp) and loss tangent (tanδ) of sample were measured by Hioki 3532-50 LCR Hi Tester and as a function of temperature from which the dielectric constant (έ) was calculated at fixed frequencies. From the plots of dielectric constant versus temperature, Curie temperature and conductivity may be studied.

## III. RESULTS AND DISCUSSION

Fig.1 shows XRD patterns of y ($Ni_{0.5}Zn_{0.3}Co_{0.2}Fe_2O_4$) + (1-y) ($BaTiO_3$) with y = 0.1, 0.3 and 0.5 composite samples. The XRD pattern confirms the presence of both the phases i.e. ferrite phase and ferroelectric phase without any impurity. XRD pattern analysis shows that the ferrite phase has a cubic spinel structure with lattice parameter a = 8.36 Å and the ferroelectric phase has a tetragonal pervoskite structure with lattice parameters a = 3.99 Å and c = 4.01 Å. The lattice parameters match fairly well with the lattice parameters of the components when present as single phases. It is also observed that, there is no chemical reaction between ferrite and ferroelectric phases has taken place. The lattice parameters of all samples are recorded in table.1.

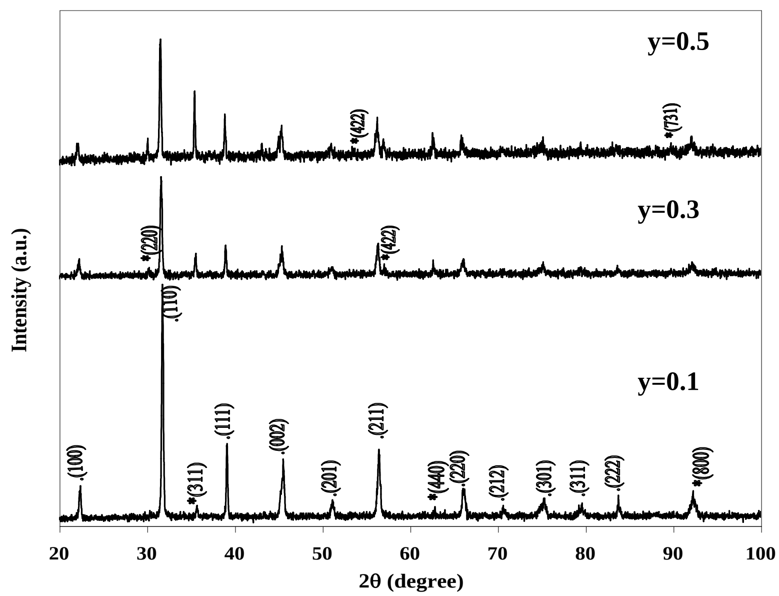



Fig.1. XRD patterns of y ($Ni_{0.5}Zn_{0.3}Co_{0.2}Fe_2O_4$) + (1-y) ($BaTiO_3$) with y = 0.1, 0.3 and 0.5 ME composites.

Fig.2.(a, b & c) shows the temperature dependence of the dielectric constant (ε′) for the composites for y= 0.1, 0.3, and 0.5 respectively. It is observed that the dielectric constant increases with a rise in temperature up to the Curie temperature ($T_C$) and then it decreases. The increase in dielectric constant with temperature is may be due to the accumulation of charges at the grain boundary. Beyond a certain temperature the charges acquire adequate thermal energy to overcome the resistive barrier at the grain boundary and conduction takes place resulting in decrease in polarization which is similar results are

obtained to many researchers. From the plot it is also seen that Tc shifts towards higher temperature as content of ferrite phase in the composites increases.

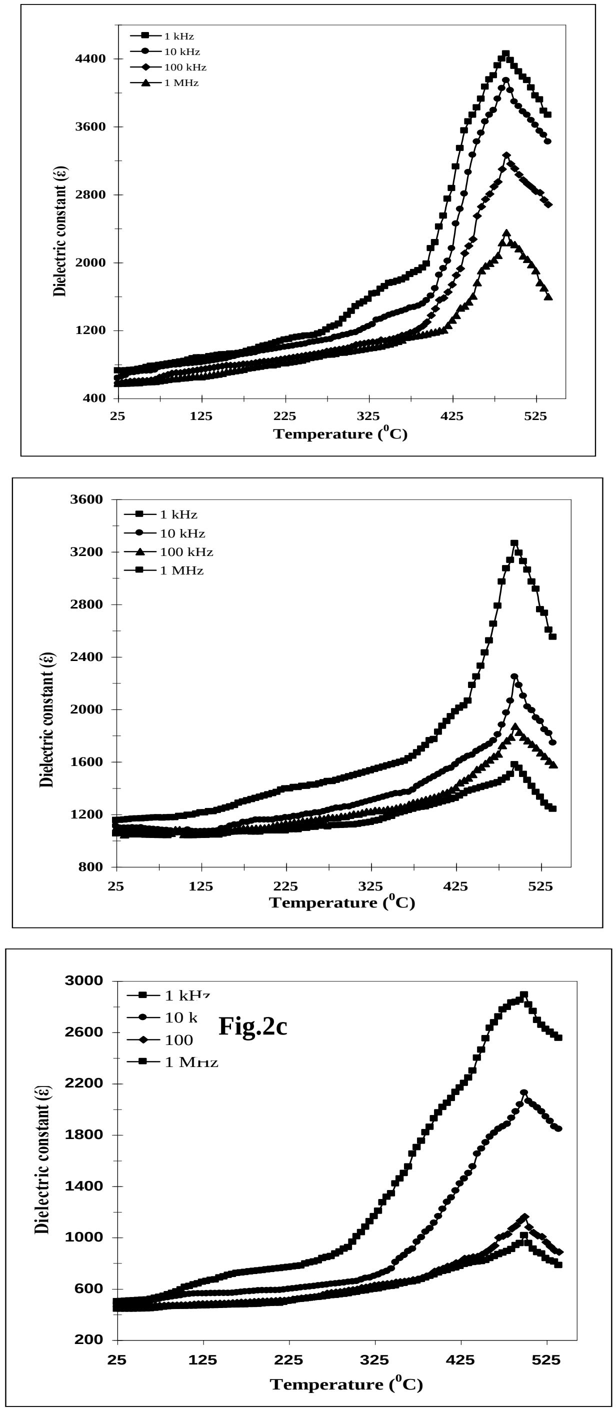
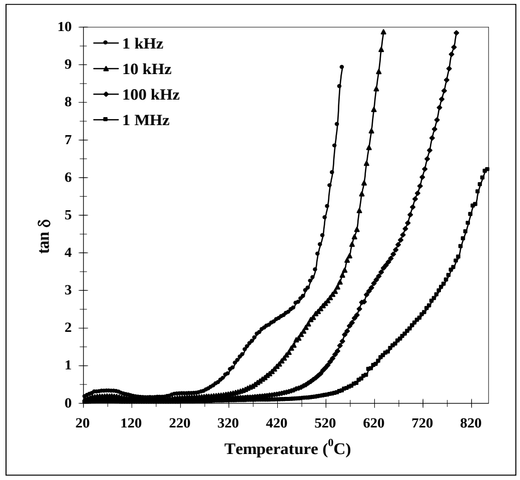
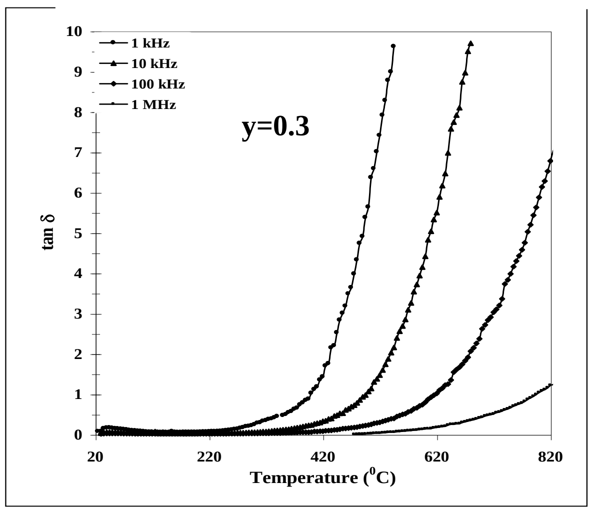



**Fig.2.(a, b & c)** Variation of dielectric constant (έ) with temperature for y($Ni_{0.5}Zn_{0.3}Co_{0.2}Fe_2O_4$)+ (1-y) $BaTiO_3$ composites.

The mobility of charge carriers increases with increasing temperature, which would lead to increase the conductivity and polarization of the samples, hence increase in dielectric constant [14].Dielectric constant (έ) is maximum at 1kHz shows that the sample prepared may be yield high ME voltage. Curie temperature and dielectric constant at 1kHz are reported in table1.



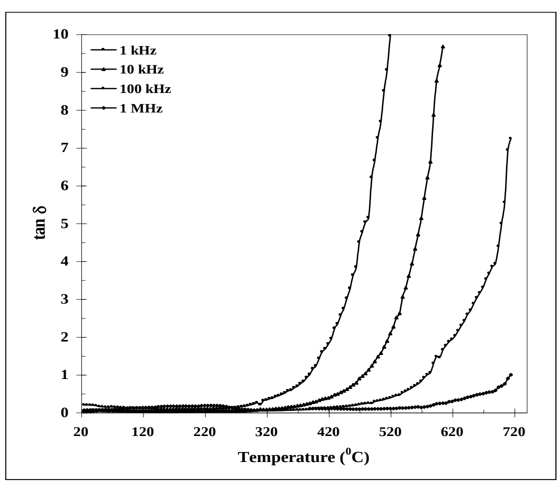




**Fig.3( a, b & c)** Variation of dielectric loss with temperature for y ($Ni_{0.5}Zn_{0.3}Co_{0.2}Fe_2O_4$) + (1-y) $BaTiO_3$ composites.

Fig.3.(a, b & c) Shows the variation of dielectric loss (tanδ) with temperature for y=0.1, 0.3 and 0.5respectively. The increase in loss tangent with increasing temperature ensures the semiconducting nature or thermally activated mechanism of conduction in the samples.

**Table.1.** lattice parameters, Dielectric constant and Curie temperature of y ($Ni_{0.5}Zn_{0.3}Co_{0.2}Fe_2O_4$) + (1-y) $BaTiO_3$ composites with y=0.1, 0.3 and 0.5.

| Composition (y) | Ferrite | Ferroelectric | | | Curie temperature ($^0$C) | Dielectric Constant (έ) at 1kHz |
|---|---|---|---|---|---|---|
| | a (Å) | a (Å) | c (Å) | c/a | | |
| 0.1 | 8.37 | 3.99 | 4.02 | 1.01 | 490 | 4452 |
| 0.3 | 8.37 | 3.99 | 4.03 | 1.01 | 500 | 2888 |
| 0.5 | 8.38 | 4.00 | 4.03 | 1.01 | 510 | 2295 |

## IV. CONCLUSIONS

The ME composites with the general formula $y(Ni_{0.5}Zn_{0.3}Co_{0.2}Fe_2O_4)+ (1-y)(BaTiO_3)$ were prepared by standard ceramic method. All the composites show the presence of ferrite and ferroelectric phases with corresponding maximum intensity peaks of (311) and (110) respectively. No extra lines were observed confirming the formation of composites without any impurity phases. The intensity of ferrite peak in the composites increases with its molar % in the composites while that of ferroelectric decreases. The dielectric constant gradually increases with temperature in the beginning and decreases beyond the Curie temperature ($T_C$).The Curie temperature is observed to increase with increasing ferrite content. The dielectric for all samples is maximum at $T_c$ and highest value is observed for 1kHz frequency.

## V. FUTURE WORK

The Authors would like to synthesize the material with high resistivity and high dielectric constant so as to yield high ME voltage coefficient.

## ACKNOWLEDGEMENT

We are thankful to U.G.C New Delhi for providing financial support for doing this research work under scheme of Major Research Project to college Teachers.

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