Study of Electrical Properties of Nizn Ferrite ($Niznfe_4o_4$) Nanopowder by Impedance Spectroscopy

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Abstract- The nickel zinc ferrites have semiconductor behaviour because resistivity of ferrites decreases with the increase of temperature. The electrical properties of NiZn ferrite $NiZnFe_4O_4$ were investigated by impedance spectroscopy over the frequency 1 Hz to 10 MHz at room temperature**.** Nickel Zinc Iron Oxide ($NiZnFe_4O_4$) Nanopowder ranging 20-30 nm in diameter has been characterized by Scanning electron Microscopy (SEM) and Raman Spectroscopy. The surface morphology of the studied compound has been investigated by Scanning Election Microscopy (SEM) indicating the homogeneous particle size and characteristic range of diameters 20-30 nm. Further, the Raman shift variation with the intensity which shows of studied compound has been analysed by Raman Spectroscopy.in which peak obtained at 330 cm^{-1}, 483 cm^{-1}, 691 cm^{-1} and 1328 cm^{-1} using laser at 785 nm. The electrical studies of the Nickel Zinc Iron Oxide ($NiZnFe_4O_4$) Nanopowder have been examined in order to acquire the electrical parameters (mainly dielectric permittivity, loss, conductivity, loss-tangent, impedance, and admittance).Appreciable rise in the conductivity (with frequency dependent) has been observed due to the decrease in the grain size i.e. nanoscale of the material. It is also observed that the relative permittivity (ε'), relative loss (ε'') and dissipation factor (Tan δ) decreases with increase in frequency.

Keywords- $NiZnFe_4O_4$, SEM, Raman spectroscopy, Loss tangent and Electrical Conductivity.

1. Introduction-

Ni-Zn ferrite has wide application in the electromagnetic interfaces known as EMI, which is used in hard disk drives, in laptops and other electronic pro- ducts [1]. The electrical properties of ferrites are depending to preparation method, sintering temperature, sintering time, rate of heating and rate of cooling [2,3]. The study of electrical resistivity provides behaviour of free and localized electric charge in the sample. In Ni-Zn ferrite, at high temperature Zn2+ volatilization marks the formation of Fe2+ ions, thereby increasing electron hopping and reducing resistivity [4,5].

Ferrites are used as core material in power transformers and in high frequency devices. An important property of these materials is their high electrical resistance, greatly reduces eddy current losses at high frequencies [6]. The influence of additives [7], grain size and grain size distribution [8], sintering time[9], temperature[10] and Ni,Zn:Fe ratio[11] on the electrical properties of ferrites have been mainly studied. However, there are no reported studies on the specific effect of frequency, and variation of electrical parameters with the frequency. Impedance spectroscopy IS, is an invaluable, non-destructive tool for analyzing the electrical properties of functional ceramics [12]. Using IS, it is possible to separate the bulk and grain boundary contributions to total conductivity [13]. A few studies on the characterization of ferrites using this technique have been reported [6,14,15,16] .

We use impedance spectroscopy IS we study the variation of Various Electrical Parameters such as Impedance (Z), Admittance (Y), Dielectric Permittivity (ε'), Dielectric Loss (ε"), Electrical Conductivity (σ), and Loss Tangent (Tan δ) of Nickel Zinc Iron Oxide ($NiZnFe_4O_4$) Nanopowder at Room Temperature.

2. Experimental Analysis

2.1 SEM characterization was performed in a (SEM, JEOL JEC3000FC) in which coating time is 60 sec operating from 1kv to 5kv and using 70% inert gas.

2.2 In the Raman spectroscopy the experiment time is 30sec, laser power is used 0.5% and the range is selected from 100-50000 Counts using RENISHAW In Via Raman Microscope model of Raman spectroscopy.

2.3 The dielectric measurements for the samples have been carried out with the dielectric cells in the form of parallel-plate capacitor. For unaligned, the dielectric cell has been prepared using indium tin oxide-coated glass plates, having surface resistance less than 1.0-1.5 ΩSq^{-1} The material has been filled in the cell at room temperature with the novo impedance analyser.

2.4 The measurement of conductivity is based upon the formula given as following

$R = (\rho d) / A$

R is proportional to the separation (d) between the electrodes, resistivity (ρ) of the material and inversely proportional to the cross-sectional area of the sample (A) Conductance (G) = $1 / R = A\sigma / d$ (conductivity $\sigma = 1/\rho$). Using $C_A = A\,\varepsilon_0 / d$. Here, $\sigma = G\,\varepsilon_0 / C_A = \varepsilon_0 / RC_A$

The tan delta or dissipation factor of the investigated compound has been determined in the following way Dissipation factor or Tan $\delta = 1/2\pi fCR$.

The Various Electrical Parameters viz. Impedance (Z), Admittance (Y), Dielectric Permittivity (ε'), Dielectric Loss (ε"), Electrical Conductivity (σ), and Loss Tangent (Tan δ) of Nickel Zinc Iron Oxide ($NiZnFe_4O_4$) Nanopowder at Room Temperature 32.1 ºC

3. Result and Discussion

3.1 SEM Results

Scanning electron microscopy (SEM) micrograph of agglomerated nanocrystalline Nickel Zinc Iron Oxide ($NiZnFe_4O_4$) Nanopowder produced. Scanning electron microscopy (SEM) images of Nickel Zinc Iron Oxide ($NiZnFe_4O_4$) Nanopowder (figure 1 & 2) indicating the homogeneous size, agglomeration of particles, with diameters about 20-30 nm. The morphology of the Nickel Zinc Iron Oxide ($NiZnFe_4O_4$) Nanopowder was characterized by SEM images as shown in Figure 1-2. From images results, we can observe a large quantity of uniform nanoparticles (NPs) with average diameter of 20-30 nm.

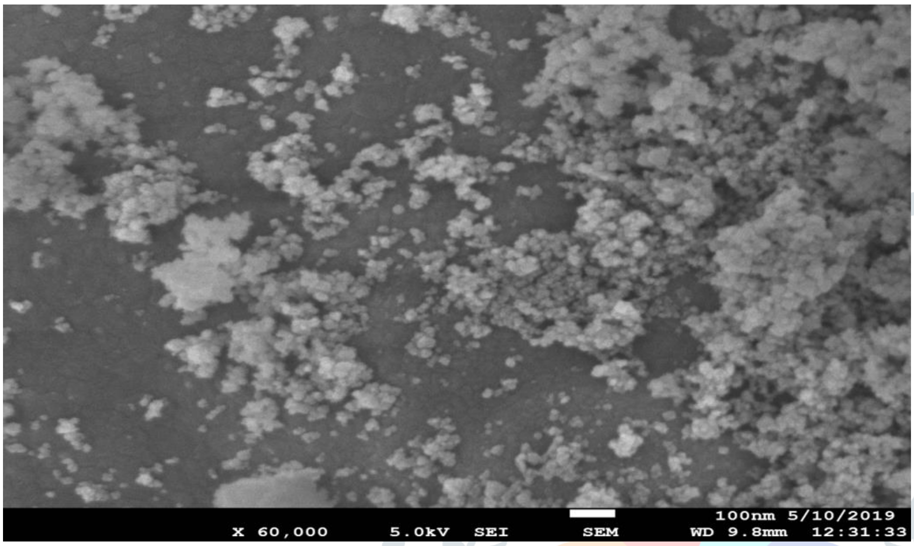

Figure1. SEM image of the Nickel Zinc Iron Oxide ($NiZnFe_4O_4$) Nanopowder.

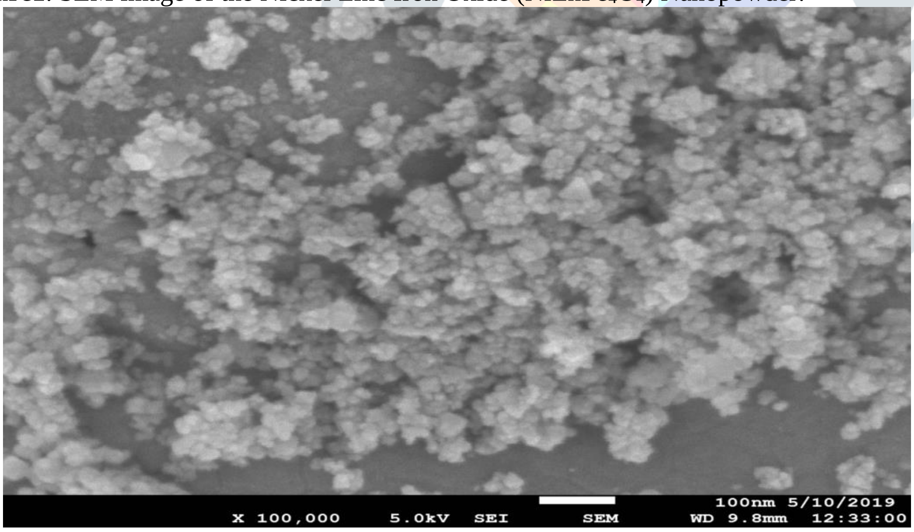

Figure2. SEM image of the Nickel Zinc Iron Oxide ($NiZnFe_4O_4$) Nanopowder.

3.2 Raman Results

Raman spectra of Nickel Zinc Iron Oxide ($NiZnFe_4O_4$) Nanopowder using a green laser with wavelength λ =785 nm. The experiment time is 30sec, laser power is used 0.1% and the range is selected from -300-2000. $NiZnFe_4O_4$ exhibit characteristic peak occurs at 330 cm^{-1}, 483 cm^{-1}, 691 cm^{-1} and 1328 cm^{-1}. The intensity relative to these peaks is ~1550, 1620, 1500 and 200.There is no significant change in the peak position and intensity if the Raman spectra of $NiZnFe_4O_4$.

The Raman shifts are consistent with those of Nickel Zinc Iron Oxide Nanopowder which confines to Nickel Zinc Iron Oxide Nanopowder.

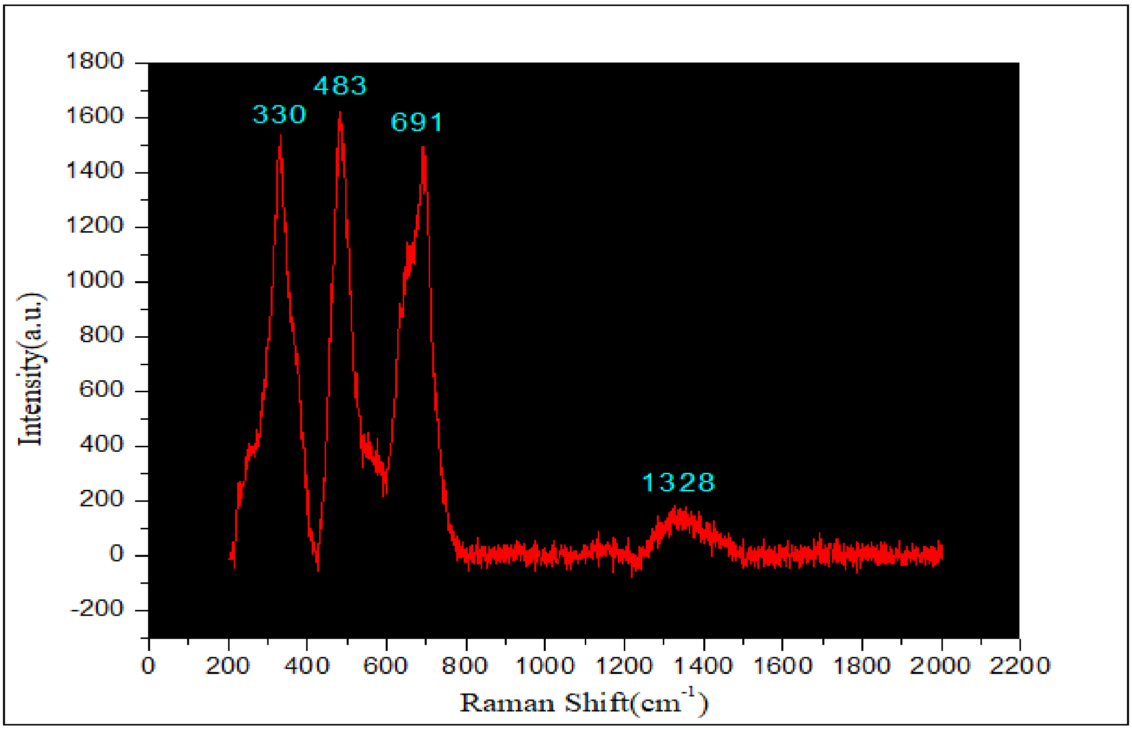

Figure 3: Variation of raman shift (cm^{-1}) vs. intensity of the Nickel Zinc Iron Oxide ($NiZnFe_4O_4$) Nanopowder at Room Temperature.

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3.3 Electrical Study

TABLE 1: Various Electrical Parameters viz. Impedance (Z), Admittance (Y), Dielectric Permittivity (ε'), Dielectric Loss (ε''), Electrical Conductivity (σ), and Loss Tangent (Tan δ) of Nickel Zinc Iron Oxide ($NiZnFe_4O_4$) Nanopowder at Room Temperature.

Frequency (Hz)	Z (Ω)	Y $(\Omega)^{-1}$	ε'	ε''	σ ($S\text{-}m^{-1}$)	Tan δ
1 kHz	2.3×10^{6}	4.35×10^{-7}	10.00	10.76	6.1×10^{-7}	1.08
10 kHz	9.87×10^{5}	1.01×10^{-6}	4.54	2.53	1.42×10^{-6}	0.55
100 kHz	3.28×10^{5}	3.05×10^{-6}	3.05	0.76	4.28×10^{-6}	0.25
1 MHz	7.29×10^{4}	1.37×10^{-5}	2.43	0.33	1.92×10^{-5}	0.13
10 MHz	2.34×10^{4}	4.27×10^{-5}	2.17	0.10	5.99×10^{-5}	0.049

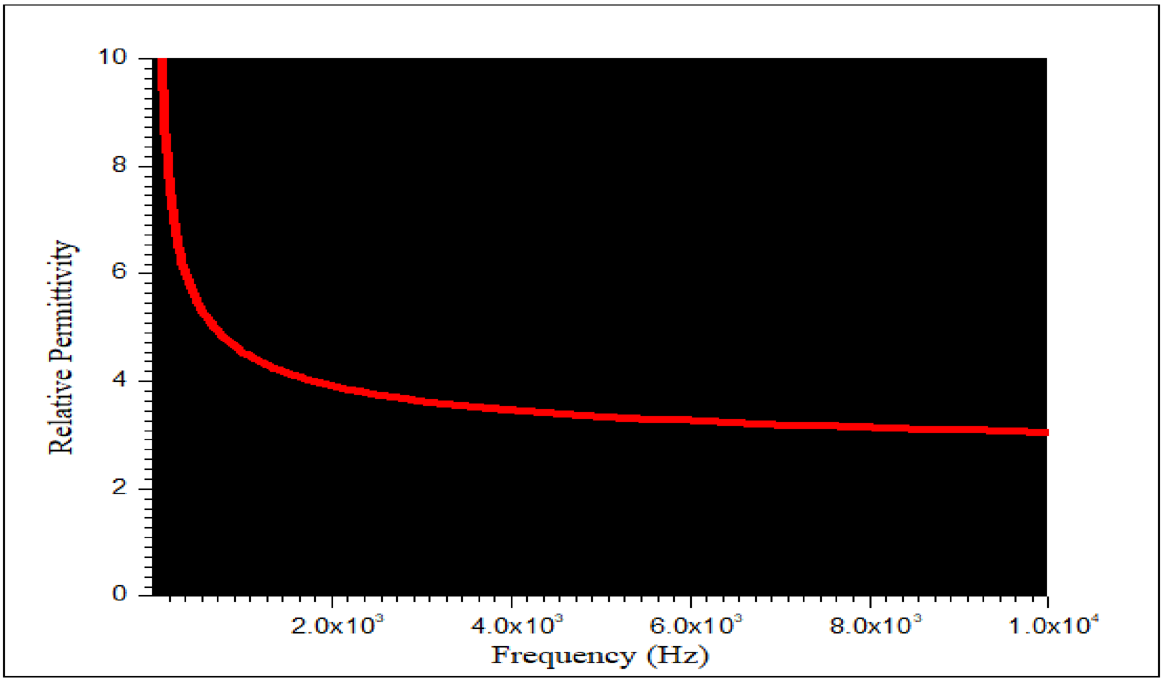

Figure 4: Variation of frequency (Hz) vs. relative permittivity (ε') of the Nickel Zinc Iron Oxide ($NiZnFe_4O_4$) Nanopowder at Room Temperature 32.1 ºC.

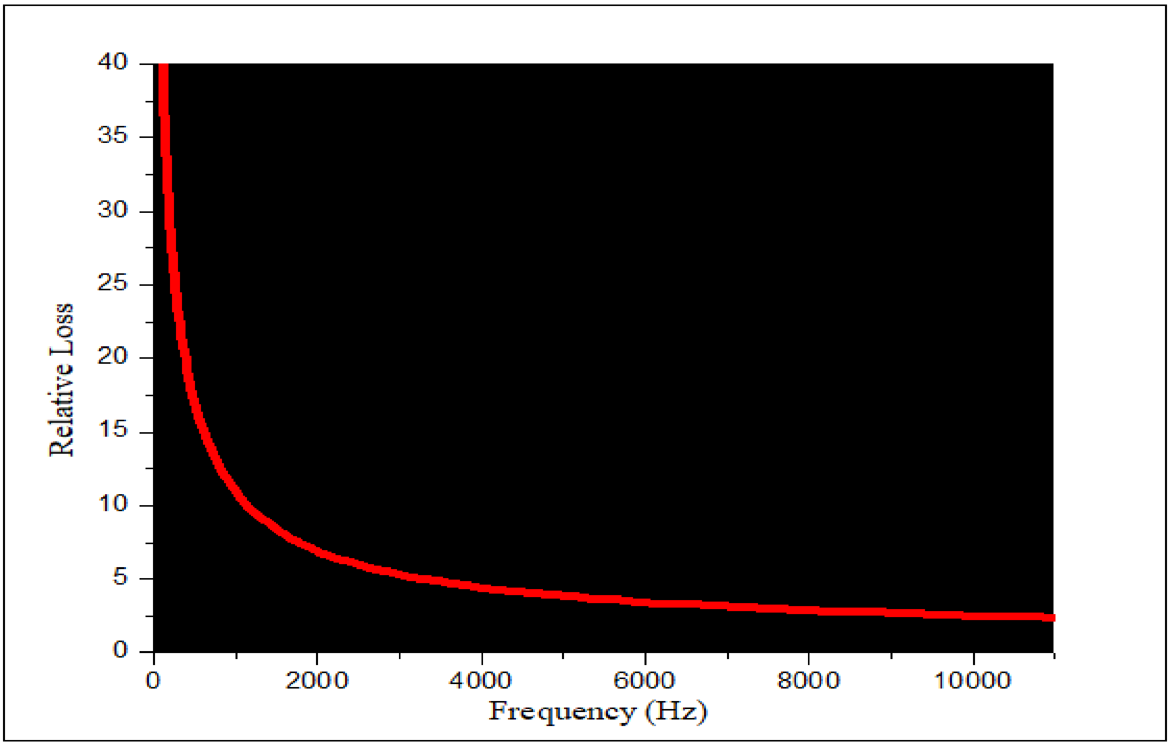

Figure 5: Variation of frequency (Hz) vs. relative loss (ε'') of the Nickel Zinc Iron Oxide ($NiZnFe_4O_4$) Nanopowder at Room Temperature 32.1 ºC.

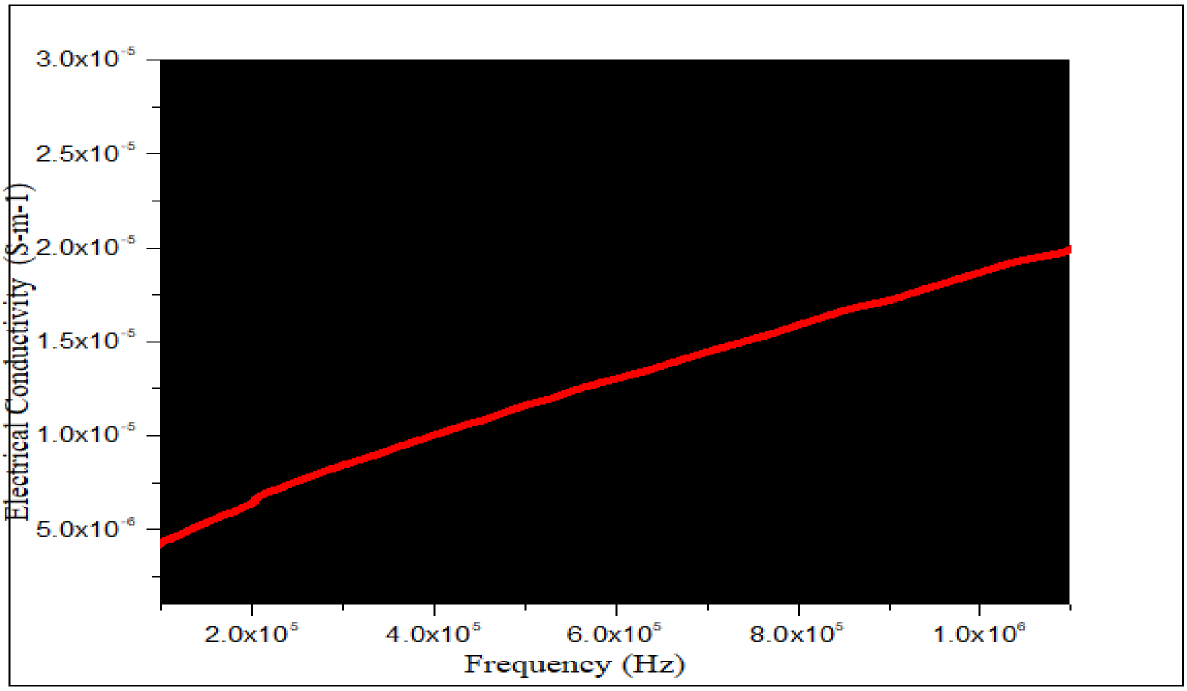

Figure 6: Variation of frequency (Hz) vs. electrical conductivity (σ) of the Nickel Zinc Iron Oxide ($NiZnFe_4O_4$) Nanopowder at Room Temperature 32.1 ºC.

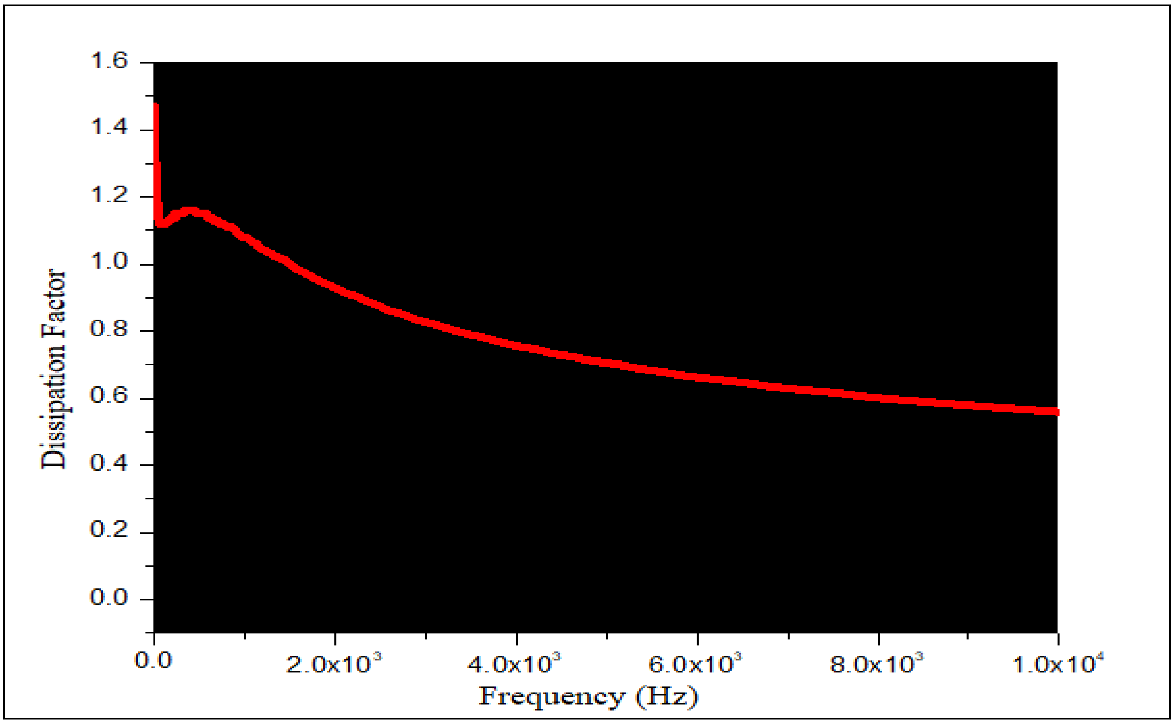

Figure 7: Variation of frequency (Hz) vs. dissipation factor (Tan δ) of the Nickel Zinc Iron Oxide ($NiZnFe_4O_4$) Nanopowder at Room Temperature 32.1 ºC.

The figure 4 representing that the values of relative permittivity (ε') of Nickel Zinc Iron Oxide ($NiZnFe_4O_4$) Nanopowder at Room Temperature has the values 10.00, 4.54, 3.05, 2.43 and 2.17 at frequencies 1 KHz, 10 KHz, 100KHz, 1 MHz and 10 MHz respectively. The values of relative permittivity (ε') decreases with the high values of frequencies.

The figure 5 representing that the values of relative loss (ε'') of Nickel Zinc Iron Oxide ($NiZnFe_4O_4$) Nanopowder at Room Temperature has the values 10.76, 2.53, 0.76, 0.33 and 0.10 at frequencies 1 KHz, 10 KHz, 100KHz, 1 MHz and 10 MHz respectively. The values of relative loss ((ε'') decreases with the high values of frequencies.

The figure 6 representing that that the values of electrical conductivity (σ) of the Nickel Zinc Iron Oxide ($NiZnFe_4O_4$) Nanopowder 6.1×10^{-7}, 1.42×10^{-6}, 4.28×10^{-6}, 1.92×10^{-5} and 5.99×10^{-5} ($S\text{-}m^{-1}$) at frequencies 1 KHz, 10 KHz, 100KHz, 1 MHz and 10 MHz respectively. Thus as frequency increases electrical conductivity (σ) also increases.

The figure 7 representing that the values of dissipation factor (Tan δ) of Nickel Zinc Iron Oxide ($NiZnFe_4O_4$) Nanopowder at Room Temperature has the values 1.08, 0.55, 0.25, 0.13 and 0.049 at frequencies 1 KHz, 10 KHz, 100KHz, 1 MHz and 10 MHz respectively. The values of dissipation factor (Tan δ) decreases with the high values of frequencies.

Conclusion-

This study concern that at room temperature the structural and electrical study of Nickel Zinc Iron Oxide ($NiZnFe_4O_4$) Nanopowder has done. It is found that the Nickel Zinc Iron Oxide ($NiZnFe_4O_4$) Nanopowder with in Nano size, shape distribution agglomeration of particles, with diameters 20-30 nm (Nanoscale) has been characterized by SEM and RAMAN SPECTROSCOPY. In addition, it is also observed that the relative permittivity (ε'), relative loss (ε") and dissipation factor (Tan δ) decreases with increase in frequency. Here small rise in the conductivity (with frequency dependent) has been observed due to the decrease in the particle size of the material (Nano scale). The Raman shift variation with the intensity which shows of studied compound has been analysed by Raman Spectroscopy in which characteristic peak occurs at 330 cm^{-1}, 483 cm^{-1}, 691 cm^{-1} and 1328 cm^{-1} using laser at λ=785 nm.

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Ethical Rules-

1. This article does not contain any text recycling (self plagrism).
2. In this article we did not use article spinning.
3. This article does not include any experiment on sample of biological origin.

Conflict Of Interest- we have no conflict of interest about the fund and also for any other issue.

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