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DIELECTRIC PROPERTIES OF NICKEL ZINC FERRITE-POLYPROPYLENE COMPOSITE

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ABSTRACT

Nickel-zinc ferrite ($Ni_{0.2}Zn_{0.8}Fe_2O_4$) was prepared using conventional solid-state method. It acts as a filler with polypropylene as the matrix. The samples were characterized by XRD and dielectric measurement was done using Agilent 4291B Impedance/Material Analyzer. It was observed that the composition of 30% doped nickel-zinc ferrite ($Ni_{0.2}Zn_{0.8}Fe_2O_4$) gives the highest value of the dielectric constant in the frequency range of 1 MHz to 1.5 GHz at room temperature.

INTRODUCTION

Polycrystalline ferrites which have many applications at microwave frequencies are very good dielectric material. Ferrites have high electrical resistivity [1], low dielectric loss and chemical inertness. The dielectric properties of ferrites are dependent on several factors including the method of preparation, sintering temperature, sintering time and chemical composition.

Polypropylene has very attractive solid-state properties such as high modulus and tensile strength, rigidity, excellent heat resistance [4]. The development of composites combining mineral and polymer material characteristics is definitely one of the most interesting perspectives for isotactic polypropylene [5].

With the vision to understanding the dielectric phenomena in polycrystalline ferrites-polypropylene composite, a study of dielectric properties at different compositions of polycrystalline ferrite-polypropylene composite was undertaken.

EXPERIMENTAL DETAILS

The filler of the composites nickel-zinc ferrite were prepared using conventional solid-state reaction method. The starting materials, NiO (99.7% purity), ZnO (99.9% purity) and Fe_2O_3 (99.7% purity) were weighed. The materials were weighed according to the stoichiometric equation below:

$$0.2(\mathrm{NiO}) + 0.8(\mathrm{ZnO}) + \mathrm{Fe_2O_3} \longrightarrow \mathrm{Ni_{0.2}Zn_{0.8}Fe_2O_4}$$

These powders were dry milled and precalcined in air at 1100°C for 10 hours. The powders were grinded and sieved to ensure homogeneous particle sizes of the powders. The powders were finally calcined in air at 1250°C for 10 hours and the grinding and sieving process repeated to ensure homogeneous particle sizes of the powders when mixing with the polymer.

A pure polypropylene was weighed according to the percentage (5% - 30%) of the doped filler. The polypropylene was heated and melted to a molten state at 160°C and blended at different percentage of filler for 10 minutes. The composite was removed from the Brabender and hot pressed to 1 mm thickness.

All the samples were examined by XRD to determine the mircostructure of the samples. The dielectric properties of the samples were determined using the Agilent 4291B Impedance/Material Analyzer.

RESULTS AND DISCUSSION

Figure 1 showed the XRD patterns for nickel-zinc ferrite ($Ni_{0.2}Zn_{0.8}Fe_2O_4$) – polypropylene at different compositions. The composite matched with 00-050-2397 and 00-008-0234 of the ICDD database that showed polypropylene and nickel zinc iron oxide respectively. $Ni_{0.2}Zn_{0.8}Fe_2O_4$ (filler) is in crystalline structure while polypropylene is not totally a crystalline structure [3]. Thus, there are lots of small peaks obtained throughout the angle.

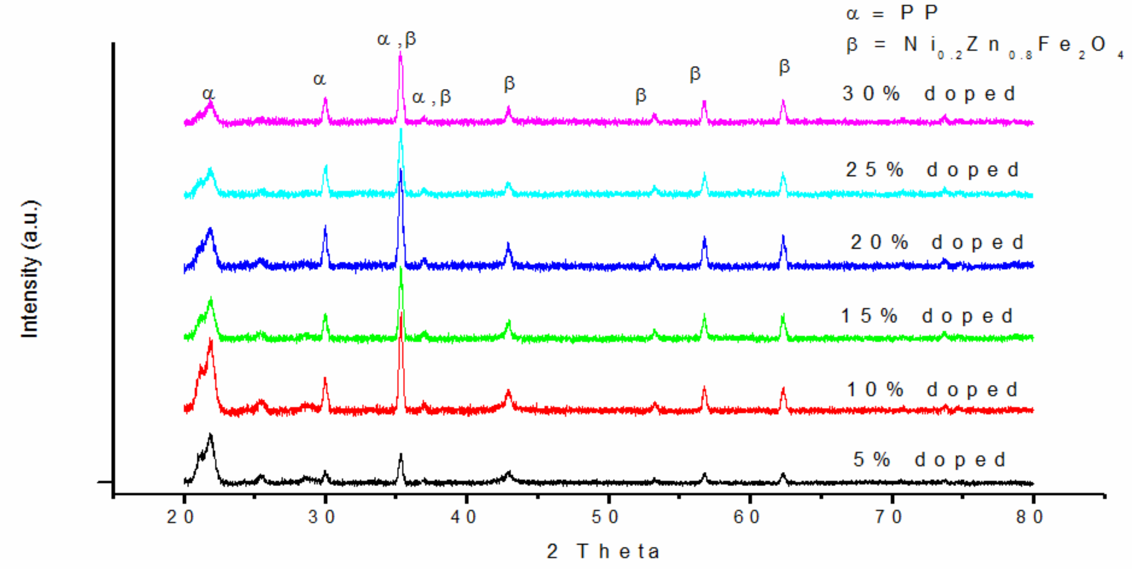

Figure 1: XRD patterns for $Ni_{0.2}Zn_{0.8}Fe_2O_4$ – Polypropylene composite at different compositions.

Figure 2 showed the dielectric constant of $Ni_{0.2}Zn_{0.8}Fe_2O_4$-Polypropylene composites from 1 MHz to 1.5 GHz. The microwave measurement of the composition of 30% doped nickel-zinc ferrite ($Ni_{0.2}Zn_{0.8}Fe_2O_4$) gives the highest value of the dielectric constant which is 2.72. This may be due to the Fe^{2+} and Fe^{3+} of the n-type and the hole exchange between Ni^{3+} and Ni^{2+} of the p-type ferrites resulting in local displacements of electrons or hole in the direction of electric field which may cause polarization[1].

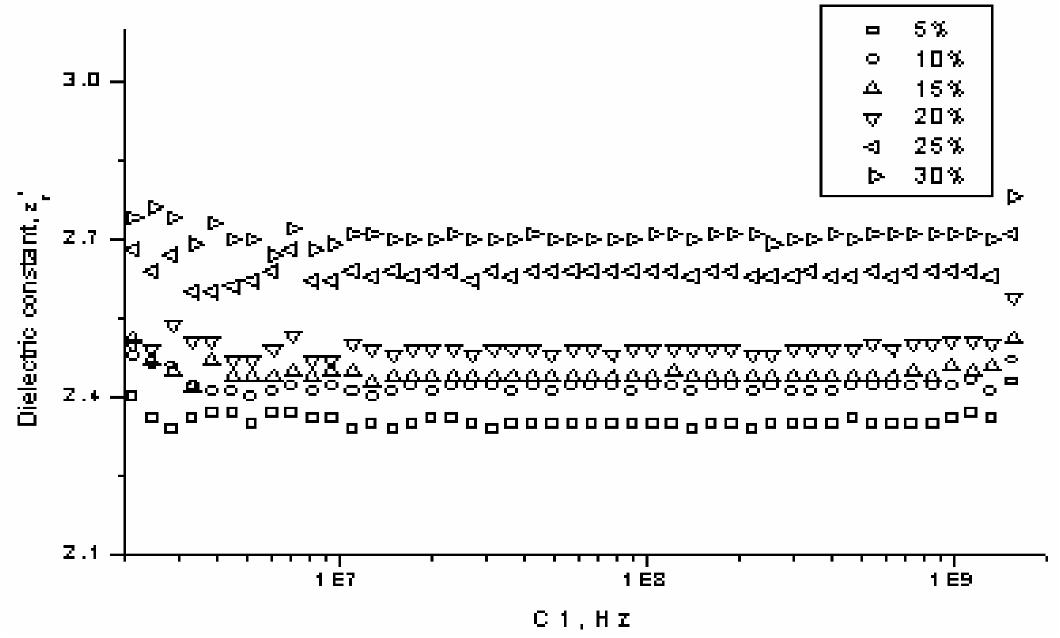

Figure 2: Dielectric constant versus frequency for $Ni_{0.2}Zn_{0.8}Fe_2O_4$–Polypropylene composite with different percentages of doped filler.

Figure 3 showed the dielectric loss of $Ni_{0.2}Zn_{0.8}Fe_2O_4$-Polypropylene composites at different composition in the frequency range 1 MHz to 1.5 GHz. The dielectric loss showed the dielectric loss decreases with increasing frequency. When the frequency approaches 1.5 GHz, the dielectric loss increases due to the higher frequency which may cause the electron to experience an unstable polarizing field and slowly move to its original position to be polarized.

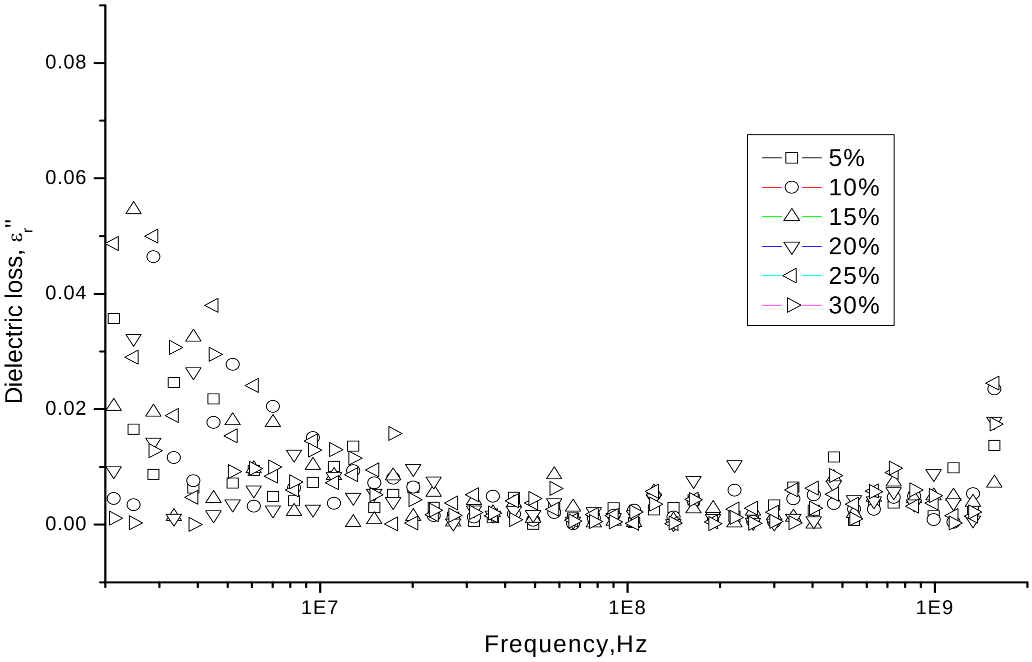

Figure 3: Dielectric loss versus frequency for $Ni_{0.2}Zn_{0.8}Fe_2O_4$–Polypropylene composite with different percentage of doped filler.

CONCLUSION

According to the results obtained, $Ni_{0.2}Zn_{0.8}Fe_2O_4$–Polypropylene composite with composition of 30% of doped filler showed the highest dielectric constant. This is probably due to the increase in the amount of the doped filler in the matrix that could increase the dielectric polarization of the composite.

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REFERENCES

[1]. G. R. Mohan, D.R., Reddy, B.S.B. (1999), *Materials Letters* **40** 39-45.
[2]. B. Weidenfeller, M.H. and F. Schilling (2002), *Composites*: Part A **33** 1041 – 1053.
[3]. V. Busico, R. Cipullo (2001), *Prog. Polym. Sci*. **26** 443-533.
[4]. Chunxia H., S. Costeux, P.W. Adams, J.M. Dealy (2003), *Polymer* **44**, 7181 – 7188.
[5]. Kotek, I. Kelnar, M. Studenovsky, J. Baldrian (2005), *Polymer* **46** 4876-4881.