11th International Conference
on Advanced Materials

ICAM 2009

Rio de Janeiro Brazil
September 20 - 25

Dielectric Loss Analysis of Nanoparticles of Zinc-Nickel Ferrite in a Polar Nanofluid

L. O. Salamazo(1); F. B. Bellucci(1); A. E. Job; M. A. L. Nobre(1)*

(1) FCT/UNESP, Universidade Estadual Paulista, e-mail: nobremal@fct.unesp.br
* corresponding author.

Abstract – A nanofluid was prepared by the dispersion of $Ni_{0,5}Zn_{0,5}Fe_2O_4$ nanoparticles in the 2-butoxyethanol. Dielectric losses of nanoparticles in the nanofluid were investigated. Measurements were carried out by impedance spectroscopy. Strong dielectric losses occur at frequencies at around 10 Hz, which maintain high level at 50 and 60 Hz.

Investigation of electrical and dielectrical properties of nanofluids (NF) from impedance spectroscopy allows the derivation of a wide set of fundamental electrical parameters, which are relevant to the development of technological applications such as: cooling liquids, drug delivery, chemical processing, functional inks, magnetic shielding, magnetic fluid seals, bioseparation and new one. Nanofluid was prepared using as fluid the 2-butoxyethanol (BTXOL-Fluka-PA) and 2 wt. % of nanoparticles. The $Ni_{0,5}Zn_{0,5}Fe_2O_4$ (NZF) paramagnetic nickel zinc ferrite oxide were synthesized by the modified polyol method (MPM) [1] from starting reagents: oxide nickel Ni_2O_3, iron oxide Fe_2O_3 and zinc oxide ZnO. Nanocrystalline oxide was prepared by the calcination of precursor at 700℃. From X-ray diffraction, the average crystallite size of NZF oxide was derived as being equal to 19.0 nm. The electrical and dielectrical characterization of the nanofluid was carried out by the impedance spectroscopy, a sample holder type coaxial capacitor was used. Measurements were performed in the frequency range from 5 Hz to 3 MHz, with an applied potential of 500 mV, at room temperature. The nanofluid impedance $Z^*_{NF}(\omega)$ should be considered as an apparent response composed by the sum of contributions of the fluid (F) and nanoparticles (NP) [2]. From adjusting of $Z'_{NF}(\omega)$ x ω and $Z''_{NF}(\omega)$ x ω curves, electric contribution of nanoparticles was derived from nanoparticle resistance R_{NP} and nanoparticle capacitance C_{NP} deriving, see equations below. Taking in account R_{NP} and C_{NP} values, functions $Z'_{NP}(\omega)$ and $Z''_{NP}(\omega)$ were derived. In the sequence, both functions $Z'_{NP}(\omega)$ and $Z''_{NP}(\omega)$ were converted to functions $\varepsilon'_{NP}(\omega)$ and $\varepsilon''_{NP}(\omega)$, respectively, see equations below. Then, dielectric loss $\tan\delta$ parameter was derived via the classical ratio $\varepsilon''_{NP}(\omega)/\varepsilon'_{NP}(\omega)$. Table 1 list the imaginary component of the dielectric permittivity (ε") of nanoparticles and dielectric loss parameter of one, both as a function of the frequency. The addition of nanoparticles to the fluid doesn't change the electrical nature of the fluid response, which is of Debye's type. Significant level of losses is attained at conventional frequencies of 10, 50 and 60 Hz.

$$Z_{NF}*(\omega)=\begin{cases} Z'_{NF}(\omega)=\dfrac{R_{NP}}{1+(\omega R_{NP}C_{NP})^2}+\dfrac{R_F}{1+(\omega R_F C_F)^2} \\ \\ Z_{NF}''(\omega)=\dfrac{R_{NP}(\omega R_{NP}C_{NP})}{1+(\omega R_{NP}C_{NP})^2}+\dfrac{R_F(\omega R_F C_F)}{1+(\omega R_F C_F)^2} \end{cases}$$

$$\varepsilon^*_{NP}(\omega)=\frac{1}{j\omega\Lambda Z^*_{NP}(\omega)}=\begin{cases} \varepsilon'_{NP}(\omega)=\dfrac{1}{\Lambda\omega\varepsilon_0}\left(\dfrac{Z''_{NP}(\omega)}{\left|Z_{NP}^*\right|}\right) \\ \\ \varepsilon''_{NP}(\omega)=\dfrac{1}{\Lambda\omega\varepsilon_0}\left(\dfrac{Z'_{NP}(\omega)}{\left|Z_{NP}^*\right|}\right) \end{cases}$$

Table 1: List of imaginary component of the dielectric permittivity (ε") and dielectric loss parameters for NZF nanoparticles.

f (Hz)	Nanoparticles	
	ε"	tanδ
10	$4,9\times10^5$	$3,1\times10^3$
5 x 10	$9,5\times10^4$	$6,1\times10^2$
6 x 10	$7,9\times10^4$	$5,1\times10^2$
10^2	$5,5\times10^4$	$3,5\times10^2$
10^3	$5,2\times10^3$	$3,3\times10^1$
10^4	$4,8\times10^2$	3,1
10^5	$5,4\times10^1$	$3,5\times10^{-1}$

[1] F. Fievet, J. P. Lagier and M. Figlarz. J. Mater. Educ. 13 (1999) 79-94.
[2] Master Science Dissertation, Felipe da Silva Bellucci, POSMAT, DFQB-UNESP, 2009, SP, Brazil