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Modulation of Electrical Parameters of Multifunctional Nanofluids Based on the Control of the Fraction and of the Type of Nanoparticles

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

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

Abstract –This work reports recent advances on measurement of electrical parameters of multifunctional nanofluids having a polar liquid as continuous phase. Functional nanoparticles of $KSr_2Nb_5O_{15}$ ferroelectric oxide and $Ni_{0,5}Zn_{0,5}Fe_2O_4$ paramagnetic oxide were dispersed in the fluid being both added at equal weight percentage. Both single-nanocrystalline oxides were synthesized by chemical route via modified polyol method. The electric and dielectric parameters of nanofluids were derived from theoretical adjust of data obtained by the technique of impedance spectroscopy.

Investigation of electrical and dielectrical properties of nanofluids (NF) allows the derivation of a wide set of fundamental electrical parameters, which are relevant to the development of technological applications such as: cooling liquids, pharmaceutical applications, chemical processing, functional inks, magnetic shielding, magnetic fluid seals, bioseparation and new applications. The $KSr_2Nb_5O_{15}$ (KSN) ferroelectric niobate oxide and 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: strontium nitrate $Sr(NO_3)_2$, potassium nitrate KNO_3, salt complex niobium $NH_4H_2[NbO(C_2O_4)_3].3H_2O$, oxide nickel Ni_2O_3, iron oxide Fe_2O_3 and zinc oxide ZnO. Nanocrystallines oxides were prepared by the calcination of precursor at 450°C and 700°C, for KSN and NZF, respectively. From X-ray diffraction, the average crystallites size of KSN and NZF oxide were derived as being equal to 54.0 nm and 19.0 nm, respectively. All nanofluids were prepared using as fluid the 2-butoxyethanol (BTXOL-Fluka-PA). Nanofluid of KSN (NF-KSN) was prepared using 2 wt. % of nanoparticles. Nanofluid of NZF (NF-NZF) was prepared using 2 wt. % of nanoparticles. Nanofluid of KSN/NZF (NF-KSN/NZF) was prepared using 1 wt. % of each KSN and NZF nanoparticles. The electrical and dielectrical nanofluids characterization 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, applied potential of 500 mV, at room temperature. The nanofluid impedance should be considered as an apparent response, since the observed response is given by the sum of contributions of the fluid and nanoparticles. Table 1 lists electrical parameters resistance (R), capacitance (C), dielectric permittivity (ε) and the relaxation frequency (f_0) and dielectric loss (tanδ) of nanofluids. According to Figure 1, impedance diagrams of nanofluids can be adjusted by an equivalent electrical circuit type RC circuit in parallel. Electrical parameters are listed in Table 1. The nanoparticles addition to the fluid doesn't change the nature of the fluid response, which is of Debye's type. Relaxation frequency and resistance of nanofluids can be modulated by adjust of fraction and relative fraction of nanoparticles.

Electrical parameter	Fluid	NF – KSN	NF - NZF	NF -KSN/NZF
R	52,0 kΩ	37.7 kΩ	59.3 kΩ	38.9 kΩ
C	87,4 pF	104 pF	105 pF	99.3 pF
ε	9.88	11.7	11.8	11.2
f_0	35,0 kHz	40.7 kHz	25.8 kHz	41.2 kHz

Table 1: List of electrical parameters resistance (R), capacitance (C), dielectric permittivity (ε) and relaxations frequency (f_0) and dielectric loss parameters for nanofluids.

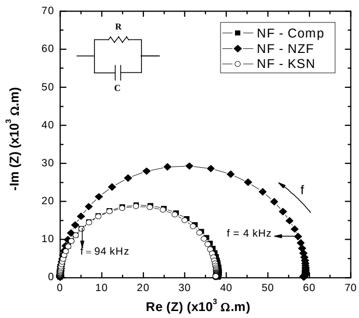

Figure 1: Impedance diagram with experimental dates (points) and theorical fit (continuos line) c of NF – Comp, NF – NZF e NF – KSN.

[1] F. Fievet, J. P. Lagier and M. Figlarz. J. Mater. Educ. 13 (1999) 79-94.
[2] Master Science Dissertation. F. S. Belluci, (2009) 152p.