Orissa Journal of Physics
ISSN 0974-8202

Vol. 25, No.1
February 2018
pp. 43-47

Temperature effect on Electrical Properties of PU/Ni(0) Nanocomposites

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Received: 26.11.2017 ; *Revised : 6.12.2017* ; *Accepted :3.1.2018*

Abstract . Polyethylene glycol and Isophorene diisocyanate are used to prepared pure polyurethane (PU) polymer. The 25 wt percent of Ni nanoparticles doped into pure polyurethane to synthesize PU/Ni (25%) nano-composites. The formation of pure polyurethane and nickel-polyurethane nano-composites were confirmed by XRD analysis. The variation of temperature on some electrical properties (i.e. tangent loss, electrical modulus, ac conductivity, Nyquist plots etc.) of the nanocomposites has produced some interesting results useful for device applications. The electrical properties of pure polyeuthane have drastically changed due to addition of nickel nanoparticles (as filler) in the polymer. The decreasing tendency of ac conductivity and low tangent loss make nickel-polyurethane nano-composites as smart dielectric materials and very useful for energy storage, biomaterials and shape memory.

Keywords: Polyurethane, Electrical properties, ac conductivity, nanocomposites.

1. Introduction

Polyurethanes (PUs) are unique polymer because of a wide range of physical and chemical properties. With well coupled monomer materials, PUs can solve the demands of various applications in different field of science and technology. PUs have found an extensive use in numerous commercial applications such as coatings, foams, adhesives, sealants, synthetic leathers, membranes, thermoplastic elastomers, as well as in many biomedical applications [1-3]. However, PUs also have some disadvantages, such as low thermal stability and low mechanical strength, etc [4]. To avoid the low faults, material scientists have taken keen interest to manufacture nano-composites because of its enhanced

mechanical properties and industrial applications [5-6]. The research on organic-inorganic nanocomposites has been the centre of attraction for material researchers in last few decades. The characteristic of the nano-polymers is completely different from the bulk during the study of electrical, mechanical, optical properties.

There are various methods of fabrication of nanocomposites materials, but the synthesis in chemical route offers some advantages over other methods in terms of homogeneity, cheap, time consumption, overall energy saving. The main objective of this paper is to measure the tangent loss factor, ac conductivity, impedance measurements of PU/Ni (25%) nano-composites synthesized by chemical route. The encouraging results output have obtained, which can provide fundamental data for developing the usage of nickel through different electrical applications.

2. Experimental

The polyurethane polymer is synthesized from the polyethylene glycol (MW-300) and Isophorene diisocyanate. Polyurethane polymer nano-composites were prepared with 25 weight percent of Ni nanoparticles. In the first step, 25 wt % of high pure nickel nanoparticles (99.999N) doped in polyurethane as follows, 3g of polyurethane was weighed and dissolved in a solvent methyl ethyl ketone (MEK) to make a solution and 0.15g of highly pure nano-size nickel powder was added. Then a light yellow colour solution was formed and heated under vigorous stirring through a mechanical stirrer at 500 rpm in 70°C temperature for 30 minutes for well homogeneous mixture. The solution was slowly evaporated until a gel was formed. Then the product was poured into teflon petridis and then dried at room temperature for 24 hour. Before making pellets, again petridis was kept in the oven at 80°C for 3 hours for avoiding air bubble. The require dimension of the sample pellets were prepared and put in a sample holder.

3. Result and discussion

XRD pattern of PU/Ni nanocomposites recorded using CuK_{α} radiation is shown in Figure 1. The nanocomposite synthesized sample exhibits trigonal structure using the PowderX [7] and the average crystallite size is 40 nm calculated using Scherer equation [8].

Figure.2 represents the variation of tangent loss as function of frequency with different temperature of PU/Ni (25%) nanocomposites. With rise of temperature, the tangent loss decreases behave like a better dielectric material. AC conductivity as function of frequency is plotted in figure.3 with variation of

temperatures and the result shows that conductivity decrease with rise in temperature. The plot of $Z^{'}$ versus frequency with different temperature is shown in figure.4 where as figure 5 represents the plot $Z^{''}$ versus frequency with rise of temperature. With increase of temperature, both real and imaginary part of the impedance increase indicates that conductivity decrease. The plot between $Z^{'}$ and $Z^{''}$ with different temperature (Nyquist plots) indicate that with rise of temperature, the curve is becoming less semicircular i.e the impedance increases, so conductivity decreases which support the earlier result of tangent loss, ac conductivity and impedance measurements. So, with higher temperature around 125 ^{0}C, the PU/Ni nanocomposites may be the suitable dielectric materials for making different electrical devices particularly energy storage [4].

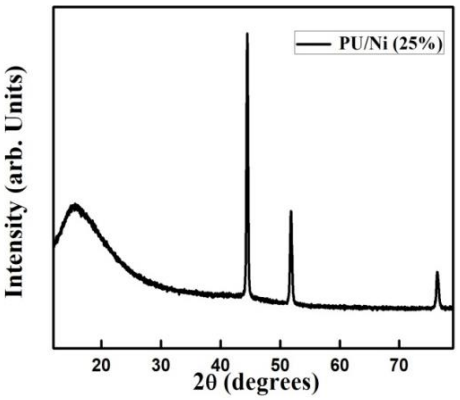

Figure 1. XRD pattern of PU/Ni (25%) nanocomposites

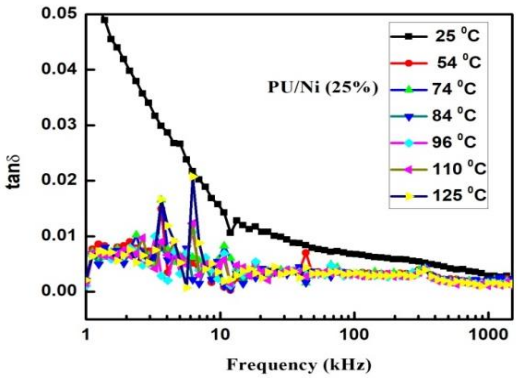

Figure 2. Tangent loss versus frequency with different temperature of PU/Ni (25%) nanocomposites

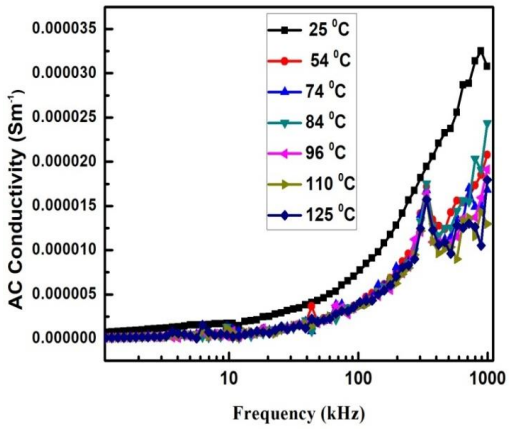

Figure 3. AC conductivity versus frequency with different temperature of PU/Ni (25%) nanocomposites

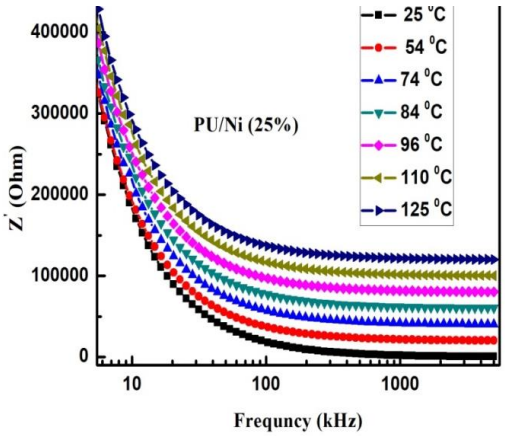

Figure 4 Real impedance versus frequency with different temperature of PU/Ni (25%) nanocomposites

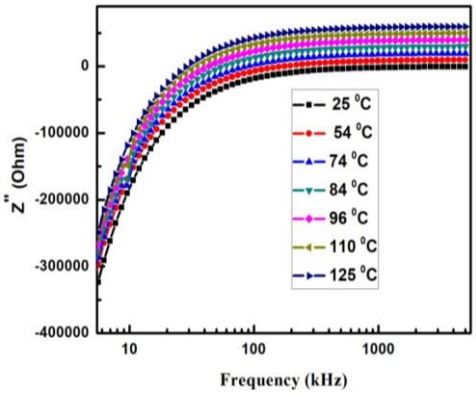

Figure 5. Imaginary impedance versus frequency with different temperature of PU/Ni (25%) nanocomposites

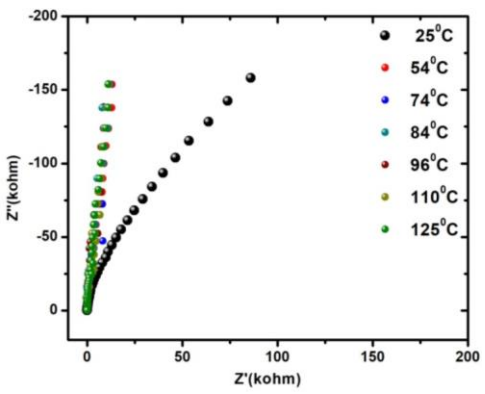

Figure 6. Real versus Imaginary impedance with different temperature of PU/Ni (25%) nanocomposites

4. Conclusion

PU/Ni (25%) polymer nanocomposites were synthesized by adding 25 weight percent of high pure Ni nanoparticles in pure PU matrix. The XRD analysis shows that PU/Ni nanocomposites have prepared with trigonal structure. Studies of the effect of temperature on tangent loss, electrical modulus, ac conductivity and Nyquist plots in PU/Ni nanocomposites have been discussed. Due to addition of nickel in the polymer forming nanoparticles has dramatic change in electrical properties. It was observed that with rise in temperature, PU/Ni nanocomposites show low ac conductivity, less tangent loss, high impedance and less semicircular nature of Nyquist plot which are the characters of a good dielectric material. So, PU/Ni nanocomposites may be use for fabricating energy storage devices.

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