Study of some electrical properties for polymer SMR20

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Abstract. In this study, some electrical properties (electrical conductivity, specific resistance, molar conductivity and degree of dissociation) were measured for natural polymer SMR20 with (molecular weight 350168 gm/mol) and impurities 5% ZnO nanoparticle, the polymer that have been used in Babylon tyres Factory. The aim of this study was to test the efficiency of the polymer in electrical industry under Iraqi environment conditions specially under the high temperature degrees so that the measures were under different temperature degrees (25, 35, 45, and 55) °C. Results revealed that most electrical properties increased with increasing of concentrations of polymer solved in toluene and temperature degrees except the specific resistance property which declined under high concentrations and temperature. The nanoparticle which was used in this study significantly enhanced the electrical properties. These results could be attributed to the binding between polymer molecules itself from one side and also the binding between polymers and solvent and with nanoparticle molecules from the other sides. Because of these limited changes, the polymer would be suitable and safe to be used in the electrical industry, while the remarkable enhancement of electrical properties enable the polymer for using in super generations industry.

1. Introduction
Polymer is along chain of repeated one chemical molecular which reflect the unique properties of polymers compared with other materials. Electrical Properties of Polymers are one of the polymer physical characters which illustrates the electric phenomena. It deals with the responsibility for determining the chemical and supramolecular structure of polymers and polymeric materials[1]. In recent years, due to unique Physical properties of nanomaterial, it has involved in many potential investigations [2]. The large energy differences between the electronic and condition bands in the polymers material have a wide range in isolated applications and in manufacture sectors [3]. Such as batteries, electrochemical devices like super capacitors, sensors and electro chromic devices [4] biosensors, medical implants[5]. Thus nanomaterial have revealed improvements in many fields, such as light, gas sensing [6], solar cells [7], medicine [8]. While, mixture between polymers and nanotechnology have further applications specially in medicine[9], nanogenerator, that base in electrical properties [10]. And another modern applications.

2. Experimental Methods
In this study three different type of materials were used: polyisoprene(1,4 cis) polymer, nanomaterial ZnO and the solvent. Polyisoprene polymer that equal SMR20 polymer in characterizes with molecular weight 350168 (gm/ml) [11]. The appropriate concentrations of (0.1 ,0.2 ,0.3 ,0.4 ,0.5 ,0.6 ,0.7 ,0.8 and 0.9 gm/ml) were dissolved in (100 ml) of toluene under stirring between 180 to 240 mins. Then a 5% ml of ZnO was added for each sample.
Table 1. polyisoprene characters [11].

| Characteristics          | Requirement   |
|--------------------------|---------------|
| Wallace plasticity (p₀) as product | 42 ± 3        |
| Plasticity retention index | 60 Maximum   |
| Dirt (45 microns)        | %0.20 Maximum |
| Nitrogen Content         | %0.50 Maximum |
| Ash                      | %1.00 Maximum |
| Acetone extract          | %2.0-4.0      |
| Density                  | 0.92(g/cm³)   |
| Refractive index(20°)    | 1.52          |

2.1 Measurements
The electrical conductivity of the samples was measured at (25, 35, 45, and 55) °C before adding nanomaterial and after adding it at 25°C only. Then the electrical properties that include electrical conductivity, molar conductivity and the degree of disintegration are calculated under the previous temperatures.

Conductivity meter was used from (L17, BISCHOF) company. The percentage error was (± 0.0004) at 20 Hz after calibrations.

2.2 Theoretical calculations
2.2.1 Electrical Conductivity
The ratio between inversely proportional to the measured resistance (ρₑl.) of the cell constant (K_cell) is called electrical conductivity and given by [12].

\[ \sigma = \frac{K_{cell}}{\rho_{el}} \] .........(1)

2.2.2 Specific resistance
The specific resistance is given by the following equation [13].

\[ g = \frac{1}{\sigma} \] ......... (2)

2.2.3 Molar Conductivity
The molar concentration of the same solution gives by [13].

\[ \Lambda = \frac{\sigma}{C_m} \] ............ (3)

2.2.4 Degree of Dissociation
The degree of dissociation is given by the following equation [14]:

\[ D.D_e = \frac{\Lambda}{\Lambda_e} \] ............ (4)

Where \( \Lambda_e \) is the extrapolation of molar conductivity to the infinity dilution. The relationship drawing between the square root of the molar concentration with conductivity and the point of intersection of the curve with the (y) axis represent it. According to Estewaled law The value of \( \Lambda \) is less than \( \Lambda_e \), where the (D.D) equal (one) for strong electrolyte and (zero) for weak electrolyte [15].

3. Results and Discussion:
3.1 Electrical Conductivity
The measured conductivity of solvent polyisoprene under different concentrations and for the fourth degrees of temperature and after adding ZnO at 25°C is shown at figures 1 and 2.
It is clear from the figures 1 and 2 that the electrical conductivities of the solvent polymer increased with the increase of the polymer concentrations and temperature degrees at the same solvent value while the nanoparticle ZnO addition enhanced the electrical conductivities at 25°C. These trend of the increasing could be attributed to the raising of the number of ions and free electrons which could enhance the electric polarization of the solution thus lead to create a new paths within the solution, allows for the charge carriers passing then increasing conductivity.

Due to the increase of ionic motivation energy with the increasing temperature degrees, the results revealed the increasing of electrical conductivities of the solvent polymer. The nanoparticle raised the number of ions and free electrons that formulated a new continued nets inside the samples which assist the ions to go throw it. [10,16-22].

3.2 Specific resistance

As shown at figures 3 and 4 the decline of the specific resistance with the increasing concentrations and temperatures and also when ZnO was added. As in equation (2) the specific resistance properties is reverse electrical conductivity. Thus the raise of ion numbers decrease the polymer resistance under all concentrations, temperature degrees and even the addition of ZnO.
Figure 3. The relationship between specific resistance and concentrations at 25°C, 35°C, 45°C and 55°C.

Figure 4. The relationship between specific resistance and concentrations at 25°C, with and without ZnO.

3.3 Molar Conductivity
From the equation (3) the values of the molar conductivity appeared at figures 5 and 6. The molar conductivity increased with the increase of the polymer concentration and temperatures at the same solvent value and also with nanoparticle addition. The increasing of concentrations, temperature degrees and nanoparticle addition motivated the polymer molecule, solvent molecule and ZnO molecule which could break more bands and enhance the number of electrical charge. The other reason of increasing trend could be the increase Vanderfz powers which lead to more attraction among particles with each other [4,23].
Figure 5. The relationship between molar conductivity and molar concentrations at 25°C, 35°C, 45°C and 55°C.

Figure 6. The relationship between molar conductivity and molar concentrations at 25°C, with and without ZnO.

3.4 Degree of Dissociation
The degree of dissociation is calculated from the equation (4) while the figures 7 and 8 shows that the values of degree of dissociation enhanced by increasing the concentrations, temperatures and addition of nanomaterial. These results could be attributed to the binding between polymer molecules itself from one side and also the binding between polymers and solvent and with nanoparticle molecules from the other sides. Thus enhancing the number of free roots in the polymer that lead to raise the degree of dissociation [4,23].
4. Conclusion
The nanoparticle which was used in this study significantly enhanced the electrical properties which enable the mixture between polyisoprene and ZnO nanoparticle for modern using in super generations industry. While the increasing of polymer concentrations solved in toluene and temperature degrees slightly increased the most electrical properties. Because of these limited changes, the polymer would be suitable and safe to be used in the applications of isolation in electrical manufacture sectors.

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