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RESEARCH ARTICLE

STUDYING OF SOME DIELECTRIC AND MECHANICAL PROPERTIES OF (PVA:PVP) POLYMER BLEND

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ABSTRACT

In this study pure (PVA) polymer film and films of (PVA:PVP) polymer blends at weight ratios (((100:0), (70:30), (50:50), (30:70)) wt%) preparation using the casting method. The dielectric and mechanical properties of (PVA:PVP) polymer blends films have been studied. The effect of the weight ratio of the (PVA:PVP) polymer blend film on the dielectric properties have been studied, the practical results show a decrease in both the dielectric constant and the dissipation factor with increased the frequency for all polymer blends films, as well as increase the dielectric constant and the dissipation factor with increasing the weight ratio of the (PVP) polymer at the same frequency. However, the results show increased the (A.C) electrical conductivity with increased the frequency for all Polymer blends films, also the (A.C) electrical conductivity increase with increasing the weight ratio of the (PVP) polymer at the same frequency. The effect of the weight ratio of the (PVA:PVP) polymer blend film on the mechanical properties have been studied, the practical results have indicated an irregular and regular reduction of tensile properties (tensile strength, elongation at break and Youn'g modulus) of (PVA:PVP) polymer blends films by increasing the weight ratio of the (PVP) polymer. Thus the results of the hardness test showed an increase in the hardness value of (PVA:PVP) polymer blends films by increasing the weight ratio of the (PVP) polymer. While the results of the impact test showed a decrease in the fracture energy value of the polymer (PVA:PVP) blends films by increasing the weight ratio of the (PVP) polymer.

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INTRODUCTION

Polymers are one of the most important products of the chemical industry, they have entered into the daily life of the individual and replaced many traditional materials, since the second world war, countries have been competing in the production of many types of industrial polymers and complex overlays, in view of the need for high-performance polymers. The focus of modern studies has changed, in the field of polymers from the development of new homogeneous polymers to the development of new polymer blends. Where the science of polymer blends became more important than in recent decades, especially in the economic and commercial fields. The success of polymer blends technology has been widely heard in the world. The polymer blend is defined as a blend between two or more polymers and is prepared by mixing polymers in a liquid state or solid state or molten phase (Grum, 2016). The blend is called either dual, triple or tetragonal depending on the polymeric constituents it consists of (Awham, 2006). The purpose of polymer blends is to obtain new properties that cannot be found in individual polymers.

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The preparation of polymer blends depends largely on the interferability of polymers as well as the acquisition of polymeric materials with good mechanical and electrical properties. There are several methods that can be adopted in the preparation of polymer blends, such as the solid state method under which the first polymer is mixed in a solid state (powder) with the second polymer, which is also powdered and then melted together in the appropriate solvent as this method is the most widely used method in the industry the second method is the liquid state or the reaction method. The first polymer is mixed with the second polymer in the liquid phase. The second polymer is polymerized through the first polymer after the mixing process (Freed, 2005).

EXPERIMENTAL PART: In the preparation of polymer blends films we are used Polyvinyl alcohol (PVA), which is product by Central House (P) Ltd of India with molecular weight of (13000-23000) g / mol, and Polyviny Pyrrolidone (PVP) K-30, is product by India's (HIMEDIA) company with molecular weight (40,000 g / mol). A pure (PVA) polymer film and (PVA:PVP) polymer blends films was prepared using the casting method by using special molds made of glass. The pure (PVA) polymer film was prepared by adding a certain weight of (PVA) polymer to distilled water using a magnetic sterrier

for (1h) at (80 °C) to obtain a homogeneous solution, and then pour the solution in a special glass mold placed on a mild surface until the solvent evaporates to obtain the pure (PVA) polymer film. In order to prepare the (PVA:PVP) polymer blends films, certain weight ratios of (PVA) polymer were mixed with certain weight ratios of (PVP) polymer and the distilled water was added using the magnetic stirrer for (1h) at (80 °C) to obtain a homogeneous solutions, the solutions are then poured into special glass molds placed on a mild surface and left until the solvent evaporates to obtain the (PVA:PVP) Polymer blends films. The thickness measurement are mode by using digital micrometer, the thickness of the (PVA:PVP) polymer blends films is (1450-1455) µm. For the purpose of dielectric measurements, the (LCR Meter) from (Agilent Impedance Analyz 4294A) company of the origin (Tawan) was used, and the frequency range of (50Hz-5MHz) in the room temperature. And for the purpose of mechanical tests:

- **For tensile test**: (tensile strength, elongation at break, Young's modulus): using a (Tinius Olsen-H10K) device of English origin.
- **For hardness test**: using a (Shore D) of the type (Check-line-dd-100) of American origin.
- **For impact test**: using a shock-resistant test device for the plastic films and paper-based (Filling Darte Impact Tester) of the type (FDI-01) of Canadian origin.

RESULTS AND DISCUSSION

Dielectric Properties

Dielectric Constant: The dielectric constant of pure (PVA) polymer film and (PVA:PVP) polymer blends films with weight ratios (((100:0), (70:30), (50:50), (30:70)) wt%) at room temperature through the frequency range of (50Hz-5MHz) is shown in Figure (1). It is observed that the dielectric constant decreases with the frequency increasing for all polymer blends films. We also note that at low frequencies all polymer blends films have high values of the dielectric constant and when the frequency is increasing the values of dielectric constant is decreasing.

It can be explained that in the low frequency zone the period of time is sufficient for the dipoles to arrange the particles and align them with the direction of the electric current between the poles, and at high frequencies, the time period is short and less than the time required by the molecules in order to be able to arrange itself with the direction of the external electric field (Rabee, 2011), and generally the high values of the dielectric constant at low frequencies due this is due to the different phase of polymer material (PVA) and polymer material (PVP) which results in interstice polarization, as well as the polarity of the electrodes, so the polarization resulting from the electrodes is closely related to the composition of the sample charge between the poles, and this depends on the composition of the sample and the distances and impurities contained within the sample. We also notice that the value of the dielectric constant at the same frequency increases with the increase of the weight ratio of the (PVP) polymer. In general, the increase in the value of the dielectric constant is due to increased the polarization (Psarras, 2007). So the reason for increasing the value of the dielectric constant at the same frequency by increasing the weight ratio of the (PVP) polymer is the presence of a (PVP) polymer, which causes the formation of the interstitial surfaces in the polymer blend, which increases the number of dipoles of the volume unit, in addition to the heterogeneous system which is due to the some vacuum shipments in the interface which effect on the practical results of the insulation (Hussein, 2012).

Dissipation Factor: The dissipation factor is the ratio of the dissipation of power in the dielectrically materials to the total passing power through the insulator. The dissipation of the energy in the dielectric materials is directly proportional to the dissipation factor, therefore, knowing the value of this factor has great benefit in applications of polymer blends, the dissipation factor for pure (PVA) polymer film and (PVA:PVP) polymer blends films with weight ratios (((100:0), (70:30), (50:50), (30:70)) wt%) at room temperature through the frequency range of (50Hz-5MHz) is shown in Figure (2). It is observed that the dissipation factor is decreasing with the increase of the frequency and for all polymer blends films. It is noted that the values of the dissipation factor are big at low frequencies and then decrease with increase of applied electric field due to the enhancement of the charge carriers that take place cross the electric charge area and decreasing the value of the dissipation factor at high frequencies until the electron's energy is equal to the Fermi level (Basha *et al*., 2016). Another reason for the change in the dissipation factor with the frequency is due to the absorption of the energy of the dipoles with the electrical field in the system to overcome the resistance of viscous substances that surround the rotation, this absorbing energy is reduces the charge carriers transmitted between border in the capacitor with increasing of frequency and thus the dipoles need a higher energy in the system to get the relax and in this case, the dissipation factor is decreasing (Zidan, 2016). We observe from the figure that the value of the dissipation factor at the same frequency increases with the increase of the weight ratio of the (PVP) polymer. In general, this increase in the value of the dissipation factor is due to increased the polarization caused by interface between (PVA) and (PVP) polymers (Psarras *et al*., 2007).

Electrical Conductivity: (A.C) electrical conductivity is a function of frequency. The (A.C) electrical conductivity of pure (PVA) polymer film and (PVA:PVP) polymer blends films with weight ratios (((100:0), (70:30), (50:50), (30:70)) wt%) at room temperature through the frequency range of (50Hz-5Mhz) is shown in Figure (3), we observe that the (A.C) electrical conductivity increases significantly with frequency increase for all polymer blends films. This increase in (A.C) electrical conductivity due to electric field pulse with increasing frequency which will lead to increased the polarization in the sample and this appears in increasing (A.C) electrical conductivity, and (A.C) electrical conductivity arises of the quick transition between the sites of different types such as electrons or dipoles (Zidan, 2016). It should be noted that the (A.C) electrical conductivity in the insulator is the amount of power lost when the alternative electric field is applying, which appear as a temperature when the rotation of dipoles in their positions and vibration of the charges by the change of alternative electric field therefore it is dependent on frequency (Popielarz *et al*., 2001). We also note in the figure that the value of the (A.C) electrical conductivity at the same frequency increases with the increase of the weight ratio of the polymer (PVP). In general, this increase in the value of (A.C) electrical conductivity due to decreased in the dielectric resistance resulting from the increase in the conductive molecules in the polymer blend film (Musa, 2005).

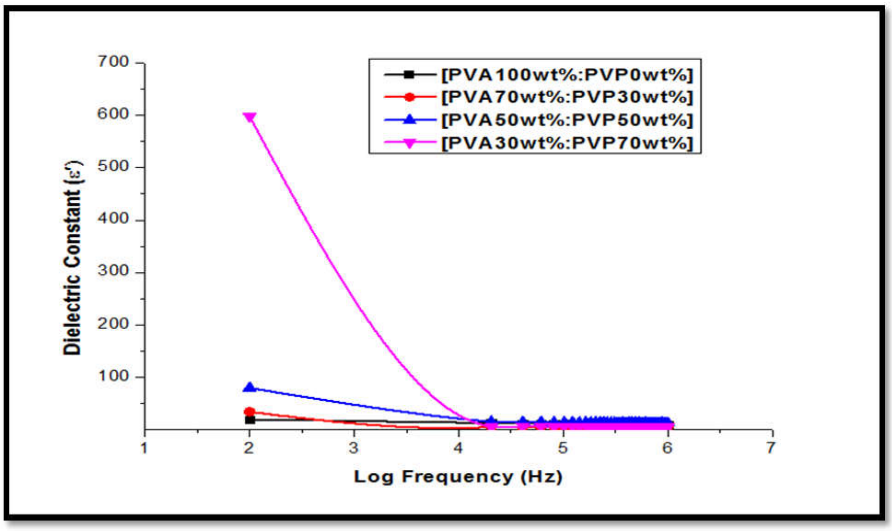

Figure 1. Dielectric constant as a function of frequency for [PVA:PVP] polymer blends films with different weight ratios

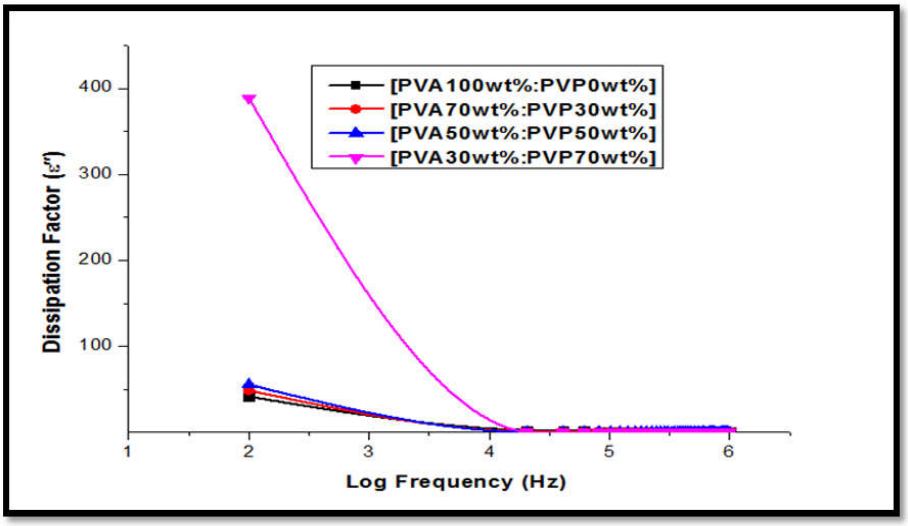

Figure 2. Dissipation factor as a function of frequency for [PVA:PVP] polymer blends films with different weight ratios

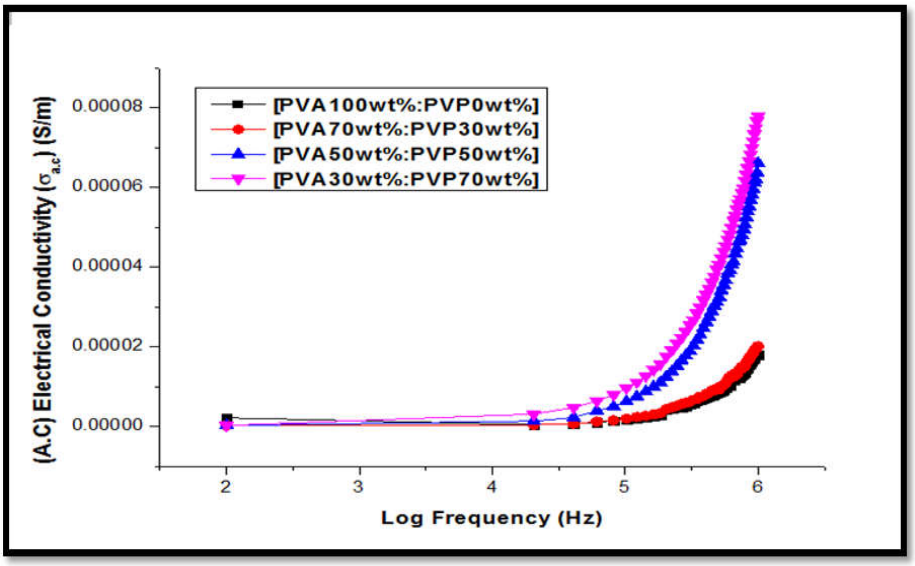

Figure 3. (A.C) electrical conductivity as a function of frequency for [PVA:PVP] polymer blends films with different weight ratios

Mechanical proprieties

Tensile Test: The tensile test was performed and the (stress-strain) curves of pure (PVA) polymer film and (PVA:PVP) polymer blends films with weight ratios (((100: 0), (70:30), (50:50), (30:70)) wt%) are shown in Figure (4), are shown in the curve of (stress-strain) of a pure (PVA) polymer film where it is composed from elastic deformation area represented by the linear relationship between stress and strain from this region, the elastic coefficient (Young's modulus) was calculated, which is represent the straight line slope. The polymeric material within the boundaries of this zone suffers from elastic deformation resulting from the tensile and elongation of the polymer chains without breaking the bonds, then this curve deviates from linear behavior as a result of cracks within the polymeric material. These cracks grow and accumulate with increased stress forming bigger cracks and continue to grow with stress so the fracture gets in the sample. In other cases, the fracture at the outer surfaces begins at the locations of deformities or defects such as scratches, wrinkles or internal cracks that act as stress concentration areas, which leads to the decrease in the stress value to limits even it exceeds the strength of internal bonds and thus breakage occurs. When adding (PVP) polymer to pure (PVA) polymer, the curve (stress - strain) changes and gets curves with different characteristics depending on the addition and weight ratio as illustrated in Figure (4), and the Table (1) shows the values of both tensile strength (T_S), elongation at break (E_b) and Young's modulus (Y_m) for all polymer blends films, which are determined from the (stress-stress) curves. The Table (1) shows that the tensile strength value of a pure (PVA) polymer film is (55.6 MPa) and the elongation at break value is (127%) and the value of the Young's modulus is (1980 MPa), but when mixing the (PVA) and (PVP) polymers, these values will change, where we note that the tensile strength value began to decrease irregularly to reach the lowest value of (15.5 MPa) at the weight ratio (50:50) for the polymer blend, and the elongation at break value began to decrease irregularly to reach the lowest value of (27.4%) at the weight ratio (70:30) for the polymer blend, while the value of the Young's modulus was reduced with the increase of the weight ratio of the (PVP) polymer. This is a irregular and regular decrease in tensile properties values of tensile strength, elongation at break and Young's modulus for polymer blends films (at all weight ratios of mixing) compared to pure (PVA) polymer film is due to the weak interaction between the molecules and the weak interstice lack between the components of the polymer blend, which reduces the tensile properties values and the fragility of polymer blends films (Ravindra *et al*., 2015). The Figures (5,6,7) illustrate the tensile properties of all polymer blends films.

Hardness Test: The hardness test was followed by the (Shore D) type of pure (PVA) polymer film and (PVA:PVP) polymer blends films with weight ratios (((100:0), (70:30), (50:50), (30:70)) wt%) as shown in Figure (8), from the figure shows that the hardness of pure (PVA) polymer film is increasing when mixed with a (PVP) polymer, the hardness continues to increase with the increase of the weight ratio of the weight ratio of the (PVP) polymer, from hardness concept can be considered a measure of plastic deformation, which material can suffer under the influence of external stress, so the mixing of twice polymers increases the hardness of the material, and this is due to the increased tangle and stacking, which reduces the movement of polymer particles, which increases the resistance of the material to the scratching and cutting and increase the material resistant to plastic deformation, the hardness of the materials depends on the type of forces that bind the atoms or molecules in the material, whenever the bonding is stronger the hardness be stronger, thus the strong bonding at the interface between the two phases of the (PVA) polymer and the (PVP) polymer (PVP) due to the increased interconnectivity of the polymer blend, which results in a closed space that increases the hardness (Deaa *et al*., 2009). Table (2) shows the hardness values for all polymer blends films.

Impact Test: The impact test is an important mechanical test, used to show the material resistance to collapse under the influence of impact forces under operating conditions, as it represents the actual energy measurement required to break the test sample, Fracture energy was calculated for pure (PVA) polymer film and (PVA:PVP) polymer blends films with weight ratios (((100:0), (70:30), (50:50), (30:70)) wt%), we note that the fracture energy decreases with the increase of the weight ratio of the (PVP) polymer as shown in Figure (9), the fracture energy depends on the amount of the weight ratio of the polymer blend and on the degree of bonding and interference between polymers as well as on the nature of polymer particles and the size of it, since as the sizes of the particles used are small, they lead to a decrease in the value of the fracture energy. This is due to the spread of polymer blends particles, which can be sites of work and spread fatigues and precise cracks within the polymer blend to in order to focus the stresses on it, as well as the fracture energy depends on the type of stress on the sample and the conditions of manufacturing and environmental conditions and the geometry shape of the sample and its dimensions. On the other hand, the density and average molecular weight and the molecular weight distribution of the polymer blend have an effect on the mechanical properties of the polymer blend, since the density is related to material crystalline, the higher density means that the product has a high crystalline result of the assembly of crystalline chains and packing very close to each other affects the final product characteristics, such as the elasticity coefficient, which increases with increasing of density, while the fracture energy decreases with increasing of density (Saaed, 2011). Table (3) shows the fracture energy values for all polymer blends films.

Table 1. Tensile properties values of [PVA:PVP] polymer blends films with the weight ratio of the blend

Blending Ratio of [PVA:PVP] (wt%)	Tensile Strength (T.S) (MPa)	Elongation at Break (E_b) (%)	Young's Modulus (Y_m) (MPa)
[100:0]	55.6	127	1980
[70:30]	55.4	27.4	1290
[50:50]	15.5	66.6	932
[30:70]	20	105	800

Table 2. Hardness values of [PVA: PVP] polymer blends films with the weight ratio of the blend

Blending Ratio of [PVA:PVP] (wt%)	Hardness (Shore D)
[100:0]	17.7
[70:30]	41.2
[50:50]	41.6
[30:70]	61.4

Table 3. Fracture energy values of [PVA:PVP] polymer blends films with the weight ratio of the blend

Blending Ratio of [PVA:PVP] (wt%)	Fracture Energy ($Kg.m^2/sec$)
[100:0]	0.7644
[70:30]	0.588
[50:50]	0.588
[30:70]	0.3234

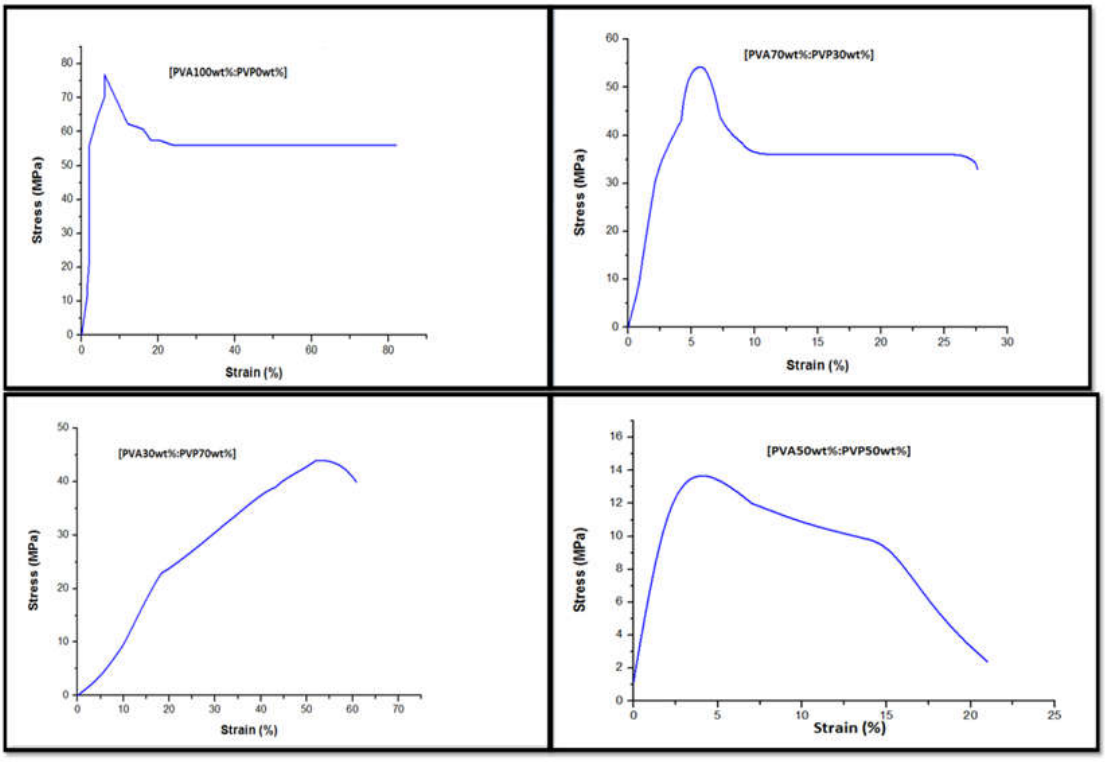

Figure 4. (Stress – Strain) curves of [PVA:PVP] polymer blends films with different weight ratios

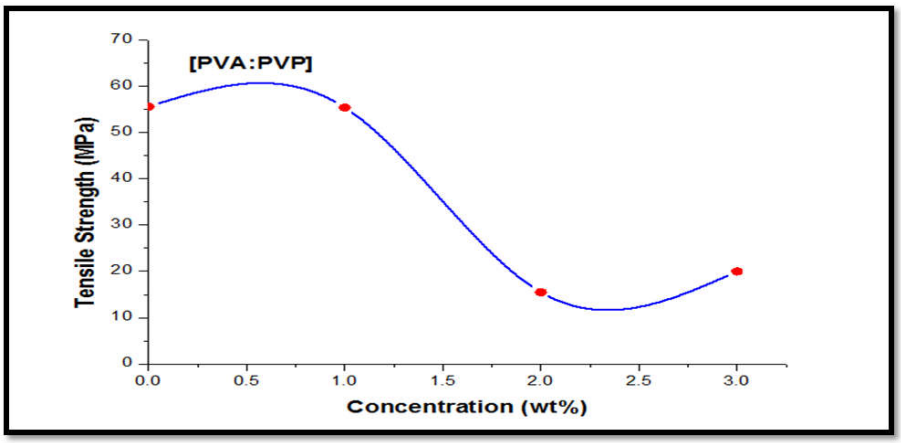

Figure 5. Tensile strength of [PVA:PVP] polymer blends films as a function of the weight ratio of the blend

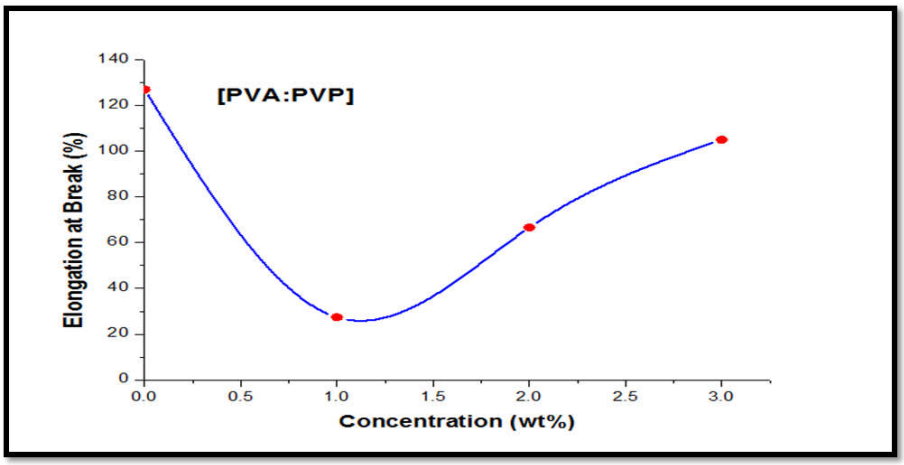

Figure 6. Elongation at break of [PVA:PVP] polymer blends films as a function of the weight ratio of the blend

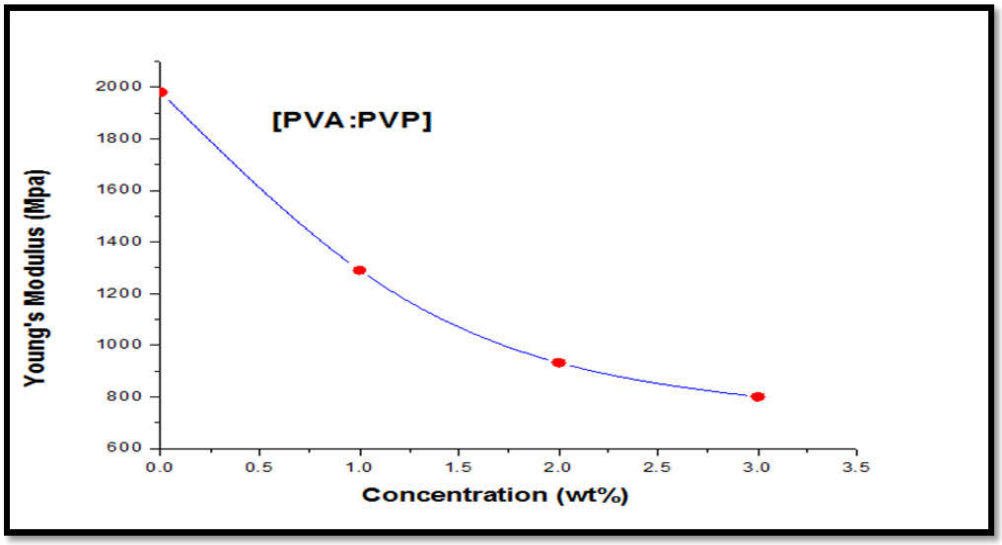

Figure 7. Young's modulus of [PVA:PVP] polymer blends films as a function of the weight ratio of the blend

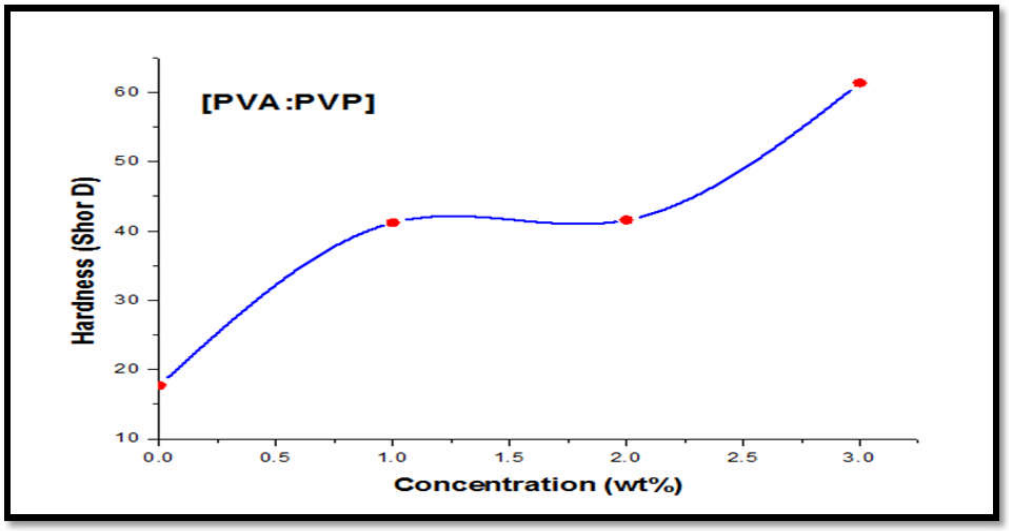

Figure 8. Hardness of [PVA:PVP] polymer blends films as a function of the weight ratio of the blend

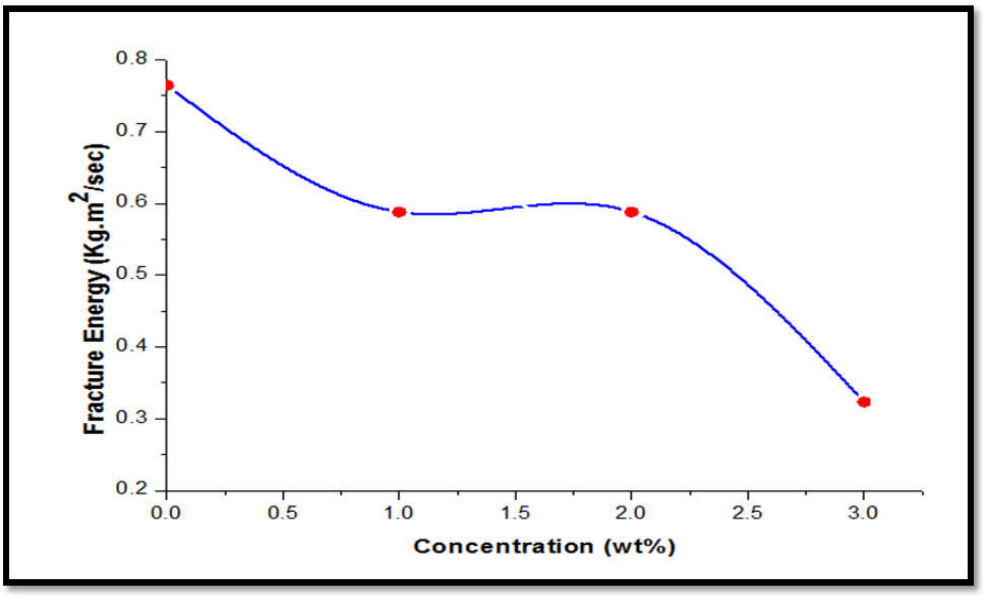

Figure 9. Fracture energy of [PVA:PVP] polymer blends films as a function of the weight ratio of the blend

CONCLUSION

The main conclusions of this study were: The results of (PVA:PVP) polymer blends films showed that the value of the dielectric constant, the dissipation factor and the (A.C) electrical conductivity increased with the increase of the (PVP) polymer at the same frequency. Decreasing the dielectric properties represented by the dielectric constant and the dissipation factor for all (PVA:PVP) polymer blends films with increasing of frequency at the low frequencies, while in the high frequencies these properties are not dependent on the frequency and remain constant indicating the possibility to apply the (PVA:PVP) polymer blends films (with different weight ratios) in instruments that require stability in dielectric properties at the high-frequencies. The study also showed an increase in (A.C) electrical conductivity for all (PVA:PVP) polymer blends films with increasing of frequency. The results of the tensile test of (PVA:PVP) polymer blends films showed an irregular and regular decrease in the value of tensile strength, elongation at break and Young's modulus with the increase of the weight ratio of the (PVP) polymer. Increase the hardness of (PVA:PVP) polymer blends films with the increase of the weight ratio of the (PVP) polymer, while the impact test showed that the fracture energy value of (PVA:PVP) polymer blends films decrease with the increase of the weight ratio of the (PVP) polymer.

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