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Study of the Ability to Improve the Structural and Apparent Properties of Polymeric Materials, Polystyrene-Polyethylene, By Means of Physical Casting

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***Abstract* - In this paper, the applications of thermoplastic, thermoset polymers, and a brief description of the functions of each subsystem are reviewed. The synthetic route and characteristics of polymeric materials are presented. The mechanical properties of polymers such as impact behavior, tensile test, bending test, and thermal properties like mold stress-relief distortion, generic thermal indices, relative thermal capability, and relative thermal index are mentioned. Furthermore, this paper covers the electrical behavior of polymers, mainly their dielectric strength. Different techniques for evaluating polymers' suitability applied for electrical insulation are covered, such as partial discharge and high current arc resistance to ignition. The polymeric materials and processes used for manufacturing cables at different voltage ranges are described, and their applications to high voltage DC systems (HVDC) are discussed. The evolution and limitations of polymeric materials for electrical application and their advantages and future trends are mentioned. However, to reduce the high cost of filler networks and improve their technical properties, new techniques need to be developed. To overcome limitations associated with the accuracy of the techniques used for quantifying residual stresses in polymers, new techniques such as indentation are used with higher force at the stressed loca on.**

Keywords: Polyethylene, Polystyrene, Mechanical properties, X- Ray diffraction, Scanning Electron Microscope.

I. INTRODUCTION

Since the common use of polymer materials, a large number of polymer substances have appeared. Each of these types depends on the nature of the use, which is due to be part of the duties of this type of polymeric material. This improvement happened either by a chemical method, a physical method, or an engineering method. The chemical method relied on a change in the composition of polymer through a change in Engineering methods depended on the design of certain conditions for the preparation and casting process so that they changed the vacuum geometry of polymeric matter, while physical methods relied on subjugating polymeric materials to non-remising external physical effects and then causing an effect on the polymeric material and its external formation through this effect. Another method that is now being studied is to use Pulmeric mixtures in specific proportions in a way similar to the method of manufacturing metal alloys and then subjecting these materials to an external physical effect. This method can include the three methods mentioned above by developing a system containing two different polymers and highlighting an external physical effect. The probability of a chemical reaction is an incoming probability and at the same time the possibility of rearranging the chains is an improbable possibility. Masking or strengthening a certain trait in the material is also a possibility, so this method may be a successful.

II. OBJECTIVE

The aim of this study is the following

1. Study of mechanical properties (hardness and bending strength, shock, compression, shearing voltage) of polyethylene and polystyrene Samples.
2. The use of X-ray diffraction and electron microscope scanning to analyse samples.

III. MATERIALS AND METHODS

3.1 Samples preparation

The use of raw grains of polyethylene and polystyrene. Polyethylene and polystyrene materials were made separately without mixing as the control element in order to manufacture the samples. We used aluminum plate in the form of a mould with a thickness of (1 mm) and the dimensions of samples (120*10*10*mm) The granules of polyethylene and polystyrene were thoroughly mixed until the mixture is in a uniform state, then the mixture is continuously heated and stirring until it dissolves and then poured into moulds and then treated the samples superficially after the casting and drying process to ensure that the dimensions of the model are controlled using silicon creped softening sheets according to the type and granular sizes [1] (400.1000.2000) respectively.

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3.2 Thermophysical treatment

Where the models manufactured from a mixture of polyethylene (PA.) and polystyrene (PS.) were placed. In a German-made electric oven of the Dinder type, the models were exposed to temperatures (40,60,80) for specific periods of time (3,6,9 hours). [2]

3.3 Surface hardness check

The surface hardness of the models was measured using a Shore (N.S.S) hardness measuring device of Japanese origin. This device is measured by inflicting a shock on the surface of the model and through this shock the hardness value is determined directly by the device that contains an indicator that gives the hardness value directly. [3]

3.4 Shock resistance check

The ability of the models to resist shock was determined by using (Charpt Impact Test) method. Where this method is based on measuring the maximum amount of energy that can be supplied to the model before a crush or breakage occurs in the structure of the model hull and in a batch of energy within a short period of time, by using the (Izod Charpy Tension Impact Test Instrument), which is manufactured by (Testing Machines, Inc, Amityville New York). [4]

3.5 Bending Toughness Check

The models were checked by the device of the British company Hi_Tech, and by this examination, the resistance ratio of each manufactured model to the constant loads applied to it was determined. Where the value of the load at which the model breaks is recorded, and then the value of the stress causing the fracture is calculated using the relationship. [5]

$$\text{Max. bending stress } (\sigma) = PL / Z = 6\,P\,L / b\,t^2 = 1.2\,P \ldots (1)$$

3.6 Shear stress check

The examination is carried out by relying on the three-point flexural test, whose parts consist of two well groomed cylindrical supports made of stainless steel that are placed on two slides that allow adjusting the distance between them by means of a graduated ruler where the sample is placed on the two supports, then the load is applied gradually from the top by means of a cylinder that has With the same diameter and the same quality. Then the shear stress is calculated, using the relationship.(2)[6]

$$S = (3\,P\,L / 2\,W\,t2) \ldots\ldots\ldots (2)$$

3.7 Compressive Strength Check

Graseby Spesac manual hydraulic press was used. As this type of press is used to prepare and press a wide range of cylindrical samples at a maximum compressive force of (15 Tons). After making a simple modification on the capping surface of the model. The following mechanism has been adopted in carrying out the compressive strength tests of the manufactured models. [7]

1. The dimensions of the sample used in the examination are mm (30 x 30 x 5), and these dimensions are obtained with the same lathe machine mentioned in the previous paragraph.
2. An initial pressure (which is relatively little) is applied to the model for a period of (5 min).
3. If the model bears this pressure and does not break, we increase the pressure gradually and for the same approved period of time.
4. At each stage of pressure increase, the model is replaced to ensure that the remaining stresses in the model do not affect the result of the initial examination.
5. Substituted models are of one origin, i.e. one model is cut into several models.

3.8 X-ray diffraction (XRD)

The XRD device was used to study the crystalline nature of the material by means of reaction Electromagnetic waves with crystal structures that cause diffraction of these waves that have approximate wavelengths of distances between atoms in a crystal. [8]

3.9 Scanning Electron microscopy (SEM)

Using the FESEM device (Zeiss Sigma 300- HV) GERMANY, where topographic images are taken on the surface of the mixture samples of polyethylene. PA and polystyrene.PS to know the surface composition and the mixing extent of the manufactured models. [9]

IV. RESULTS AND DISCUSSION

1. Hardness as a function of treatment time

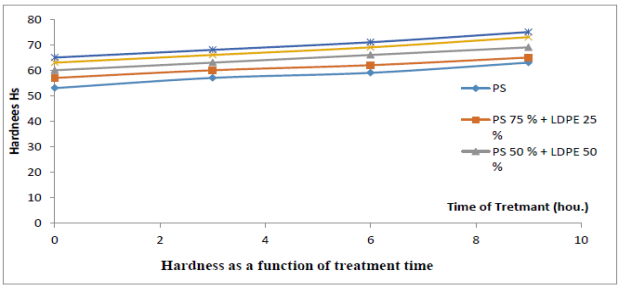

Figure 1: Represents the hardness assays as a function of treatment time

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It is noted from Figure (1) that the surface hardness increases with the increase in the time of heat treatment for all Samples, which is an expected result, as the heat treatment process will lead, in one way or another, to an increase in the uniformity of the surface layer and bypassing the manufacturing defects represented by micro cracks, and in this case it will lead to an increase in The ability of surface resistance to affect it and thus increase the surface hardness of the material. [10]

It is also noted from Figure (1) that the surface hardness of (PS.) is higher than all the percentages of participation in the formation of the mixing models, and that the lowest percentage was (P.S 75%_P.A25%), immediately followed by the lowest percentage is (P.S), this discrepancy In the surface hardness values and their change depending on the change in the mixing ratio, it may be attributed to him that the nature of the composition of the material (P.A), which is linear materials with weak side linkage, while (P.S) is linear chains with higher evil linked, this case makes that (P.A) is one of the materials that have Weak resistance to impact, while (P.S) has the highest ability to build and therefore the highest surface hardness, and accordingly, the surface hardness of the material decreases or increases depending on the contribution of the ratio of PA., S.[10]

2. Shock resistance as a function of heat treatment time

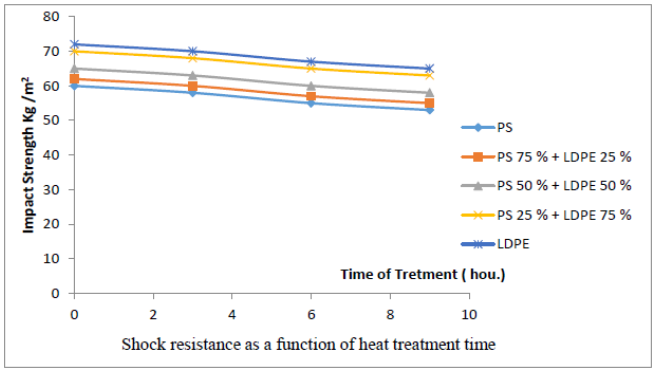

Figure 2: Represents the shock resistance as a function of the heat treatment time

It is noted from Figure (2) that the shock resistance decreases with the increase in the heat treatment time, and this result is an expected result, since the heat treatment process in plastic materials leads to a loss of part of the elasticity in the model or in the material, this case will lead to the material's cohesion ability With each other, especially on the surface, it will decrease significantly, which leads to a weakening of the material's resistance ability to resist shock, as it is noted from the figure that the highest percentage of shock resistance occurred at P.A material and the lowest at P.S material, and that the ratio changes depending on the contribution ratios. This case also is related. Direct with the nature of the structure and composition of the two materials. [11]

3. Bending strength as a function of treatment time

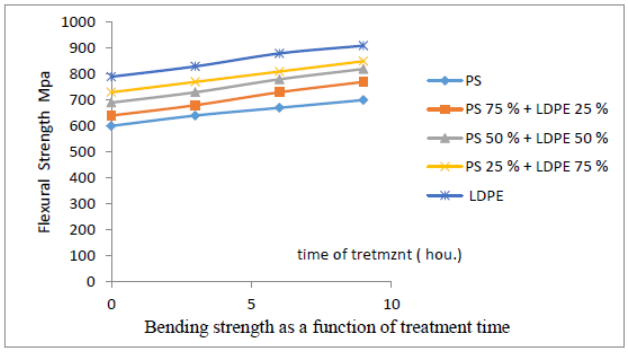

Figure 3: Represents the bending strength as a function of treatment time

It is noted from Figure (3) that the value of the bending resistance increases with the increase in the heat treatment time of a model. This case can be explained on the basis that subjecting the models to a moderate thermal effect and during appropriate periods of time corresponding to the amount of heat supplied to the model will generally lead to enhancing the equilibrium property among the three factors affecting the bending resistance of the material, these factors are (tensile, shear, and compression), and therefore the improvement in the bending resistance is due to an improvement in the ratios of the effect of the three factors. Polymer material, which is the stereotyped structure, which largely depends on the process of balancing these components. [12]

4. Shear stress as a function of treatment time

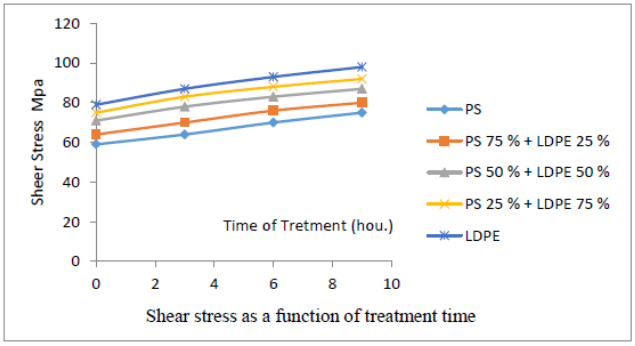

Figure 4: Represents the shear stress as a function of the treatment time

In order to explain the shear stress, we must understand that the more the material is capable of creating resistance in the process of separating the components of the polymeric chains from each other, the more the material's ability to resist the shear stress will increase. The matter is an increase in the resistance of the components of the material to separate, P.S is less resistant to shear stress than P.A, which is higher among the prepared models and the amount of the value of the

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material changes depending on the contribution ratio and the reason for this is that P.S has in its composition a material with a side-strength structure, which gives strength In its cohesion and resistance to shear stress, this case is lacking in P.A. [13]

5. Compressive strength as a function of treatment time

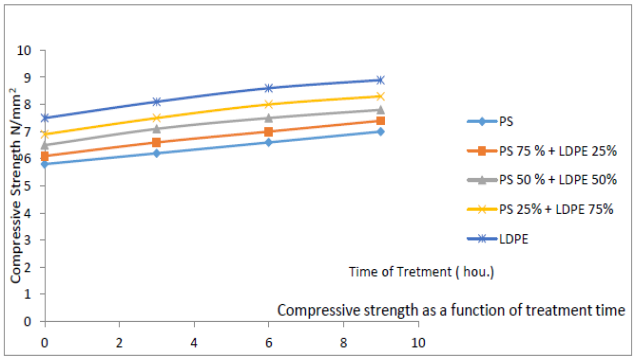

Figure 5: Represents the compressive strength as a function of treatment time

It is noted from the figure that the compressive resistance of materials increases with the increase in the heat treatment time and that P.S is one of the least compressive resistant materials, while we find P.A is one of the highest compressive resistant materials. The greater its ability to resist compressive strength, and in this case we find it stiffness in P.A material, and the heat treatment will lead to an increase in the agglutination of the material and its basic components. [14]

X-ray examinations

1) The model (P.S 60%_P.A 40%) represents (80°-60°-40°C) ((6-Hour)

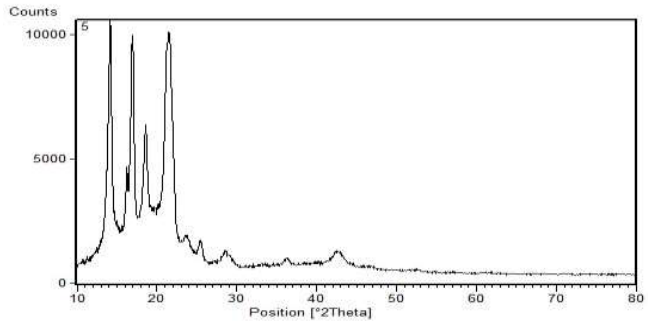

Figure 6: Modulus at 40°

It is noted from Figure (6) that the diffraction spectrum of X-rays consists of a linear spectrum located at angles 14, 17, 19, 21 with weak peaks at angles 23, 25, 29, 43. It is also noted from the figure that the width of the middle of the beam is Relatively few at the high peaks, and it is large at the low peaks, and this means that the quantitative sizes of the basic compounds that make up the mixture are small quantitative sizes that are on the order of parts of a micrometer, but at the low peaks, the width of the middle of the band is large, and this means that the quantitative sizes are large.

It is also noted from Figure (6) that the spectrum background is low at angles greater than 30, but at angles less than 30 it is high, and this means that there are regions that tend to random and irregular, while there are regions that may mean the beginning of the crystallization stage, the ends of the linear regions in the spectrum are Relatively accurate, which means that the material or the constituent elements of the material are highly crystallized elements. [14]

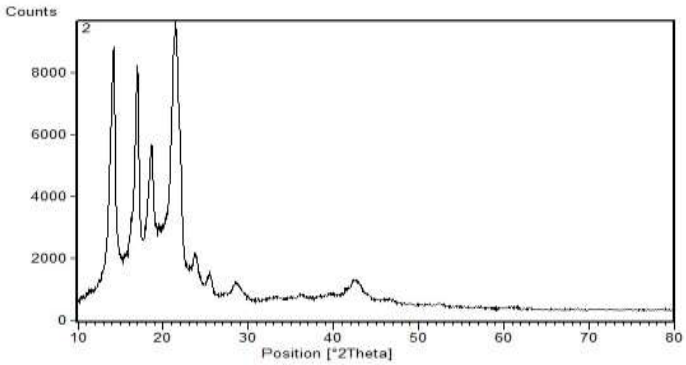

Figure 7: Modulus at 60°

It is noticed from Figure (7) at a temperature of 60° that the only difference is the difference in the value of the height of the high linear peaks. This means that there is a process of disintegration or decomposition of the components of the mixture with rearrangement of the formation.

2) The model (P.S 40%_P.A 60%) represents (80°-60°-40°C) ((6-Hour)

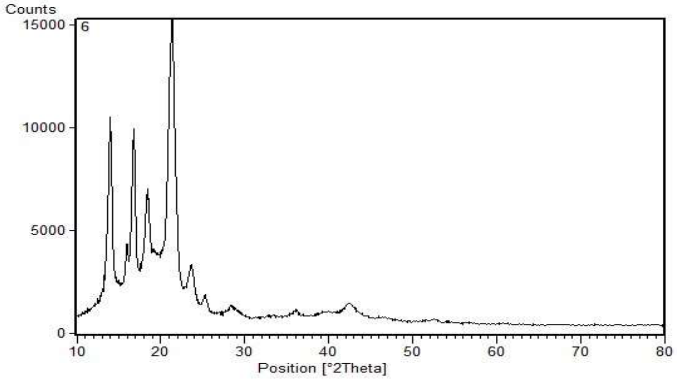

Figure 9: Laboratories at 40°

It is noticed from the figure that all the observations that were observer in Figure (6), (7), (8) are present in Figure (9)

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with a difference in the peaks of the peaks, and that this result confirms that the nature of the P.A formula and the formula The two P.S compositions are different in terms of the contribution ratios of the elements.

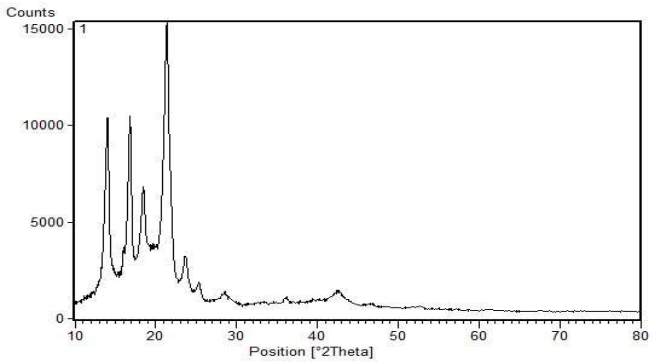

Figure 10: Modulus at 60°

At a temperature of 60°, it is noticed that there is no noticeable change in the value and positions of the X-ray diffraction spectrum, and this means that the high temperatures and the treatment time were not sufficient to cause the noticeable change in the X-ray diffraction spectrum, which means a change in the composition of the material. [16]

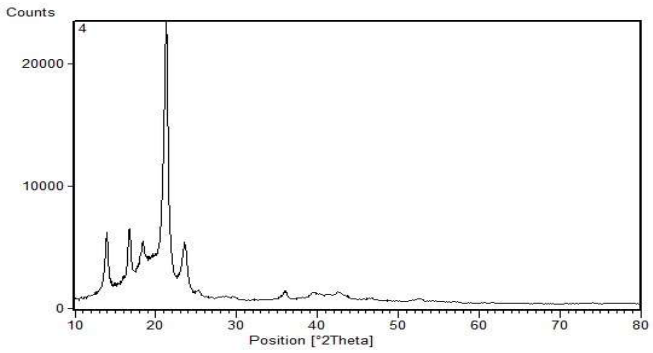

Figure 11: Modulus at 80°

At a temperature of 80c, a change in the X-ray diffraction spectrum is clearly observed, and this change includes a noticeable increase in the peak located at the angle value of 21 with a noticeable decrease in the rest of the peaks, and this is a result that may mean the transformation of the mixture into a system that consists mainly From a single element with the presence of elements that contribute relatively little, and it is possible that they are the elements of a link between the components of the basic element, in addition to the fact that the basic element has shown a high crystallization state in terms of the end of the peak and it is in quantitative sizes that fall within the range Microbial As for the bonding elements, it is noted that there are large quantitative sizes with a lower crystallization rate. [7]

Examinations

1) The model (P.S 40%_P.A 60% at (60°C) (6-Hour)

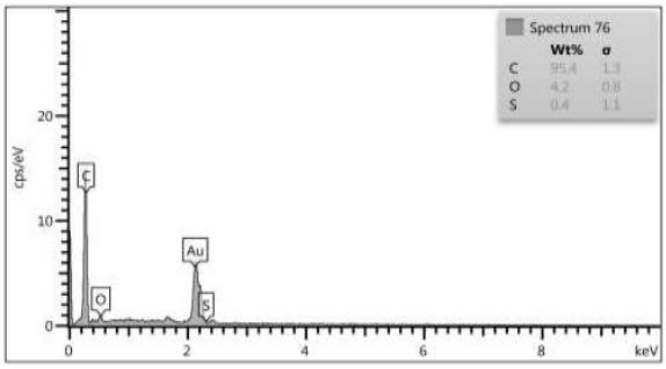

Figure 12: The shape

It is noticed from Figure (12) that the surface structure contains irregular sites, this means that there is no complete mixing between the two materials of the mixture, and it is noted that there is a surface structure that is free of permeability to the inside of the mixture body. [3]

2) The model (P.S 40%_P.A 60% at (80 °C) (6-Hour)

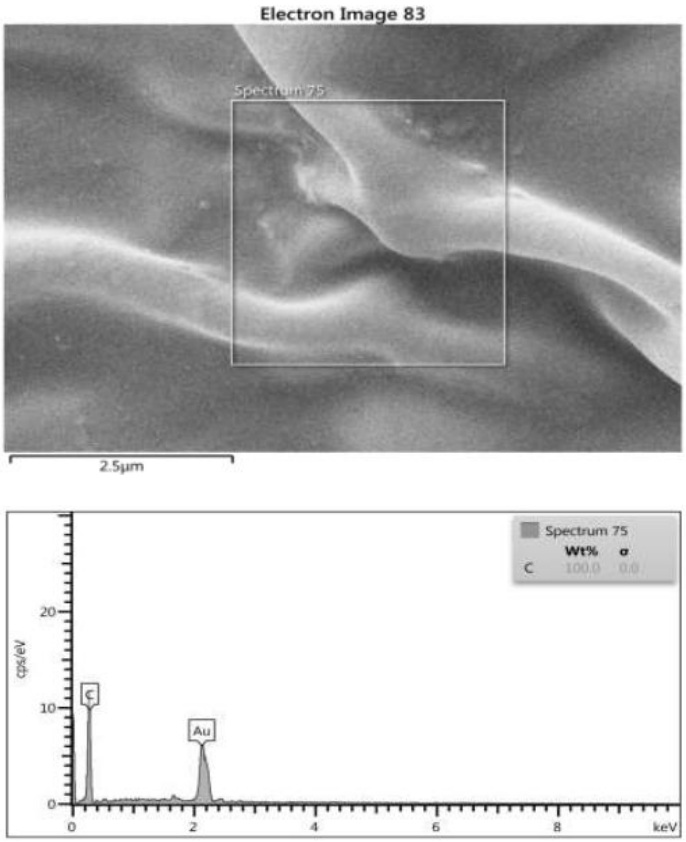

Figure 13

At a temperature of 80 °, it is noticeable that these sites disappear with the appearance of a relatively homogeneous

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surface, and that the topography of the surface has had a kind of prominence, which means a change in the nature of the mixture due to disintegration and reconnection. It is noted from the LED curves at a temperature of 60° the presence of multiple phases has different energies, while at a temperature of 80° it is noted that some phases have disappeared and the focus remains on two phases, which is another confirmation of dissociation and reconnection. [5]

3) The model (P.S 60%_P.A 40% at (40 °C) ((3-Hour)

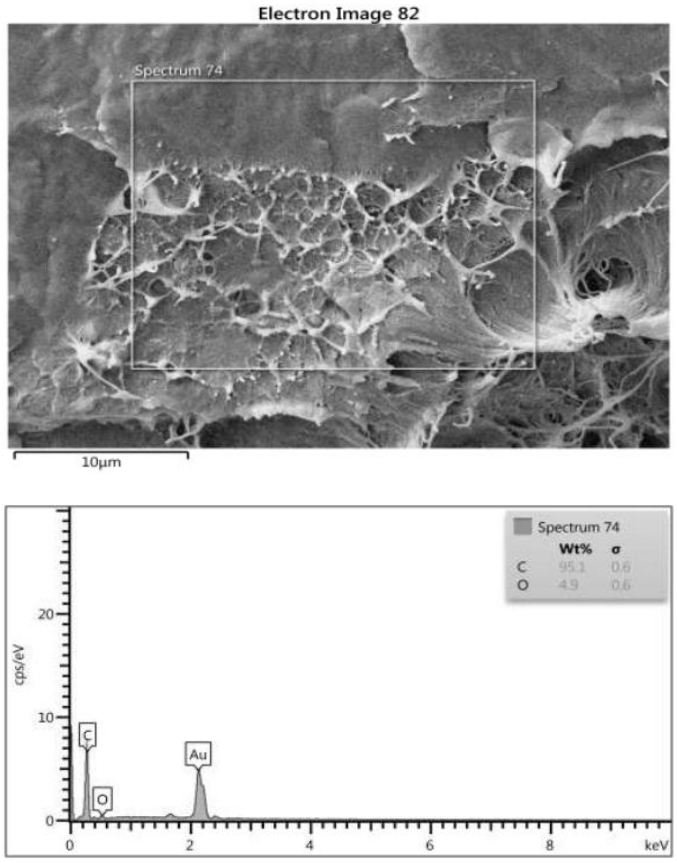

Figure 14

It is noted that there is a state of mismatch with the presence of some gaps, which is an indication of the complete lack of miscibility in such mixtures, and that the LED curve shows the presence of phases that differ from the phases of the shapes (12), (13) which means that the mixing ratio affect the nature of the installation. [16]

V. CONCLUSIONS

This paper extensively reviewed polymer materials, thermoplastics, and thermosets for application in electrical apparatus. Polyethylene has been the widely applied material manufacturing cables at the medium and high voltage range due to its high electrical for strength and low production costs. Using a cross linking process, good thermal and mechanical characteristics can be achieved with XLPE, HDPE, and EPR. On the other hand, at low voltage for indoor applications, PVC is replaced with superior polymeric insulation due to safety and public health regulations. For HVDC applications, polymeric insulated cables have not been as successful as oil-impregnated paper cables because of some operational conditions that reduce reliability and increase the functioning costs.

On the other hand, smart polymeric materials were more useful in biological and medicinal applications due to their sensitivity to the environment. However, it has been observed that more research is required in the mechanical, electrical, and thermal stresses of polymers to increase the reliability and power density. Besides, residual stresses are a common phenomenon that affects the production of injected molded polymers. These stresses come up due to deformations/bends, twists, or pressure. The high pressure during molding also leads to complex situations such as chain reaction, stretching, and relaxation. These residuals are usually quantified using techniques with lower accuracy. To improve the accuracy, new techniques such as indentation are typically employed.

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