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Electrical Properties of Preparing Biodegradable Polymer Blends of PVA/Starch Doping with Rhodamine –B

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Abstract:

This research focuses on the characteristics of polyvinyl alcohol and starch polymer blends doping with Rhodamine-B. The polymer blends were prepared using the solution cast method, which comprises 1:1(wt. /wt.). The polymer blends of PVA and starch with had different ratios of glycerin 0, 25, 30, 35, and 40 % wt. The ratio of 30% wt of glycerin was found to be the most suitable mechanical properties by strength and elasticity. The polymer blend of 1:1 wt ratios of starch/PVA and 30% wt of glycerin were doped with different ratios of Rhoda mine-B dye 0, 1, 2, 3, 4, 5, and 6% wt and the electrical properties of doping biodegradable blends were studied. The ratio of Rhodamine-B 5% wt to the polymer blends showed high conductivity up to 1×10^{-3}. In general, the electrical conductivity was increased with high temperature, which is similar to the behavior of semi-conductive polymers.

Key words: Biodegradable polymers, Electrical conductivity, PVA, Starch.

Introduction:

Among the many essays to combine tissue-engineering essential into strategies to repair nearly all portions of the body neuronal fixing up stands out, electrical stimulation has been shown to expand the nerve regeneration procedure and this, as, a result, makes the use of electrically conductive polymer blends attractive for the manufacturing of scaffolds for nerve tissue engineering(1, 2). This is in part due to the intricacy of the nervous anatomical system, its performance and the incapability of traditional repair way, which are based on single components of either biomaterials or cells alone.

One of the most available and cheaper polysaccharide sources is starch (3), which has a good characteristic of biodegradability and it can be easily degraded in water. The augmentation of starch has led to the originality of starch/ polyvinyl alcohol blends (4). Recently, a group of decomposing polymers in nature with semi-electro conductive properties have been prepared (5, 6).Industrial and natural dyes are used to dope some polymers and polymer blends to change their properties from dielectric to semi-conductive. This method has been used to dope polymers because polymers are known for their isolation properties (7).

These blends are considered as the biodegradable materials, which diminish the accumulation of wastes (8). PVA has been little to end users despite its outstanding chemical, physical and mechanical properties to those used in which it is supplied as a solution in water (9, 10). Chemical structure of Rhodamine-B was shown in Fig. 1.

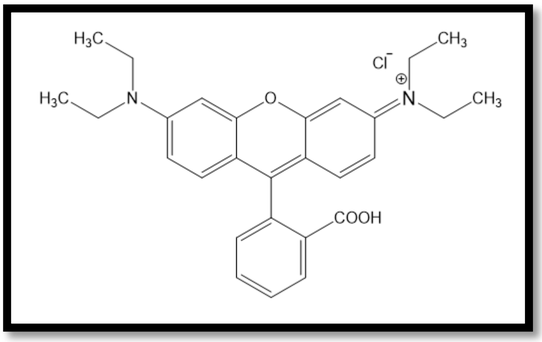

Figure 1. Chemical structure of Rhodamine-B.

This study aims to investigate the mechanical properties and electrical properties of biodegradable polymer blends of starch/PVA doped with different ratio Rhodamine-B and convert them from insulating materials into semiconducting materials through the doping process, therefore these materials can be used in the manufacture of solar cells or similar applications, and these materials are environmentally friendly and biodegradable.

Materials and Methods:

PVA was purchased from Merck and used as received. Cornstarch was purchased from Sigma Aldrich and commercial glycerin is purchased from the pharmacy. A universal testing machine (Z wick Rell) was used from type (BTI-FR2.5TN.D14), power-operating card (100-129 V / 4, 4-3,7A) at Polymer Research Center, Basrah University, Iraq. In addition, the digital device: Keithley Series 2400 Source Meter (England) was used.

Preparation of polymer blends

Polymer blends in this work were prepared by solution cast method by dissolving equal ratios of polyvinyl alcohol (PVA), starch (1:1) wt ratio in distilled water for 30 minutes, and stirred with high-speed mixer at a constant temperature 60 °C. Then, different ratios of glycerin 0, 25, 30, 35, and 40% wt were added. The mixture was stirred well for 25 minutes to guarantee the homogenous distribution of plasticizer in the polymer blends. All solutions were then cast onto glass Petri dishes and left to dry at room temperature. The dried films were kept in a desiccator filled with silica gel desiccants for further drying.

Preparation of doping polymer blends with Rhodamine-B

A mixture of polyvinyl alcohol (PVA) and starch (1:1) was dissolved in distilled water with 30 % wt of glycerin at 60 °C temperature for 30 minutes and stirred with high-speed mixture; this combination was mixed with different ratios of Rhoda mine-B 0, 1, 2, 3, 4, 5, and 6% wt. The mixture was stirred well for 25 minutes to guarantee the homogenous distribution dye in the polymer blends. All samples were cast on aluminum plates.

Characterization and measurements

Mechanical properties

Figure 2, shows the relationship between the stress at yield (yield strength is the stress at which a material begins to throw into disarray plastically). Preceding to the yield point the material will distort elastically and will restore to its primary shape when the used stress is removed. It is to be noted that the 30% wt glycerin ratio was the best in terms of tensile strength and elongation was 30.4%, whereas with young modulus it was 0.313Mpa. So, the ratio was chosen to be the main ratio of the polymer smoothing process and measurement of the electric substance. It could be observed that the starch/PVA blend with (30) % wt ratio of glycerin in the formulation presented higher tensile strength and elongation, compared to the other ratios. This behavior is due to the increase of the glycerin amount in the polymer blends, which results in increasing the mobility of the PVA and pluronicF-127 in the blends, and in the same time the increasing of hydrogen bonding between the series of polymer blends and make it stronger, Fig. 3 and 4 Show elongation and Young's modulus of polymer blends of starch/PVA with different ratios of glycerin. Figure 5 shows the mechanism of hydrogen bonding between PVA/starch blend with glycerin.

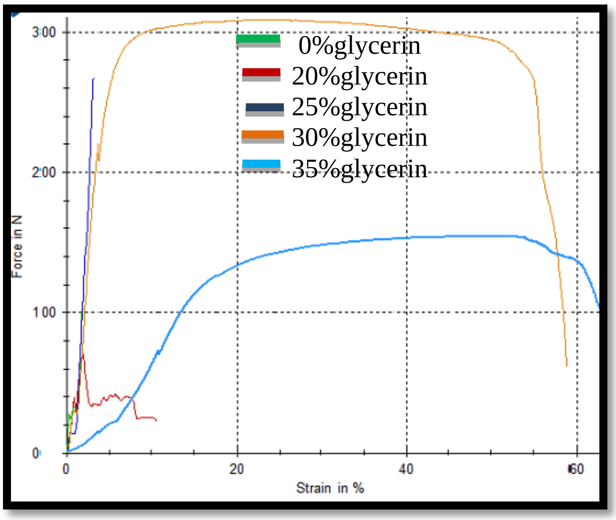

Figure 2. Stress-strain curves of polymer blends of starch/PVA with different ratio of glycerin.

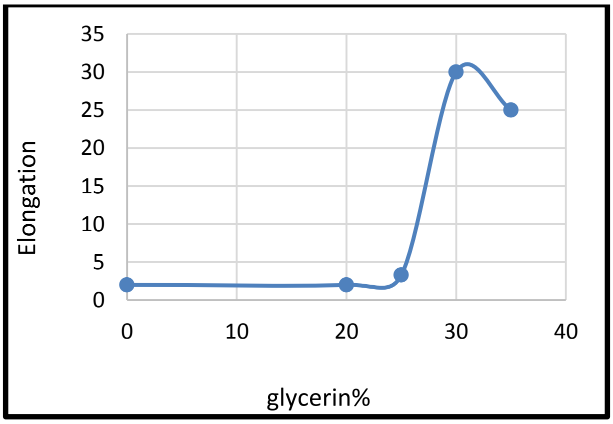

Figure 3. Elongation of polymer blends of starch/PVA with different ratio of glycerin.

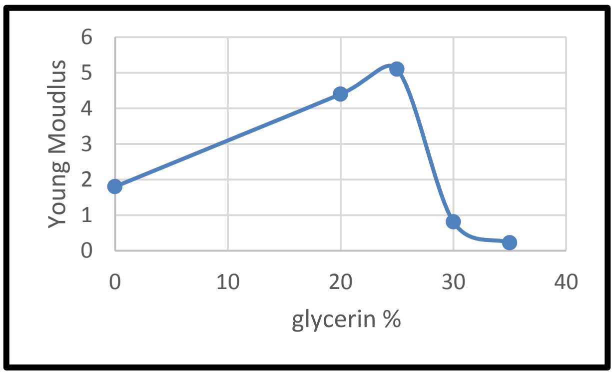

Figure 4. Young's modulus of polymer blends of starch/PVA with different ratio of glycerin.

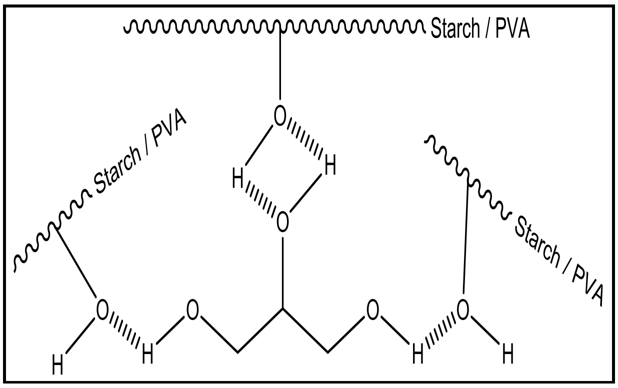

Figure 5. hydrogen bonding between PVA/starch blend and glycerin.

Electrical properties

Aluminum plates (TLC) are cut with equal dimensions (2cm×2cm). These plates are then cleaned using acetone as well as distilled water to obtain a degree of purity. The solution (the material to be measured) is deposited in the normal casting method (casting) and left to dry. Aluminum electrodes are deposited on top of the sediment. This method is called, a sandwich, and these poles are equal in diameter by 0.25mm, after which these models, which are ready to measure the electrical conductivity for the purpose of obtaining their electrical properties ratio is a consequence of the high cohesively of the polymeric blends.

Electrical Conductive polymer blends have shown : potential for use as a medium for electrical stimulation, which has shown: to be favorable in a lot of regenerative cure procedure including neural, and cardiac tissue engineering(11), evaluates the potential use of starch/PVA/glycerin/ Rhodamine-B films as a semiconducting material for tissue engineering applications. To determine the mechanism of conductivity in polymer blend membranes, the advantage of (current - voltages) should be studied. The current-voltage ratio of thin and thin film-encrusted polymers was calculated by 5% using the digital device: Keithley Series 2400 Source Meter and within the voltage range (1-20Volt) and temperature range (30-70°C) Electrical conductivity were also calculated according to the following law (12).

As:

$$\sigma = \frac{d}{A} x \frac{I}{V} \ldots$$

I: - Circuit current and measured (Ampere)
V: - The voltage of the circuit (Volt).
A - The area of the pole is measured (cm).
d: - thickness of the membrane (cm)

In our experimentation, electrical conductivity was studied as a function of the outright temperature as shown in Fig. 6. It is clear that the temperature increased from 1×10^{-6} to 1×10^{-5}. Figure 7 shows the conductivity of the 5% impregnated polymer, which is the best obtained, as the conductivity increases by increasing the temperature up to a maximum of 1×10^{-3}. This indicates the creation of secondary levels between the coupling and the valence package.

Figure 8 shows the conductivity of the polymer blend at 6% where the conductivity increases by increasing the temperature but less than 5% at the connection and the connection 1×10^{-4} begins to decline and stability at 2×10^{-5}. Generally, the electrical conductivity increases as a result of the doping polymer, due to the increase in the percentage of free electrons present, which depends on the mechanism of conduction (13). The reasons behind the increased is the setting temperature which increased the temperature, the electronic energy more active and that lead to filling the hole in state that generates pair(electrons-holes) (14).

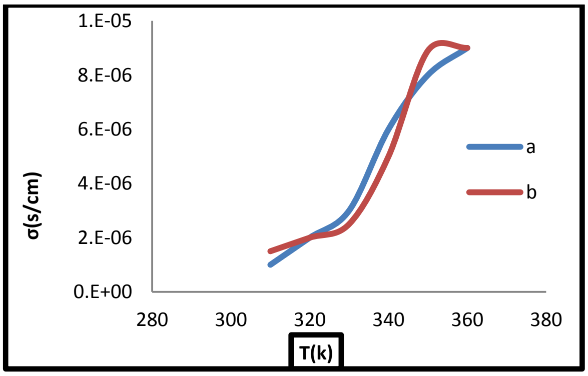

Figure 6. Electrical conductivity as a function of the temperature of a- polymer blend with 30%glycerin b-polymer blends of 30%glycerin and 1% of Rhodamine-B.

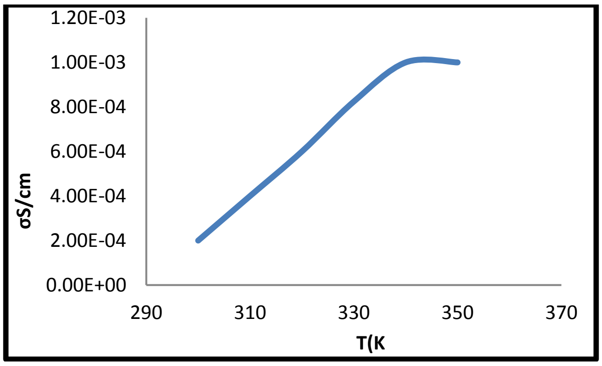

Figure 7. Electrical conductivity as a function of temperature polymer blends with 30%glycerin and 5% of Rhodamine-B.

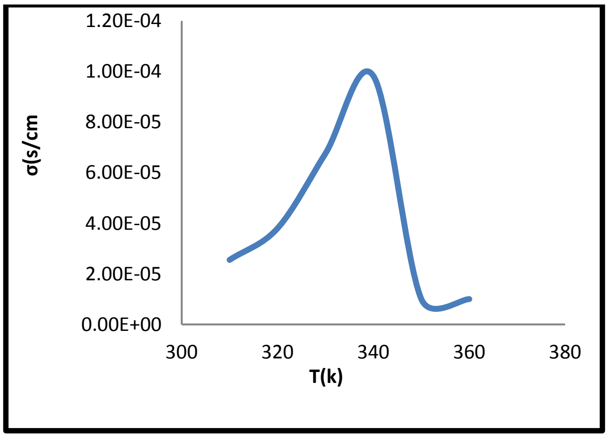

Figure 8. Electrical conductivity as a function of temperature polymer blends with 30%glycerin and 6% of Rhodamine-B.

Conclusion:

PVA and starch polymer blends with different percentages of glycerin 0, 20, 25, 30, 35, and 40% wt are prepared and the mechanical properties show that the best percentage of the used glycerin as plasticizer is 30%. The elongation ratio is about 30.4% and the young modulus is 0.313Mpa. The study of the electrical properties of the polymer blends doped with Rhodamine-B 0, 1, 2, 3, 4, 5, and 6% wt with a change in temperature shows the ratio of Rhodamine-B 5% wt to the polymer blends which is high conductive up to 1×10^{-3}. In general, the electrical conductivity increases with high temperature and this is similar to the behavior of semi-conductive polymers. Nevertheless, it can be possible to present well-soluble and conductive polymer blend membranes at the same time also, it is possible through manufacturing some devices connected to the important polymers in some important medical aspects in the field of nerve conduction which significantly decreases the pollution of the environment due to the nature of the non-biodegradable conductors in the environment which does not degrade with time.

Authors' declaration:

- Conflicts of Interest: None.
- We hereby confirm that all the Figures and Tables in the manuscript are mine ours. Besides, the Figures and images, which are not mine ours, have been given the permission for re-publication attached with the manuscript.
- Ethical Clearance: The project was approved by the local ethical committee in University of Basrah.

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الخواص الكهربائية خليط المحضر من (بولي فاينيل الكحول: نشأ) القابل للتحلل والمطعم بصبغة الرودامين B

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الخلاصة:
تم التركيز في هذا العمل على الخصائص للخليط (بولي فينيل الكحول مع النشا والكليسرين) والمشوب بصبغة الرودامين B. اذ تم استخدام طريقة الصب الاعتيادي للمحاليل المستخدمة. وهذه المحاليل تشمل بولي فاينيل الكحول والنشا بنسبة 1:1 وتم تشويب هذا الخليط بالكيلسرين وبنسب تشويب%(0,25,30,35,40) نسبة مئوية نسبية اذ اعطت النسبة أفضل نسبة مئوية 30% أفضل خواص ميكانيكية. وكذلك شوب الخليط (بولي فاينيل الكحول مع النشا وبنسب 1:1 مع نسبة 30% من الكليسرين) بصبغة الرودامين B وبنسب 0, 1, 2, 3, 4, 5, 6% , نسبة مئوية نسبية وتم اجراء القياسات الكهربائية لهذه النسب وكانت افضل نتيجة عند النسبة 5% حيث كانت اعلى توصيلية هي 1×10^{-3} . بصورر عامة يمكن القول ان التوصيلية تزداد بزيادة درجة الحرارة وهذا يشبه سلوك اشباه الموصلات.

الكلمات المفتاحية: البوليمرات المتحللة بايلوجيا، التوصيلية الكهربائية ،بولي فاينيل الكحول، النشا.