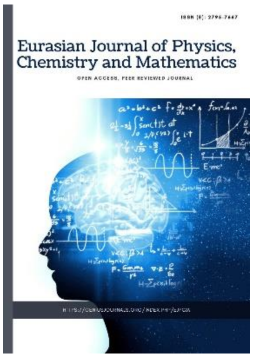

Preparation and Study of Some Mechanical Properties of Polymeric Films (PVA) Reinforced by $CdCl_2.H_2O$ Salt.

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ABSTRACT

In the present study, pure (PVA) polymer film and films reinforced with $CdCl_2.H_2O$ salt with various values of the weight ratio ((3,7,11, and 15) wt%) were prepared with the use of the solution casting method. where mechanical properties, such as hardness and impact were studied For all composites films. Where the effects of weight ratio of salt on hardness (Shore D) of composite films was studied (PVA-$CdCl_2.H_2O$), The experimental results showed that the hardness increased with increasing the weight percentage of salt $CdCl_2.H_2O$. The additional value reaches its peak at the weight ratio (7wt %) and subsequently declines as the weight ratio of added salt rises. The impact of salt weight ratio on fracture energy and impact resistance of PVA-$CdCl_2.H_2O$ composite films was investigated. It was discovered that raising the weight ratio of added $CdCl_2.H_2O$ salt increases the value of fracture energy and impact resistance. In comparison to pure polymeric (PVA) film, the effect of weight ratio of salt on the tensile properties represented by ultimate tensile strength (U.T.S) and young's modulus (Ym) has been studied, and the values of the tensile properties represented by ultimate tensile strength (U.T.S) and young's modulus (Ym) of all composite films (at most weight ratios of the reinforcement with $CdCl_2.H_2O$).

Keywords: Polyvinyl Alcohol (PVA), $CdCl_2.H_2O$ Salt , Hardness (Shore D), Fracture Energy , Impact Strength , Tenslie Strength

Introduction

Polymeric materials have become one of the most important achievements of the chemical industry, as they have entered into the details of the daily life of the individual and have replaced many traditional materials. Since World War II, countries have been racing to produce many types of industrial polymers as well as compounds prepared from them [1]. The total volume of polymers is increasing daily compared to metals and ceramics and is expanding at a faster rate with the increase in economic expansion, due to their distinctive characteristics, color fastness, transparency, electrical and thermal insulation properties, and corrosion resistance [2]. Many of the unusual technological applications and modern industries need materials that have a mixture of properties, as the need for alternative materials with multiple industrial uses has become, and these alternative materials must be characterized by high quality specifications and properties with low cost in economic terms, and therefore materials known as compound materials were produced. [3] Despite the use of overlapping materials since antiquity, they have become at the present time a very necessary material in many modern industrial applications. composite materials have made a qualitative leap and entered the field of industry in a way that is comparable to other materials such as metals and their alloys, due to the compound materials possessing high mechanical, electrical and optical properties that It is suitable for many industries [4].

Materials Used

1-Matrix Material

The matrix material that used in preparing the composite material is a polymer called polyvinyl alcohol (PVA), manufactured by a company (Central Drug House (P), Ltd). It has a (13,000g/mol) molecular weight and is in the form of white granules. It is odorless and non-toxic and it dissolves in distilled water only when heated to a temperature of (80 °C) or above, and it is slightly soluble in ethanol. Figure (1) shows the structural formula of polyvinyl alcohol [5].

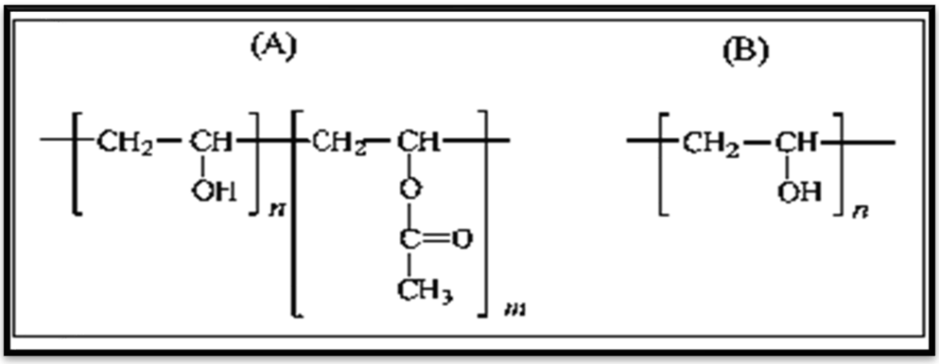


Figure
(1): Structural formula of polyvinyl alcohol [5].
A) Partial hydrolysis (B) Total hydrolysis

2- Reinforcement Material

Hydrated cadmium chloride

It is a chemical compound with the chemical formula $CdCl_2.H_2O$. It is in the form of white crystals and has a larger solubility in distilled water. It is a product of the Indian company (HIMEDIA) and its average molecular weight is (201.3 g/mol).

Preparation of Pure (PVA) Polymer Film and Reinforced Films with $CdCl_2.H_2O$ salt

Pure (PVA) polymer film, as well as films reinforced with $CdCl_2.H_2O$ salt have been prepared with the use of the casting approach through utilizing special molds that are made from the glass. The cleaning process was carried out for these molds to get rid of dust and dirt and put them on a moderate surface. For the objective of obtaining a homogenous solution, (1gm) of (PVA) polymer was mixed with (15ml) of distilled water using a magnetic stirrer for 1 hour at (80 °C). After that, the solution is poured into a particular glass mold, which is then placed on a moderate surface and allowed until the solvent evaporates, resulting in the appropriate sample film. Certain weight percentages of (PVA) polymer have been combined with certain weight ratios of $CdCl_2.H_2O$ salt to make films reinforced with $CdCl_2.H_2O$ salts. (3,7,11, and 15 (wt%)) and then we add distilled water to them in an amount of (15 ml) with the use of magnetic stirrer for a period of (1 h) at (80 °c) for the purpose of obtaining homogeneous solutions, and after that, solutions are poured in special glass molds that are placed upon moderate surface and left to the point where solvent is evaporated and we get required samples films.

Devices of Measurements

1-Hardness

A (D) Shore instrument (Check-line dd-100) of American origin was utilized to conduct the hardness test of the pure (PVA) polymer film and the films reinforced with $CdCl_2.H_2O$ salt.

2- Filling Darte Impact Tester

A Filling Darte Impact Tester of Canadian origin was used to conduct the impact resistance test of the pure (PVA) polymer film and the films reinforced with $CdCl_2.H_2O$ salt for plastic films and paper clips (FDI-01).

3 -Tinius Olsen

In order to perform the tensile test of the pure (PVA) polymer film and the films reinforced with $CdCl_2.H_2O$ salt, a device of the type (Tinius Olsen - H10K) of English origin was used.

Results and discussion

Hardness Test

The (Shore D) hardness test was performed on pure (PVA) polymer film and films reinforced with $CdCl_2.H_2O$ salt with a variety of weight ratios (3, 7, 11, and 15wt percent), as shown in Figure (2), where the hardness of the pure (PVA) polymer film is (52.5) and increases with an increase in the weight ratio of the added $CdCl_2.H_2O$ salt, reaching its highest value of (53.1) when the weight ratio (7wt %) of cementation with $CdCl_2.H_2O$ salt, After that, as the weight ratio of the new material increases, the hardness decreases $CdCl_2.H_2O$ salt, and this is as a result of high viscosity that the prepared compound acquires in the case of the addition of high weight percentages of reinforced materials ($CdCl_2.H_2O$ salt) to inside of the matrix material (Polymer (PVA)) in the liquid state, which causes difficulty in penetration of the $CdCl_2.H_2O$ salt into the interlayer space of the polymer (PVA) in prepared composite material, as it leads to the formation of numerous gaps inside prepared composite material when it solidifies, and that causes hardness decrease [6].Table (1) lists hardness values for all of the composite films.

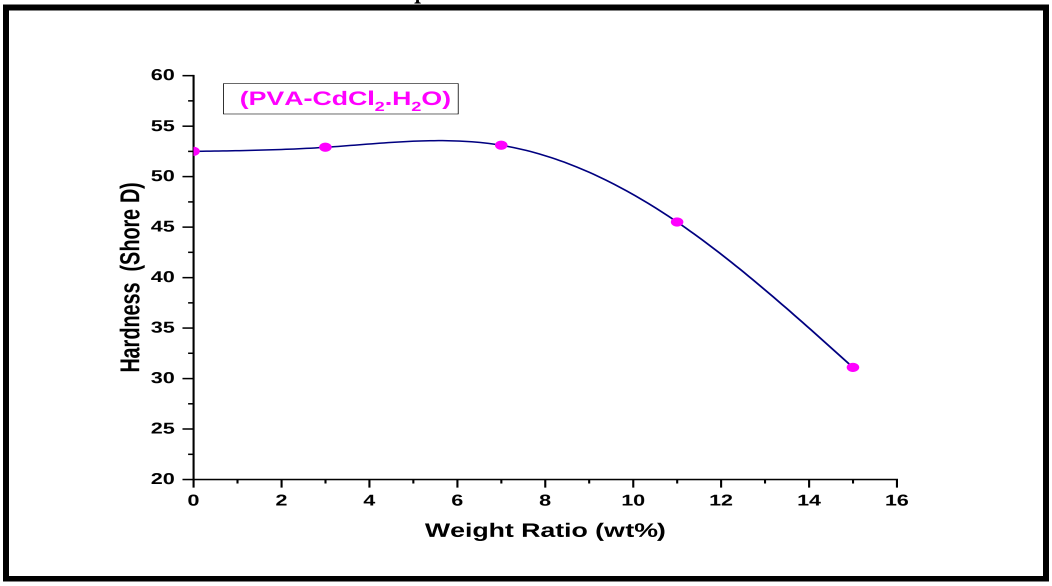


Figure (2): Hardness of the ($PVA-CdCl_2.H_2O$) composite films as function of the weight ratio of $CdCl_2.H_2O$ salt.

Table 1: Hardness value of ($PVA-CdCl_2.H_2O$) composite films with weight ratio of $CdCl_2.H_2O$ salt.

Weight Ratio (wt%) of Salt	($PVA-CdCl_2.H_2O$) Hardness
Pure (PVA)	52.5
3	52.7

7	**53.1**
11	**45.5**
15	**31.1**

Impact Test

The fracture energy and impact strength of pure (PVA) polymer films and films augmented with CdCl2 were calculated. Using the (falling body) method, H2O salt with various weight ratios (3,7, 11, and 15wt%), as shown in Figures (3) and (4), it can be noted from the two figures that the fracture energy value of the pure (PVA) polymer film equals (0.49 $Kg.m^2/sec^2$) and the impact resistance value of the pure (PVA) polymer film is (0.169 Kg/sec^2), when reinforced with $CdCl_2.H_2O$ the value increases both fracture energy and impact resistance with an increasing weight ratio of $CdCl_2.H_2O$ salt was added, In other words, the absorbed energy required for fracture and impact resistance increases in a linear connection as the weighted fracture increases, as shown in the two figures. The $CdCl_2.H_2O$ salt slows the growth of the fissure, which results in a change in the fissure's shape and orientation. This change in the geometry of the crack resulted in an increase in the surface area of the fracture and an increase in energy expenditure, all of which increased the material's resistance. That is, the addition of the $CdCl_2.H_2O$ salt to the pure (PVA) polymer improved the mechanical properties. The increased weight ratio of added $CdCl_2.H_2O$ is responsible for the increase in fracture energy and impact resistance. reduces a considerable portion of the impact energy given to the sample compared to $CdCl_2.H_2O$ salt. which boosts the material's resilience [7,8]. The fracture energy and impact resistance values for all composite films are shown in Table (2).

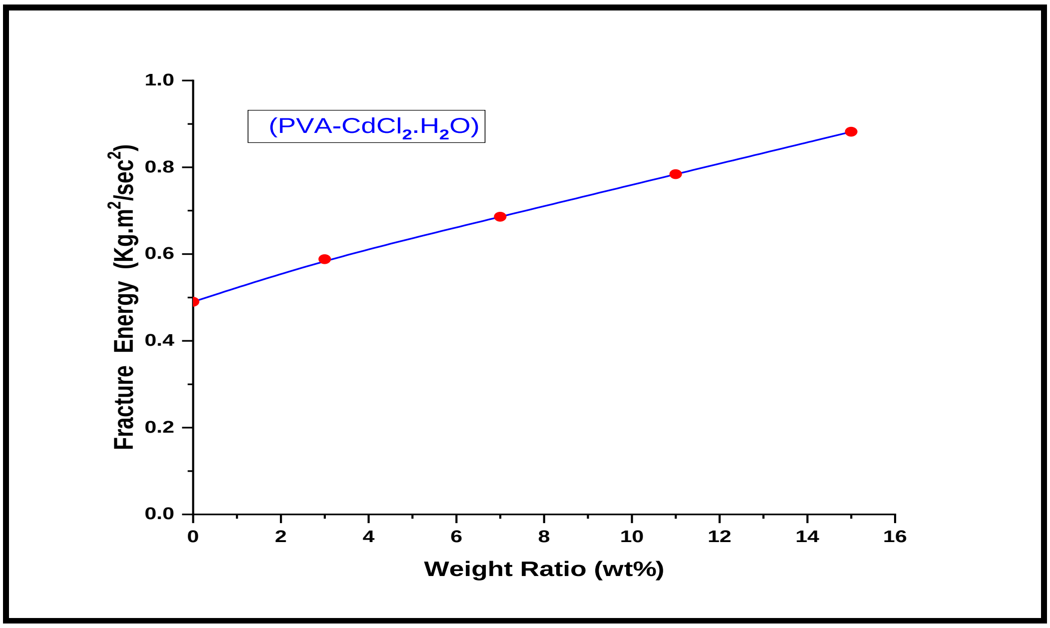


Figure (3): Fracture Energy of the ($PVA-CdCl_2.H_2O$) composite films as function of the weight ratio of $CdCl_2.H_2O$ salt.

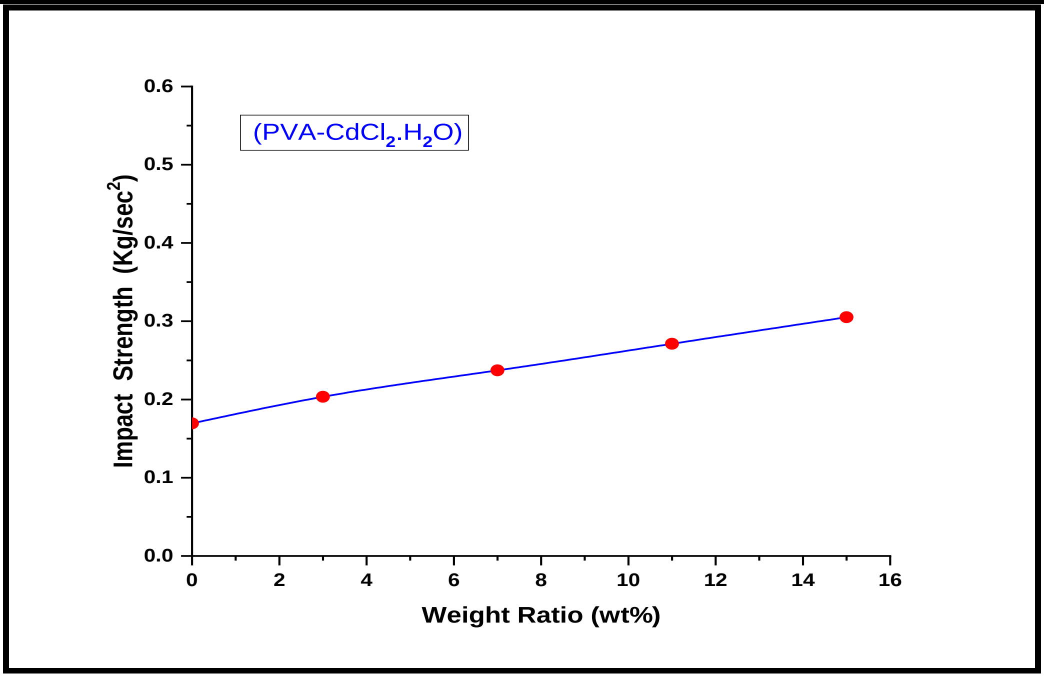


Figure (4): Impact Strength of the (PVA-$CdCl_2.H_2O$) composite films as function of the weight ratio of $CdCl_2.H_2O$ salt.

Table 2: Fracture Energy and Impact Strength values of (PVA-$CdCl_2.H_2O$) composite films with weight ratio of $CdCl_2.H_2O$ salt.

Weight Ratio (wt%) of Salt	(PVA-$CdCl_2.H_2O$) Fracture Energy ($Kg.m^2/sec^2$)	(PVA- $CdCl_2.H_2O$) Impact Strength (Kg/sec^2)
Pure (PVA)	0.49	0.169
3	0.588	0.203
7	0.686	0.237
11	0.784	0.271
15	0.882	0.305

Tensile Test

The pure (PVA) polymer film and the films reinforced with $CdCl_2.H_2O$ salt were both tensile tested, and (strain-stress) curves were obtained. Figure (5) shows the (stress) curve for the pure (PVA) polymer film with various weight ratios (3,7,11, and 15wt %), where we find that it consists of an elastic deformation region represented by linear correlation between the stress and the strain, and the elasticity modulus (also known as young's modulus) has been estimated from this region, This symbolizes the straight line slope, where the polymeric material experiences an elastic deformation within the borders of this region, As a result of the polymeric chains being stretched and elongated without the bonds being broken, Then this curve deviates from the linear behavior due to the generation of cracks within polymeric material. Those cracks grow and they aggregate with the increase of stress, forming larger cracks that continue to grow with the applied stress to the point where the fracture occurs in the sample [9]. In other cases, fracture starts on the outside at deformations or flaws such as scratches, notches, or internal fractures, which operate as stress concentration locations, causing an increase in the stress value to the point where the internal bonding strength is exceeded, and so the fracture occurs. The (strain - strain) curve changes when the reinforcement material ($CdCl_2.H_2O$ salt) is added to the base material (polymer ((PVA)), and we receive curves with variable properties depending on the added reinforcement type and its weight ratios, as can be seen from the two figures. (6) and (7). Table (3) lists values of the U.T.S and young's modulus (Y_m) for all if the composite films that were determined from (strain-strain) curves. As we note from the table, value of tensile strength of the pure (PVA) polymer film was (149MPa) and the value of the young's modulus was (3290MPa), but when reinforced with $CdCl_2.H_2O$ salt We notice that the maximum tensile strength value begins to decrease irregularly, while young's modulus value shows that it has increased at the weight ratio (3wt%) of cementing with $CdCl_2.H_2O$ salt reaches (4540 MPa), the value of young's modulus decreases with the increase weight ratio of $CdCl_2.H_2O$ salt additive. The decrease in the values of tensile properties represented by the ultimate tensile strength and Young's modulus of all composite films (at most weight ratios the reinforcement with $CdCl_2.H_2O$ salt in comparison with the pure polymer (PVA) membrane is due to weak interactions between molecules as well as lack of interfacial adhesion between components of composite, which leads to a reduction of tensile properties and brittleness of the compound [10]. Figures (8) and (9) show the behavior of tensile strength and young's modulus a function weight ratio of $CdCl_2.H_2O$ salt, respectively.

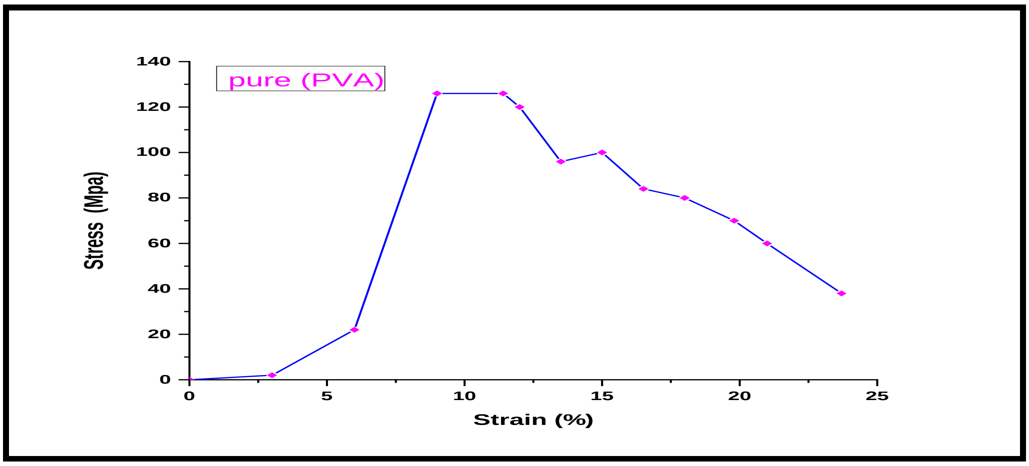
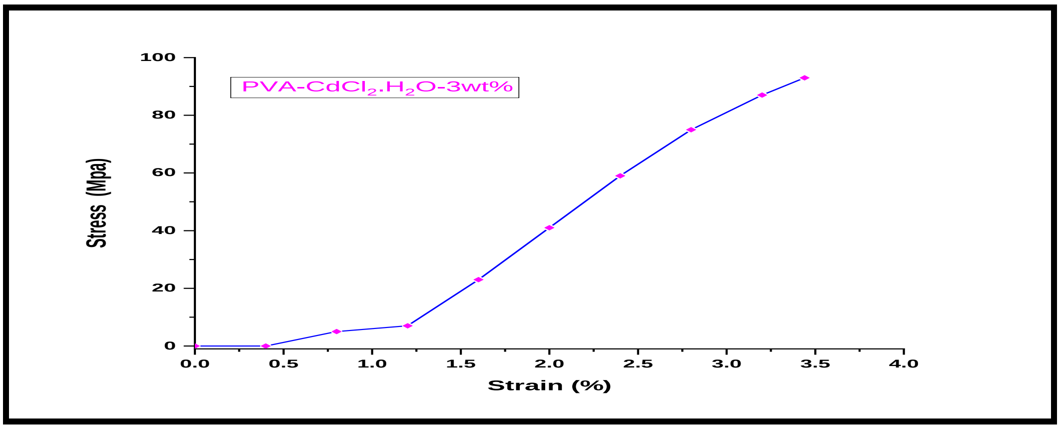


Figure (5): Curve (stress-strain) of a pure PVA polymer film



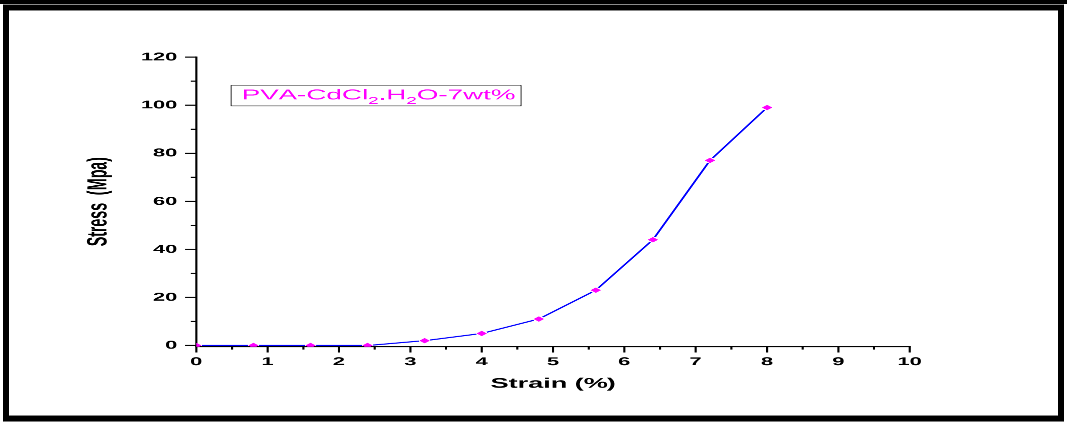


Figure (6) : (stress-strain) curve of the (PVA-CdCl$_2$.H$_2$O) composite films by weight ratios (3,7) of CaCl$_2$.2H$_2$O salt.

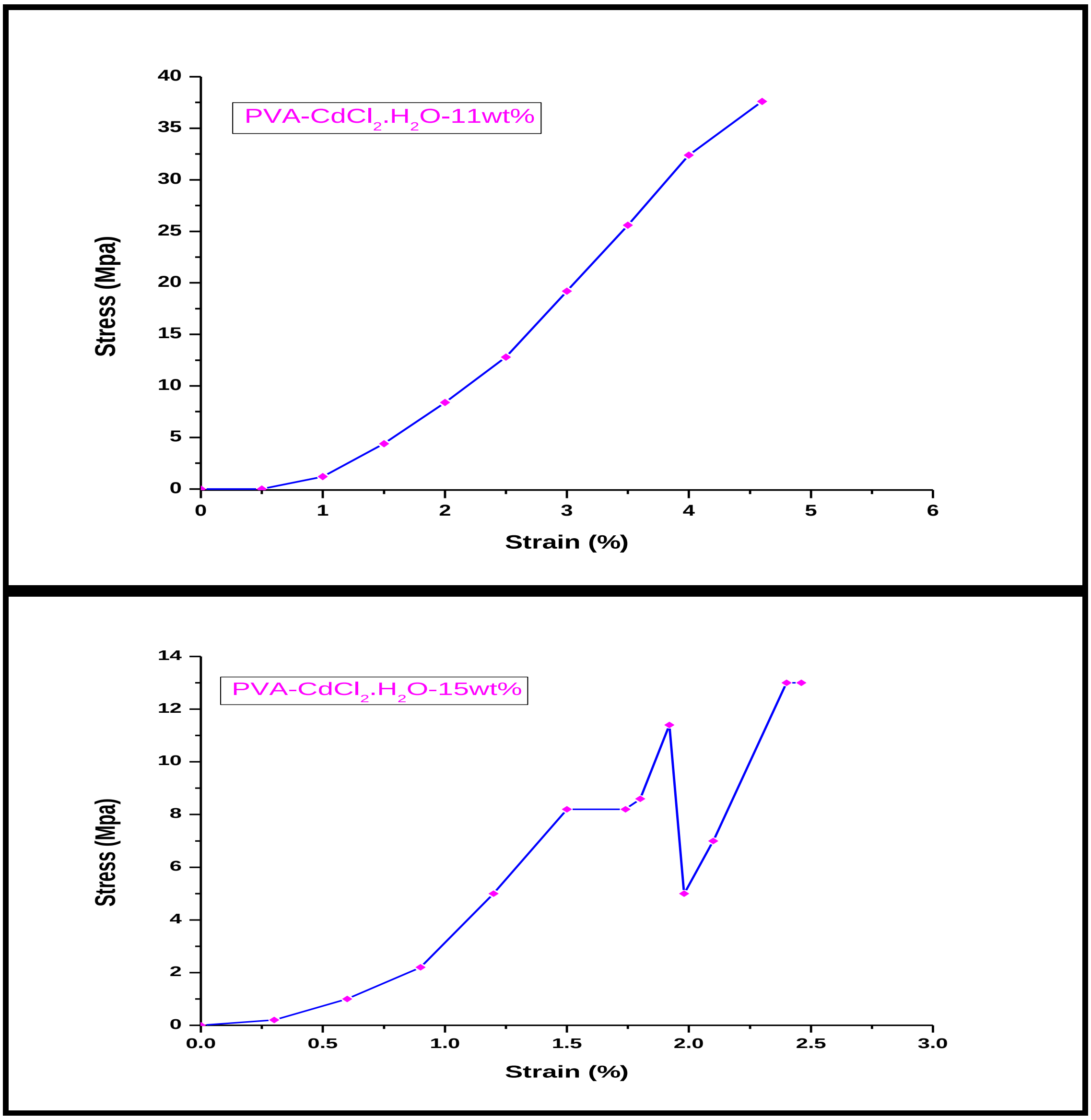


Figure (7) : (stress-strain) curve of (PVA-CdCl$_2$.H$_2$O) composite films by weight ratios (11,15) of CaCl$_2$.2H$_2$O salt.

Table (3): Ultimate tensile strength value and Young's modulus of the ($PVA-CdCl_2.H_2O$) composite film with weight ratio of $CdCl_2.H_2O$ salt.

Weight Ratio (wt%) of Salt	($PVA-CdCl_2.H_2O$) Ultimate Tenslie Strength (U.T.S) (MPa)	($PVA-CdCl_2.H_2O$) Young's Modulus (Y_m) (MPa)
Pure (PVA)	149	3290
3	93.4	4540
7	98.7	1350
11	37.7	861
15	13.3	609

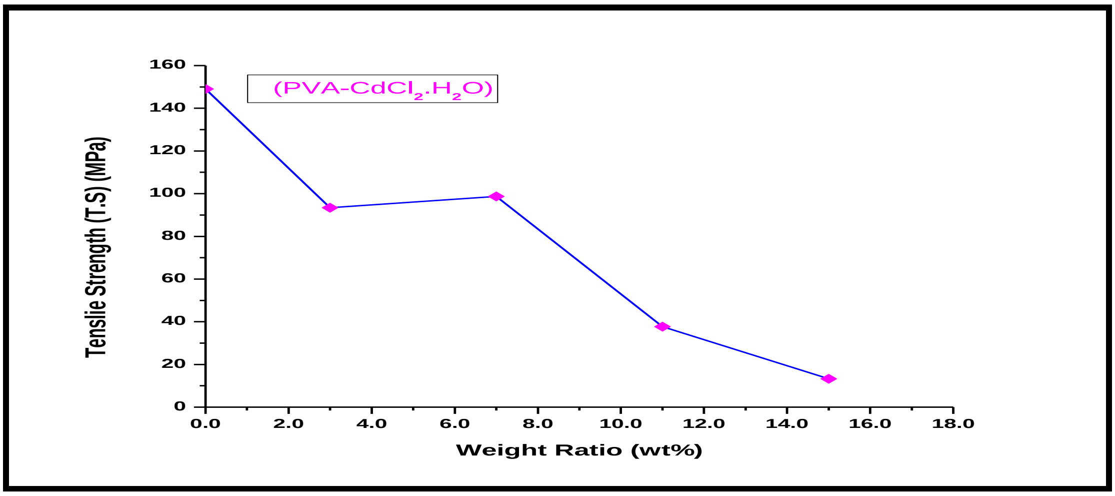


Figure (8): Ultimate Tensile Strength of the ($PVA-CdCl_2.H_2O$) composite films as weight ratio function of $CdCl_2.H_2O$ salt.

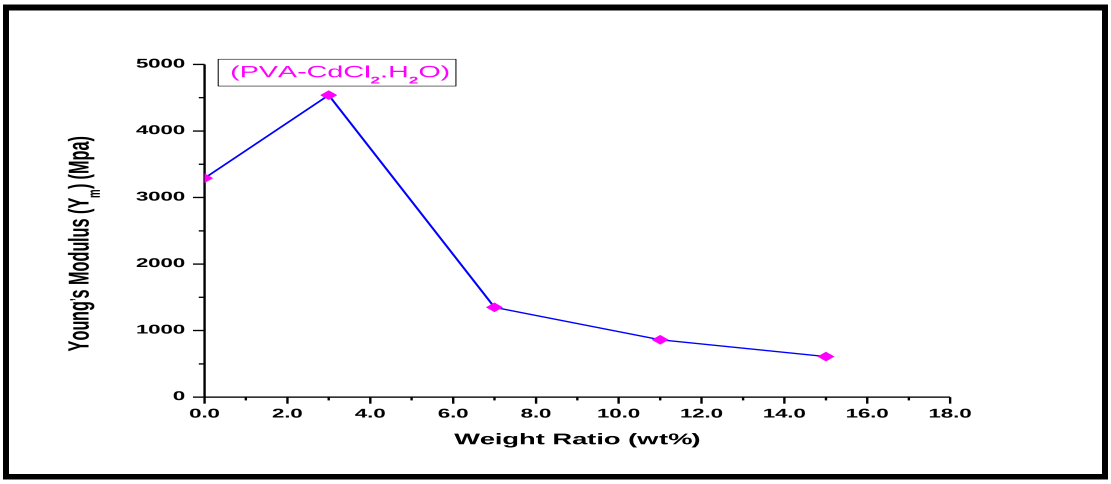


Figure (9): Young's modulus of the ($PVA-CdCl_2.H_2O$) composite films as function of the weight ratio of $CdCl_2.H_2O$ salt.

Conclusions

Following research and testing on pure (PVA) polymer films and films reinforced with $CdCl_2.H_2O$ salt at various weight ratios ((3, 7, 11, and 15) wt %), Where as the hardness (Shore D) improves with increasing weight ratio of additional $CdCl_2.H_2O$ salt until it reaches its maximum value at weight ratio (7wt%), it subsequently declines as the weight ratio of added salt increases. The impact values of fracture energy and impact resistance increased as the weight ratio of added $CdCl_2.H_2O$ salt increased. For all composite films (at most weight ratios of the reinforcement with $CdCl_2.H_2O$ salt), the values of the tensile qualities represented by the U.T.S and the young's modulus ((Ym) decreased in comparison.

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