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Some Of The Optical, Thermal, Mechanical And Electrical Properties Of (PVA-$Mgcl_2.6H_2O$-$Crcl_3.6H_2O$) Films

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Abstract

The casting method was used to create pure and reinforced Polyvinyl Alcohol (PVA) polymer films with various weight ratios ((3,7,11,15) wt%)).Pure (PVA) films reinforced with chromium chloride salt ($CrCl_3.6H_2O$) and magnesium chloride salt ($MgCl_2.6H_2O$) salt were examined for optical, thermal, mechanical, and electrical (insulating) properties.

The effect of the weight ratio of ($CrCl_3.6H_2O$, $MgCl_2.6H_2O$) salts on the optical energy gap of pure (PVA) film was explored by recording transmittance and absorbance spectra in the range of (190-1100 nm).It was discovered that as the weight ratio of ($CrCl_3.6H_2O$, $MgCl_2.6H_2O$) salts grows, the optical energy gap reduces, indicating that the electronic transitions are indirect.The mechanical properties of pure (PVA) film were investigated in relation to the weight ratio of ($CrCl_3.6H_2O$, $MgCl_2.6H_2O$) salts. The hardness value of the pure (PVA) film increases as the weight ratio of the two additional salts increases, according to the hardness test.Furthermore, when investigating the influence of salt reinforcement on the thermal characteristics of pure (PVA) film, it was discovered that when the weight ratio of the two additional salts increases, the thermal conductivity coefficient of the pure (PVA) film increases and then decreases erratically.The dielectric constant test showed that as the weight ratio of ($CrCl_3.6H_2O$, $MgCl_2.6H_2O$) salts increases, the value of the dielectric constant of pure (PVA) film at the same frequency increases.

Keywords: Polyvinyl Alcohol (PVA) , ($CrCl_3.6H_2O$) salt , ($MgCl_2.6H_2O$) salt , Composites ,Optical Properties , Thermal Properties , Mechanical Properties ,Electrical Properties.

Introduction

Polymers are gaining popularity as a result of their diverse variety of applications. Combining other polymers or inorganic components with polymers is a good way to improve the material's performance and create new composite systems that surpass the original blend [1].Polyvinyl Alcohol (PVA-[-CH_2-CHOH-]n-) is the world's most widely used synthetic polymer, due to its remarkable chemical resistance, physical characteristicsand total biodegradability [2].(PVA) has a carbon chain backbone with hydroxyl groups that can act as a hydrogen bonding source to aid in the formation of polymer complexes [3].Inorganic substances can interact with the hydroxyl group of (PVA). Several types of inorganic metal salts have recently been utilized as fillers in (PVA) films, and these metal salts have had a significant impact on (PVA) film mechanical properties [4].Various inorganic fillers can greatly increase the mechanical, thermal, optical, electrical, and other properties of polymers [5]. Fillers are often used in the plastics industry to achieve the same levels of performance as much more expensive engineering plastics at a cheaper cost, as well as to facilitate surface bonding by allowing a polymer to quickly wet the filler's surface[6].In this study, we investigated the fabrication of (PVA) films reinforced with various weight ratios of($CrCl_3.6H_2O$, $MgCl_2.6H_2O$) (pure,3 wt%, 7 wt%, 11 wt% and 15 wt%). Novel film properties in terms of optical, thermal, mechanical, and electrical properties are crucial for their development.

Materials and Methods

Central Drug House (P) Ltd., New Delhi, India, provided polyvinyl alcohol (PVA) polymer powder with a molecular weight of 13000 g/mol and an (87-89)% degree of hydrolysis. It isclear, white, odorless, harmless, and soluble in distilled water.

(THOMAS BAKER) supplied magnesium chloride, ($MgCl_2.6H_2O$) salt in the form of white crystal powder soluble in distilled water with a molecular weight of 203.30 g/mol.and Chromium Chloride ($CrCl_3.6H_2O$) salt (molecular weight 266.45 g/mol, green powder soluble in distilled water) was obtained from (Central Drug House (P) Ltd., New Delhi, India).
Thermal films had a thickness of (40-140) µm, optical films had a thickness of (400.05) µm, and mechanical and electrical films had a thickness of (1450) µm, all of which were measured with a digital micrometer at room temperature.

At (80°C), the pure (PVA) polymer and ($CrCl_3.6H_2O$, $MgCl_2.6H_2O$) salts were totally dissolved in distilled water at (80°C) for 1 hour with a magnetic stirrer in various weight ratios(3, 7, 11 and 15) wt.%.. After that, the solution is poured into glass plates and leftto cure for (24 hours) to eliminate any remaining solvents.

The absorbance and transmittance in the wavelength range (190-1100) nm were measured using a Shimadzu UV/VIS-160 twin beam spectrophotometer. The Lee's Disc method for evaluating the thermal conductivity of insulating materials was used to get the thermal conductivity coefficient (k) (Griffin & George Ltd.).The device type (Shore D) was used to test the hardness (Check-line-dd-100). A device (LCR Metter) of the type was used to perform the electrical (dielectric) test indicated by the dielectric constant (ε') as a function of frequency (LCR-8105G).

Results and Discussion

Optical properties

The energy gap of the permissible indirect transfer has been calculated by drawing the relationship between $(\alpha hv)^{1/2}$ and the photon energy ((hv) for the pure (PVA) polymer films reinforced with salt ($CrCl_3.6H_2O$, $MgCl_2.6H_2O$) with different weight ratiosWe extend the tangent line to intersect the photon energy axis (x-axis) at the point $(\alpha hv)^{1/2}=0$, which represents the energy gap value of the permissible indirect transmission as shown in the figures, by extending it from the best straight line through which most of the points pass after the absorption edge The energy gap value of the pure polymer (PVA) film is (5.753eV), but after reinforcement with salt ($CrCl_3.6H_2O$, $MgCl_2.6H_2O$) with different weight ratios, the energy gap value starts to decrease slightly as the weight percentage of salt ($CrCl_3.6H_2O$, $MgCl_{2,}$ $6H_2O$) additivesincreases. The reason lying behind such decrease in the value of the energy gap with an increase in the weight ratios of salts ($CrCl_3.6H_2O$, $MgCl_2.6H_2O$) added is attributed to the formation of local levels in the energy gap that facilitate the passage of the electron from the valence bundle to the local levels in the conduction bundle (this means the electron conduction depends on the reinforced materials) [7]. Table 1 represents the energy gap values, and Figure 1 represents the permissible indirect transmission values.

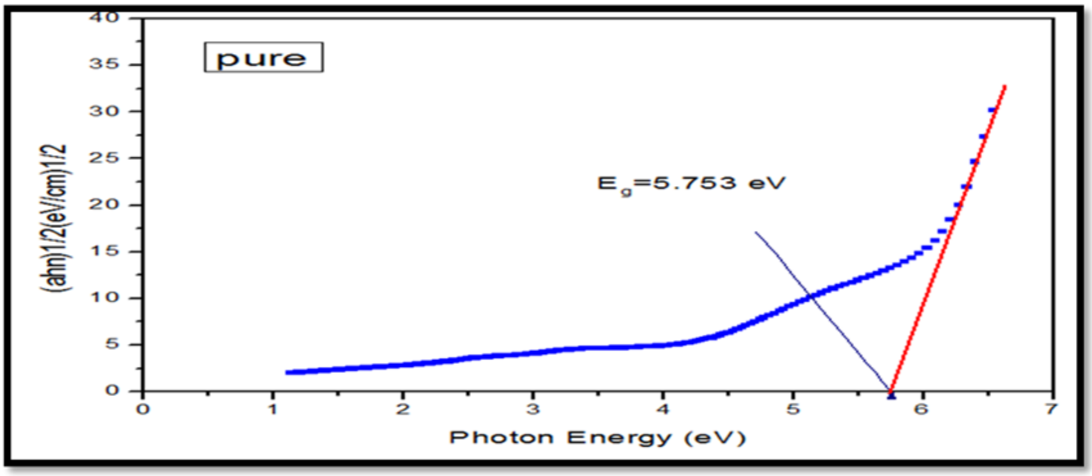
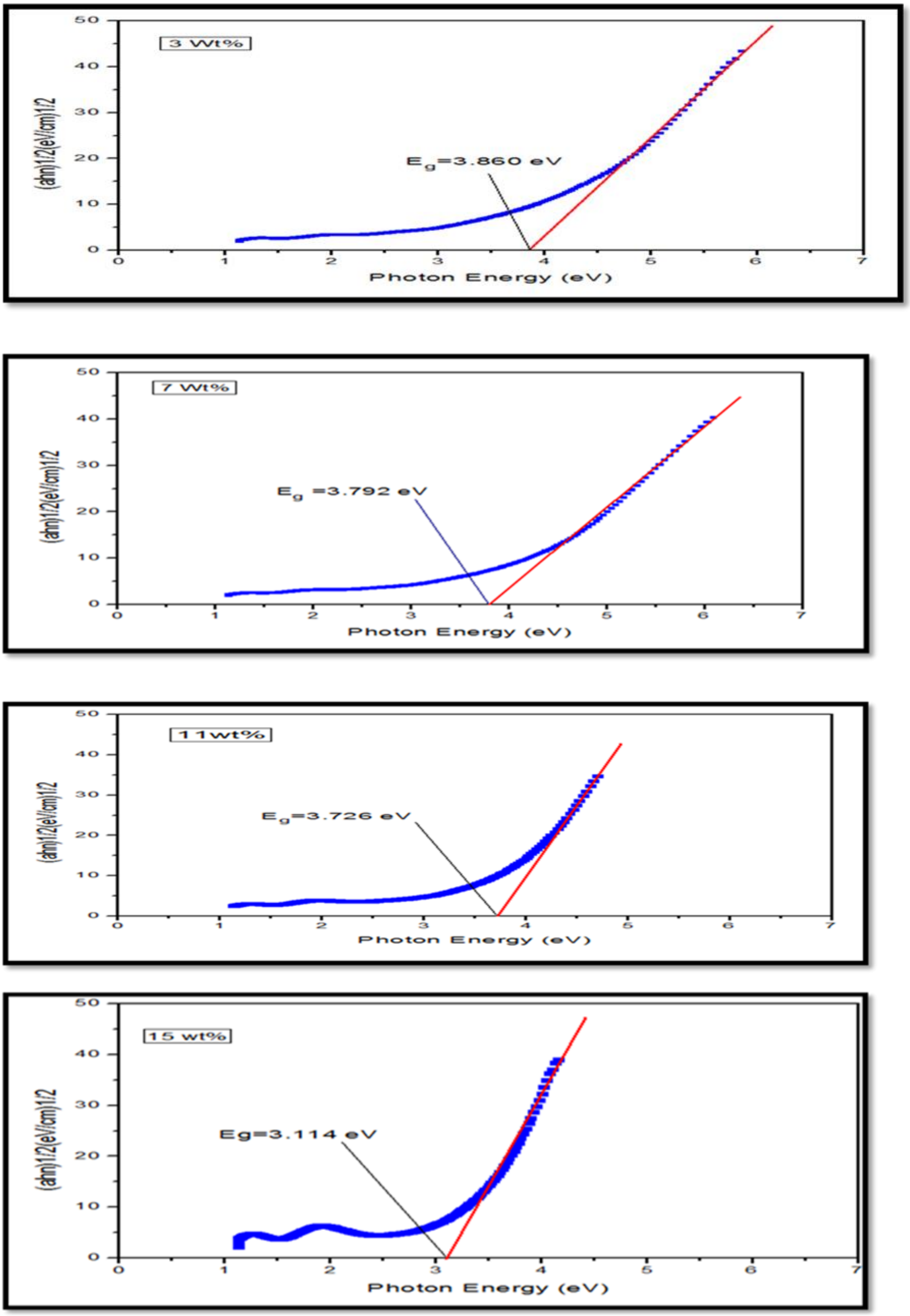


Figure (1): Shows the Energy gap value of the Permissible Indirect Transmission of the pure (PVA) polymer films.



Figure(2):Energy gap Value of the Permissible Indirect Transmission of the Composites films ($PVA-MgCl_2.6H_2O-CrCl_3.6H_2O$) with the weight Ratios (3,7,11,15) of the Salt ($CrCl_3.6H_2O$, $MgCl_2.6H_2O$).

Table (1):Energy gap value of the Permissible Indirect Transmission of the Composites films ($PVA-MgCl_2.6H_2O-CrCl_3.6H_2O$) with the weight Ratios of the Salt ($CrCl_3.6H_2O$, $MgCl_2.6H_2O$).

Weight Ratio (wt%) of Salts	**($PVA-MgCl_2.6H_2O-CrCl_3.6H_2O$)** **E_g (eV)**
Pure (PVA)	**5.753**
3	**3.860**
7	**3.792**
11	**3.726**
15	**3.114**

Thermal properties

Thermal Conductivity Coefficient

(Lee's Disc Method) was used to obtain the thermal conductivity coefficient (k). Figure (3) depictsthe thermal conductivity coefficient of pure PVA films reinforced with salt ($CrCl_3.6H_2O$, $MgCl_2.6H_2O$) at various weight ratios; as shown in the figure,the value of the thermal conductivity coefficient of the pure PVA film is (0.023 W/m.K). And when reinforced with salt ($CrCl_3.6H_2O$, $MgCl_2.6H_2O$), the value of the thermal conductivity coefficient changes and begins to increase irregularly as the weight ratios of salt ($CrCl_3.6H_2O$, $MgCl_2.6H_2O$) added increase, eventually reaching its highest value of (0.139 W/m.K) at the weight ratios (11wt%) of the reinforcement. In general, the procedure of salt reinforcement (CrCl3.6H2O, MgCl2.6H2O) increased the value of the thermal conductivity coefficient of the pure (PVA) polymer film at all weight ratios. The thermal conductivity coefficient is unstable due to the heterogeneity between the base material (polymer (PVA)) and the reinforcement materials (salt $CrCl_3.6H_2O$, $MgCl_2.6H_2O$)) as well as the widesurface area of the salty ($CrCl_3.6H_2O$, $MgCl_2.6H_2O$) [8]. The thermal conductivity coefficient values for all the composite filmsare listed in Table 2.

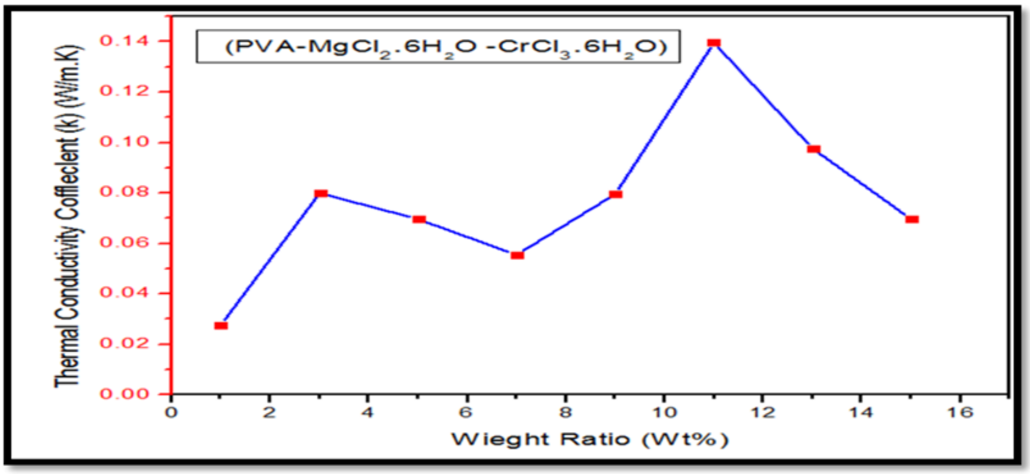


Figure (3): shows the Values of the Thermal Conductivity Coefficient of the Composite films ($PVA-MgCl_2.6H_2O-CrCl_3.6H_2O$,) with the Weight Ratio of the Salt ($CrCl_3.6H_2O$, $MgCl_2.6H_2O$).

Table (2):Values of the Thermal Conductivity Coefficient of the Composite films ($PVA-MgCl_2.6H_2O-CrCl_3.6H_2O$,) with the Weight Ratios of the Salt ($CrCl_3.6H_2O$, $MgCl_2.6H_2O$).

Weight Ratio (wt%) of Salts	($PVA- MgCl_2.6H_2O-CrCl_3.6H_2O$) k (W/m.K)
Pure (PVA)	0.023
3	0.080
7	0.055
11	0.139
15	0.069

Mechanical properties

Hardness Test

The (Shore D) hardness test was performed onpure PVA films reinforced with salt ($CrCl_3.6H_2O$, $MgCl_2.6H_2O$) atdifferent weight ratios (3,7,11,15 wt%)), as shown in Figure (4). It is clear from the figure that the hardness value of the pure polymer film (PVA) increases with the increase in weight ratio of the added salt ($CrCl_3.6H_2O$, $MgCl_2.6H_2O$). The concept of hardness can be thought of as a measurement of the amount of plastic deformation that a material can undergo when subjected to external stress.As a result of adding the reinforced material to the base material, the material's hardness rises, as does its resistance to plastic deformation [9]. Furthermore,the penetration of the reinforcing material into the base material and into the interspaces andgaps increases the contact area, resulting in the formation of a link between the base and reinforcement materials, which strengthened the composites and increased their hardness [10]. Table (3) shows the hardness values for all the composite films.

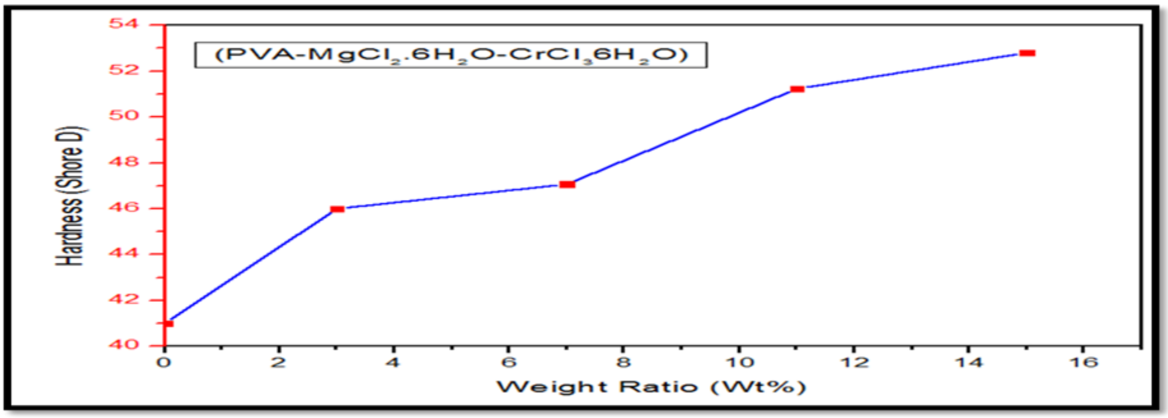


Figure (4): The hardness of the Composite films ($PVA-MgCl_2.6H_2O-CrCl_3.6H_2O$) as a Function of the Weight Ratio of the Salt ($CrCl_3.6H_2O$, $MgCl_2.6H_2O$).

Table (3): The Hardness Values of the Composite films ($PVA-MgCl_2.6H_2O-CrCl_3.6H_2O$) with the Weight Ratio of the Salt ($CrCl_3.6H_2O$, $MgCl_2.6H_2O$).

Weight Ratio (wt%) of Salts	**($PVA-MgCl_2.6H_2O-CrCl_3.6H_2O$) Hardness**
Pure (PVA)	**41**
3	**46**
7	**47.07**
11	**51.23**
15	**52.80**

Electrical (Insulation) Tests

Dielectric constant

At room temperature and within the frequency range, the dielectric constant of pure (PVA) polymer films supplemented with salt (CrCl3.6H2O, MgCl2.6H2O) with varied weight ratios has been computed (50Hz-5MHz). For all composite films, the dielectric constant drops as the frequency increases, as seen in Figure (5).We also noticed that at low frequencies, all of the composite films had high dielectric constant values, and that as the frequency increases, the dielectric constant values fall, which can be read as being in the low frequency area.The time period is sufficient for the dipoles to arrange and align the molecules along the direction of the electric current flowing between the two poles [11]. The high dielectric constant values at low frequencies are owing to the distinct phases of the base and supporting materials, which cause interpolarization, as well as the polarity of the electrodes, which causes polarization.The composition of the sample charge between the two poles has a close relationship, and this is dependent on the sample's composition as well as the distances and impurities contained inside the sample. We can also see in the figure that the dielectric constant at the same frequency increases as the weight ratio of the additional salt ($CrCl_3.6H_2O$, $MgCl_2.6H_2O$), increases, and that this increase in the value of the dielectric constant is due to polarity [12].

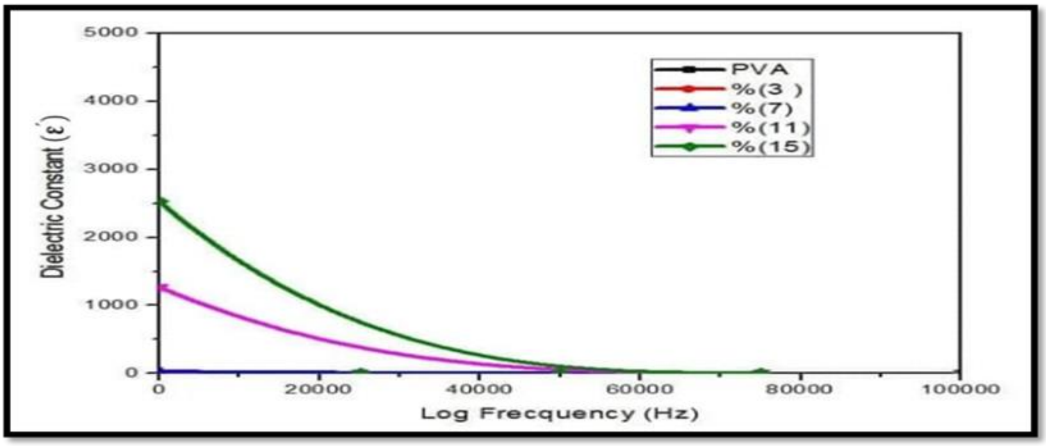


Figure (5): The Dielectric Constant as a Function of Frequency for a pure (PVA) polymer film reinforced by Weight Ratios (3, 7, 11, 15) wt%) of Salt ($CrCl_3.6H_2O$, $MgCl_2.6H_2O$).

Conclusions

Optical Tests:

With the increase in the weight ratio of the added $CrCl_3.6H_2O$, $MgCl_2.6H_2O$ salts, the energy gap value of the allowable indirect electronic transition of the composites films (PVA-$MgCl_2.6H_2O$-$CrCl_3.6H_2O$) reduced, indicating that the created films can serve as an excellent UV shield.

Thermal Tests:

The thermal conductivity coefficient of the composite films (PVA-$MgCl_2.6H_2OCrCl_3.6H_2O$) begins to increase irregularly with the increase in weight ratio of the added salts ($CrCl_3.6H_2O$, $MgCl_2.6H_2O$), andbecause the thermal conductivity coefficient of all composite films is relatively low, they can be used as a heat insulation barrier.

Mechanical Tests:

The hardness value of the pure (PVA) polymer film increases with the increase in weight ratio of salt ($CrCl_3.6H_2O$, $MgCl_2.6H_2O$) added.

Electrical (Insulation) Tests:

Because the dielectric constant of the composite films (PVA-$MgCl_2.6H_2OCrCl3.6H_2O$) falls with increasing frequency and increases with increasing the weight ratio of the salts ($CrCl_3.6H_2O$, $MgCl_2.6H_2O$) added at the same frequency, these produced films can be used to make electric batteries.

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