

Preparation and Study of Some Properties, Apparent Porosity, True Density and Water Absorption of Polymeric Films (PVA) Reinforced by $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ Salt.

Akraam M. Saba, Sabah A. Salman and Rana S. Mahmood

Preparation and Study of Some Properties, Apparent Porosity, True Density and Water Absorption of Polymeric Films (PVA) Reinforced by $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ Salt.

Akraam M. Sabar*, Sabah A. Salman and Rana S. Mahmood

Department of Physics – College of Science – University of Diyala

akraammahdi65@gmail.com

Received: 11 June 2022

Accepted: 3 July 2022

DOI: <https://dx.doi.org/10.24237/djps.1804.606C>

Abstract

In the present study, pure (PVA) polymer film and films reinforced with $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ salt with various values of the weight ratio ((3,7,11, and 15) wt%) were prepared with use of the solution casting method. The effects of the salt weight ratio upon apparent porosity of composite films (PVA- $\text{CdCl}_2 \cdot \text{H}_2\text{O}$) was investigated, and the practical results revealed that the apparent porosity decreases when $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ salt's weight ratio increases. The effects of weight ratio of salt on true density of films of the composite (PVA- $\text{CdCl}_2 \cdot \text{H}_2\text{O}$) was studied, and it was found that the true density increases with the increase in weight ratio of added $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ salt. The effect of weight ratio of salt on the water absorbance of the composite films (PVA- $\text{CdCl}_2 \cdot \text{H}_2\text{O}$) was also the result, and the experimental results showed that the water absorbance decreases with increasing weight ratio of the added $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ salt. The aim of the study is to the possibility of improving some of the physical properties of the polymer polyvinyl alcohol (PVA) by adding cadmium chloride salt in different weight ratios ((3,7,11, and 15) wt%) by preparing films by the method of pouring the solution.

Keyword: Polyvinyl Alcohol (PVA), $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ Salt, Apparent Porosity, True Density, Water Absorption.

Preparation and Study of Some Properties, Apparent Porosity, True Density and Water Absorption of Polymeric Films (PVA) Reinforced by $CdCl_2.H_2O$ Salt.

Akraam M. Saba, Sabah A. Salman and Rana S. Mahmood

تحضير ودراسة بعض الخصائص المسامية الظاهرية والكثافة الحقيقية والامتصاصية المائية لغشاء

بوليمر (PVA) النقي والاعشوية المدعمة بملح $CdCl_2.H_2O$

أكرام مهدي صبار، صباح أنور سلمان ورناسعد محمود

جامعة ديالى - كلية العلوم - قسم الفيزياء

الخلاصة

في هذه الدراسة تم تحضير غشاء بوليمر (PVA) النقي والاعشوية المدعمة بملح $CdCl_2.H_2O$ بنسب وزنية مختلفة ((3,7,11,15) wt%) باستخدام طريقة صب المحلول. تم دراسة تأثير النسبة الوزنية للملح على المسامية الظاهرية للأغشية المترابك (PVA- $CdCl_2.H_2O$)، وبينت النتائج العملية أن المسامية الظاهرية تقل كلما زادت النسبة الوزنية لملح $CdCl_2.H_2O$ المضاف وتمت دراسة تأثير النسبة الوزنية للملح على الكثافة الحقيقية لأغشية المترابك (PVA- $CdCl_2.H_2O$) ووجد أن الكثافة الحقيقية تزداد بزيادة النسبة الوزنية لملح $CdCl_2.H_2O$ المضاف. كما تمت دراسة تأثير النسبة الوزنية للملح على الامتصاصية المائية للأغشية المترابك (PVA- $CdCl_2.H_2O$)، وأظهرت النتائج التجريبية أن الامتصاصية المائية تقل مع زيادة النسبة الوزنية لملح $CdCl_2.H_2O$ المضاف.

الكلمات المفتاحية: بولي فاينيل الكحول (PVA)، ملح $CdCl_2.H_2O$ ، المسامية الظاهرية، الكثافة الحقيقية، الامتصاصية المائية.

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].

Preparation and Study of Some Properties, Apparent Porosity, True Density and Water Absorption of Polymeric Films (PVA) Reinforced by $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ Salt.

Akraam M. Saba, Sabah A. Salman and Rana S. Mahmood

Due to the demand for alternative materials with numerous industrial uses and the requirement for materials that have a variety of qualities, materials known as compound materials were created. Compound materials are defined by high quality specifications and properties at low cost in economic terms. [3] Although overlapping materials have been used since antiquity, they are now a crucial component in many contemporary industrial applications. Due to the compound materials' strong mechanical, electrical, and optical qualities, they have made a qualitative leap and entered the realm of industry in a way that is equivalent to other materials like metals and their alloys [4].

Materials Used

Matrix Material

The matrix material that used in preparing the composite film 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].

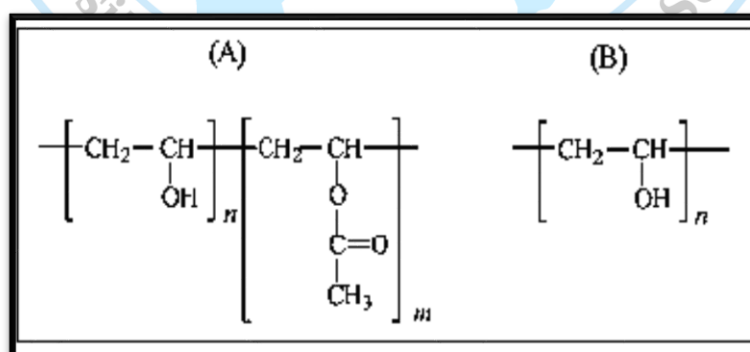


Figure 1: Structural formula of polyvinyl alcohol [5]. A) Partial hydrolysis (B) Total hydrolysis

Preparation and Study of Some Properties, Apparent Porosity, True Density and Water Absorption of Polymeric Films (PVA) Reinforced by $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ Salt.

Akraam M. Saba, Sabah A. Salman and Rana S. Mahmood

Reinforcement Material

Hydrated cadmium chloride

It is a chemical compound with the chemical formula write the purity of all material. 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 $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ Salt

Pure (PVA) polymer film, as well as films reinforced with $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ 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. Pure (PVA) polymer film was prepared by mixing (1gm) of (PVA) polymer with (15ml) of distilled water using magnetic stirrer for a period of (1h) at temperature of (80 °C) for the purpose of obtaining homogeneous solution. After that, the solution has been poured into a special glass mold is placed upon a moderate surface and left to the point where the solvent evaporates for obtaining the required sample film. For the purpose of preparing films reinforced with $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ salt, certain weight percentages of (PVA) polymer have been mixed with specific weight percentages of $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ salt (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.

Preparation and Study of Some Properties, Apparent Porosity, True Density and Water Absorption of Polymeric Films (PVA) Reinforced by $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ Salt.

Akraam M. Saba, Sabah A. Salman and Rana S. Mahmood

Results and discussion

Apparent Porosity

The apparent porosity of pure PVA polymer film and the films that have been reinforced with $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ salt were calculated with various weight ratio values ((3, 7, 11 and 15) wt%), and as shown in Figure (2), as can be noted from this figure, the apparent porosity value of the pure (PVA) polymer film is (0.7917%), and when reinforced with $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ salt, we notice that the apparent porosity decreases with the increase in the concentration of $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ salt. This is due to the convergence and granulation of the particles together and the closure of the porosity, and thus the apparent porosity of these films decreases. The apparent porosity depends on three important factors: temperature, porosity formation (open pores) and the holes within the films due to the release of gases, and the effect of these factors is reversed [6]. Porosity is influenced by the raw materials used in the preparation, as it is influenced by size and distribution of particles, as well as by pressure during the process of immersion of samples in water [7]. Table (1) lists values of apparent porosity of all composite's films.

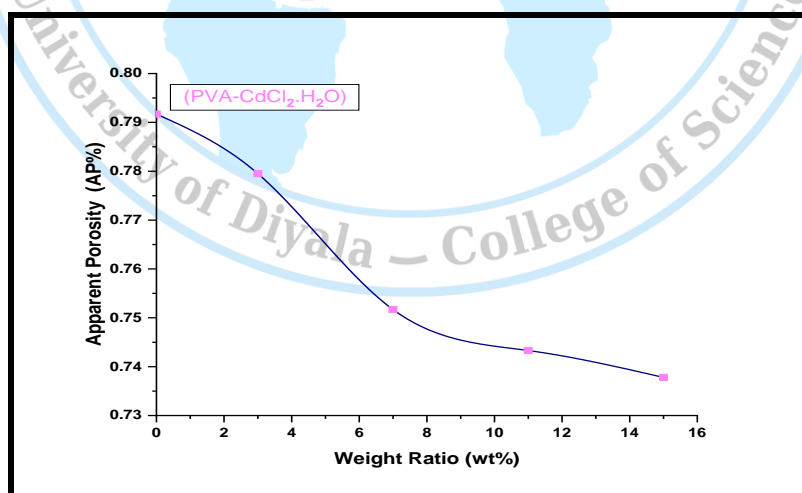


Figure 2: Apparent Porosity of the (PVA- $\text{CdCl}_2 \cdot \text{H}_2\text{O}$) composite films as function of the weight ratio of $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ salt.

Preparation and Study of Some Properties, Apparent Porosity, True Density and Water Absorption of Polymeric Films (PVA) Reinforced by $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ Salt.

Akraam M. Saba, Sabah A. Salman and Rana S. Mahmood

Table 1: Apparent Porosity value of the (PVA- $\text{CdCl}_2 \cdot \text{H}_2\text{O}$) composite films with weight ratio of $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ salt.

Weight Ratio (wt%) of Salt	(PVA- $\text{CdCl}_2 \cdot \text{H}_2\text{O}$) Apparent Porosity (AP%)
Pure (PVA)	0.7917
3	0.7795
7	0.7517
11	0.7433
15	0.7378

True density

The true density of the pure (PVA) polymer film and the films reinforced with $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ salt were calculated with various weight ratios (3,7,11,15wt%), and as shown in Figure (3), as can be noted from the figure that the true density value for a pure polymer (PVA) film it is ($260.3 \text{ Kg} / \text{m}^3$), and when reinforced with $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ salt, we notice that the true density increases with the increase in the concentration of $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ salt added due to the chemical composition of the salt where it has an effect on the density at a certain temperature, which causes the increase in the density. Also, the method of immersing the sample in water is important to increasing the convergence of the granular components of the sample, which leads to an increase in the amount of accumulated granules per unit sample volume, which leads to a higher density of the sample when immersed in water, and this does not mean reaching materials at their full density. The increasing density results in an increase in temperature, because the number of pores in the sample decreases, and thus the density increases [8]. Table (2) shows the true density values of all composite films.

Preparation and Study of Some Properties, Apparent Porosity, True Density and Water Absorption of Polymeric Films (PVA) Reinforced by $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ Salt.

Akraam M. Saba, Sabah A. Salman and Rana S. Mahmood

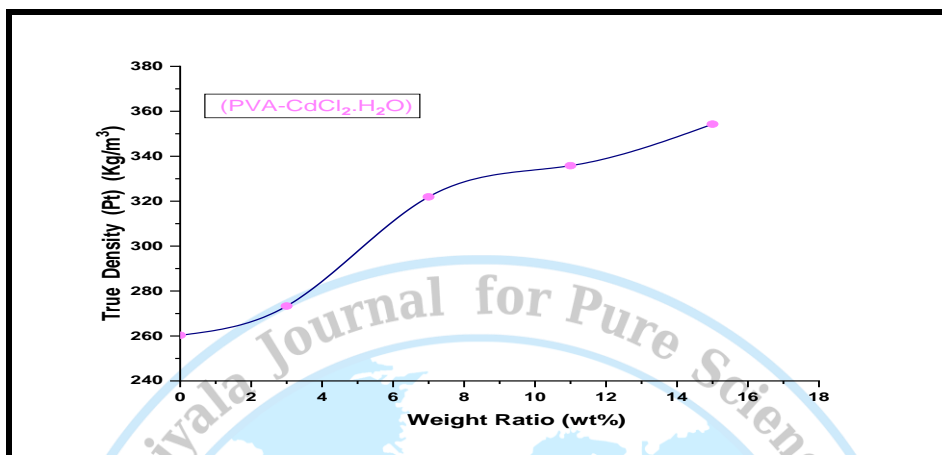


Figure 3: True density of the (PVA- $\text{CdCl}_2 \cdot \text{H}_2\text{O}$) composite films as function of the weight ratio of $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ salt.

Table 2: True density value of the (PVA- $\text{CdCl}_2 \cdot \text{H}_2\text{O}$) composite films with weight ratio of $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ salt.

(PVA- $\text{CdCl}_2 \cdot \text{H}_2\text{O}$) True Density (Pt) (Kg/m ³)	Weight Ratio (wt%) of Salt
260.3	Pure [PVA]
273.3	3
321.9	7
335.8	11
354.3	15

Water Absorption

The water absorbance of the pure (PVA) polymer film and the films reinforced with $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ salt were calculated with different weight ratio values ((3,7, 11, and 15) wt%), as shown in Figure (4). As can be noted from the figure, water absorbance value of the pure (PVA) polymer film was (3.0408 %), when reinforced with $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ salt we notice that the water absorbance decreases with the increase in the concentration of the added $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ salt. This behavior is due to the increase of the liquid phase resulting from the interaction of the solid phase with the components of the film, where there is a phase relationship between water absorption and apparent porosity [9,10]. Table (3) shows the values of water absorbance of all composite films.

Preparation and Study of Some Properties, Apparent Porosity, True Density and Water Absorption of Polymeric Films (PVA) Reinforced by $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ Salt.

Akraam M. Saba, Sabah A. Salman and Rana S. Mahmood

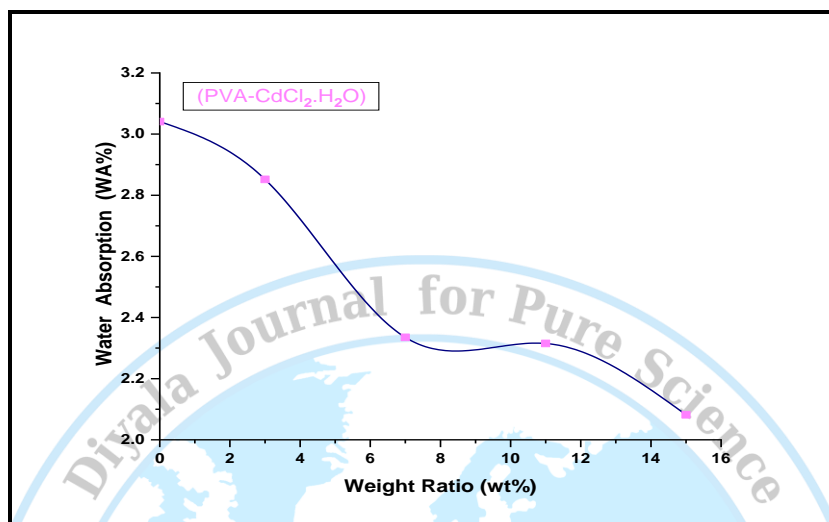


Figure 4: Water Absorption of the (PVA- $\text{CdCl}_2 \cdot \text{H}_2\text{O}$) composite films as function of the weight ratio of $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ salt

Table 3: Water Absorption value of the (PVA- $\text{CdCl}_2 \cdot \text{H}_2\text{O}$) composite films with weight ratio of $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ salt.

(PVA- $\text{CdCl}_2 \cdot \text{H}_2\text{O}$) Water Absorption (WA%)	Weight Ratio (wt%) of Salt
3.0408	Pure [PVA]
2.8517	3
2.3350	7
2.3150	11
2.0820	15

Conclusions

Following research and analysis on films made of pure (PVA) polymer and films reinforced with $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ salt at different weight ratios ((3, 7, 11, and 15) wt %). The tests for apparent porosity and water absorption revealed decrease as the weight ratio of the added $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ salt was increased. However, the true density test revealed that it rose as the weight ratio of $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ salt was raised.

Preparation and Study of Some Properties, Apparent Porosity, True Density and Water Absorption of Polymeric Films (PVA) Reinforced by $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ Salt.

Akraam M. Saba, Sabah A. Salman and Rana S. Mahmood

References

1. M. C. Gupta, A. P. Gupta, Polymer Composite, (New Age International LTD, Publishers, 2005)
2. R. J. Crawford, Plastic Engineering, 2nd Edition, (Pergman Press, UK., 1987)
3. K. J. Pascoe, An Introduction to the Properties of Engineering Materials, 3rd Ed., (Van Nostr and Reinhold (U.K) CO. Ltd., 1978).
4. W.D. Callister, G. David, Material Science and Engineering, An Introduction, 9th Ed.,(John wiley and Sons Inc, 2014)
5. L. J. Broutman, R. H. Krock, Modern Composite Material, (Eddison Wisely, London, 1967).
6. S. K. Behera, P. Barpanda, S. K. Pratihari, S. Bhattacharyya, Mater Lett, 58(5), 1451-1455(2004)
7. A. M. Bhavikatti, S. Kulkarni, A. Lagashetty, International Journal of Engineering and Technology, 3(1),687-695(2011)
8. R. H. Akbarnejad, V. Daadmehr, F. Sh. Tehrani, F. Aghakhani, S. Gholipour, Magnet and Superconducting Research Lab, Alzahra University, Tehran, 12, 1-12(2011)
9. F. A. Chiad, A. H. Ali, Engineering and Technology Magazine, 28(10), 1-10(2010)
10. N. I. Mahamed, College of Science, University of Baghdad, (2017)