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# A Study the optical Properties of (PVA\_PEG/SrO) nanocomposites

A Research

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Education / Physics of Materials and its applications

By

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**2021 A.D**

**1443 A.H**

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

( فَتَعَالَى اللَّهُ الْمَلِكُ الْحَقُّ وَلَا تَعْجَلْ بِالْقُرْآنِ مِنْ قَبْلِ أَنْ يُقْضَىٰ إِلَيْكَ  
وَخِيئَهُ ۗ وَقُلْ رَبِّ زِدْنِي عِلْمًا )

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## *Dedication*

To the light, the enlightening, the Hadi, the Bashir, the first teacher of humanity, the chosen messenger, our prophet and our intercessor, Muhammad, upon him and upon his God, the best prayer and the most complete peace.

To those who landed the sticks of glory traveled under his feet patriotic.

To my father's pure soul.

To whom I accompanied her prayers always and forever my beloved mother.

To my partner through thick and thin, my dear wife.

To adorn the life of my children.

To all who helped me and stood by my brothers, sisters, my friends.

To those who told me of the torment of their knowledge, my virtuous teachers.

I dedicate to you the fruit of my humble effort.

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# Abstract

In this work, a nanocomposite (Polyvinyl Alcohol PVA-Polyethylene Glycol PEG/ Strontium Oxide SrO) was prepared to study the optical properties, by used casting method where distilled water was used as a solvent for both polymers (Polyvinyl alcohol PVA-Polyethylene glycol PEG) and then adding the nanoparticles. (Strontium Oxide SrO) to the mixture in different proportions (0.01, 0.02, 0.03 and 0.04) wt.%. After obtaining a good homogeneity for the nanocomposite. The optical microscopy image showed the formation of a continuous network inside the polymers of SrO nanoparticles at All ratios (0.01, 0.02, 0.03 and 0.04) wt.%. are homogeneous and also arranged and this system can allow the passage of charge carriers The results of the optical properties of the nanocomposites (Polyvinyl Alcohol PVA - Polyethylene Glycol PEG / Strontium Oxide SrO) showed that the transmittance and energy gap values It decreases with the increase in the concentration of SrO nanomaterial, while the values of the absorption coefficient, extinction coefficient, refractive index, and real and imaginary dielectric constants increase with the increase in the concentration of Strontium oxide nanoparticles.

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## List of Symbols

Symbol	Physical meaning	Units
A	Absorptance	%
B	Constant	-
c	Velocity of light	2.998x10 <sup>8</sup> m/s
d	Thickness	Cm
E	Energy	eV
$E_g^{opt}$	Energy gap	eV
$E_{ph}$	Energy of phonon	eV
f	Photon frequency	Hz
h	Plank constant	6.63x10 <sup>-34</sup> J.s
$I_A$	Absorbed light intensity	Lumen
$I_o$	Incident intensity of light	Lumen
K	Extinction Coefficient	m <sup>2</sup> /mol
N	Complex refractive index	-
n	Refractive Index	-
R	Reflectance	%
r	Exponential constant	-
T	Transmittance	%
$T_g$	Glass transition temperature	C°
$T_m$	Melting temperature	C°
$\alpha$	Absorption coefficient	cm <sup>-1</sup>
$\lambda$	Wavelength of light	Nm
$\sigma_{op}$	Optical Conductivity	1/sec

## List of Abbreviations

Symbol	Physical meaning	Units
FTIR	Fourier Transformation Infrared Ray	-
PVA	Polyvinyl Alcohol	-
PEG	Polyethylene Glycol	-
SrO	Strontium Oxide	-

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# *Chapter*

# *One*

**Introduction and  
Literature Review**

## 1.1 Introduction

The term “Nanotechnology” is nowadays commonplace not only in all relevant scientific and technical areas, but also to a considerable extent in the public domain, based on reports in newspapers, on television and, justified or not, in a series of commercially available products with “nano” as part of their names. On the one hand, this development could be considered in a positive sense, indicating nanotechnology as an accepted new technology. On the other hand, it contains some risks that should not be neglected. This is due to the rather complex definition of nanotechnology and nanoscience as a sectional science, involving natural and materials sciences, engineering and medicine [1].

In nanotechnology, the primary role of classical physical principles is replaced as molecular and atomic dimensions are approached. Physical technical and chemical aspects influence the fabrication and the use and application of nontechnical structures on an equal basis a field that is influenced by and uses quantum phenomena, complement these aspects. In contrast to classical chemistry, small ensembles or even individual particles can play a decisive role [2].

Nanotechnology is the technology dealing with both single Nano objects and materials, and devices based on them, and with processes that take place in the nanometer range [3].

Nanotechnology or nanoscale science is concerned with the investigation of matter at the nano scale, generally taken as the (1 to 100) nm range. The breakthrough in both academic and industrial interest in these nanoscale materials over the past ten years has been interested because of the remarkable variations in solid-state properties. The “Nano”

as word means dwarf (small man) in Greek, Nano as SI unit refers amount of  $10^{-9}$ , such as nanometer, nanolitter and nanogram [2].

The reasons of the enthusiasm arising from the “nanosciences” are numerous. Among them, the very large surface to volume ratio exhibited by many nanoscaled materials opened novel possibilities in surface-based science, such as heterogeneous catalysis [4].

Furthermore, it is discovered that properties of the materials change as their size approaches the nanoscale, in other words, as the fraction of specific atoms at the surface of a material becomes significant. For example, inert materials such as platinum become catalysts, semiconductors like silicon become conductor, etc., the applications of nanotechnology has only been increasing in the recent years, and the highest potential application is in the field of materials, followed by electronics and medicine [5].

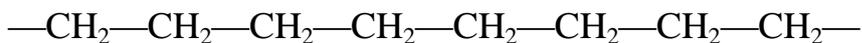
## 1.2 Polymer Structure

Polymer science was arise the great industrial laboratories of the world of the need to make and understand new kinds of plastics, rubber, adhesives, fibers, and coatings. polymer science come to academic life perhaps because of its origins, polymer science tends to be more interdisciplinary than most sciences, combining chemistry, chemical engineering, materials, and other fields [6].

It should be noted that the term monomer or monomer unit is often used to mean either the chemical repeat unit or the small molecule that polymerises to give the polymer. These are not always the same in atomic composition, as will be clear from what follows, and the chemical bonding must of course be different. The simplest polymers are chain-like molecules of the type:



Where A is a small group of covalently bonded atoms and the groups are covalently linked. The simplest useful polymer is polyethylene [7].



A polymer is a large molecule built up from numerous smaller molecules. These large molecules may be linear, slightly branched, or highly interconnected. In the latter case, the structure develops into a large three-dimensional network. The small molecules used as the basic building blocks for these large molecules are known as monomers. For example, the commercially important material poly (vinyl chloride) is made from the monomer vinyl chloride. The repeat unit in the polymer usually corresponds to the monomer from which the polymer was made. There are exceptions to this, though. Poly(vinyl alcohol) is formally considered to be made up of vinyl alcohol ( $\text{CH}_2\text{CHOH}$ ) repeat units but there is, in fact, no such monomer as vinyl alcohol [8].

### 1.3 Classification of Polymers

#### 1.3.1 Thermal classification of polymers:

Polymers are classified according to the effect of temperature into:

##### a. Thermoplastic polymers:

The properties of these polymers are changed by the effect of temperature. When the temperature increases, This material becomes elastic and sticky. By lowering temperature, these polymers return to their original solid state because the molecules in a thermoplastic polymer are connected by relatively weak intermolecular forces (Vander Vales forces). When heated, these molecules can slide over each other as in polystyrene, polyethylene, polypropylene and polyvinyl chloride [9].

**b. Thermoset Polymers:**

These polymers are chemically changed when heated. Thermosets are usually three-dimensional networked polymers in which there is a high degree of cross-linking between polymer chains. After being heated, these polymers become insoluble, non-conductive of heat and electricity and hard because molecules of these polymers are connected by strong covalent chemical. Phenol formaldehyde resin and urea-formaldehyde resin are examples of this type of polymers [10].

**1.3.2 Chemical classification of polymers**

Polymers are classified depending on the structural composition in to:

**a. Linear polymers:**

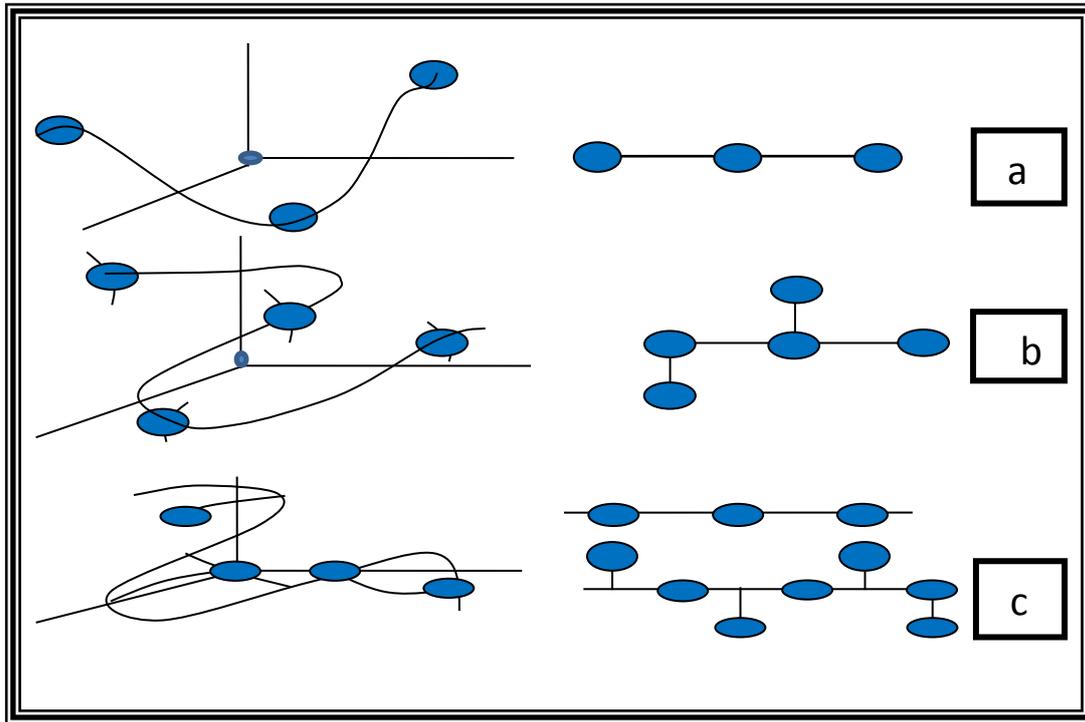
The essential structural unit for these polymers is one molecular series of certain length connected with each other in a linear shape, it does not contain the branch except the totals twisted which is part of monomer [8] as in fig. (1-1-a).

**b. Branched polymers:**

Here the long chain is branching and it is characterized by this type of installation that the branches as a Ladder or a Comb or as a Crusader. The branches have different lengths[7] as in fig. (1-1-b).

**c. Cross linked polymers:**

In this type, the chemical bonds are interwoven with each other in a complex way. The format string consists of three dimensional polymerhains linked together by more than one site, or when use monomers containing effective totals rather than being included in two effective totals [6] as in the fig. (1-1- c).



**Figure (1-1): The types of polymeric chains [11]**

**a-Linear b- Branched c- Cross linked**

### 1.3.3 Polymers dependent on homogeneity

Polymers are classified depending on the homogeneity of repeating units into:

#### **a. Homo polymers:**

Where the building blocks of a polymer are of one type in polytherphethals ethylene [7].

#### **b. Copolymers:**

Where the building blocks of a polymer are more than one type, as in the polymer styrene – butadiene [8].

#### **c. Composite Polymers:**

It is the process of adding some material to homogeneous polymers in order to change in some of its characteristics and the entering of new recipes on it [6].

### **1.3.4 Polymers dependent on the chains lengths and molecular weights**

#### **a. Mono disperses polymers:**

All particles in this case are of equal size and have the same weight; this type of polymers is not common [11].

#### **b. Poly disperses polymers:**

Polymers resulting from polymerization consist of a wide range of molecular weights, i.e., different chains in length, where not all chains grow during the polymerization process to the length itself. This means that the existence of a diverse distribution of the lengths of the chains and thus there is a multiplicity of molecular weights [12].

## **1.4 Nanomaterials**

Nanomaterials: A materials with dimensions below 100 nm and they have at least one unique properties that is different from the bulk material and the characteristics can be applied in different fields such as nanoelectronics, pharmaceutical and cosmetic. Several methods have been studied in fabricating these nanostructures, which include laser ablation, chemical vapor deposition (CVD) [13]. and template-directed growth [14]. in order to integrate one-dimensional nanomaterial into a device, a fabrication method that enables well-ordered nanomaterials with uniform diameter and length is important. Template-directed growth is a nanomaterials fabrication method that uses a template which has nanopores with uniform diameter and length [15]. using chemical solutions or electro deposition, nanomaterials are filled into the nanopores of the templates and, by etching the template, nanowires or nanotubes with similar diameter and length as the template nanopores are obtained. Because the size and shape of the nanomaterial depends on the nanoholes of the template, fabricating a template with uniform pore diameters is very important [16].

Nanomaterials can be classified by different approaches according to the X, Y and Z dimension, according to their shape and according to their

composition. A nanomaterial is an object that has at least one dimension in the nanometre scale [17].

Nanomaterials are categorized according to their dimensions into four classes [18]:

1. Zero-dimension confinement (quantum dot).
2. One-dimension confinement (quantum wire).
3. Two-dimensions confinement (quantum well).
4. Three-dimensions confinement (bulk).

## **1.5 Polymers Sources**

Polymers are two main sources:

### **a. Natural polymers:**

It is compounds come from plant or animal such timber, cotton, natural rubber, wool and silk. The natural food that is the natural polymers is starch, protein and cellulose [19].

### **b. Synthetic polymers:**

A polymer which is prepared from simple chemical compounds and represent the most industrial important polymers, including plastics, synthetic leather, nylon fabrics and some other dyes [20].

## **1.6 Polymer Nanocomposites**

Composites can be defined as materials that consist of two or more chemically and physically different phases separated by a distinct interface [21].

The development of nanotube, platelet and particle reinforced polymer composites has grown in importance in recent years due to their attractive applications in various fields. Much interest in these materials comes from the incorporation of one, two and three-dimensional Nano fillers into a polymer matrix giving high aspect ratios and/or large surface

area to volume ratios [22]. In recent years, Nano composites with practically all polymer systems have been used to improve one property or another, with varying degrees of success.

A range of factors that influence not only the morphology but also the final properties of composites have been identified, including interfacial interactions between the filler and the polymer phase (optimization of filler surface modification, kinetic and thermodynamic factors influencing intercalation and exfoliation, etc.), the nature of the polymer (polar or nonpolar, molecular weight, etc.), the nature of the filler (aspect ratio, size, geometry, cation - exchange capacity, etc.), the processing methodologies, and the amount of inorganic filler. Yet, these improved properties are the result of many different mechanisms at play, owing to the presence of inorganic fillers within the polymers consequently, an enhancement of one property does not directly translate into an enhancement of the other properties. Thus, it is important to gain insights into these different factors and considerations that are responsible for enhancing the various properties, the optimization of which may—in time— lead to Nano composites being designed according to need [23].

## 1.7 Literature Review

**Suman Mahendia *et, al.in(2011)*** [24] studied the D.C conduction and optical behaviour of undoped and nano-Ag doped PVA films . They found that value optical energy gap reduced from 4.92 eV to 3.93 eV at adding silver nanoparticles and observed increase in conduction.

**S. Chiad *et, al.in(2011)*** [25] studied the effect of thickness on the optical parameters for (PVA: Ag). They find out that transmittance, reflectance, absorption coefficient, refractive index, extinction coefficient

and (real, imaginary) parts of dielectric constant are affected by increasing the thickness.

**Bahaa H. Rabee *et al.*(2012)** [26] studied the optical properties of (PVA-LiF) composites .Results showed that the absorbance increases with the increase of the weight percentage of lithium florid absorption coefficient, extinction coefficient, refractive index and real and imaginary parts of dielectric constants are increasing with increase the content.

**T. Dhakal *et al.*(2012)** [27] studied the optical characterizations of PVP and PEG on the Behavior of Silver Nanoparticle-Polymer composites. Films were synthesized by wet chemical method in the presence of polyvinyl pyrrolid one (PVP) and polyethylene glycol (PEG). A mixture of two stabilizing agent PVP and PEG are found to play a crucial role in controlling the morphology of Nano crystalline silver particles in the composite. They were studied Uv-vis spectroscopy, FTIR, and surface enhances Raman studies, XRD measurement and SEM.

**H. Nemea *et al.*(2013)** [28] studied the doping effect on optical constant of polyvinyl chloride (PVC) and find the poly-vinyl chloride with different weight percentages from ((CH<sub>3</sub>COO) Ag) with polymer and by different thickness. The absorption and transmission spectra have been recorded in the wavelength range (190-890) nm. The absorption coefficient, refra.

**M. Ghanipour and D. Dorrnian.in (2013)** [29] studied the effect of Ag-nanoparticles doped in polyvinyl alcohol on the structural and optical properties of PVA films and found the (FT-IR) spectrum peaks correspond to molecular vibrations and chemical bonds, indicate the presence of silver in the PVA polymer structure. The optical band gap energy of the samples is decreased with increasing the concentrations of

silver nanoparticles. Refractive index and dielectric constant are decreased with increasing the concentration of Ag nanoparticles.

**A. El Sayed and W. M. Morsi. In(2014)** [30] studied the optical and dielectric characterizations of  $\text{Fe}_2\text{O}_3/(\text{PVA}+\text{PEG})$  films. They prepared the films a template-free sol–gel method. They found that the transmittance percentage (T %) of the films showed a decrease from 80.26 to 33.24 %. The direct optical band gap also decreased from 5.28 to 4.83eV whereas the refractive index significantly increased with increasing the hematite content. The dielectric measurements were performed in the temperature range (303–413) K and frequency range 30 KHz–3.0 MHz according to the temperature dependence of the dielectric constant ( $\epsilon'$ ).

**B.H. Rabee et al. in (2016)**[31]. studied the optical properties for (PVA-PEG-ZnO) nanocomposites, they found the absorbance of (PVA-PEG-ZnO) nanocomposites increases with the increasing of the concentrations of zinc oxide nanoparticles. The optical constants increase with the increasing of the concentrations of zinc oxide nanoparticles and vice versa with both the energy band gap.

**S.A. Jabbar et al, in (2017)** [32]. studied the effect of the extract of willow leaves (EWL) on (PVA-PEG) blend the results of the optical properties show the absorbance of blend is increased with the increasing of the extract of willow leaves concentrations. The energy gap is decreased with the increasing of the extract of willow leaves volumetric percentages. The optical constants of bio composites are increased with the increasing of the extract of willow leaves concentrations.

**C.R. Indulal *et. al.* . in (2019)** [33] Studied the optical and Photo-catalytic of Zinc Strontium Oxide Nanocomposites for Technological Applications. Nanocomposites of Zinc Strontium Oxide(ZnSrO) has been synthesized by chemical co-precipitation method. Structural properties of the samples are studied using XRD technique. The optical band gap analyses of the samples are carried out using UV-Visible spectroscopy. Photo-catalytic degradation power of the nanocomposites is measured with congored and malachite green dyes.

## **1.8 The Aim of the Study**

The general aim of this work is preparation of (PVA-PEG/SrO) Nano composites and study of the optical properties of Nanocomposites.

# *Chapter* *Two*

## **Theoretical Part**

## 2.1. Introduction

This chapter includes a general description of the theoretical part of this study, physical concepts, scientific classifications, relationships that can be used to interpret the study results.

## 2.2. The Optical Properties

Many polymers in everyday use contain fillers and coloring agents that render them opaque. The optical properties of the base polymer are thus unclear. On the other hand, the clarity of optical transmission of many polymers and the fact that they are almost colorless, coupled with their low density and excellent mechanical properties, are the reasons for their use to replace glass in many applications[9].

### 2.2.1 Absorbance (A)

The intensity of the absorbed light ( $I_A$ ) by the material to the incident intensity of light ( $I_o$ ) as a ratio is defined as absorbance that is given in the following equation [34].

$$A = \frac{I_A}{I_o} \quad (2.1)$$

#### 2.2.1.1. Fundamental Absorption Edge

The fundamental absorption edge can be defined as the rapid increasing in absorbance when absorbed energy radiation is almost equal to the band energy gap; therefore, the fundamental absorption edge represents the less difference in the energy between the upper point in the valence band to the lower point in the conduction band [35].

#### 2.2.1.2. Absorption Regions

Absorption regions can be classified into three regions [35]

### A. High Absorption Region

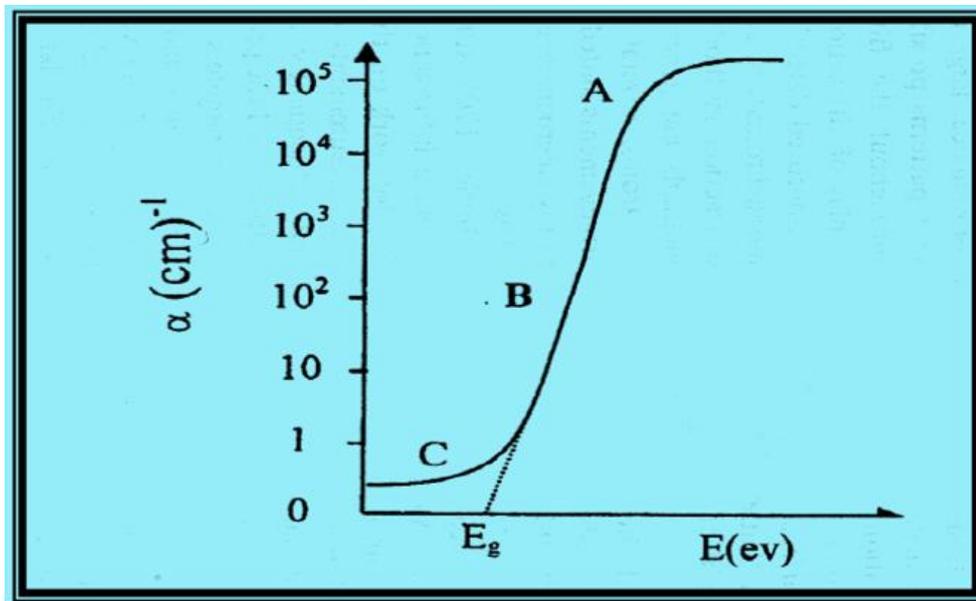
This region is shown in Figure (2.1). In part (A), the magnitude of absorption coefficient ( $\alpha$ ) is larger or equal to  $10^4 \text{ cm}^{-1}$ . From this region, the magnitude of forbidden optical energy gap ( $E_g^{\text{opt.}}$ ) can be introduced.

### B. Exponential Region

This region is shown in Figure (2.1). In part (B) the value of absorption coefficient ( $\alpha$ ) is equal to ( $1 \text{ cm}^{-1} < \alpha < 10^4 \text{ cm}^{-1}$ ). It refers to transition between the extended levels from the Valens band (V.B.) to the local level in the conductive band (C.B.) and vice versa, transited from local levels in (V.B.) to the extended levels in the bottom of conductive band (C.B.).

### C. Low Absorption Region

The absorption coefficient ( $\alpha$ ) in this region is very small, it is about ( $\alpha < 1 \text{ cm}^{-1}$ ). The transition happens in this region because of the state density inside space motion resulted from faults structural[35], as in Figure (2.1) part (C).



Figure( 2.1):The variation of absorption edge with absorption regions [36].

### 2.2.1.3. Electronic Transitions

Electronic transitions are divided into two types:

#### 1. Direct Transitions

Where the bottom of the conduction band and valance band at the same point in the space ( $\Delta k = 0$ ). In this case, the absorption will appear at ( $E_g = hf$ ). This type occurs without a noticeable change in momentum. There are two types of direct transitions, when a transition occurs between top and lower point for valance band and conductive band in sequence so that it is called allowed direct transitions, while when a transition occurs between neighboring points for top and lower point so that is called forbidden direct transitions[37].

The absorption coefficient for this transition type is given by :

$$a_{hv} = B(hv - E_g^{\text{opt.}})^r \quad (2.2)$$

where:  $E_g^{\text{opt.}}$  energy gap between direct transition.

B: constant depended on type of material.

r: exponential constant, its value depended on type of transition,

r = 1/2 for the allowed direct transition.

r = 3/2 for the forbidden direct transition.

#### 2. Indirect Transitions

In the electronic optical indirect transition, the bottom of conduction band and top of valance band are in different regions of space (k). This type of transitions occurs by the help of the phonon to conservation of movement resulted from variation in wave vector for the electron. There are two types of indirect transitions, when the transition is between top point of valance band and lower point of conduction band which is found in different regions of a space (k) so that called (allowed indirect transition)[37,38], as shown in Figure(2.2).The absorption coefficient for transition with a phonon absorption is :

$$a h\nu = B(h\nu - E_g^{\text{opt.}} \pm E_{ph.})^r \quad (2.3)$$

Where:  $E_{ph.}$ : energy of phonon, is (-) when phonon absorption, and (+) when phonon emission.

( $r = 2$ ) for the allowed indirect transition.

( $r = 3$ ) for the forbidden indirect transition.

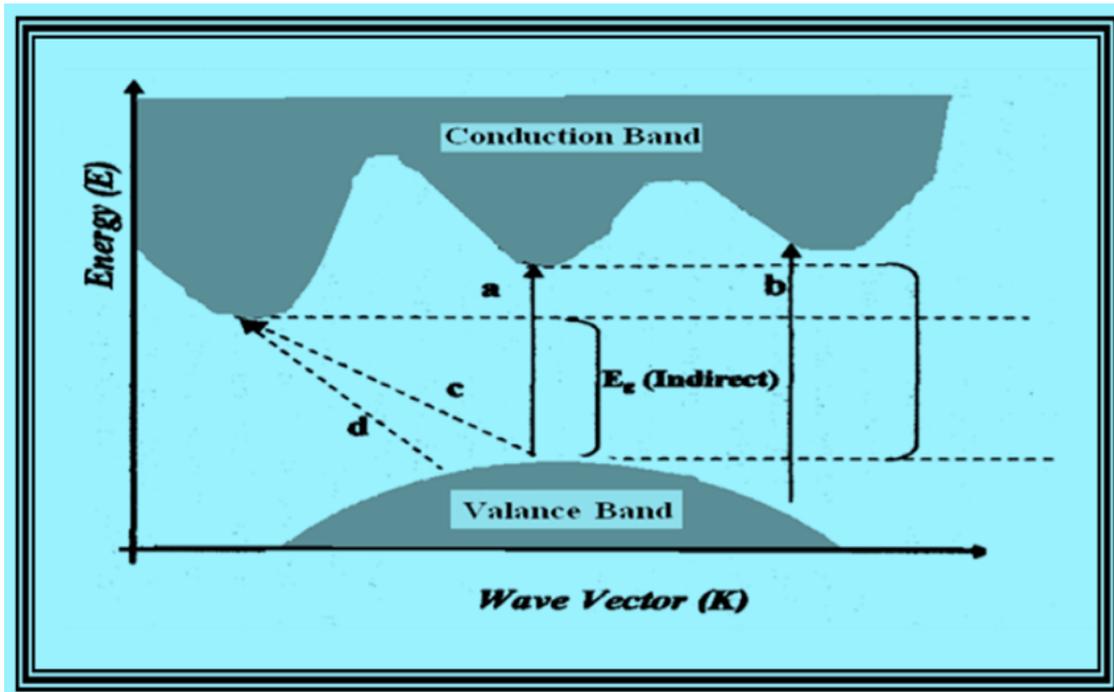


Figure (2.2): The transition types [39]

- (a) allowed direct transition. (c) allowed indirect transition.  
 (b) forbidden direct transition. (d) forbidden indirect transition.

## 2.3.2. Optical Constants

### 2.3.2.1. Absorption Coefficient ( $\alpha$ )

The absorption coefficient ( $\alpha$ ) is defined as the gradually reduction of the flow of incident ray energy on a unit area along the direction of wave diffusion inside a medium. The absorption coefficient depends on the photon energy and properties of the semiconductor regarding the gap energy of the semiconductor and the type of electronic transitions [40, 41].

From the equation related to the absorption of ray, the relation between the incident light intensity ( $I_0$ ) and the penetrating light intensity ( $I$ ) is described in the following equation [42]:

$$I = I_0 e^{-at} \quad (2.4)$$

where  $t$  is the thickness of the matter:

$$at = 2.303 \log I/I_0 \quad (2.5)$$

Where the amount of  $\log I/I_0$  represents the absorbance ( $A$ ). The absorption coefficient can be calculated as follows[43].

$$a = (2.303) A/t \quad (2.6)$$

### 2.3.2.2. Refraction Index ( $n$ )

It is the ratio of light speed in vacuum to its speed in a medium. This index shows how far a matter is affected by the electromagnetic waves. The refraction index consists of two parts: real and imaginary. It can be expressed by the following equation [44].

$$n = \frac{c}{v} \quad (2.7)$$

where ( $n$ ) is the refraction index, ( $c$ ) is the light speed in vacuum and ( $v$ ) is the light speed in matter.

Reflectance ( $R$ ) can also be defined as the ration of the reflected ray relation at the borderline between two mediums to the incident ray. The relation between reflectivity and refractive index is shown in the following equation:

$$R = (n - 1)^2 + K^2 / (n + 1)^2 + K^2 \quad (2.8)$$

where ( $k$ ) is the Extinction Coefficient.

The absorbance ( $A$ ) and transmittance ( $T$ ) can also be calculated from the following equation [45]:

$$R + A + T = 1 \quad (2.9)$$

Refractive index can be expressed by the following equation [45]:

$$n = \sqrt{\frac{4R - K^2}{(R-1)^2}} - \frac{(R+1)}{(R-1)} \quad (2.10)$$

### 2.3.2.3. Extinction Coefficient (K)

The imaginary part of the complex refractive index  $N$  is called the extinction coefficient, as shown in the following equation :

$$N = n - iK \quad (2.11)$$

Where  $(n)$  is the real part of the refractive index. The extinction coefficient can be calculated by using the following equation [46].

$$K = \alpha \lambda / 4\pi \quad (2.12)$$

Where  $(\lambda)$  is the wavelength of incident ray.

*Chapter*  
*Three*

**Experimental Part**

### 3.1. Introduction

This chapter includes the preparation process, devices and measurement techniques. A general description of materials (polyvinyl alcohol, Polyethylene glycol and strontium oxide ) used in this work are given by optical microscopic and optical properties measurements.

### 3.2. The Utilized Materials

The utilized materials in this study are:

#### 3.2.1. Matrix Material

Polymers: two types of polymers are used in this work:

##### 3.2.1.1. Polyvinyl Alcohol (PVA)

PVA is one of the earliest and best known polymers [47], with the formula  $(C_2H_4O)_n$ , as shown in Figure (3.1). use in a variety of applications and is currently used extensively in semiconductors applications [47]. shown in Figure (3.1) .

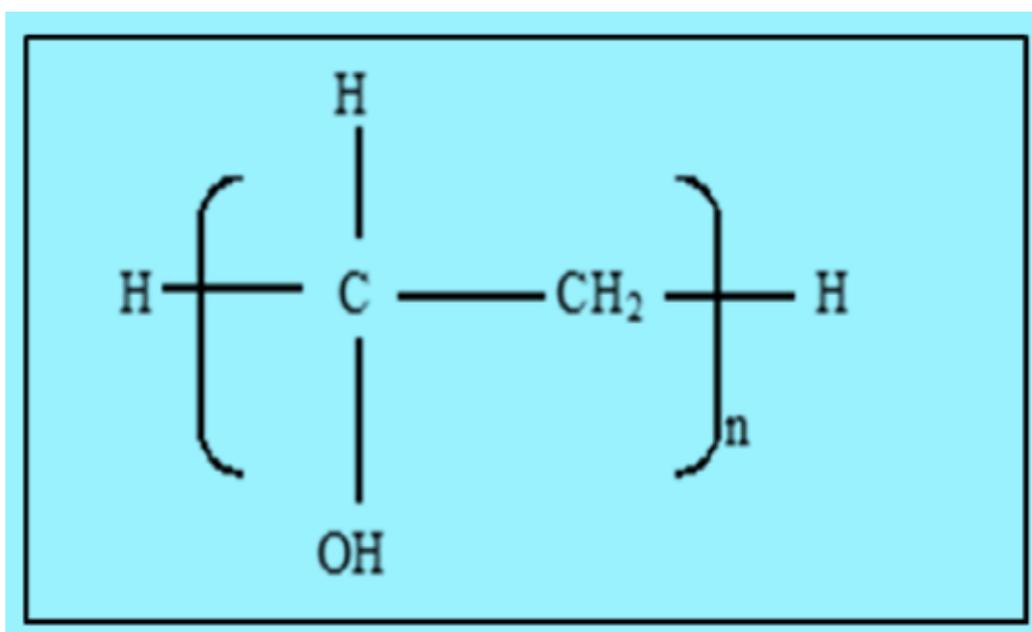


Figure (3.1): The Chemical Structure of PVA [48]

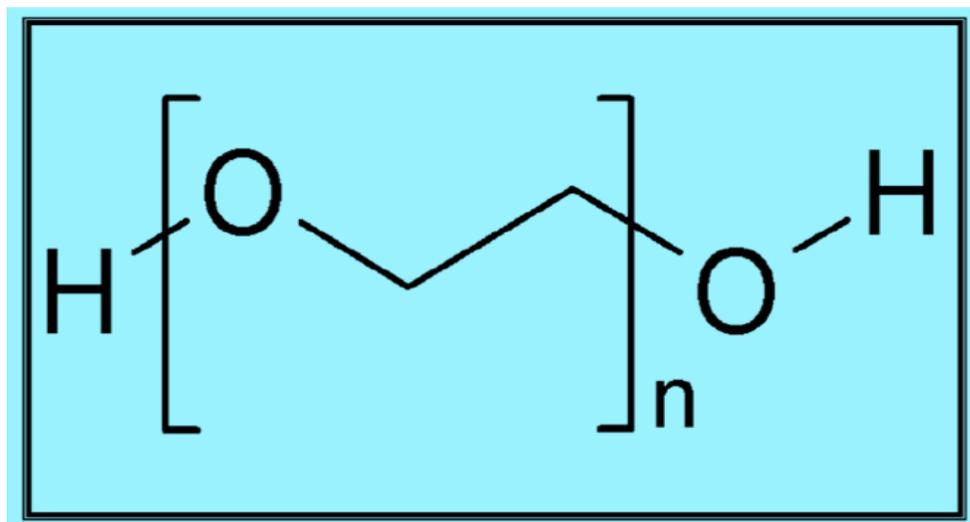
Poly (vinyl alcohol) is a water-soluble synthetic polymer and is an odorless, translucent, tasteless, white or cream colored granular powder, because with the existence of many hydroxyls, PVA is easily soluble in water and soluble in hydroxyl-contained organic compounds. The prominent properties of poly (vinyl alcohol) are its biodegradability in the milieu and biocompatibility. Poly (vinyl alcohol) has high tensile strength and flexibility, high oxygen and aroma barrier property. It also has admirable film forming, blending and adhesive properties [49]. The transmission for visible light is very high. Polymeric composites of PVA are known for their importance in technical applications [50]. PVA has unique properties, good chemical stability, eco-friendly, optical and electrical properties. The significant feature of polyvinyl alcohol is its semi crystalline nature which is the presence of both amorphous and crystalline regions causing interfacial effects which increases the physical properties [51].

**Table (3.1): Physical and chemical properties of polyvinyl alcohol (PVA)[52].**

Property	Description
<b>Appearance</b>	White to an ivory white granular powder
<b>Molecular formula</b>	$(C_2H_4O)_n$
<b>Solution PH</b>	5- 6.5
<b>Density g/cm<sup>3</sup></b>	1.3 g/cm <sup>3</sup>
<b>Refractive index</b>	1.55
<b>Glass transition temperature T<sub>g</sub> °C</b>	85 °C
<b>Melting temperature T<sub>m</sub> °C</b>	230 °C

### 3.2.1.2. Polyethylene Glycol (PEG)

The chemical formula is  $[H (OCH_2CH_2)_n OH]$ . Chemical name is a hydro-o-hydroxypoly (oxy-1, 2-ethanediyl) Polyethylene glycol is a polymer that has the ability to dissolve in water and mix with other polymers. Aqueous solutions of higher molecular-weight grades may form gels. Liquid polyethylene glycols are soluble in acetone, alcohols, benzene, glycerin, and glycols. Solid polyethylene glycols are soluble in acetone, dichloromethane, ethanol (95%), and methanol; slightly soluble in aliphatic hydrocarbons and ether, but insoluble in fats, fixed oils, and mineral oil. PEG is used to make emulsifying agents and detergents, and as plasticizers, humectants, and water-soluble textile lubricants. The wide range of chain lengths provides identical physical and chemical properties [53]. Figure (3.2) shows the chemical structure of Polyethylene glycol.



**Figure (3.2) The Chemical Structure of Polyethylene glycol [54].**

It is widely used in a variety of pharmaceutical formulations including parenteral, topical, ophthalmic, oral and rectal preparations. Polyethylene glycol has been used experimentally in biodegradable polymeric matrices used in controlled-release systems. PEG or polyethylene glycols are used in great variety of applications because of their chemical structure, their

low toxicity, their solubility in water and their lubricating properties. They provide flexibility in choosing properties to meet the requirements of many different applications. In the rubber industry, they serve as heat transfer agents, mold release agents, rubber compounders, lubricants, and pigment carriers [54]. Table (3.2) shows the physical properties of PEG.

**Table (3.2) Physical Properties of (PEG) [55].**

Physical properties	Units	Result
Molecular weight	g/mol	4000
Solution PH		4.5-7.5
Viscosity at 99 C°	mm <sup>2</sup> /s	110-158
Viscosity at 25 C°	mm <sup>2</sup> /s	solid at specified temp.
Melting point	C°	50-58
Density	g/cm <sup>3</sup>	1.09
Refractive Index at 25 C°		1.456
Solubility in Water % by weight		50
Surface Tension at 25 C°	N/m	solid at specified temp.
Glass transition temperature T <sub>g</sub>	C°	53-55
Liquid specific heat at 30-60 C°	kJ/kg/K	2.25
Coefficient of thermal expansion at 20 °C	C° -1	solid at specified temp.
Thermal conductivity at 26 °C	W/m.K	solid at specified temp.

### 3.2.2 Additive Material

#### Strontium oxide( SrO):

Strontium peroxide is an inorganic compound with the formula SrO that exists in both anhydrous and octahydrate form, both of which are white solids. The anhydrous form adopts a structure similar to that of calcium carbide. Strontium oxide is an alkaline oxide, interacts with water with a hydrolysis reaction and diffuse heat to give strontium hydroxide:



It can be reduced by cutting from aluminum metal to metal strontium in an oxygen-free medium [56,57]. Table (3.3) shows the physical properties of SrO



**Table (3.3) Physical Properties of SrO[58,59,60]**

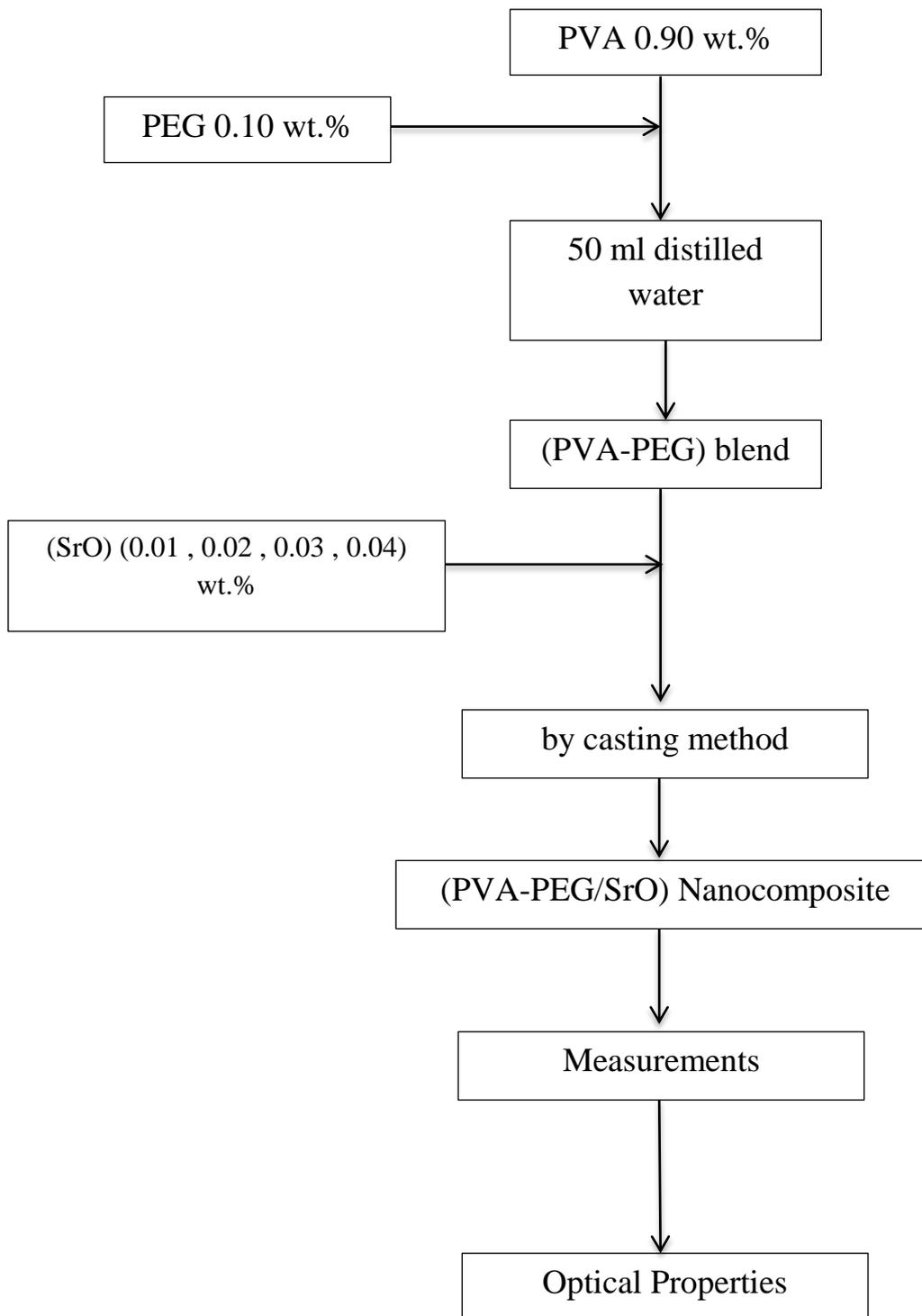
Chemical formula	SrO
Molar mass	119.619 g/mol
Appearance	white powder
Odor	odorless
Density	4.56g/cm <sup>3</sup> (anhydrous) , 1.91 g /cm <sup>3</sup> (octahydrate)
Melting point	215C°
Solubility in water	slightly soluble

### 3.3 Preparation of ( PVA-PEG/ SrO ) :

The nanocomposites of (PVA-PEG/SrO) prepared by dissolving 1gm of polymers in 50 ml of distilled water with different concentrations which 90wt.% PVA and 10 wt.% PEG by using magnetic stirrer to mix the polymers for 1 hour to obtain more homogeneous solution. The SrO nanoparticles are added to nanocomposites mixture with different concentrations which are (0.01 , 0.02 , 0.03 and 0.04) wt.%. as shown in Table (3-4). The casting method is used to prepare the samples of (PVA-PEG/SrO) nanocomposites in the template (petri dish has diameter 10 cm). The stages of the experimental work and procedure are illustrated in Figure ( 3.4).

**Table (3.4) illustrate the samples no. and (PVA-PEG/SrO) Nano composites wt. %.**

Sample No.	PVA Wt.%	PEG Wt.%	SrO Wt.%
0	0.90g	0.10	0
1	0.90g	0.09	0.01
2	0.90g	0.08	0.02
3	0.90g	0.07	0.03
4	0.90g	0.06	0.04



**Figure (3.4): Scheme of Experimental Part.**

### 3.4. Measurements of Structural Properties for (PVA-PEG/SrO) nanocomposite

#### 3.4.1. Optical Microscope :

The sample of (PVA-PEG-SrO) are examined by using the optical microscope, which is supplied from Olympus name (Toup View) type (Nikon -73346) and equipped with light intensity automatic controlled camera. Under magnification (10x), this measurement was implemented in the University of Babylon /College of Education for Pure Sciences, as shown in Figure (3.5).

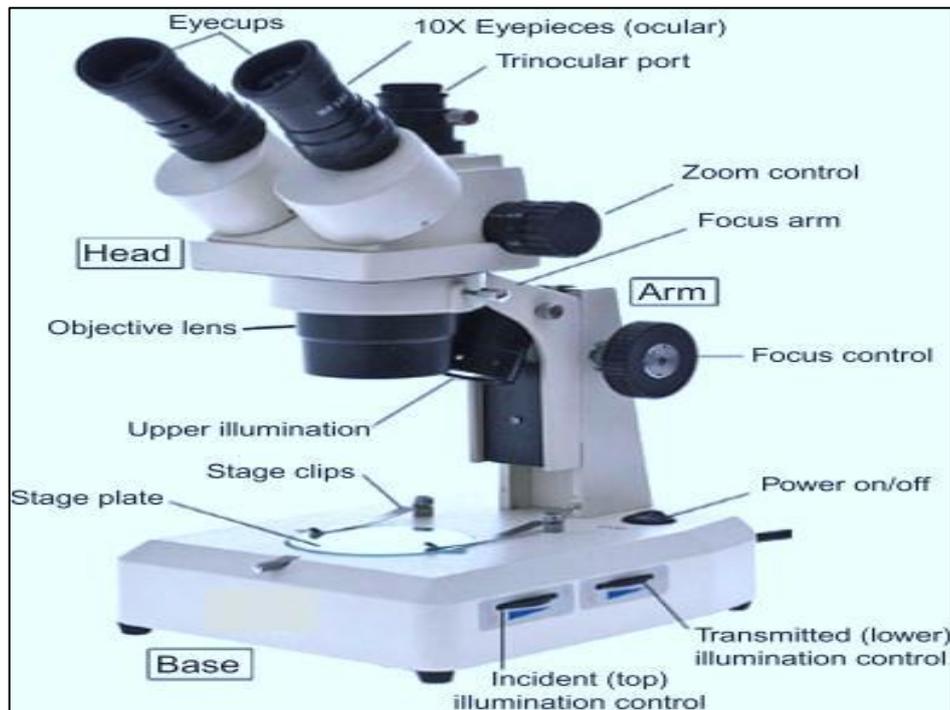


Figure (3.5): Scheme of Optical Microscope

### 3.4.2. Optical Properties Measurements:

The optical properties of (PVA-PEG/SrO) are measured by using the double beam spectrophotometer (Shimadzu, UV-18000A) in wavelength (190-400) nm. This measurement was implemented in the University of

Babylon /College of Education for Pure Sciences as shown the Figure (3.6).

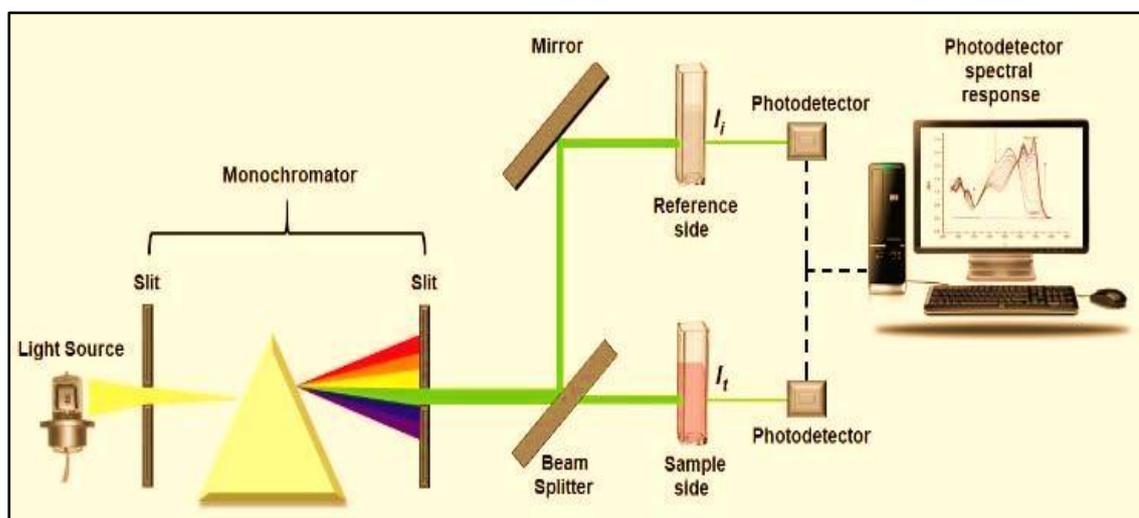


Figure (3.6): Scheme of UV-Visible Spectrophotometer (Shimadzu -1800)

# *Chapter* *Four*

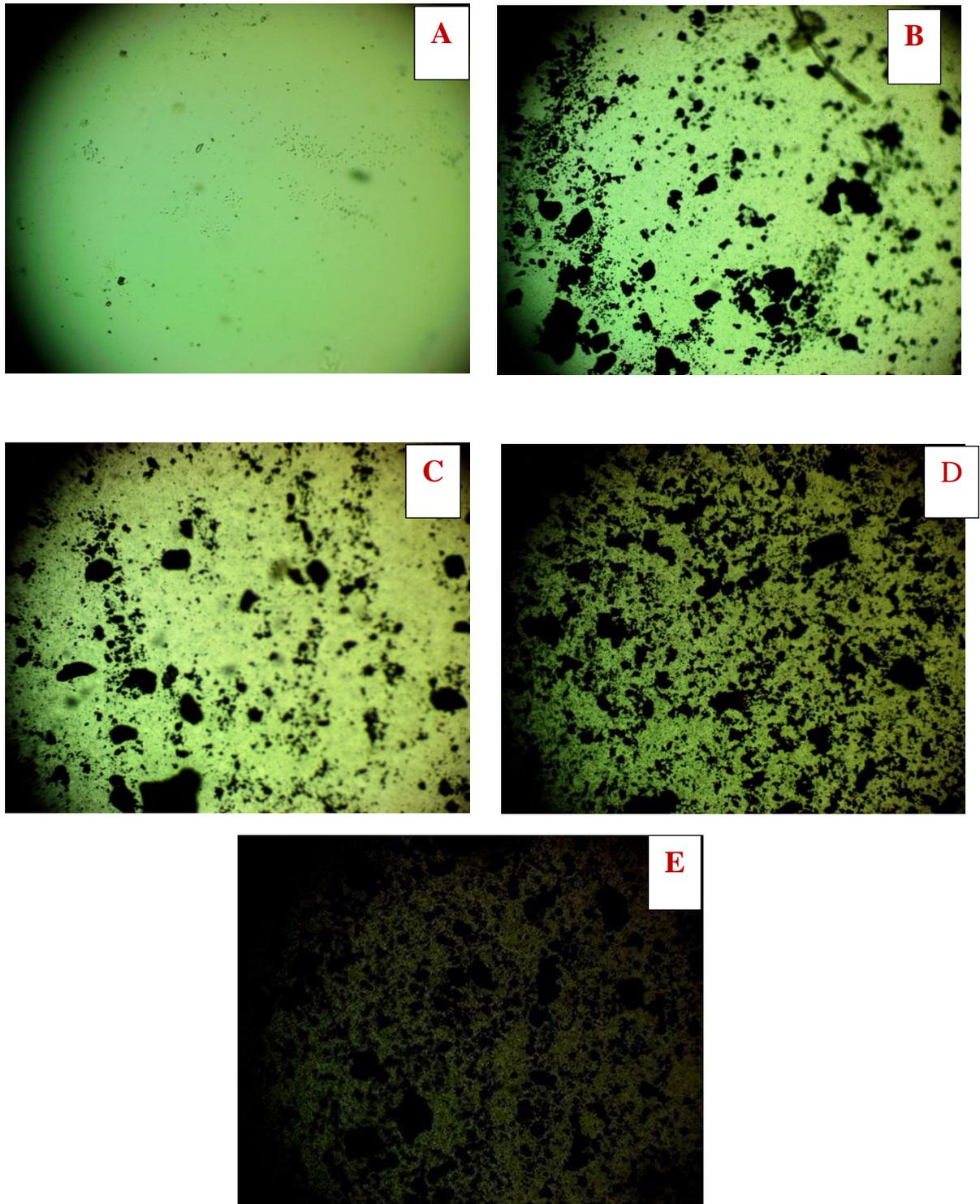
## **Discussions**

### 4.1. Introduction

This chapter include results and discussion of the optical properties of (PVA-PEG/SrO) Nanocomposites.

### 4.2 The Optical Microscope:

Figure (4.1) shows the optical images of PVA-PEG and PVA-PEG/SrO nanocomposites with different concentrations of SrO at magnification power 40X. These images illustrated fine homogeneity of the matrix with a good distribution of SrO into the blend-polymer composites. The OM images exhibited a successful preparation of the PVA-PEG/SrO nanocomposites using this method. In comparison among the polymers blending films with PVA-PEG/SrO nanocomposites films that were displayed a notable modification with increasing the ratio of the SrO. The contribution of SrO exposed many changes in all these films without any aggregations or affect of the transparency of the films. Additionally, the fine distribution was considerably got better with increasing the ratio of the SrO, especially in the sample (D), as illustrated in figure (4.1) (E) in agreement with other authors finding [61].



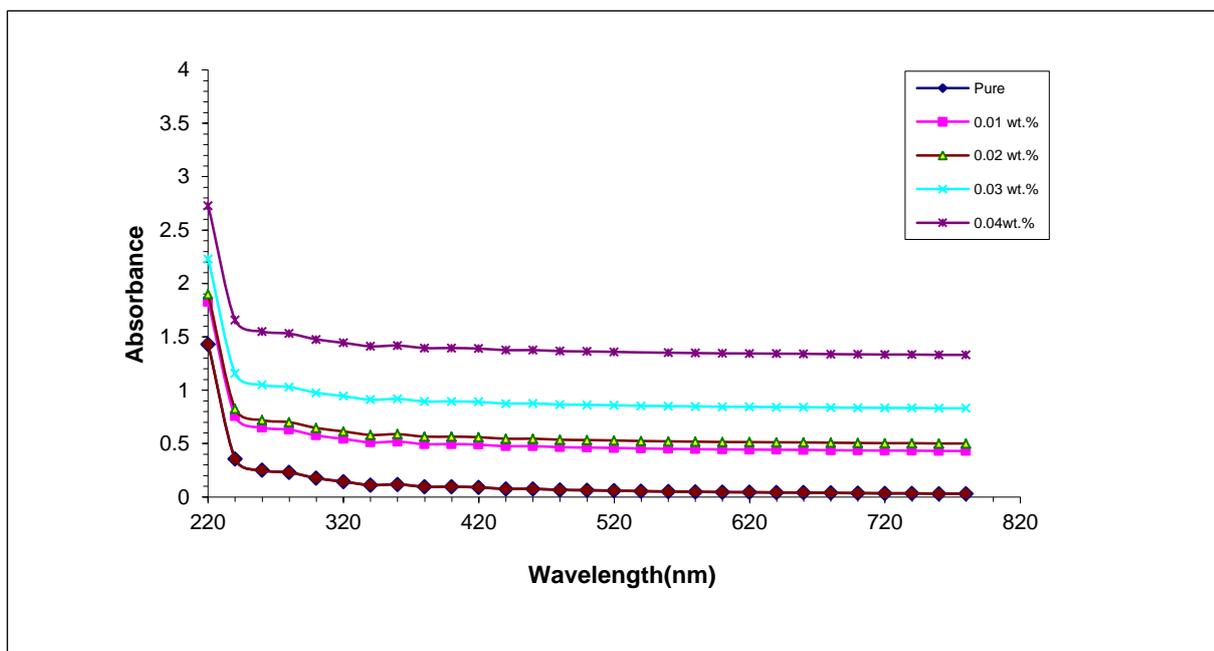
**Figure(4.1) Photomicrographs(10x)for(PVA-PEG/SrO) Nano composites  
(A) (PVA-PEG) blend,(B) 0.01wt%SrO (C)0.02wt% SrO(D)0.03wt%SrO  
and (E) 0.04wt%SrO**

### 4.3.The Optical Properties

The fundamental intention of studying the optical properties of the (PVA- PEG/SrO) Nanocomposites were corresponded to the addition effect of SrO nanoparticles on the optical properties of (PVA-PEG) blend. The energy gaps and other optical constants, such as extinction coefficient, absorption coefficient, as well as identifying the types of electronic transitions of (PVA- PEG/SrO) Nano composites were calculated at room temperature.

#### 4.3.1. Absorbance

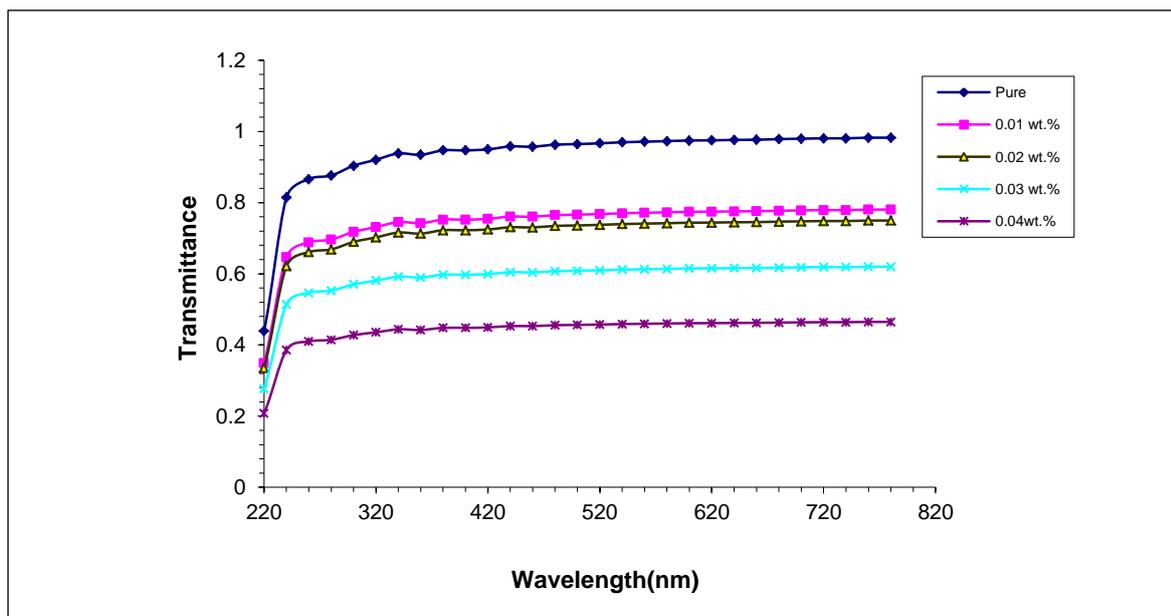
The absorbance of (PVA-PEG/SrO) Nano composites with variable concentration of for wavelength range (220-820) nm was recorded at room temperature. Figure (4.2) display the variation of optical absorbance with wavelength for (PVA- PEG/SrO) Nano composites. From this figure, it can note that the spectra reveal that all these films show more absorbance in ultraviolet region. All Nano composites show that low absorbance is in the visible region, this behavior can be explained as follows: at high wavelength the incident photons have enough energy to interact with atoms will cause transmitting photon. But when the wavelength decreases, the interaction between incident photon and material increase , and then the absorbance increase [63]. Consequently with the increasing of the SrO nanoparticles concentrations the absorbance increased .These results are similar to the results reached by the researchers [64] .



**Figure (4.2) The absorbance as a function of wavelength for (PVA- PEG-SrO) Nano composites with different concentrations.**

### 4.3.2. Transmittance

Figure (4.3) shows the spectral transmittance as a function of wavelength by adding a different ratio of SrO nanoparticles. The transmittance decreased with increasing of SrO nanoparticles concentrations because the existing of SrO nanoparticles, these nanoparticles molecules fill the vacancies between (PVA-PEG) blend.[65,66]



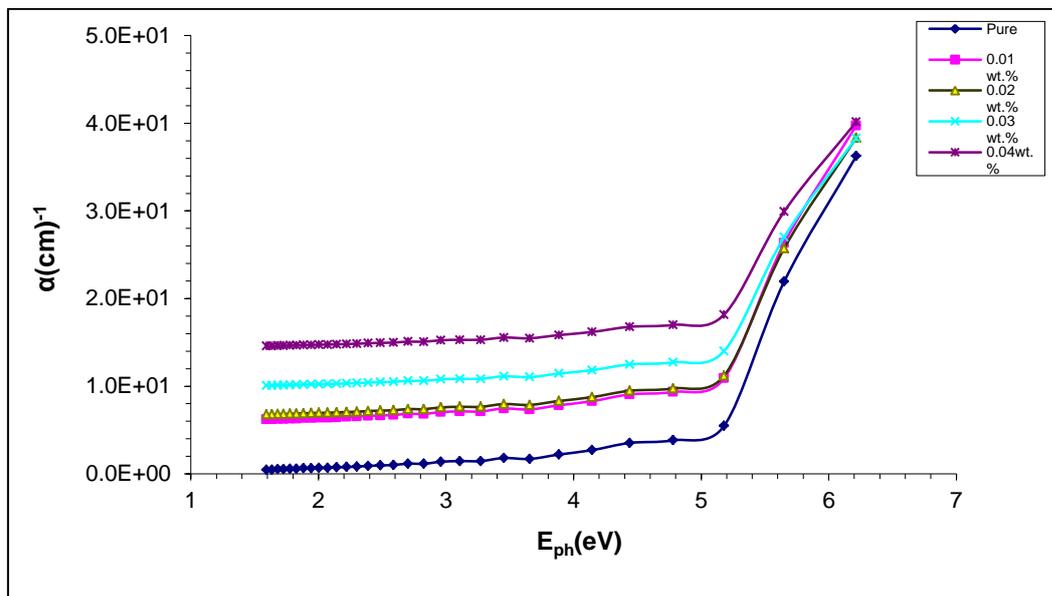
**Figure(4.3) The transmittance as a function of wavelength for (PVA-PEG/SrO) Nano composites with different concentrations.**

### 4.3.3. Absorption Coefficient ( $\alpha$ )

The absorption coefficient  $\alpha$  is calculated by using equation (2.6). Figure (4.4) illustrates the absorption coefficient  $\alpha$  as a function of wavelength for (PVA-PEG/SrO) Nano composites. From figure below it could be noting that the changing in the absorption coefficient is small at high wavelength (low energies) this is indicates the possibility of low electronic transitions. At a low wavelength (high energies), the change of absorption coefficient is large this is indicates the large probability of electronic transitions are the absorption edge of the region [67].

The absorption coefficient helps to conclude the nature of electronic transitions, when the high absorption coefficient values ( $\alpha > 10^4$ )  $\text{cm}^{-1}$  at high energies, direct electronic transitions, the energy and moment are maintained by the electrons and photons. Whereas the values of the absorption coefficient is low ( $\alpha < 10^4$ )  $\text{cm}^{-1}$  at low energies, indirect transition of electron occurs, and the electronic momentum is maintained with the assistance of the phonon [68]. In this work the values of

absorption coefficients are low energies and indirect electronic transitions have been deduced.



**Figure(4.4)** The absorption coefficient as a function of wavelength for (PVA-PEG/SrO) Nano composites with different concentrations.

#### 4.3.4. Energy Gaps (allowed and forbidden) of the Indirect Transition

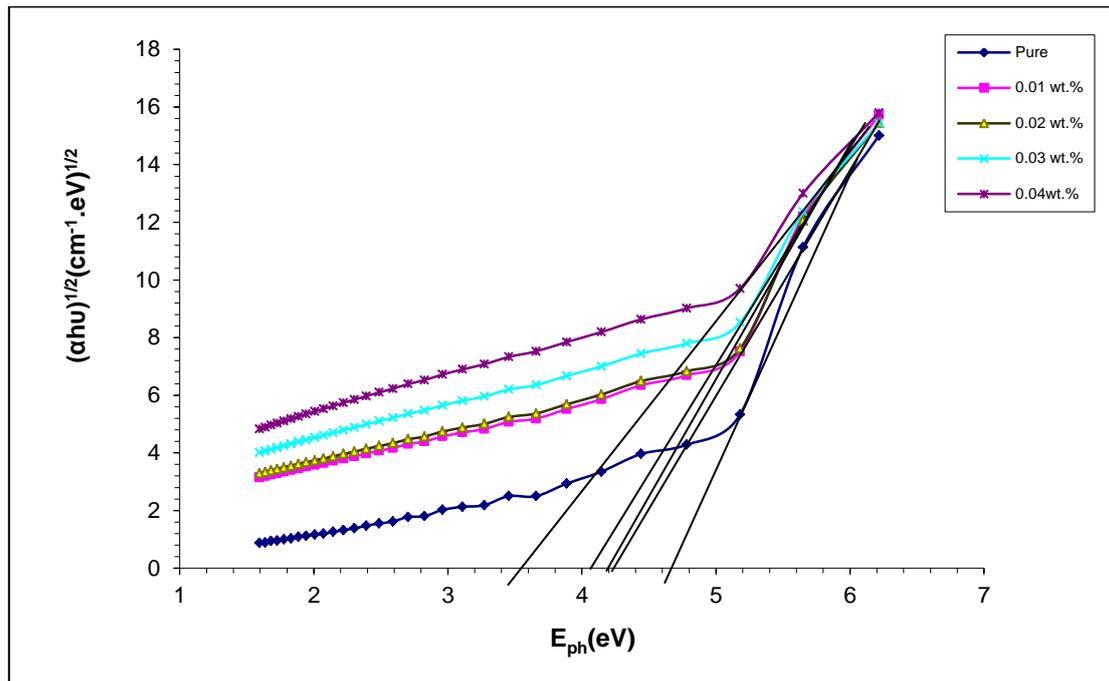
Both the allowed and forbidden indirect transition have been calculated by using equation (2.3). When the value of  $r = 2$ , the allowed indirect transition is calculated, but when the value of  $r = 3$ , the forbidden indirect transition is calculated. Figure (4.5) shows the relation between  $(\alpha h\nu)^{1/2}$  for (PVA- PEG/SrO) Nano composites as a function of photon energy. On drawing a straight line from the upper part of the curve toward the (x) axis, at the value  $(\alpha h\nu)^{1/2} = 0$ , we get an energy gap for the allowed indirect transition [69]. The obtained values are shown in tables (4-1). We can see that the values of energy gap decrease with the increasing of the SrO nanoparticles. This attributed to the creation of

on-site levels in the energy gap, the transition in this case is conducted in two stages that involve the transition of an electron from the valence band to the local levels of the conduction band as a result of increasing the SrO nanoparticles. This behavior is attributed to the electronic conduction depends on added impurities, the increasing of the SrO nanoparticles concentrations provides electronic paths in the polymer which facilitate the crossing of an electron from the valence band to the conduction band ,this explains the decreasing in energy gap with the increasing of the SrO nanoparticles concentrations [70].

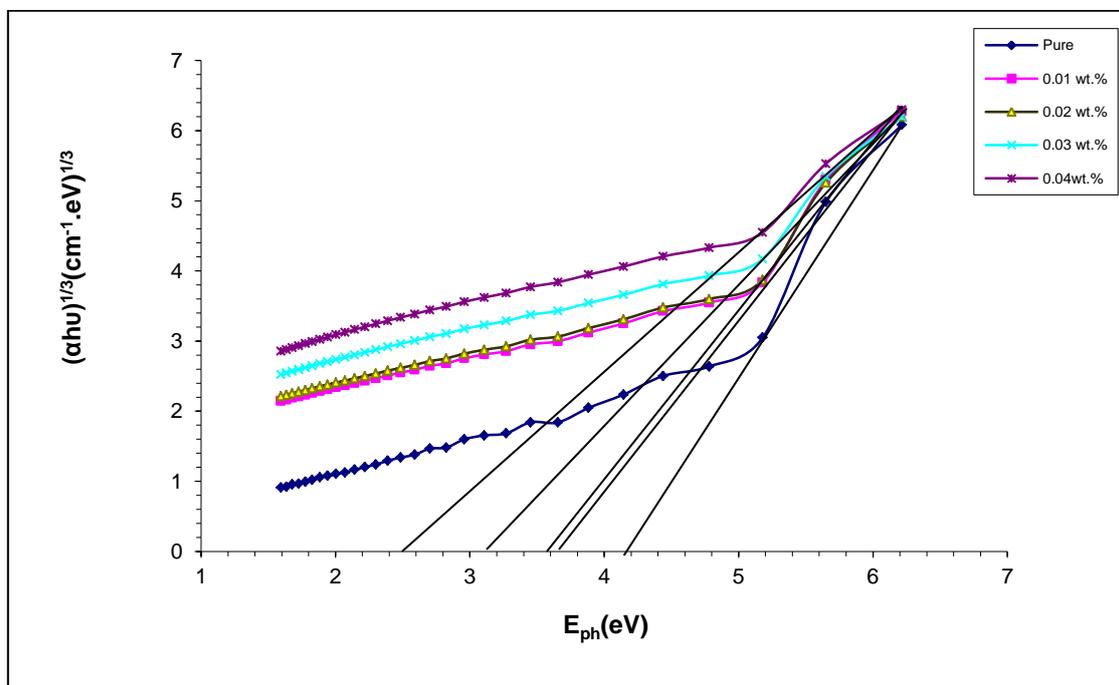
The forbidden transition of the indirect energy gap is calculated in the same way. From table (4-1) and figures (4.6), (4.7) noting that the energy gap for the allowed and forbidden indirect transition for at (PVA-PEG- SrO) Nano composites for different concentrations.

**Table (4.3): The values of energy band gap for the allowed and forbidden indirect transition for (PVA-PEG-SrO) Nano composites.**

SrO Nanoparticles concentrations	E <sub>g</sub> (eV)	
	Allowed	Forbidden
0	4.63	4.18
0.01	4.21	3.63
0.02	4.20	3.59
0.03	4.15	3.16
0.04	3.55	2.56



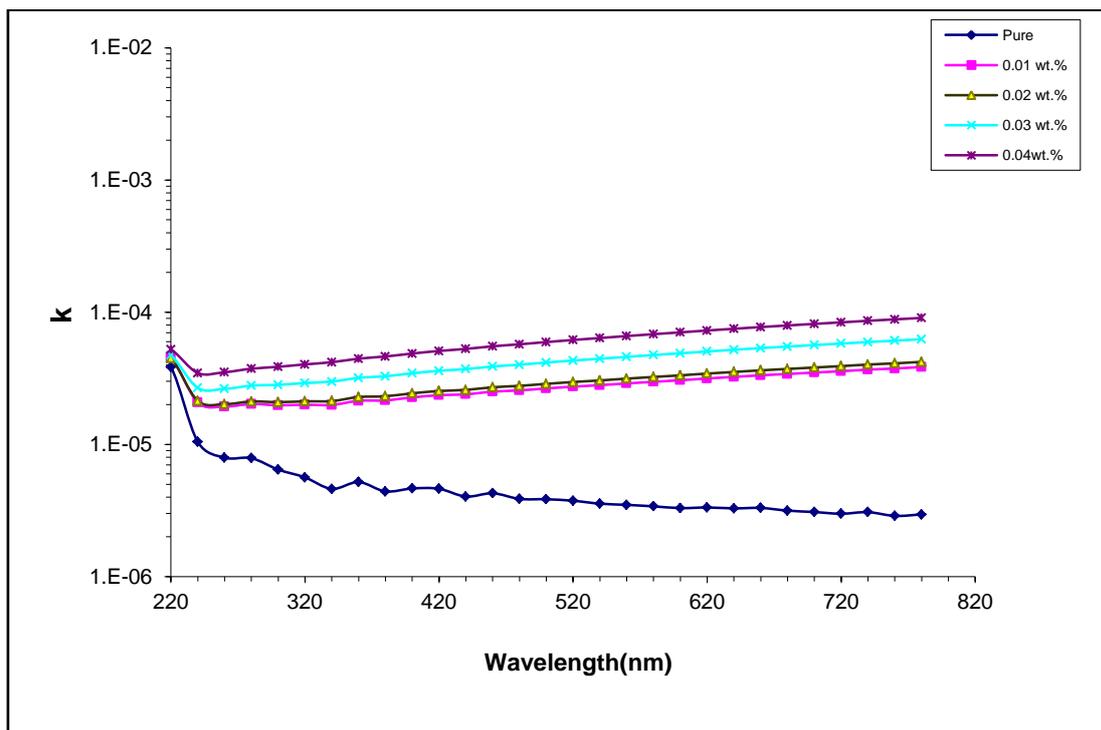
**Figure (4.6)** The energy gap for the allowed indirect transition  $(\alpha h\nu)^{1/2}$  as a function of photon energy of (PVA-PEG/ SrO) Nano composites with different concentration.



**Figure (4.7)** The energy gap for the forbidden indirect transition  $(\alpha h\nu)^{1/3}$  as a function of photon energy of (PVA-PEG/ SrO) Nano composites with different concentration.

### 4.3.5. Extinction Coefficient (K)

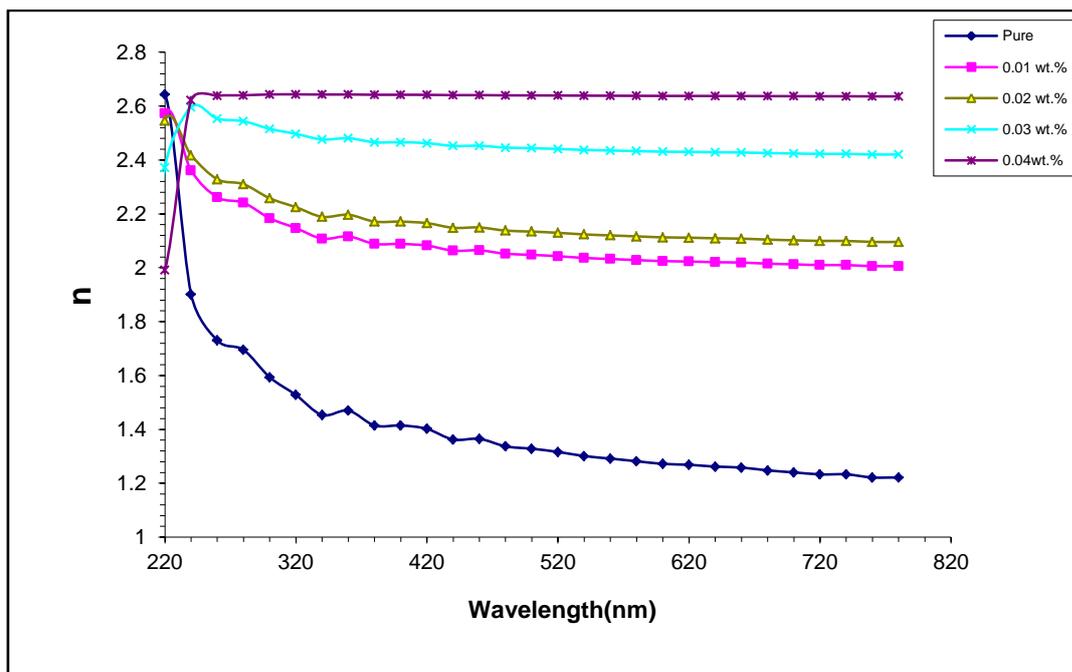
Extinction coefficient ( $k$ ) can be calculated by using equation (2.12). The behavior of the extinction coefficient as a function of the wavelength is shown in figure (4.8) for (PVA-PEG/SrO) Nano composites respectively. It can be noted that ( $k$ ) value decreasing of low SrO nanoparticles concentrations and approximately constant at visible and near infrared region, hence, the extinction coefficient increases with the increasing of the wavelength according to equation (2.12). This is attributed to increasing of absorption coefficient with the increasing of SrO nanoparticles concentrations [71]. Can concluded from the equation (2.12) the absorption coefficient has a direct relation with ( $k$ ).



**Figure (4.8) The Extinction coefficient as a function of wavelength for (PVA-PEG/SrO) Nano composites with different concentrations.**

### 4.3.6. Refractive Index (n)

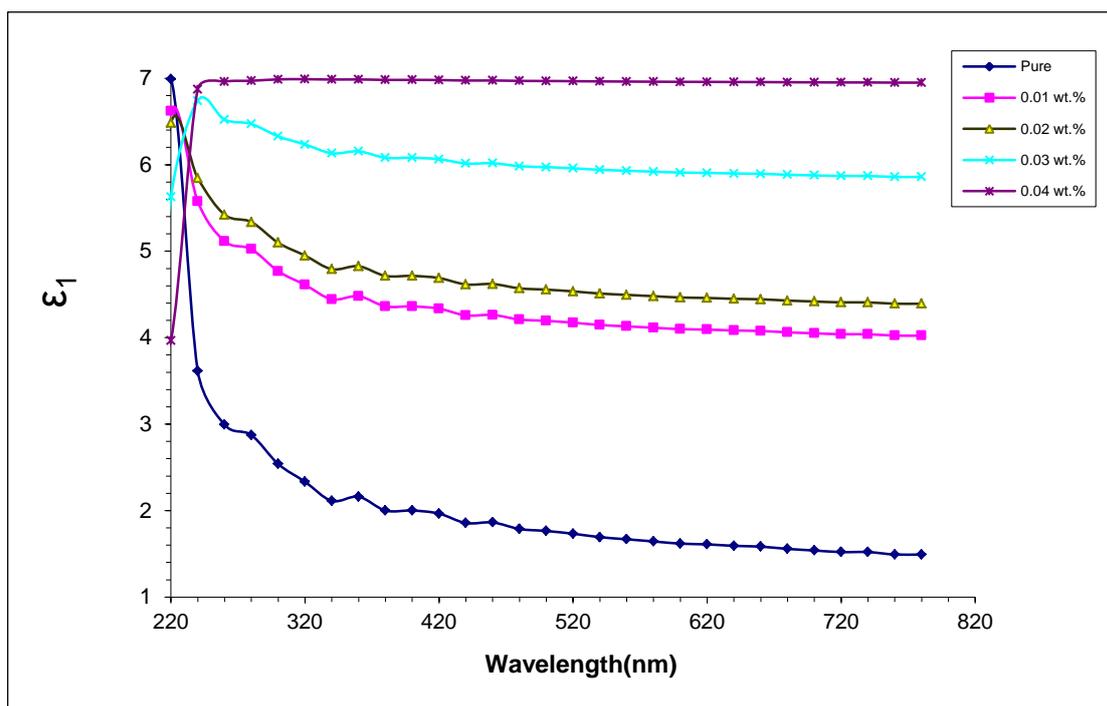
The dispersion curves of the refractive index ( $n$ ) in the normal dispersion region ( $\lambda = 220 - 820$  nm) can be represented in figure (4.9) for (PVA-PEG/SrO) Nano composites. It is found that the values of ( $n$ ) decrease with the increasing of wavelength and reach to nearly constant value at the very long wavelength. Also, it is found that ( $n$ ) increases with increasing SrO nanoparticles concentrations. The refractive index of (PVA-PEG) blends increasing after embedding increasing SrO nanoparticles may be due to the structural modification in polymeric matrix [72] . where the refractive index is calculated from equation (2.10).



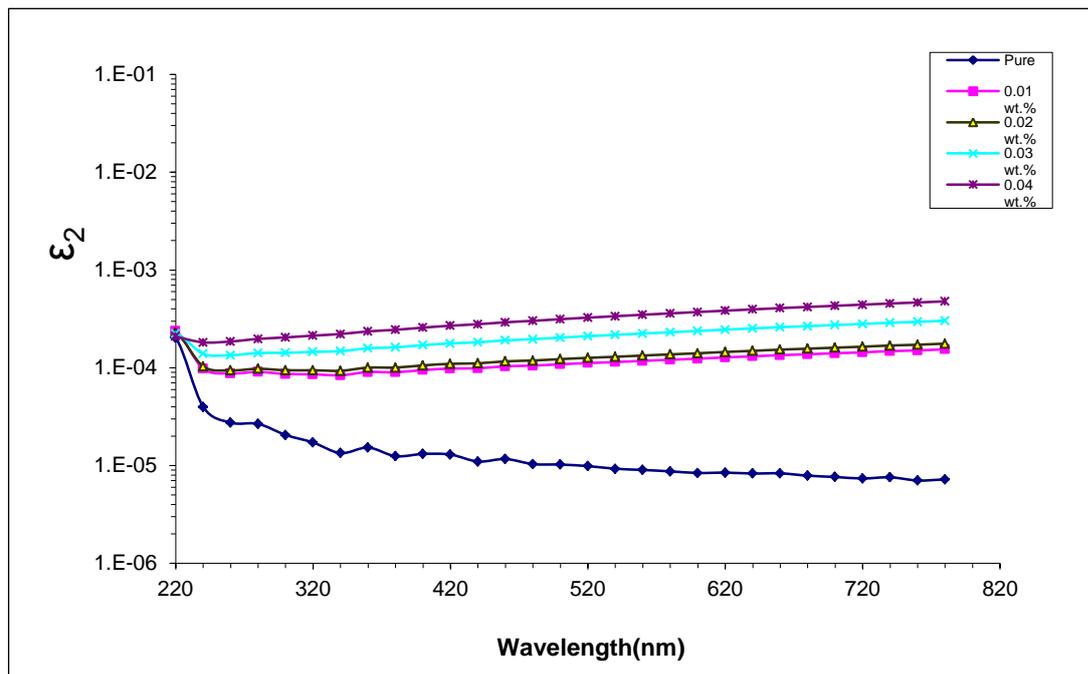
**Figure (4.9) The refractive index( $n$ ) as a function of wavelength for (PVA-PEG/SrO) Nano composites with different concentrations.**

### 4.3.7 . Real and Imaginary Part of Dielectric Constant

The real and imaginary parts of dielectric constants ( $\epsilon_r$ ,  $\epsilon_i$ ) can be represented as shown in figures (4.10) , ( 4.11 ) for films of pure (PVA-PEG / SRO) and (PVA-PEG / SRO) nanocomposites with different (SRO) nanocomposites concentrations. From this figures, it is noticed that the behavior of  $\epsilon_r$  was the same as refractive index due to the small values of  $K^2$  compared to  $n^2$ , whereas  $\epsilon_i$  basically relies on the values of  $K$ , that is connected to the variety of absorption coefficient. Also, it is seen that the maximum values of the  $\epsilon_r$  and  $\epsilon_i$  were reached in the low wavelength region (absorption region) and the values of  $\epsilon_r$  is higher than that of  $\epsilon_i$ .



**Figure (4.10) Real Part Constant as a function of wavelength for (PVA-PEG/SrO) Nano composites with different concentrations.**



**Figure (4.11) Imaginary part of Dielectric Constant as a function of wavelength for (PVA-PEG/SrO) Nano composites with different concentrations.**

# *Chapter*

# *Five*

## **Conclusion and Future Work**

**5-1 Conclusions**

1. The results of the optical microscopy of (PVA-PEG/SrO) Nano composites show the addition of SrO nanoparticles distributed through the polymeric blend with homogenous and ordered shape as well as the apparent of SrO network inside the polymer blend.
2. The absorbance increased with increasing of concentration of SrO nanoparticles. The results indicate that absorbance for (PVA-PEG/SrO) Nano composites. This conclusion is useful to determine the industrial applications such as photo detectors.
3. The absorption coefficient (PVA-PEG/SrO) Nano composites is less than  $(10^4)$  (cm)<sup>-1</sup> at all concentrations from these result is being indirect transition.
4. The optical properties of (PVA-PEG/SrO) Nano composites contain refractive index (n), extinction coefficient (K) and the dielectric constant (real and imaginary) part increase with increasing the concentration of SrO nanoparticles.
5. The energy gap for indirect transition (allowed, forbidden) of (PVA-PEG/SrO) Nano composites decreased with increasing of SrO nanoparticles concentration.

**5-2 Future work**

1. Study of the thermal properties of the (PVA-PEG/SrO) Nano composites.
2. Study of the mechanical properties of the (PVA-PEG/SrO) Nano composites

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في هذا العمل ، تم تحضير المترابك النانوي (بولي فينيل كحول- بولي إيثيلين جلايكول / أوكسيد السترونتيوم) (PVA-PEG / SrO) لدراسة الخصائص البصرية ، باستخدام طريقة الصب حيث تم استخدام الماء المقطر كمذيب لكلا البوليمرين (بولي فينيل كحول (PVA) و بولي إيثيلين جلايكول (PEG) . ثم تمت إضافة نسب مختلفة من الجسيمات النانوية أوكسيد السترونتيوم (SrO) (0.01 ، 0.02 ، 0.03 and 0.04) wt% . بعد الحصول على تجانس جيد للمترابك النانوي (PVA-PEG / SrO). أظهرت نتائج الدراسة تحسن في الخصائص البصرية حيث أظهر المجهر البصري في جميع العينات تشكيل شبكة مستمرة من الجسيمات النانوية داخل البوليمرات في جميع النسب (0.01 ، 0.02 ، 0.03 ، 0.04) wt% حيث تكونت ممرات متصلة من المواد النانوية تسمح بمرور ناقلات الشحنة من خلالها . كما أظهرت نتائج الخواص البصرية للمركبات النانوية (PVA-PEG / SrO) أن قيم النفاذية وفجوة الطاقة المحظورة تتناقص مع الزيادة النسبية في تركيز المادة النانوية SrO المضافة ، بينما تزداد قيم معامل الامتصاص ، ومعامل الخمود ، ومعامل الانكسار ، وثابت العزل الحقيقي والخيالي مع زيادة تركيز الجسيمات النانوية لـ (SrO).



جمهورية العراق  
وزارة التعليم العالي والبحث العلمي  
جامعة بابل  
كلية التربية للعلوم الصرفة  
قسم الفيزياء

# دراسة الخصائص البصرية للمترابك النانوي (PVA – PEG/ SrO )

## بحث مقدم

الى مجلس كلية التربية للعلوم الصرفة في جامعة بابل وهو جزء  
من متطلبات نيل درجة الدبلوم العالي تربية /فيزياء المواد  
وتطبيقاتها

من قبل الطالب

صلاح مهدي فرحان دهلة

بكالوريوس كلية التربية الجامعة المستنصرية ٢٠٠٧م

بإشراف

أ.د. علي رزاق عبدالرضا