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Magnetic Field Effect on Optical Properties (PVA) Doped (Al_2O_3) Nanoparticles

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بِسۡمِ ٱللَّهِ ٱلرَّحۡمَٰنِ ٱلرَّحِيمِ

(وَلَقَدْ آتَيْنَا دَاوُودَ وَسُلَيْمَانَ عِلْمًا وَقَالَا الْحَمْدُ لِلَّهِ الَّذِي فَضَّلَنَا عَلَى كَثِيرٍ مِنْ عِبَادِهِ الْمُؤْمِنِينَ)

صدق الله العلي العظيم

سورة النمل (الآية 15)

Dedication

To my father who gave me the endurance to complete my road,

To my mother the best woman in the universe,

To my brothers and sisters,

To my close friends,

To my teachers,

To my country with honour and dignity,

and

Everyone who has helped me.

Ghufran

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Abstract

In this work, films were prepared consisting of (PVA) Polymer doped with(Al_2O_3)nanoparticles with a different weight ratio(0,1,3and5) wt % of the weight used in preparing by casting method the solution, using chloroform alcohol as a solvent, and at laboratory temperature.

Fourier infrared spectroscopy was used to test the prepared films noting that there was no chemical reaction between the components of the materials from which the films were prepared.

The optical properties of the samples were studied using an absorption spectrometer within the range (190-1100) nm. The study proved that the optical properties of the samples (absorption, absorption coefficient attenuation coefficient, refractive index, real and imaginary dielectric constant) of these films increased with the increase in the weight ratios of (Al_2O_3) nanoparticles in the films, while the transmittance and energy gap decreased, where the energy gap values were recorded between (4.7-3.9eV) at the highest weight ratio of (5) wt% of nanoparticles.

Use the optical microscope to find out the distribution of the nano-material (Al_2O_3) within the prepared films in a homogeneous manner and the absence of lumps their.

The effect of the magnetic field films doped (Al_2O_3) nanoparticles with different weight ratios was studied where an improvement in the optical properties, as the transmittance became large for the light falling on it and the other optical properties decreased, namely (absorption, absorption coefficient, attenuation coefficient, refractive index, real and imaginary dielectric contants).

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List of symbols

Symbols	Physical meaning	Units
A	Absorbance	%
B	Constant depended on type of material	m/s
C	Velocity of light in vacuum	m/s
E	Electrical field intensity	v/m
$\boldsymbol{\varepsilon}$	Complex dielectric constant	-
$\boldsymbol{\varepsilon_0}$	Vacuum permittivity	-
$\boldsymbol{\varepsilon_1}$	Real part of the dielectric constant	-
$\boldsymbol{\varepsilon_2}$	Imaginary part of the dielectric constant	-
$\boldsymbol{E_{Ph}}$	Energy of phonon	eV
$\boldsymbol{h}$	Plank constant	J.s
$\boldsymbol{E}$	Photon energy	eV
$\boldsymbol{I_A}$	Absorbed light intensity	Lumen
$\boldsymbol{I_0}$	Incident intensity of light	Lumen
$\boldsymbol{I_p}$	Conduction current	A
$\boldsymbol{k_0}$	Extinction coefficient	m^2/mol
L	Polar length	-
N	Refraction index	-
N	Concentration of charge carriers	cm^2/v.s
$\boldsymbol{n^*}$	Complex refractive index	-
P	Total dipole moment	D
R	Reflectance	-
$\boldsymbol{E'}$	Urbach energy	eV
$\boldsymbol{\sigma_{op}}$	Optical conductivity	S^{-1}
$\boldsymbol{D}$	Thickness	cm
V	Velocity of light in medium	m/s

υ	Frequency	Hz
α	Absorption coefficient	cm^{-1}
λ	Wavelength	Nm
μe	Electrical dipole moment	c-m
M	Magnetization	A/m

List of abbreviations

Abbreviations	Meanings
Al_2O_3	Aluminum oxide
C.B	Conduction bond
M_w	Molecular weight
PVA	Polyvinyl Alcohol
V.B	Valence bond

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1.1 Introduction

In recent years, the use of most polymers was limited to the manufacture of cheap products which were used for simple purposes . However, the speedy technical development has required the replacement of some materials being used in industry with others having better specifications; consequently, polymers have replaced iron and aluminum for some purposes that require high temperature and stress [1.]Polymer composites have unrivaled properties like light weight ,high flexibility, and possibility to be produced at low temperature and low cost [2]. The polymers can be divided into two denominations : industrial and natural. The natural polymers include proteins, cellulose ,starches and rubber, either the industrial polymers include poly(vinyl chloride), polypropylene, nylons polyethylene, Polyvinyl Alcohol , Polyacrylamide and polyesters polycarbonate, etc.[3]. Over the past few years, a little word with big potential has been rapidly insinuating itself into the world's consciousness, that word is "Nano". Nanotechnology is one of the leading scientific fields today since it combines knowledge from the fields of physics, chemistry, biology, medicine, informatics, and engineering. It is an emerging technological field with great potential to lead in great breakthroughs that can be applied in real life.Nanotechnology tools and techniques enable the fabrication and control of new nano and biomaterials, as well as nanodevices [4].Nanotechnology, often known as nanoscale science, is the study of matter at the nanoscale, which is defined as the range of (1 to 100) nm. A breakthrough in academic and industrial interest in these nanomaterials over the past 10 years has been of interest due to the remarkable differences in solid-state properties. In Greek, "Nano" means little man while the SI unit "Nano" corresponds to (10-9 m) magnitudes, such as nanometers, nanoliters, nanograms [5.]The nanosciences have attracted a lot of interest for a number

of reasons. Among them, the very large surface to volume ratio showed by many nanoscaled materials opened novel possibilities in surface-based science , such as heterogeneous catalysis [6.].Moreover, it has been discovered that the properties of materials change as their size approaches the nanoscale, or when a portion of certain atoms on the material's surface becomes significant. For example, inert metals such as platinum can act as catalysts, semiconductors such as silicon can act as conductors that become conductive, etc., the applications of nanotechnology have only increased in recent years, and the highest potential application is in the field of materials, followed by electronics and medicine [7].

1.2 Polymer Structure

Polymer science was born in the great industrial laboratories of the world of the need to make and understand new kinds of plastics, rubber, adhesives, fibers, and coatings. Only much later did 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 as well [8]. Polymerization is The process of continuous connections to a chain or network structure of one or two, often more, forms of small molecules, resulting in a very large molecule with hundreds or thousands of atoms. These large molecules are classified as monomers, as the essential building blocks [9]. The size and shape of near to their properties are the polymers. The polymer form has a strong relationship with the size of the different units that make up the macromolecules and to the different primary and secondary bonding forces that are present within the chain and between the chains [10].

1.3 Classification of Polymers

Polymers cannot be classified under one category because of their complex structures, different behaviors and vast applications.We can, therefore, classify polymers based on the following considerations.

1.3.1 Thermal Classification of Polymer

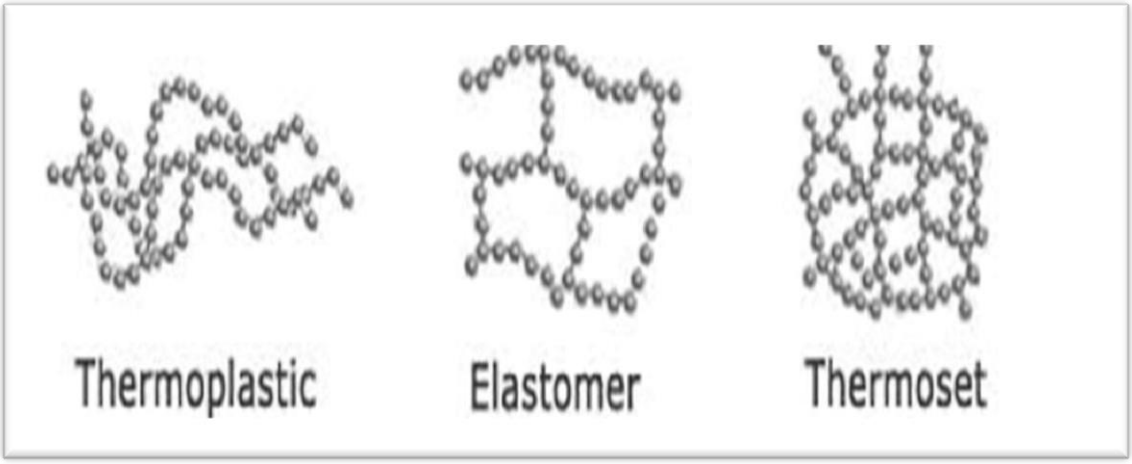
According to the effect of temperature, polymers can be classified into three types as follows: [11,12]:

a.Thermoplastic polymers: The effect of temperature on these polymers affects their properties. As the temperature increases, the polymers be sticky and flexible polymers return to their solid state if the temperature decreases. This is due to the thermoplastic polymer's molecules being held together by intermolecular powers are relatively weak (Van der Waals forces). These olecules, including polystyrene, polyethylene, polypropylene, and polyvinyl chloride, slip over each other when heated, as shown in the figure (1.1.a).

b. Elastomers Polymers: Elastomers are a form of network polymer that is lightly cross linked and can be extended to extreme lengths reversibly. They have very tightly randomly coiled molecules when not stressed, which are expanded polymers bent as they are stretched. This reduces the randomness of the chains resulting in a lower entropy in the material, and this entropy decrease is due to the retroactive force observed. When a material is extended, cross-links prevent molecules from moving past one another. The rubbers become glassy or crystal clear as they cool (partially). When heated they don't flow because of cross-links in a traditional sense. Vulcanized rubber and neoprene as shown in figure (1.1.b).

c- Thermoset Polymers: These polymers have been modified chemically. When hot. When heated thermosets are typically networked polymers with a high degree of interconnection between polymer chains. These polymers are

insoluble after heating, they are not heater and electric conducting and hard because their molecules are connected by strong chemical bonds. Examples of this kind of polymers are phenol formaldehyde resin and urea formaldehyde resin. As seen in figure. (1.1.c).



a b c

Figure (1.1): Schematic representation of (a-polymer thermoplastic, b-polymer elastic, c-polymer thermoplastic) [13].

1.3.2 Classification Based on the Structure of the Polymers:

There are three different types based on the structure

1.Linear polymers: these polymers are linearly organized. Only a bi-functional monomer can form linear polymers. They are usually thermoplastic polymers and, except for very high molecular weight materials, are soluble in solvents. These polymers have the ability to crystallize more than other polymers and have the desired mechanical properties. The fundamental structural unit for these polymers is a molecular sequence of a certain length linked in linear form. Polyethylene, poly (vinyl chloride), polystyrene, poly (methyl methacrylate), nylon, and fluorocarbons are some of the most common linear polymers [14], as shown in figure (1.2.a)

2.Branched Polymers: The reaction between polyfunctional molecules results in structural units that can be connected in such a way as to form non-linear structures. In certain situations, the side growth of each polymer chain can be stopped before the chain has a chance to link up with another chain. The resulting polymer molecules are said to be bundled. Branching can produce several physical properties in a polymer, such as a decrease in solvent solubility, a rise in the softening point and also a decrease in thermoplastic properties. For example, high density polyethylene (HDPE) is primarily a linear polymer, while low density polyethylene (LDPE) contains short chain branches [15], as shown in figure (1.2.b).

3.Cross Linked Polymers: Polymer chains, in this category are intertwined and are interconnected with more than one site, it is clear in figure (1.2.c). By covalently or ionic ally bonding polymer chains together, a network is formed that reduces molecular freedom, increases thermal resistance, and increases polymer rigidity while reducing flow properties. Chemical reactions that occur after heating create cross-linked covalent bonds. Cross-linked polymers are no longer dissolved and instead swell in the presence of a solvent (except ionic ally cross linked). A gel is a cross-linked polymer that has swollen. The degree of crosslinking has a major effect on the polymer's physical and mechanical properties. When the degree of crosslinking is increased, the rubber properties decrease and the melting point increases. When the degree of crosslinking is high, the polymer becomes non-fusion and non-conductive to heat and electricity For example, Bakelite (used in electrical insulators),Melamine etc. [16].

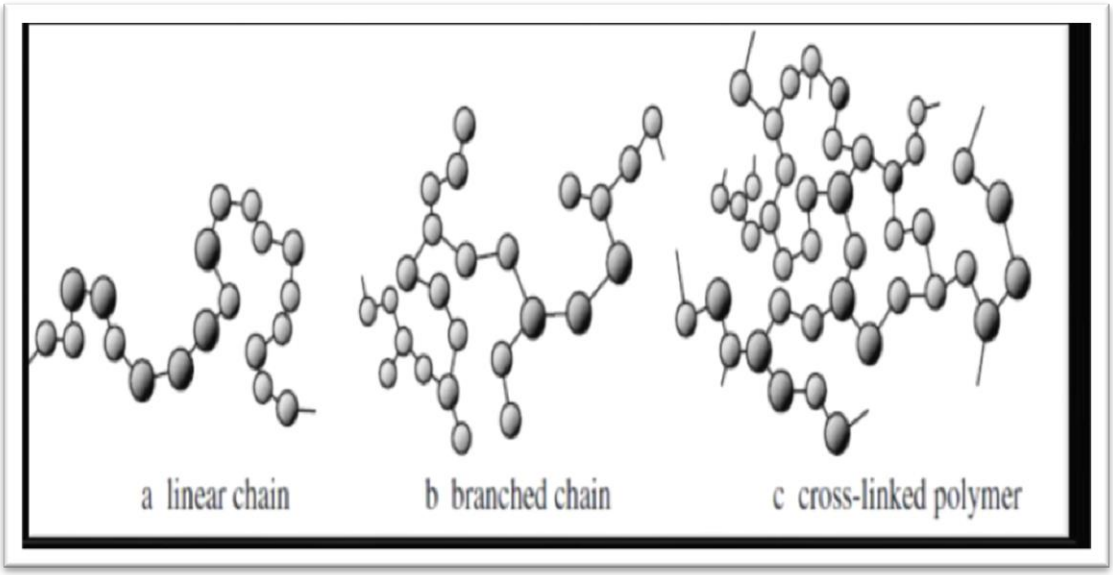


Figure (1.2): Constructivism Authority for (a- Linear polymer, b- Branched polymer, C - Cross linked polymer) [17].

1.3.3 Classification of Polymers Dependent on Homogeneousness

Polymers are classified according to the homogeneity of the repeater units. In to: [18,19]

1- Homo polymers

If the building blocks of the polymer are of the same kind as in poly therphethal ethylene.

2-Copolymers

Where polymer construction blocks have more than one shape, as is the case in polymers.

3- Polymers Composite

It is the method of introducing such materials to homogenous polymers to alter their properties and to join new recipes.

1.3.4 Classification Based on Sources Polymers

Polymers are of two primary origins: [20,21].

1- Natural Polymers:

Natural polymers There are plant or animal based compounds such as wood, cotton, natural rubber, wool, and silk. Starch, protein and cellulose are the natural foods that are natural polymers. Natural polymers may have some properties such as biocompatibility, biodegradability and low toxicity.

2- Synthetic Polymers:

Polymer made of simple chemical compounds that constitutes the most important industrial polymers, including plastics, synthetic leather, nylon materials and a number of other colors. Synthetic polymers provide some other properties such as mechanical and physical properties and thermal stability.

1.4 Nanomaterials

One nanometer (nm) is one-billionth of a meter. Thus nanomaterials are materials in which a single unit is sized between (1-100)nanometers. These materials often have unique properties resulting from their size ,shape, and chemical composition [22]. Two principal factors cause the properties of nanomaterials to differ significantly from other materials increased relative surface area and quantum effects [23].

1.5 Nanocomposites

Nanocomposites are composites in which at least one of the phases shows dimensions in the nanometer range [24]. These are high performance materials that exhibit unusual property combinations and unique design possibilities and are thought of as the materials of the 21st century with an estimated annual growth rate of about 25% and huge demand for engineering polymers, their potential is so promising that they are useful in several applications ranging from packaging to bio-medical. Literature survey reveals that about 18,000

publications, including papers and patents, have been published on nanocomposites in the last two decades. It has been reported that at the nanoscale (below about 100 nm), a material's property can change dramatically. With only a reduction in size and no change in the substance itself, materials can exhibit new properties such as electrical conductivity, insulating behavior, elasticity, greater strength, different color and greater activity-characteristics that the very same substances do not exhibit at the micro or macro scale [25]. The general idea of nanocomposites is based on creating an extensive interface between the nanosized building blocks and the polymer matrix [26]. The mechanical, electrical, thermal, optical, electrochemical, catalytic properties of the nanocomposites will differ markedly from the component materials [27].

1.6 Applications of nanocomposites in industry:

1.Fiber/textile electrically conductive textiles, sensors, mechanical reinforcement, electromagnetic shielding, microwave, absorption, electrical energy storage (capacitors), actuators) [28].

2. Chemical sensors, pressure sensors (Detection and identification of gases, including atmospheric pollutants, Flammable gases, solvent vapors like Touch sensors for interaction Between operators and machines) [29].

3. Refractive index tuning (Optical connectors, optical fibers and switches, signature management) [30].

4. Aerospace (Impact/damage resistant carbon fiber-reinforced polymers, transparent materials (canopies), surface coatings for signature management, Corrosion protection [31].

5. Ultraviolet irradiation resistance (Components and coatings exposed to sunlight, space coatings, textiles exposed to sunlight, paint and other surface protection) [32].

6. Porous nanocomposites (Shock absorbing materials, acoustic absorbents, vehicle seat with the advantage of reduced flammability) [33].

7. Existing industrial (Functional and lightly loaded components, presently made from plastics or light alloy (handles,components of portable weapons systems, especially where injection molded plastic can replace metal components.

8. Ballistic protection (Body/personal armour where flexibility of movement is required, in particular protection against blunt weapons (stones, sticks and bars for arms and legs [34].

1.7 Materials used in the Study :

1.7.1 Polyvinyl alcohol (PVA)

The chemical formula of poly vinyl alcohol (PVA) $[(CH_2CH(OH)]_n$ and it is a polymer with exceptional properties such as water solubility, biodegradability, biocompatibility, non-toxicity, and non-carcinogenetic that possesses the capability to form hydrogels by chemical or physical methods [35]. PVA has high enough tensile strength and satisfactory flexibility. To improve deformability PVA is usually plasticized by the variety of low molecular compounds mostly containing polar groups [36], which associate with hydroxyl groups of PVA chain (with or without water assistance) developing hydrogen bonds, thus reducing direct hydrogen bonding between PVA macromolecules [37]. The comparatively high biodegradability in the environment may be one of the most important and desirable characteristic of PVA, because the polyvinyl type polymer consisting of a carbon-carbon main chain is scarcely biodegradable [38]. This property of PVA has been reevaluated recently, and much effort has been made to produce PVA-based biodegradable polymeric materials having preferred physical and chemical

properties for use in industrial and medical fields [39]. Table (1.1) shows to physical properties of (PVA).

Table (1.1): The physical Properties of PVA polymer [40]

Physical properties	*Units*	*Results*
Molecular weight	g/mol	150000
Solution PH		5.0-7.0
Density	g/cm^3	1.19-1.31
Viscosity	mm^2/s	4200
Specific volume	m^3/kg	7.7×10^{-4}
Specific heat	J/kg·K	1674
Thermal conductivity	W/(m.K)	0.2
Thermal stability		Gradual discoloration about 100 ^{0}C, darkens rapidly above 150 ^{0}C, rapid decomposition above 200 ^{0}C
Meltingpoint (unplasticized)	$^\circ$C	230 for fully hydrolyzed grades, 180-190 for partially hydrolyzed grades
Tg	$^\circ$C	75-85
Storage Stability (solid)		Indefinite when protected from moisture
Electrical conductivity	$(Ohm.cm)^{-1}$	$1*10^{-13}$
Stability to sunlight		Excellent

1.7.2 Nanoparticle of Al_2O_3

Aluminum oxide is a trivalent chemical compound with a chemical formula of Al_2O_3 and this oxide is considered one of the most important oxides in many nanoscale applications and fields. It can be called alumina oxide or aloxite, according to its shape and special applications. It is also considered important in the production of aluminum metal. It is also used as an abrasive material because of its hardness and as a heat-resistant substance due to its high temperature.

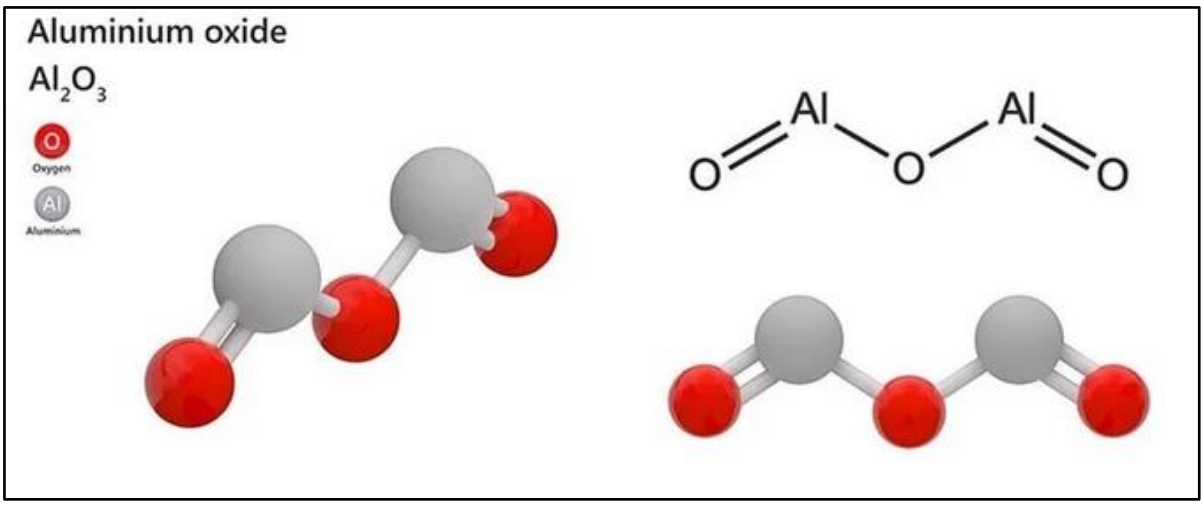


Fig (1-3). Alumina (Al_2O_3) Nanoparticles

Al_2O_3 and various oxides are founded in many uses including luminescent compounds [41] additives for polymer [42]; on another hand, alumina is cost effective and is used in other applications. It also has high properties such as abrasion resistant, high electrical insulation, good thermal conductivity and hardness [43]. Alumina is also used in other applications such as gas laser tubes, high-temperature and high-voltage electrical insulators [44]. Polymer compounds exhibit unique properties that enable them to be used in a number of applications with easy processing techniques and optical properties. The most famous water-soluble polymer is the poly-vinyl alcohol polymer used in optoelectronic devices with good optical properties [45]. It is a semi-crystalline vinyl polymer with good dielectric, high transparency and low light scattering

with low refractive index [46]. Aluminum Oxide (Al_2O_3) has various features, namely it has good corrosion resistance in various environments, has excellent bioinert properties and has high temperature resistance and good electrical resistance [47].

1.8 The Effect of Molecular Forces on the Polymer Properties

Molecular forces have a significant influence on the physical properties of polymers melting point, glass transition point, viscosity, and solubility Thermal stability, crystallization, etc. It is usually expressed as a measure of strength in polymers in terms of cohesion energy, which is known as the amount of energy needed to move a molecule of a substance in its liquid or solid state to a position far away from neighboring particles. This energy is usually measured in a unit volume. It is then called specific cohesive energy or cohesive energy density. This energy is usually equivalent to the heat of vaporization for liquid materials and equivalent to the heat of sublimation for solid materials. The cohesion energy for polymers is relatively different from simple compounds because polymers are usually characterized by high molecular weights, so the cohesion energy of one molecule is very large, even greater than the energy of the basic bonds in the polymer chain. Accordingly, the polymer molecule begins to disintegrate before it volatilizes and separates from the other molecules. The cohesion energy of polymers has a significant effect on the melting point of the polymer and the degree of its glass transition. The following table shows the extent to which some physical properties of the polymer depend on the cohesion energy density [51].

Table (1-2): Effect of intensifying cohesion energy on some physical properties of some industrially important polymers [52]:

Polymer	The solvation medium (cohesive energy density).	The degree of glass transition (T_g ^oC)	Crystal Melting Point (T_m ^oC)
Polyethylene	141	- 125	7.
Polypropylene	165	- 20	8.
polyvinyl chloride	190	87	9.5
Polyisobutylene	10	- 50	7.8
Poly iso benzene	28	- 72	8.1
Polystyrene	239	100	8.6
PMMA	105	9.1	
Poly Tri Ethylene Phthalate	267	69	10.7
PVA	50	13.6	66
Polyacrylonitrile	317	120	15

1.9 Literature Survey

In 2010, Zhanhu Guo et al. prepared Iron oxide nanoparticles in an environmentally friendly manner at 300 degrees Celsius and sodium chloride was applied as a barrier to disperse iron oxide particles and to prevent agglomeration. It was found that the presence of sodium chloride and iron nitrate with nanoscale dimensions (19 nm for 20:1 and 14 nm for 50:1) also showed the presence of a polyvinyl alcohol polymer that reduces the agglomeration and growth of particles. [53].

In 2015, Hussein Hakim et al. studied the effect of the optical properties of polymers (polyvinyl alcohol and polyethylene glycol) b9y doping these polymers with aluminum oxide nanoparticles in different weight ratios by

pouring the solution. These samples were characterized by a spectrophotometer and the absorption spectra were obtained within the wavelength (220-800). The results showed that the values of the properties (real and imaginary part of the dielectric constant, refraction, extinction and adsorption coefficient) increase with the increase in the doping of the polymers with the oxide used in different proportions [54].

In2015, Shurooq Sabah. prepared samples of (PVA) transformed polyvinyl polymer dopant with different percentages of aluminum oxide nanoparticles and studied their effect on dielectric properties such as dielectric constant and electrical conductivity, and they found that it increases with increasing concentration of doping ratio of aluminum oxide, as it was found that dielectric constants increase when an increasing electric field is applied[55].

In 2015, Sathish Sugumaran et al. prepared composite poly (vinyl alcohol)–aluminum oxide (PVA–Al2O3) thin films successfully prepared on precleaned glass plates by dip coating method. The presence of metal–oxide (M–O) bond in the films was identified by Fourier transform infrared spectroscopy. These samples were prepared and described structurally and optically, and it was found from the characterization of the samples after they were annealed that they are amorphous, through the ultraviolet device. It was found from these samples that they have a high light transmittance of up to 80%, and it was found that it increases with increasing the annealing temperature, and it was noted that when the annealing temperature increased, the values of the prohibited field of the samples decreased (3.74-3.78 eV), as well as an improvement in the dielectric constant and the prohibited field. And the optical permeability, as well as the refractive index of samples PVA: Al2O3 with the loss of dielectric, in addition to that it can be used in electronic applications and transistors for thin films [56].

In 2019, Menazea et al. The enhanced the physiochemical properties of Polyvinyl Alcohol (PVA) film by embedding with nano structured metal oxides

(CdO, Al_2O_3, and Cu_2O), nanosecond Nd:YAG pulsed laser ablation in liquid technique (PLAL). This process was carried by ablation of metal targets (cadmium, copper, and aluminum) immersed in PVA solution by high intensity pulsed laser in the focusing condition. The enhancing of the PVA properties were appear by studying the structure, optical and morphology of the prepared films before and after embedding by technique as X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), UV–Visible. [57].

In 2019, **T.S. Soliman and S.A. Vshivkov.,** Samples of polyvinyl alcohol polymer doped with iron nanoparticles were prepared by solution casting method. These samples were described by ultraviolet light, electron microscope, spectrophotometer and ultraviolet visible device. The effect of doping iron nanoparticles on polyvinyl alcohol was studied. It was found that there is a growth in the size of nanoparticles as calculated by the Debye–Scherrier equation. Some optical properties such as Urbach energy [58].

In 2020, Saja F. Ghazi and Zaid A. Hasan. Have studied the effect of the magnetic field on the optical properties of polymer doped with nano-magnesium oxide based on Faraday rotation, where it was found that the absorption increases with increasing concentration, without applying a magnetic field where the proportion was direct, while the remaining optical properties decreased with the increase in the concentration of the dopant And when the researcher applied a magnetic field to these samples, it was found that the optical transmittance increased for all samples, while the rest of the optical properties became less, and thus it was found that there is an improvement in the optical properties by applying the magnetic field [59]

In 2020,Zaid A. Hasan. prepared films from a mixture of polymers (PMMA - PS) dotted with copper nanoparticles in different concentrations, where the optical properties in the field (190-1100 nm) were studied. The value of the forbidden field and the optical transmittance, while the values of the real and imaginary isolation constants are increased [60].

In 2020,Priyanka Dhatarwal and R.J. Sengwa. prepared a mixture of two polymers, PVP/PVA, doped with aluminum oxide nanoparticles with different percentages within the range 1-5%, which has electronic and photonic applications, has been prepared. The samples were characterized by a spectrophotometer and the transmittance and reflectivity as well as the absorption of the previous samples were obtained, and then the absorption coefficient and the forbidden field of its direct and indirect types were calculated, as well as the Urbach energy. It was found that there is a decrease in the values of the forbidden field with an increase in the concentration of the doping ratio of the aluminum oxide nanoparticles. It was also found that with the increase in the doping concentration, the concentration of the filler and the dissipated energy increases and thus improve the values of the optical properties [61].

In 2021,Hussein Ali Hussein Slman, and Zaid A. Hasan. prepared films consisting of a mixture of polymers (PMMA-PS) dotted with iron oxide nanoparticles in different concentrations by casting method with percentages of (0,2,4,6) %. The samples were characterized by a spectrophotometer and the optical properties were studied within the field (190-1100) nm it was found that increasing the concentration of the dopant leads to an increase in the absorption coefficient, absorption and refractive index, as well as the damping coefficient and the isolation constants in its real and imaginary particles, while the optical transmittance decreased with the increase in the doping concentration. It was found that the compound that was prepared from the polymer mixture has a strong bonding and an effect on the optical properties [62].

In 2021,S. S. Nemah and Z. A. Hasan. studied Faraday's effect on the optical properties similar to metallic nanoparticles, as he used a magnetic field and studied its effect on the prepared samples. It was found that the optical absorbance is directly proportional to the increase in the dopant concentration of

metallic nanoparticles in the absence of a magnetic field, while it was found that there is an inverse proportion to the values of optical properties. They applied a magnetic field to the prepared samples and found that the transmittance value has a greater value, while the rest of the optical properties have become less and thus these optical properties have been improved by applying a magnetic field by Faraday effect [63].

In 2021,Z. A. Hasan studied the photomagnetic effect on films consisting of polymers of ferromagnetic nanoparticles, as it relied on the nonlinear optical rotation within the generated magnetic field, where it was applied with intensity (450 mT) and wavelength (540 nm) on the films composed of PMMA polymerase and isoform ($NiFe_2 O_4$). The results showed that the magnetic field affects the optical properties directly with an increase in the concentration in the case of absorption, while the rest of the optical constants change inversely [64].

1.10 The Aim of the Study

Improving the optical properties of the (PVA-Al_2O_3) nanocompositeby films adding percentages of the nanomaterial(Al_2O_3) , as well as studying the effect of the magnetic field on these properties.

2.1 Introduction

This chapter is a detailed description of the theoretical section that we will tackle in this work, in addition to the most important basic theoretical concepts of optical properties, mathematical relationships and laws that will be used to explain and clarify the results of this study.

2.2 The Optical Properties

Knowing the spectrums of absorption and transmittance of a polymer assistsin identifying many optical properties in different ranges of wavelengths. Conducting examination at the ultraviolet spectrum range enables us to know the type of the bonds, orbital and energy bands. The study at the visible spectrum range provides sufficient information about the behavior of a matter to solar applications. The study at the infrared range is very important in knowing the general structure of a polymer and the elements consisting its chemical structure .

The importance of the optical properties of metal oxides lies in technical applications, as they give us information about electronic transitions and their types and the neuronal structure of energy. These properties become apparent when the electromagnetic rays falling on these metal oxides interact, resulting in several processes such as absorption, reflection, transmittance and scattering... etc. This can be seen in Figure (2-1). These metal oxides have the characteristic of a rapid increase in absorption when the energy of the absorbed radiation is equal to the energy of the prohibited field, which separates the two bands of equivalence and conductivity and is called the basic absorption edge. the following [65]:

$$R + T + A = 1 \ldots\ldots\ldots\ldots (2\text{-}1)$$

Where: R-reflectivity, T- transmittance, A-absorbance

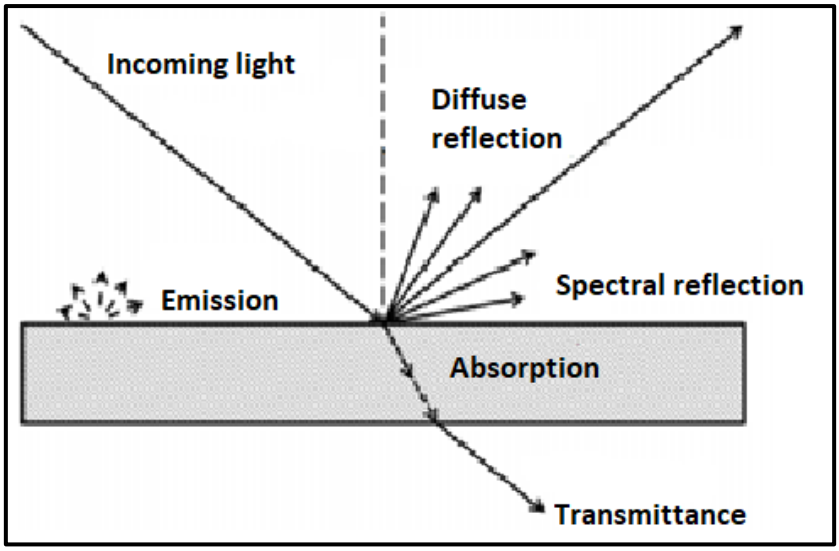


Fig (2-1): Reflection, absorption and transmittance of light[65]

2.2.1 Absorbance (A)

The light absorption process takes place within the range extending from infrared to ultraviolet. The absorption of radiation in the near ultraviolet field and the near infrared and visible field, according to the process of generating pairs (electrons and holes) when the energy is greater than the basic absorption limit and it is easy to know the energy of the forbidden field. Absorption may occur at energies lower than the basic absorption limit. The reason for this is the vibration of atoms, impurities, and defects in the crystal lattice. Absorption processes can be divided into three basic processes, and these processes:

- Electron absorption.
- Phononic absorption.
- Free support absorption.

The following relationship shows the absorption and which shows the ratio between the intensity of the incident light (I_0) and the intensity of the absorbed light (I) [66,67]:

$$A = \log \frac{I_0}{I} \ldots\ldots\ldots\ldots\ldots (2\text{-}2)$$

2.2.2 Transmittance (T)

Assuming that intensity of the light is passing through film Io, the intensity of the light on surface of a thin film, its thickness d, and the absorption coefficient in α, we write the following exponential relationship (according to Lambert) [68,69]

$T = e^{-\alpha d}$ …… (2-3)

The absorbance was defined with equation :

A = log 1/T ..... (2-4)

Reading the knowledge of the values of the absorbance coefficient A, the transmittance can be calculated from the formula:

$T=e^{-2.303A}$ …….(2-5)

2.2.3 Absorption Coefficient (α)

It is defined as the value of the transmittance of the light ray in matter, when we say that the absorption coefficient is large, that means that the light ray that penetrates into the material is attenuated (its intensity is weakened), while when we say that the absorption coefficient is small, this means that the material is transparent. The absorption coefficient is the reciprocal of the wavelength, i.e its unit is cm^{-1}.

When a beam of light falls on an object, part of the radiation is reflected and another part is transmitted inside the body, and part of it is absorbed in the body. Since the spectral absorption coefficient is the amount of the absorbed part inside the body, and this amount is confined between (0 and 1) when the optical absorption coefficient approaches zero, we say that the material is transparent to light, while when it approaches one, the material has completely absorbed the radiation.

We will get the values of the absorption coefficient (α) for the prepared samples based on the transmittance spectra according to the following formula [70]:

$\alpha = \frac{-1}{d} \, lnT$……(2- 6)

2.2.4 Extinction Coefficient (k_o)

K_0 is defined by the amount of energy absorbed by the electrons of the atoms, where the absorption coefficient is calculated from the formula:

α=2.303 A/d……(2-7)

then we find the damping values from the formula ;

$K_0 = \frac{\alpha\lambda}{4\pi}$……(2-8)

and the extinction coefficient K_0. From the refractive index relationship, the imaginary damping index of the refractive index given by formula [68,73]

$n=n_0-iK_0$……(2-9)

2.2.5 Refractive Index (n)

The real refractive index n is defined speed of light in a vacuum to its speed in the material: n = C/ν. It is calculated from in the following equation:

$n_0 = [(1+R/1-R)^2 - (K_0^2 +1)]^{1/2} + (1 + R/ 1-R)$. ..... (2-10)

The n_o depends on the type of material, and on the morphological structure. and as we mentioned in the previous paragraph, the refractive index n is basically a complex quantity given by the formula

$n=n_0-iK_0$ ..... (2-11)

where (n_o: the real refractive index), which is the amount that we calculate [71].

Also, the reflectivity (R) is given by the Fresnel relation :

$$R = \frac{(n-1)^2 + K^2}{(n+1)^2 - K^2} \quad \text{.....(2-12)}$$

Where this relationship is used in thick samples only, the following condition must be fulfilled: that the sample is thick enough so that the reflection is not affected by the reflection on the second side.

By solving the last equation through the initial algebraic treatment [72], we arrive at the refractive index relationship:

$$n = \left(\frac{1+R}{1-R}\right) \mp \sqrt{\frac{4R}{\left(1-R^2\right)} - k^2} \qquad \text{.....(2-13)}$$

A sign is used that makes (n) in a uniform dissipation where the refractive index decreases with increasing wavelength (regular dissipation) except where the absorption region has abnormal behavior (anomalous dissipation). this

relationship is used when the reflection does not affect the back surface

2.2.6 Dielectric Constant (ε)

The charges of the material are polarized electricaly when the beam falls on the material and it interacts with the charges. This polarization expresses the dielectric constant ε, that is ability of electrons of the material to respond to light. We cannot directly calculate each damping, dielectric and refraction coefficients, except from their respective equations, but we can calculate both absorbance and permeability directly, and the complex dielectric constant can be calculated from the formula [74]

$\varepsilon = \varepsilon_r + 4\pi i \sigma op$. ……(2-14)

Where ε_r denotes the properties of bound charges, while σ_{op} denotes free charges. On the other hand, ε has the following complex

$\varepsilon = \varepsilon_r - i\varepsilon_i$. ……(2-15)

Where ε_r (real part), and ε_i (imaginary part) of the value of ε. The complex refractive index n is related to the extinction coefficient K_o. and on the other hand, the dielectric constant ε according to the following formula [75]

$n = \sqrt{\varepsilon}$ ……(2-16)

and squared both sides of this formula:

$\varepsilon = (n_0 - iK_0)2 = n_0^2 - K_0^2 - 2in_0K_0$. ……(2-17)

By equality the formula s, we find:

$\varepsilon_r = n_0^2 - K_0^2$ ……..(2-18)

$\varepsilon_i = 2n_0K_0$……(2-19)

2.2.7 Fundamental Absorption Edge of Polymers

The study of optical properties is one of the important properties through which it can be obtained many information, including what is related to the internal structure and the nature of bonds and areas of use. by knowing the amount of absorbance, transmittance and reflectivity of the polymeric models in the range (200–400 nm) within the near ultraviolet (UV) range, the energy can be determined. The gap and type of bonds, and in the visible spectrum (VIS) region, which extends to (750 nm), give us an idea about the field of use of these materials in solar applications, and more than (750 nm), i.e., the infrared spectrum (IR) gives us information about the general composition of the polymer and the elements involved in its general composition [76,77].

The absorption coefficient (α) is defined as the percentage of decrease in the flux of radiation energy with respect to a unit the distance to the direction of wave propagation within the medium. It depends on the type of absorbent material and the wavelength for incident light and to calculate the absorption coefficient, the formula of Beer lambert's law is used, which states that when a single-wave light beam of the intensity of $\mathbf{I_o}$ through a sample of thickness **d**, the intensity of the window beam **I** is given by formula (2-2), [78]

2.2.8 The absorption edge has three main region

1. High Absorption Region (A)

This area is characterized by a high absorption coefficient whose value is greater or equal to 10^4 cm-1 and represents the transitions from the extended levels in the valence band to the conduction band as shown in Part A of Figure (2-2) through which the value of the optical energy gap can be known through the equation (2-22).

2. Exponential Region (B)

In this region, the value of the absorption coefficient ranges from: $1 < \alpha < 10^4$ cm^{-1}. This region results from the occurrence of transitions from the extended levels in the valence bundle to the local levels at the bottom of the conduction bundle, as well as from the local levels at the top of the valence bundle to the extended levels at the conduction bundle. The absorption coefficient in this region is given according to Urbach's relationship with the following equation:

$\alpha=\alpha_0 \exp(E/E')$…….(2-20)

Tail Width for positional cases. This region is represented in part B of the Fig (2-2).

3. Low Absorption Region (c)

In this region, the value of the absorption coefficient (α) is very small, less than (1 cm^{-1}) . This region is the electronic transitions between the tails within the optical energy gap (Eg), as shown in Part (C) of the Fig(2-2).

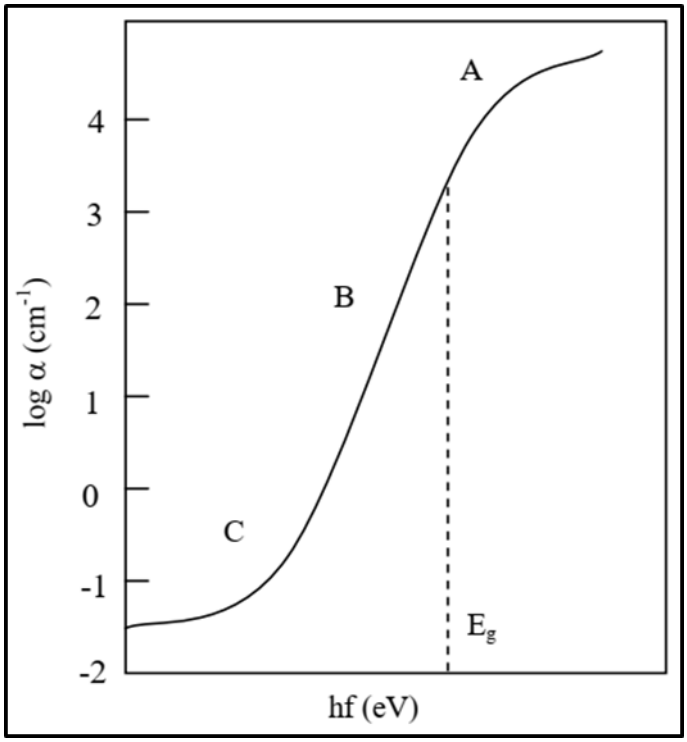


Fig (2-2): Main regions of the optical absorption coefficient spectrum[79]

2.3 Electronic transfers

Electronic transformations are broadly divided into two groups [80]:

1. Direct transition

In semiconductors, this transformation occurs when the (C.B) base is exactly above the tip (V.B). This implies that the wave vector has the same value (K=0). The absorption occurs in this condition ($hv=E_g^{opt}$). This form of transition calls for energy and momentum conservation laws. There are two forms for direct transitions. [81]

a) Direct allowed transition: It occurs from the top (V.B) points and the bottom (C.B), as seen in the figure (2.3-a).

b) Direct forbidden transitions: As given in this figure (2.3-b), this transition occurs between the close high points of (V.B) and the lower points of (C.B) [82]. For this transition form, the absorption coefficient is indicated:

$$\alpha h \upsilon = B (h \upsilon - E_g^{opt)\, r} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2.21)$$

Where: E_g^{opt}: energy gap between direct transition.

α: is the absorption coefficient.

B: constant depended on type of material.

h: is the Planck's constant.

υ: is the photon frequency.

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 curve (E-K), in these transitions the bottom (C.B.) is not above the top of (V.B.) The electron transits between (V.B.) and (C.B.) are not perpendicular if the magnitude of the electron's wave vector is not identical before and after transfer. This kind of transformation occurs with the beneficial "Phonon" particle for energy conservation and energy law. Two kinds of indirect transitions exist [83], they are:

c) Allowed indirect transitions:

These transitions occur between the top of the (V.B.) and the bottom of (k-space), as shown in figure (2.3-c) (C.B).

d) Forbidden indirect transitions

As shown in the figure, such transitions occur between points near the top of (V.B.) and points near the bottom of (C.B) [84]. (2.3-d). The coefficient of transition absorption is denoted by Phonon on absorption:

$$ah\upsilon = B(h\upsilon - E_g^{opt} \pm E_{ph})^r \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.22)$$

Where: E_{ph} : Phonon energy : (-) is absorbed by phonon, and (+) is emitted by phonon.

(r = 2) for the allowed indirect transitions

(r = 3) for the forbidden in direct transitions

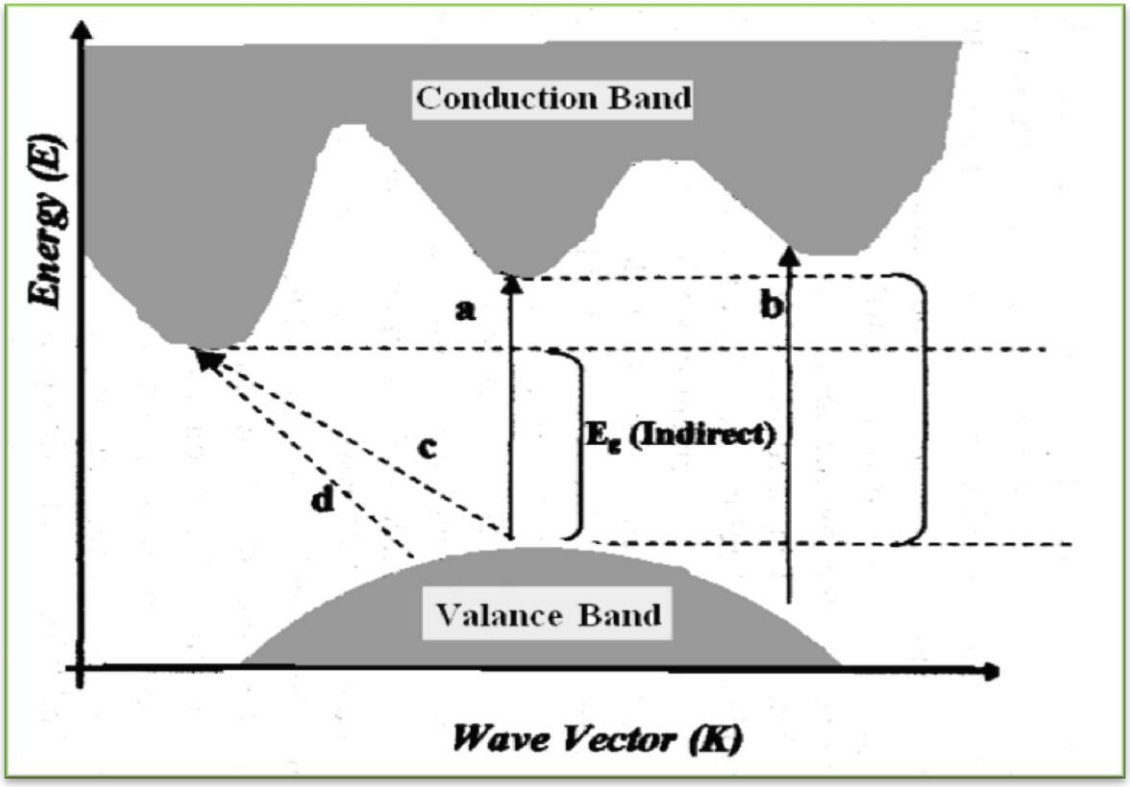


Figure. (2.3): The transition types [84]

a) Allowed direct transitions. (b) Forbidden direct transitions.

(c)Allowed indirect transitions. (d) Forbidden indirect transitions.

2.4 Polar and nonpolar polymers

Chemical bonds are generally polar (molecularly possessing a permanent dipole moment) or non-polar, and the bond is highly polar when it is ionic, and the bond is nonpolar when it is covalent linking similar atoms, as in the

hydrogen molecule H_2 and O_2. The arrangement of all chemical bonds is in terms of intensity. Polarity is between the first and second cases:

The bonds are considered polar when the electronic density of the bonds C-COOCH3, C-F, C-Cl is high on the side of the group attached to the carbon atom and few near the carbon atom, but when these bonds are symmetrical with each other, they are not polar like polytetrafluoroethylene, although it contains bonds and hydrocarbon polymers are generally non-polar, such as polyethylene (because of the similarity of the atoms' aggregates) surrounding the carbon atom [83,84].

2.5 Magnetization and induced field

The magnetic dipole moment is generated when a charged particle moves in a current loop, which is proportional to the area of the loop and the intensity of the current, as well as when the electron revolves around the nucleus, an angular moment is generated. Einstein explained that magnetism is related to this angular moment, as the magnetic moment is directly proportional to the angular moment resulting from the rotation of the electron around the nucleus. This is what the classical electromagnetic theory says.

$$\mu_e = \frac{e}{2m} l \dots\dots (2-23)$$

The orbital angular moment of the electron is given by the relationship.

$$L = r \times p \dots\dots\dots. (2-24)$$

Since the charge of the electron is negative $e = -|e|$, the angular moment and the magnetic moment are opposite each other.

It is the magnetic moment of a unit volume at a known point and is given by the relationship

M=N.m…….(2-25)

Where: m: the magnetic dipole moment per atom, N: the number of atoms per unit volume. and that is if the moments of the solitary dipoles in an element of the volume under study are regular and in the same direction. M is measured in amperes per meter and similar to the polarization P in insulators.

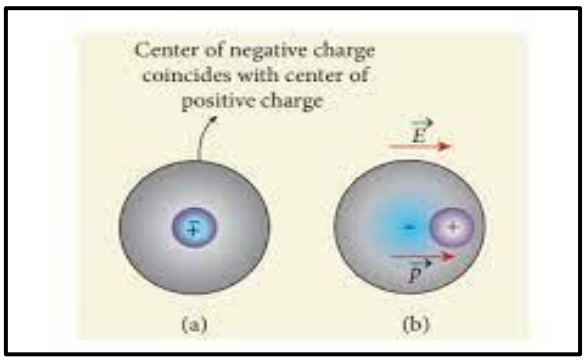


Fig (2-4).(a) Non polar molecules without external field (b) with the external field[85]

The magnetizing current density $J_m$is given by the relationship

$$\nabla \times M = J_m \ldots\ldots\ldots..(2-26)$$

That is, it is equal to magnetization wrap $\nabla \times M$. The density of the actual current that generates the same amount of magnetic field generated by magnetization [85,86].

3.1 Introduction

In this chapter, a detailed description of some devices used and working way as well as some spectral used as an infrared spectrum (FTIR), visual microscope, photometer and magnetic system to study the magnetic impact on the prepared samples.

3.2 Materials used in this investigation :

The materials used in this study are;

3.2.1 Polyvinyl alcohol (PVA)

The material Polyvinyl alcohol (PVA) used is a white powder, the molecular weight is 150000 g/mol and could be obtained from local markets, and high purity (99.9%).

3.2.2 (Al_2O_3) Nanoparticles

Nanoparticles Al_2O_3 (Size: 50 nm, purity: 99.99%), Hongwu nanometer manufacturer), It was obtained as white powder from local markets

3.3 Preparation of (PVA - Al_2O_3) Nanocomposite

In this study , films were prepared (PVA-Al_2O_3) nanocomposite,The firt used 1g of PVA put into a (50 ml) glass beaker containing (30ml) chloroform alcohol ($CHCl_3$)as asolvent using a magnetic stirrer at room temperature until complete dissolution as a result ,the magnetic stirrer was continued for 25 minutes until the substances were completely dissolved in the beaker.The solution is poured into a petri dish with a diameter of (9cm)(clean form dust,dirt and dry) and placed on a horizontal surface and left to dry for 24 hoursin the laboratory preservative to keep from dust and using lukewarm water,The same previous steps were repeated with addition of particles (Al_2 O_3) nanoparticles with different weight ratios (1,3,5%) of the weight used for the first sample.The thickness of the dried samples were measured using micrometer and found (0,105)micro as it is clear in fig(3-1).

Table (3-1) weight percentages for nanocomposites (PVA-Al_2O_3)

PVA(gm)	Al_2O_3(gm)
100%	0%
99%	1%
97%	3%
95%	5%

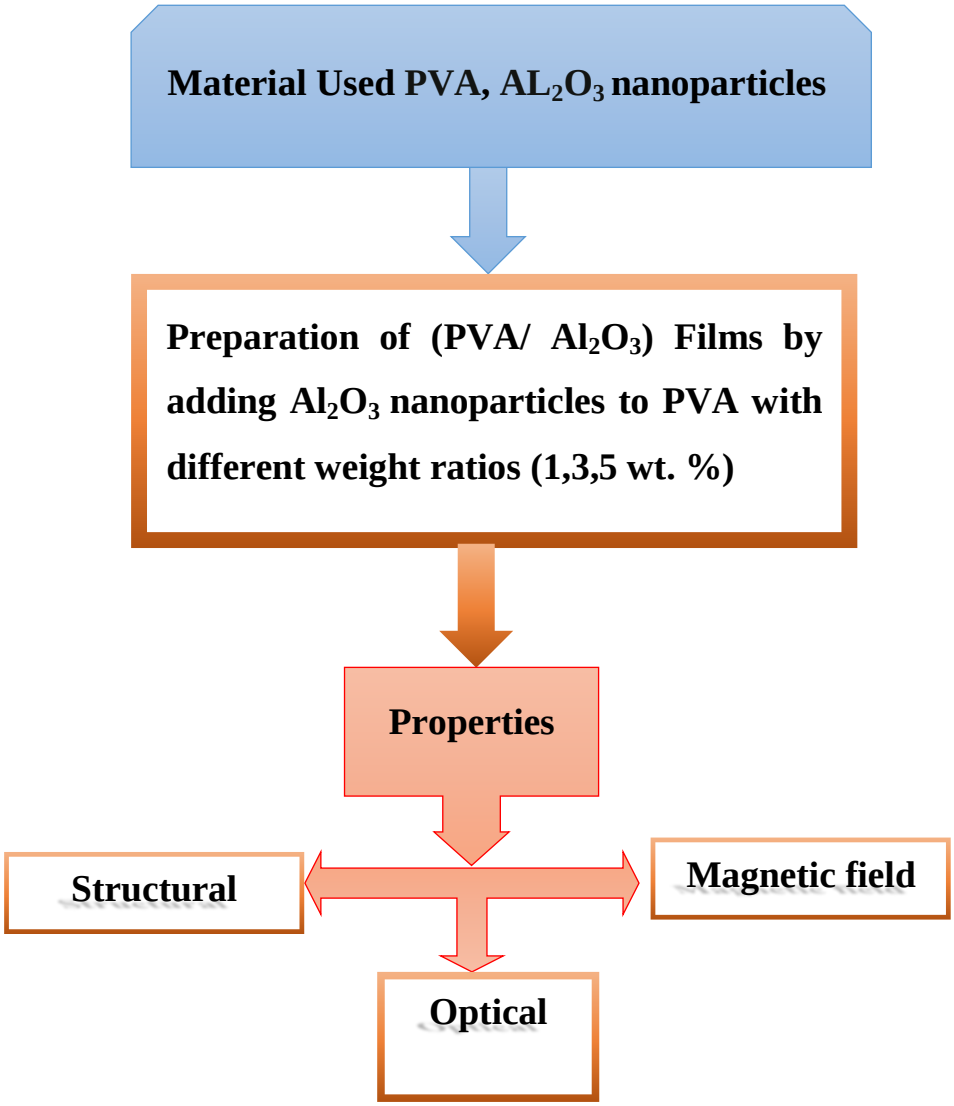


Fig (3 -1). The preparation condition of (PVA and Magnetic field - Al_2O_3 nano) films and the structural, optical

3.4 Properties of Polyvinyl Polymers :

3.4.1 Optical properties

The polyvinyl polymer fluorescent bright yellow. The maximum emission points are in the yellow-green field of the visible spectrum, at 551 nm and 520 nm. Electroluminescence has recently been discovered and because polyvinyl has good hole-transfer capabilities within the group of electroluminescent polymers, it has been used not only as a light-emitting layer but also as a hole-transporter in electroluminescent equipment, [87,88].

3.4.2 Addition of impurities and their effect

The doping creates structural and electronic modifications in the polymer main chain. Alloying usually improves electrical conductivity. The doping can be achieved by initiating oxidation or reduction reactions in the main chain of the polymer.

The doping with dyes consists of adding a fluorescent dye to the polymer. The symmetry between electrons and holes does not remain in the dopant polymer, and this explains the difference in the mobility of electrons and holes within the polymer chain, [88].

3.5 Properties of PVA

Table (3-2) some properties of PVA

Property	Value
Chemical formula	$(C_2H_4O)_x$
Density	1.2–1.3 g/cm^3
Melting point	200 °C (473 K)
Refractive index	1.47 at 632 nm

3.6 Properties of Al_2O_3

Table (3-3) Properties of Al_2O_3 Nanoparticles

Property	Description
Chemical symbol	Al_2O_3
Density	3.9 g/cm^3
Molar mass	101.96 g/mol
MP(Melting point)	2040 $^\circ$C
BP(Boiling point)	2977 $^\circ$C

3.7 Equipments of Structural Properties :

3 .7.1 Optical Microscope

The morphology has been designed for samples (PVA- Al_2O_3) and nanoscale molecules used the OLYMPUS NAME (NIKON-73346), which contains an automatically controlled light to severely enlarge (10x) and (20x) and this device exists at Babylon University at the Faculty of Physics Department, which is shown in the following figure (3-2)

Fig (3-2) Image of optical microscope

3.7.2 FTIR Spectral Spectrometer

Infrared energy is not enough to make an electronic stirring in most articles, but it is sufficient to make vibrations (competance or flex) in molecular links, all types of links respond to this amount of energy to spoils that sucks in an infrared area provided that absorbing is changed in polar determination, these vibrations are complementary and their resolve means that the boat absorbs infrared energy in a particular part of spectrum [89]

- Nearby infrared (14000-4000 cm^{-1}).
- Infrared medium (4000-650 cm^{-1}).
- Remote infrared (650-20 cm^{-1}).

Since most spectral analyzes are conducted in the Central Infrared Zone, because this area occurs most molecular vibrations and researchers where envisions find information to determine the molecular structure of the compounds.

This mutation will be used for quantitative analysis and characterization of materials used, resulting materials and nanomaterials and this device from the version of Brocker German, type Vertex -70 within the wave number (500-4000) cm. This device is located at the University of Babylon, Faculty of Physics Department. The following shape shows a picture of an FTIR deviec.

Fig (3-3) Image of FTIR spectroscopy Device

3.7.3 Uv-Vis Properties Measurements

The fields of spectroscopy are generally distinguished according to the wavelength range in which the measurements are made, and among these areas we can distinguish: ultraviolet, visible and infrared rays, and in this technique we will measure spectrophotometry in the ultraviolet and visible fields, It is a technique for determining optical properties, and the principle of this technique depends on the interaction of light with the sample to be analyzed, and part of the incident beam is absorbed or passed through the sample, when the material absorbs light in the ultraviolet and visible range, the absorbed energy causes disturbances in the electronic structure of the thin films This results in a transfer of electrons from a lower energy level to a higher energy level [90].

For this purpose, we used (Shimadzu, UV-1800 OA, JAPAN) as shown in Figure (3-4). The Absorption Spectrum is Recorded at room temperature.

Fig (3-4) UV photographic of spectrophotometer

Through the spectroscopy results of the samples, we will draw curves representing the transmittance changes in terms of wavelength in the field of ultraviolet and visible rays, and these curves can be used to calculate the thickness of the samples in addition to the optical properties, including the energy gap and refractive index .... etc.

3.8 Set up work system

In this section, measurements of the magnetic field affecting the prepared samples will be taken, using several experimental tools to make these measurements, namely :

3.8.1 Laser Diode

This diode has the physical properties, as shown in the following table

Table (3-4) The physical properties for laser diode

Property	**Magnitude and unit**
Wavelength	540 nm
Output power	1.5 m W
Polarization Ratio	Linear
Working life	> 10000 h
Power Stability	5 %
Tube working voltage	120 V
Divergence Angle	< 1.3 m rad

3.8.2 Teslameter

A Tesla meter is used to measure the strength of the magnetic field generated in the coil, which operates according to parameters (with an alternating current voltage of 230 volts - at a frequency of 50 Hz) by which the susceptibility to magnetic diameter is measured.

3.8.3 DC Power Supply

The power source provides a variable voltage (0-30 V), and gives a direct current (5 A).

3.8.4 The Detector:

With this detector, we can obtain the height of the Gaussian shape of the spot position, and it is also possible to monitor the changes that may occur.

3.8.5 The Coil

We can generate a magnetic field with this coil, and this magnetic field can also change with the change in the intensity of the current.

When an electric current passes in the coil, it causes a rise in temperature due to the electrical resistance. In order to avoid overheating in this coil, a coil of appropriate and thick wire thickness has been used and has many advantages.

Table (3-5). Properties of the coil

Property	**Magnitude and unit**
Type of wire	Copper
Value of the Current	1 A
Diameter of wire	1 mm
Number of turns	8800

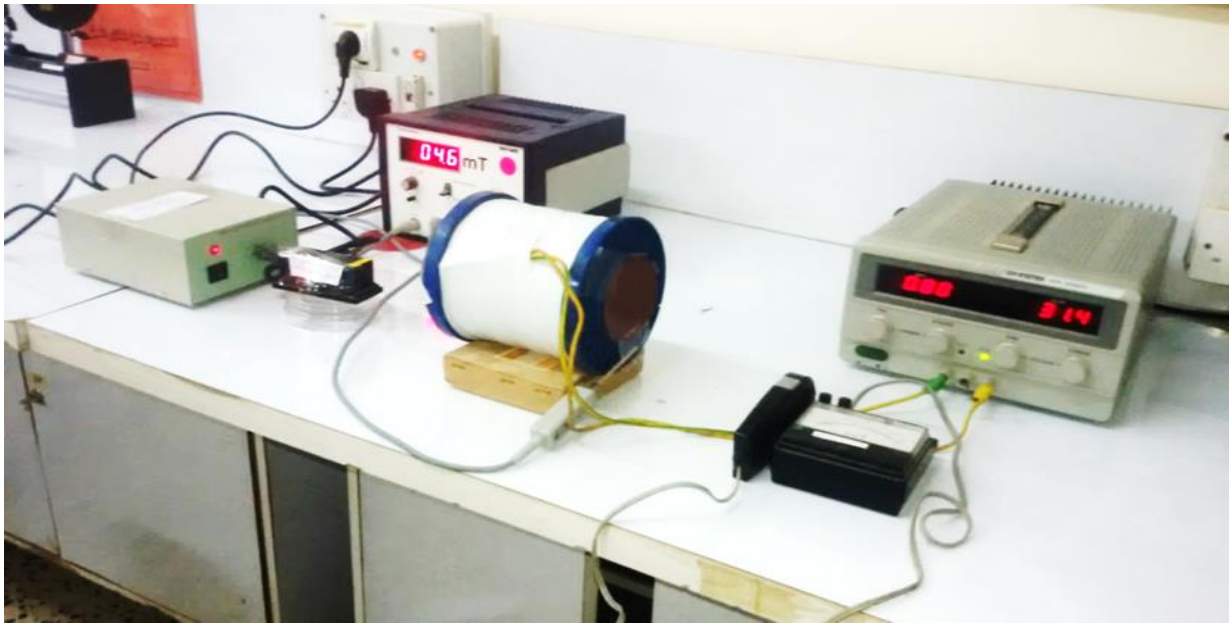


Figure (3 – 5): The magneto – optic system set up

3.9 The Magneto Optic System

This magnetic-optical system is made of a diode laser that works on the basic Gaussian mode at a wavelength of (540 nm) and a condenser that contains two lenses of glass in a confocal configuration to obtain a narrow spot laser with a diameter of about (2 mm). This laser beam is polarized according to the direction of propagation at an angle of 45 degrees with the direction of the cell, where this polarization is formed by a wire mesh polarizer. This experimental system is clarified according to the figure (3-5).

When the laser beam falls on the sample (PVA/Al_2O_3) located inside the coil, the laser beam is filled with the cell that is perpendicular to the vector of the laser beam generating tools.

Before we apply the magnetic field, we take the radiation intensity of the laser spot (I_0). Then, we apply a magnetic field to the cell (PVA/Al_2O_3) for all samples of different concentrations, and take the intensity of the laser beam each time it passes through the cell. We repeat the measurements several times during a period of time not exceeding ten minutes.

4.1 Introduction:

Chapter four includes the results of characterization and discussion of samples of nanocomposites (PVA-Al_2O_3). Where this chapter contains the optical measurements of these compounds and the effect of doping different concentrations of aluminum oxide nanoparticles by optical microscopy to know their surface structure, The field also affects the PVA film's optical properties, optical microscopy and Fourier infrared spectroscopy (FTIR).

4.2 The Structural Properties Measurements

The Structural Properties have been studied:

4 .2.1 Infrared analysis of the Fourier transform (FTIR)

The spectrometer (FTIR) is widely used in the analysis of a wide range of materials such as thin films and powders. It provides information both for mixture composition and polymer-polymer reactions using those vibrational modes attributed to free and hydrogen hydroxyl and carbonyl groups.

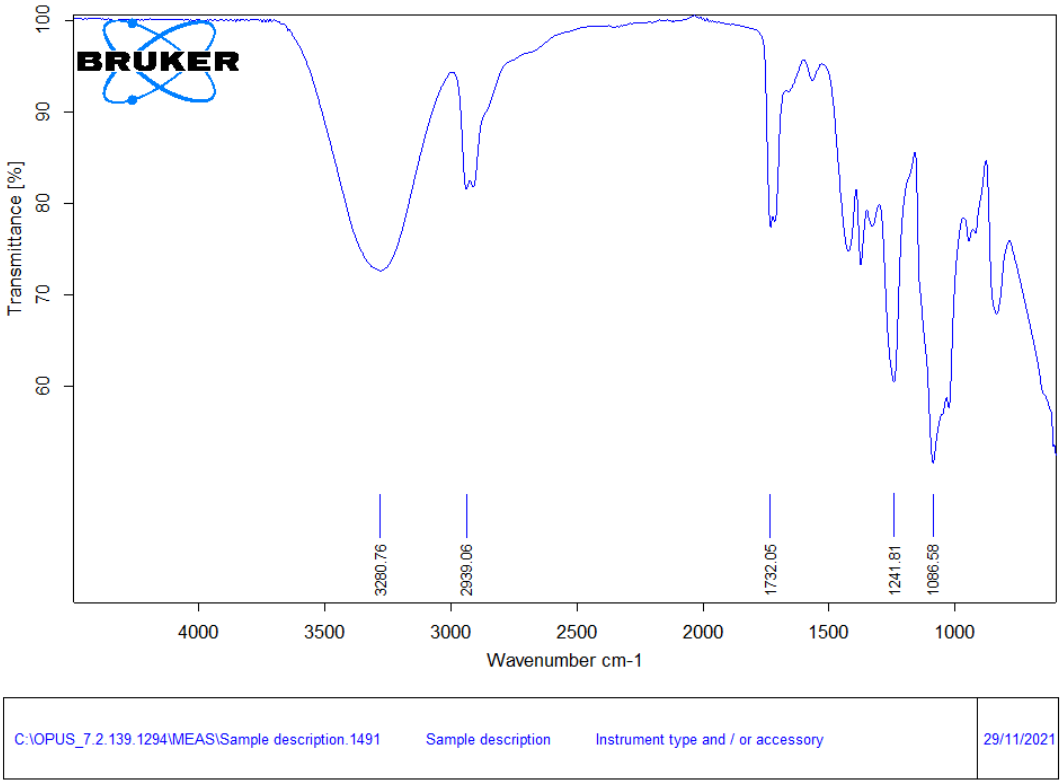
FTIR spectra of (PVA-Al_2O_3) nanocomposites with different doped ratios of Al_2O_3 nanoparticles are Record measurements at normal room temperature in the spectrum range 500-4000 cm^{-1}.

FTIR spectroscopy of (PVA-Al_2O_3 nanocoposite) films are shown in Figure 4.1(A). This film exhibits peaks at (3282.05, 2938.33, 1732.39, 1241.22,1085.76) cm^{-1} It is assigned to links (O-H, C-H s, C=O) stretching's, bending of CH_2, C-O stretching, CH_2 rocking, CH_2 stretching and O-H wagging, respectively[90].

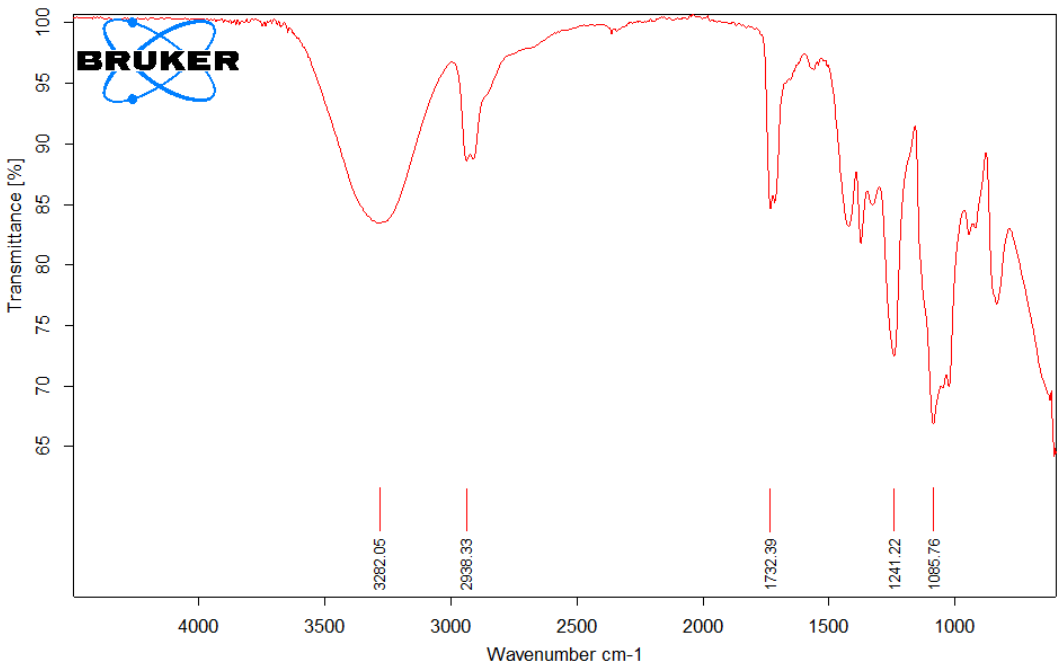
The (O-H) stretching has the most characteristic alcohol bonds and is within the spectrum (3000-3500) cm^{-1}. The band returns to the band around 1415 cm^{-1} to the curvature of the (CH_3) bond and the bands around it 2940 cm^{-1} correspond to CH_2 asymmetric stretching. The range at 916.15 cm^{-1} is due to the syntenic structure and is caused by the CH_2 vibration. The band at 1143 cm^{-1} is

assigned to PVA crystal and around 1750 cm^{-1} of the carbonyl that results from the absorption of the remainder of the acetate during the period of manufacture of PVA by the hydrolysis of polyvinyl acetate. The band at 1330 cm^{-1} was assigned to the combination frequency of (CH+OH).The peaks at 1649 cm^{-1} have been attributed to the C=C stretching mode.

The figure (4.1.A) shows the FTIR spectra of (PVA) while Figure (4.1.B), (4.1C) and (4.1.D) show the FTIR spectra of (PVA-Al_2O_3) nanocomposites Changing the FTIR spectrum in range (2500 to 3700) cm^{-1} shows that the product of the polymer chains corresponds to the (O-H) bond stretching, and the C-H bond stretching. [87] by the addition of Al_2O_3 nanoparticles to polymer blends, two significant changes are observed. There are slight changes in the intensity of absorption and in the vibrational bands, this indicates decoupling between the corresponding vibrations due to interaction between Al_2O_3 nanoparticles and(PVA) [90].



(A)



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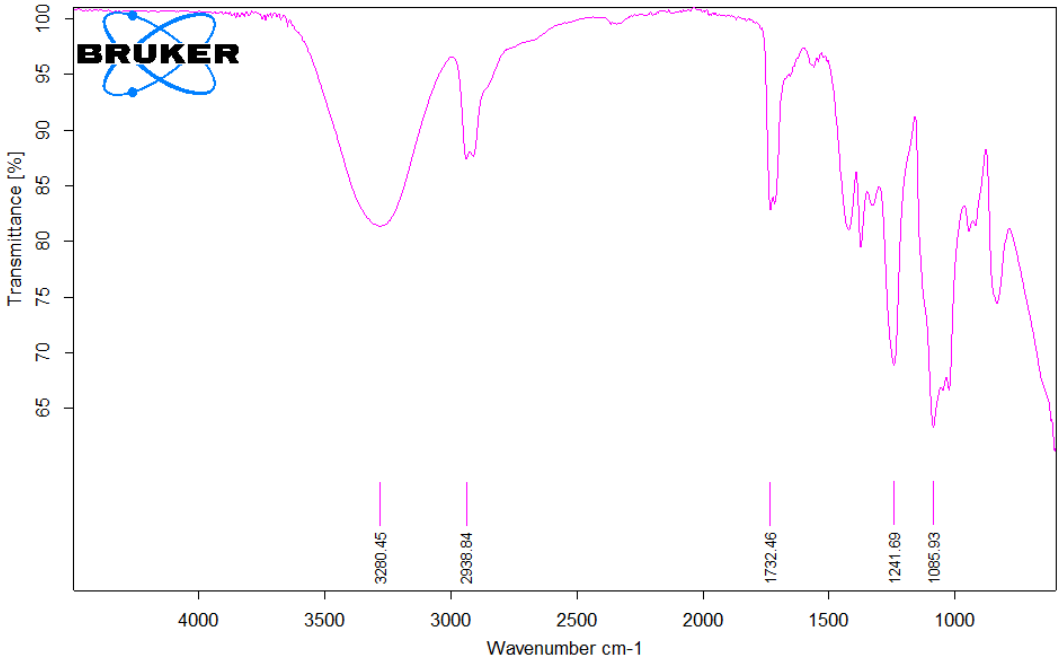
(B)



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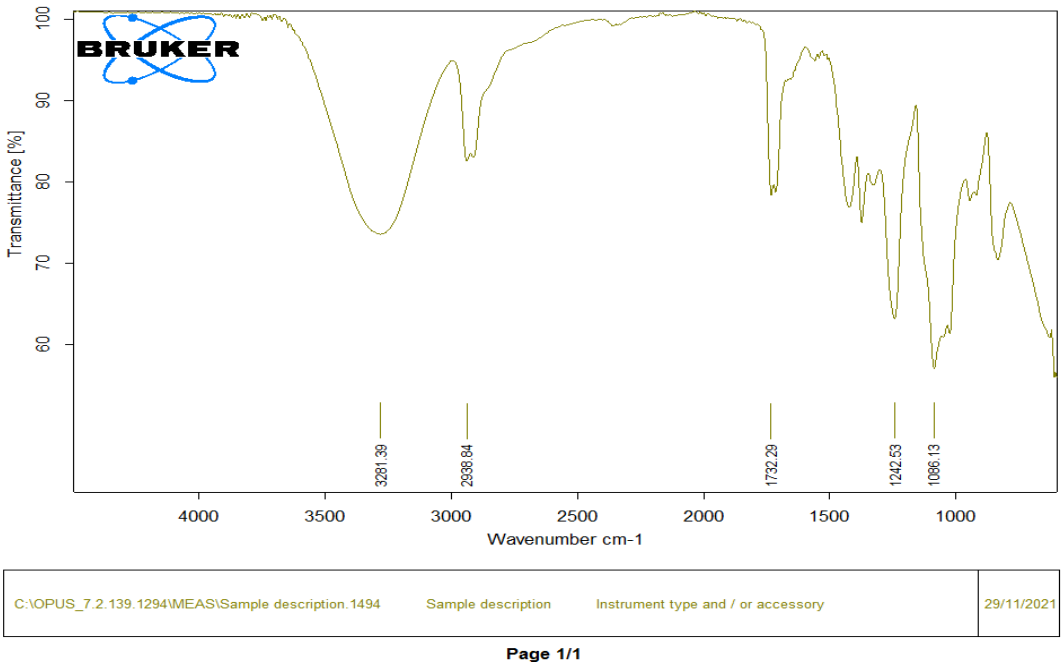
(C)



(D)

Figure (4.1)**:** FTIR spectra for PVA- Al_2O_3 nanocomposite; (A)for(PVA), (B)for 1wt.%, (C) for 3wt.%, (D) for 5wt %.

4.2.2 The Optical Microscope

The results of light microscopy tests for these nanocomposites showed a clear change in the surface of the nanocomposites. Where all the optical microscope images of the prepared films appeared with a magnification of (10x). Figure (4.2) below shows optical microscopy images of the pure sample as well as the mixture of (PVA) and nanocomposites (PVA- Al_2O_3) with different doping concentrations of AL_2O_3 in PVA polymer compared to image of pure sample. Figure (4-2) shows (B-C-D) images of the mixture of (PVA-Al_2O_3) and (PVA- Al_2O_3) nanocomposites with different concentrations, compared to the image of the pure sample, as it was found from this comparison that there are many differences in the surface between these samples after adding different concentrations of aluminum oxide nanoparticles, the figures show that when we increase the doping concentration of aluminum oxide nanoparticles to a higher concentration, the fillers will form an uninterrupted network inside the polymer. This system allows the passage of charge carriers through these paths [90].

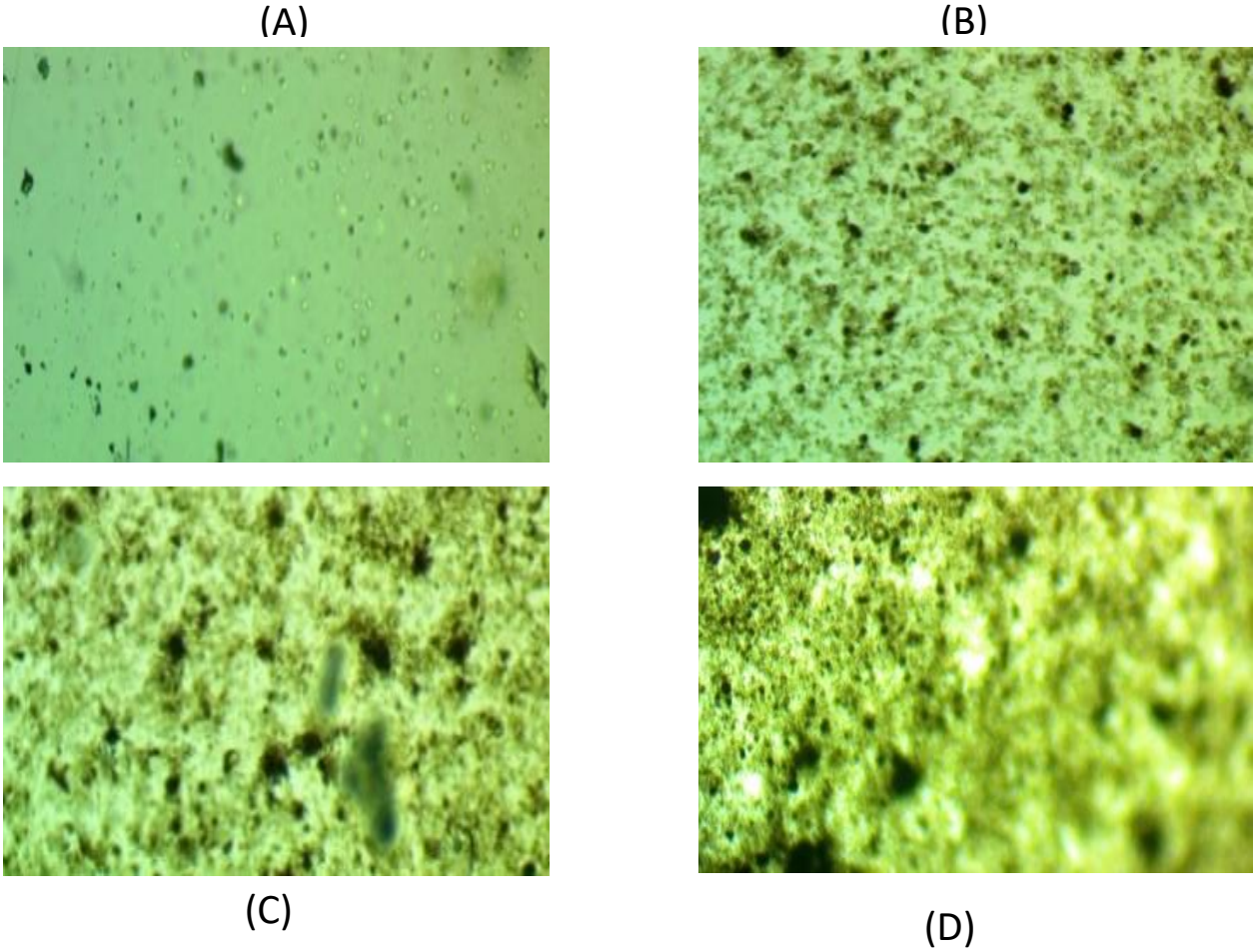


Fig. (4.2) Photomicrographs (10x) for (A) (PVA)Pure: (B) (PVA- Al_2O_3 nano nanocomposites, 1wt.%. (C) (PVA- Al_2O_3 nano) 3wt.%. (D) 5wt.% (PVA- Al_2O_3 nano)

4.3 Optical properties measurement of the prepared samples

It aims to characterize and study the optical properties of nanocomposites (PVA-Al_2O_3) nanocomposite is to know the effect of doping aluminum oxide nanoparticles on optical properties of PVA. This optical study includes the optical transmittance and absorption of nanocomposites at room temperature, as well as calculating absorption, refractive and extinction coefficients, as well as dielectric constants in their real and imaginary parts, optical conduction of samples as well as calculating the prohibited field of permitted and prohibited electronic transitions and determining the types of electronic transitions.

4.3.1 Absorbance (A)

The absorption spectrum of PVA-Al_2O_3 nanocomposites with varying alloy concentration of Al_2O_3 for the wavelength range $(190 - 790nm)$ was recorded at room temperature. Figure (4.3) shows that the optical absorption varies with the wavelength of (PVA-Al_2O_3) nanocomposites. From this spectrum, we note that it reveals that all films show greater absorption in the UV. We note from all the compounds that the absorption decreases in the visible light egion, this behavior is due to the fact that at a higher wavelength, the incident photons do not have enough energy to interact with atoms, so the photon will be transmitted. As for near the basic edge of absorption, the wavelength will decrease, and here, the, radiation and the matter on which it will fall will interact, and thus the photon will be absorbed by the matter. We note that the absorption increases with the increase in the weight ratios of nano-material. This is due to the absorption of the incident light by free electrons. These results agree with the results of the other researcher [91,92].

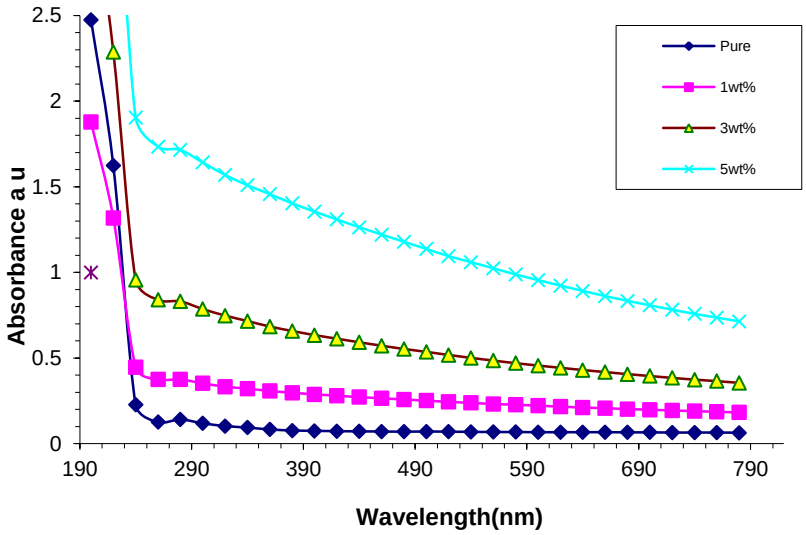


Figure (4-3): Absorption spectrum of (PVA- Al_2O_3) nanocomposite. compounds as a functionof wavelength

4.3.2 Transmittance (T)

Figure (4.4) shows that the transmittance for all samples decreases with the increasing concentration (Al_2O_3) nanoparticles. We note that the optical transmittance increases with a decrease in doping concentration of particles Al_2O_3, and this increase is attributed to the increase in the crystal size of the grains [90]. As for the low transmittance in the wavelength range of the spectrum $(200 - 400\ nm)$, this is due to the absorption of light photons. However, it rose in the near infrared range at about 800 nanometers [93].

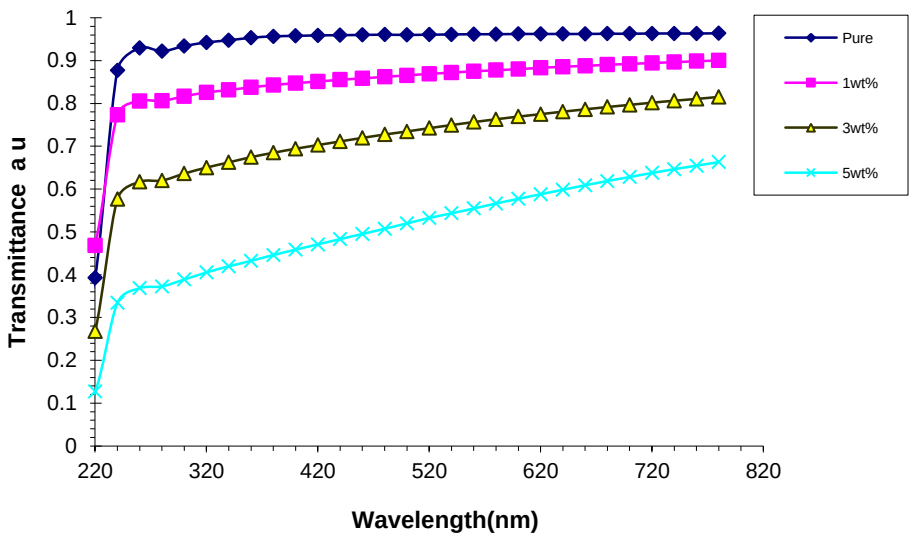


Figure (4-4): The transmittance spectra of (PVA- AL_2O_3) nanocomposites.

4.3.3 Absorp tion coefficient (α)

Figure (4.5) shows that the absorption coefficient α is dependent on the E_{ph} of the samples (PVA- Al_2O_3). At higher wavelengths, the energy decreases, and here we notice that the value of the optical absorption coefficient is the smallest, and therefore the chance of electron transfer becomes very small, due to the weak energy of the photon, which is unable to move the electron between two energy bands from valence to conductivity ($h\upsilon < E_g^{opt}$) .

At higher energies the absorption will be higher. Thus, there is a great potential for electron transitions and here, the energy of the photon will be enough for the

electron to move from the valence band to conduction band. When the energy of the photon that falls on the material is greater than the value of the energy of the forbidden field, so here the absorption coefficient will show the type of electronic transition, and at high energies ($\alpha > 10^4$ cm^{-1}) when the wavelength is low, direct electronic transmission will often occur and, the energy and moments are conserved. While, At low energies, the values of the absorption coefficient are low ($\alpha < 10^4$ cm^{-1}), and here "indirect electron transfer" can occur, and the moment and energy are conserved. Figure. (4.5) shows that the highest value of absorption is at a concentration of 0.03 of Al_2O_3, then it decreases when the concentration increases, especially at high energies, and it changes rapidly near the edge of light absorption. As the concentration increases, the edges of the absorption shift towards higher photonic energies. We also note that the absorption of the samples is the greatest possible at short wavelengths and then decreases with increasing wavelength to reach a low value in the visible field [94].

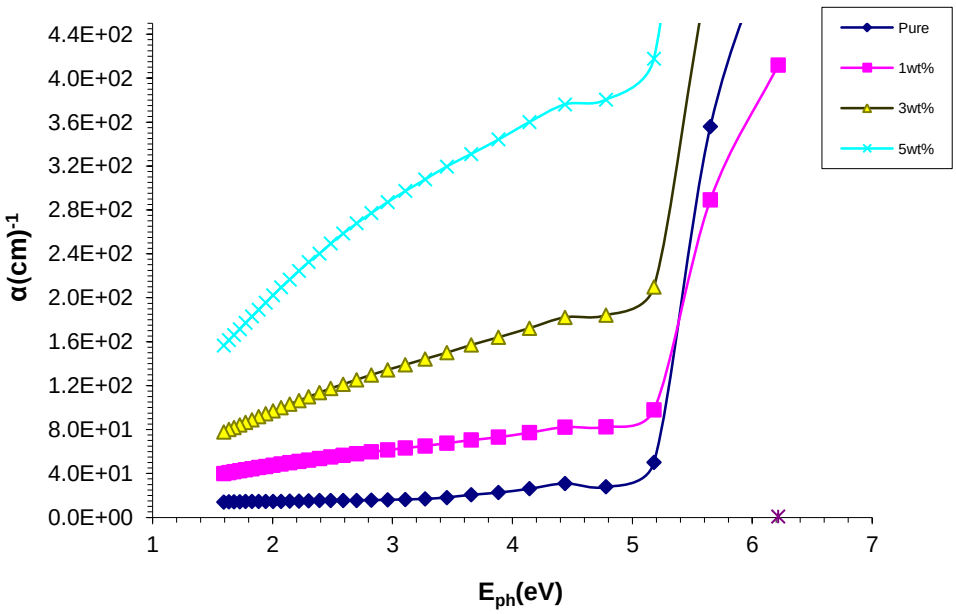


Figure (4-5) **:** The absorption coefficient (PVA- Al_2O_3)nanocomposite

4.3.4 Energy gap (Eg)

To calculate of the width of E_g: There are two basic types of direct electronic transitions in the energy structure of the material: allowed electronic transitions, and forbidden electronic transitions. Absorption coefficient (α) of two transitions had been calculated from following form: $(\alpha h\upsilon = B(h\upsilon - E_g)^r$, where: B (constant) relates to the properties of valence and conductivity bands, $h\upsilon$: the absorbed photovoltaic energy [95].

The value of the exponent (r) depends on the nature of the transitions. In allowed direct transfers, its value is 1/2, and formula. takes the form: $(\alpha h\upsilon)^{1/2} = B^{1/2}(h\upsilon - E_g)$

In the case of forbidden direct transitions, its value is 2/3, and formula takes the form: $(\alpha h\upsilon)^{3/2} = B^{3/2}(h\upsilon - E_g)$, and the value of the energy gap E_g corresponding to direct electronic transitions is determined graphically from the graph of the graph of $(\alpha h\upsilon)$m changes terms of $(h\upsilon)$ Then the best and farthest linear part of the curve is taken and plotted as a straight-line tangent to it.

So that an extended intersection of this tangent with the horizontal axis $(h\upsilon)$ corresponds to the value of the energy gap E_g, and becomes $(\alpha h\upsilon)^m = 0$. Figures. (4-6),and (4-7) represent the energy gap of the films in allowed and forbidden direct electronic transitions.

We note from the two figures (4-6),and (4-7) that the forbidden band gap of the allowed and forbidden direct electronic transitions decreases with the increase in the concentration of aluminum oxide nanoparticles, as the increase in concentration leads to a deflection of the absorption edge towards lower energies. This is due to the fact that the rate of grains size increases with increasing concentration, and consequently, the concentration of charge carriers is increases, and thus value for band gap field decreases [96].

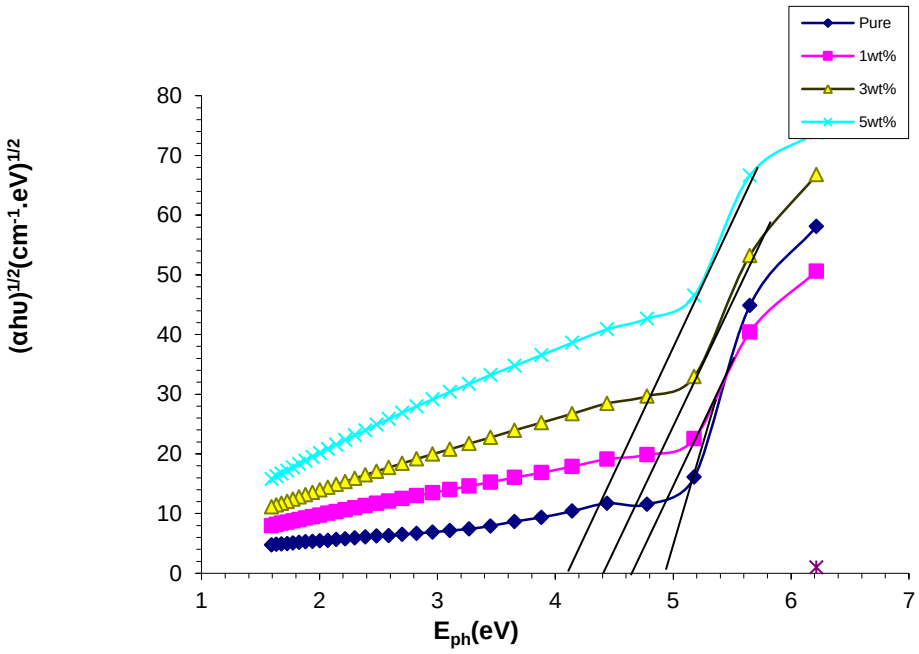


Figure (4-6): (α hv) $^{1/2}$ vs . hv plot of doped PVA –Al_2O_3 nanocomposite of different percentage with energy Allwed indirection transitions.

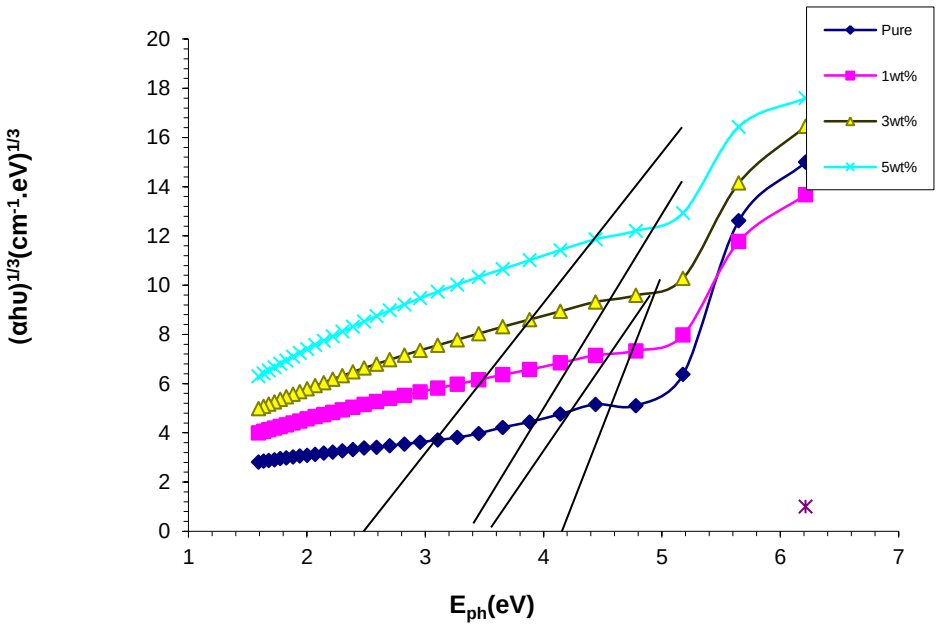


Figure (4-7) : (α hv) $^{1/3}$ vs . hv plot of doped(PVA –Al_2O_3) nanocomposite of different percentage with energy of forbidden indirection transitions

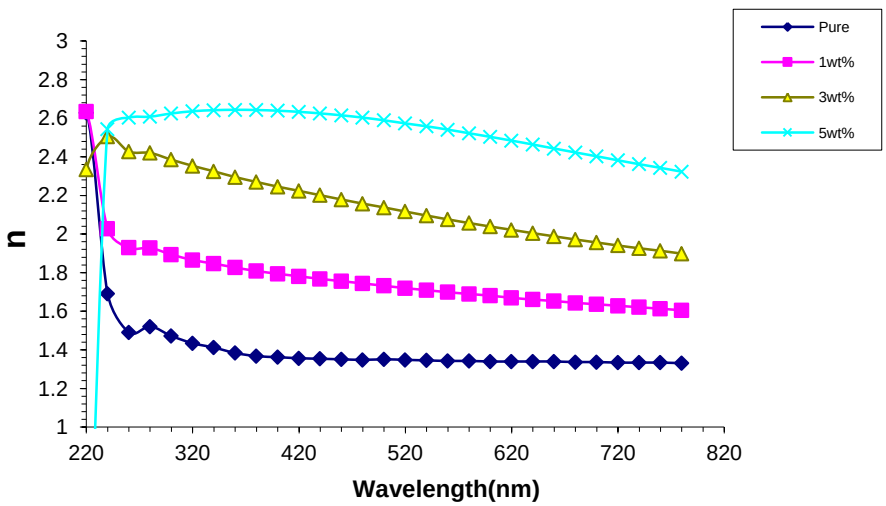
Table (4-1) the energy gap values for both types of electronic transfers.

The samples	Allowed energy gap (ev)	Forbidden energy gap(ev)
Pure	4.7	4.42
1%	4.2	3.7
3%	4	3.3
5%	3.9	3.1

4.3. 5 Refractive index (n)

We can know the true refractive index n at the speed of light in a vacuum to its speed in a substance: n = C / ν, which is calculated from the relationship: (2-9) The n_o depends on the type of material, and on the morphological structure. As we mentioned in the previous paragraph [97].

nanocomposites as a function of wavelength. The figure shows that with the increase in the wavelength, the refractive index will increase for the sample PVA, and here, the scattering is of an abnormal type until the curve reaches the top, while the uniform dispersion appears when the curve begins to decline and this is due to the decrease in absorption. From this Figure, we find that the refractive index values will increase with increasing concentration of nanoparticle weight percentages (Al_2O_3) in Polymers. The reason is that increasing the concentration of (Al_2O_3) leads to an increase in the density of nanocomposites[98].



Figure(4-8) : The refraction index of (PVA –Al_2O_3.) nanocomposite as a function wavelength at different percentage.

4.3.6 Extinction coefficient (K)

The change of extinction coefficient, as a function of wavelength, is shown in Figure (4-9). From this figure, we find in the ultraviolet rays' high values of the extinction coefficient, and the reason for this is due to the high absorption of the samples. At higher wavelengths, the extinction coefficient values decrease, then the extinction coefficient values begin to increase with the increase in the molar ratio of doped. We also notice at high energies an increase in the spectrum, which is attributed to the high photon absorption and then an increase in the extinction coefficient. [99].

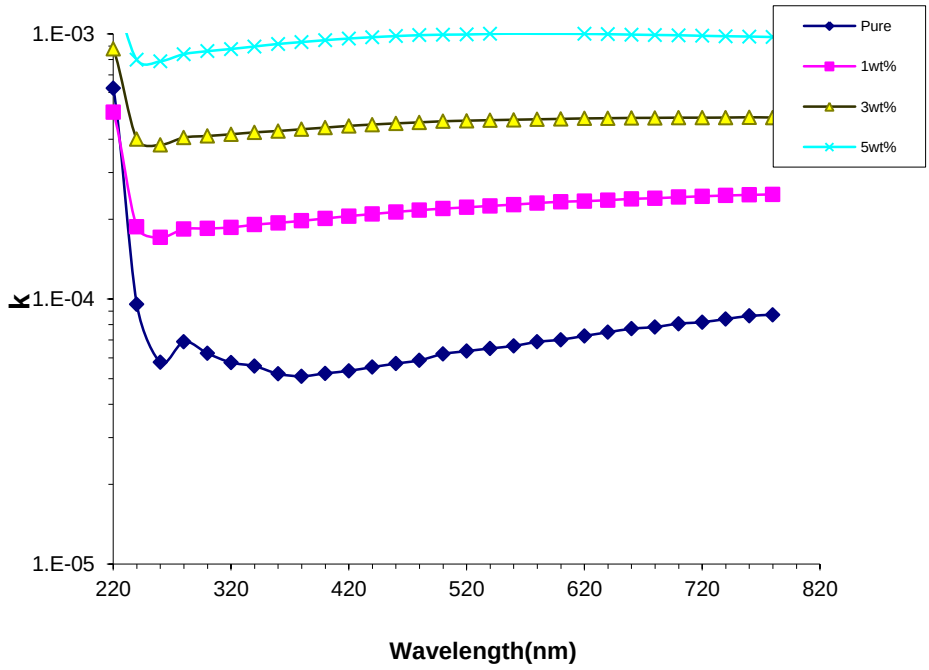


Figure (4-9) : The extinction coefficient of (PVA –Al_2O_3.) nanocomposite as a function wavelength at different percentage.

4.3.7 Dielectric constant

Figures (4-10) and (4 – 11) represent the variations of real dielectric constant ε_r as function of wavelength λ (nm) for films. The real dielectric constant depends on n_2 and k_2, but the imaginary dielectric constant depends on

k and n. Real and imaginary dielectric constant ($\varepsilon_1, \varepsilon_2$) for (PVA-Al_2O_3 nanocomposite.

The curves real 'dielectric constant are almost similar to the refractive index because of their connection together, where the effect of the extinction coefficient is weak.

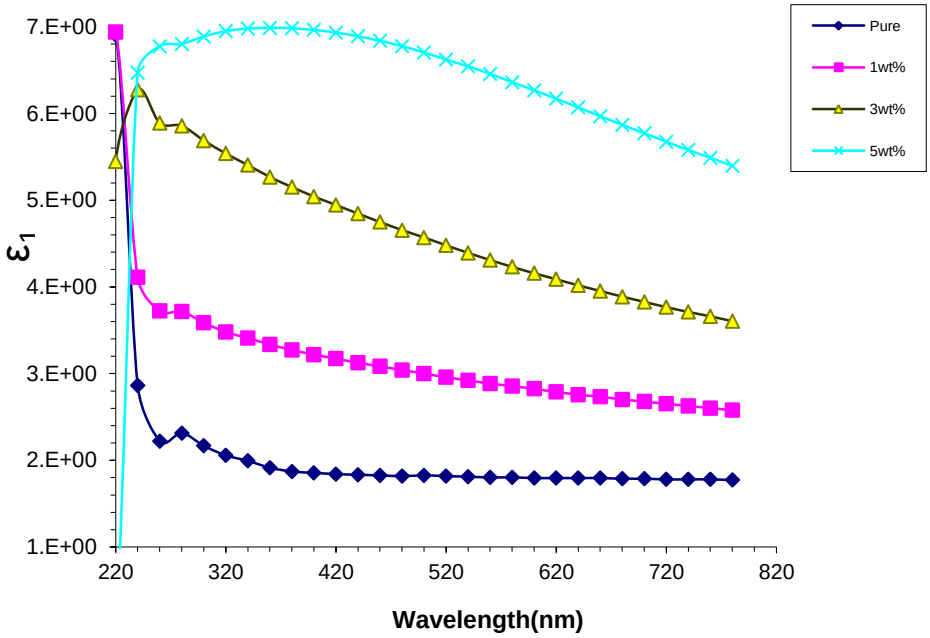


Figure (4-10) : The real dielectric constant of (PVA –Al_2O_3.) nanocomposite as a function wavelength at different percentage.

The imaginary dielectric constant(ε_2) represents the energy lost due to the movement of dipoles when shedding an external field. We notice from Figure (4 – 11) that the value of (ε_2) for (pure-0.01-0.03) samples is almost constant at long wavelengths, while for the sample (0.05) it is low at short wavelengths and then increases at long wavelengths.

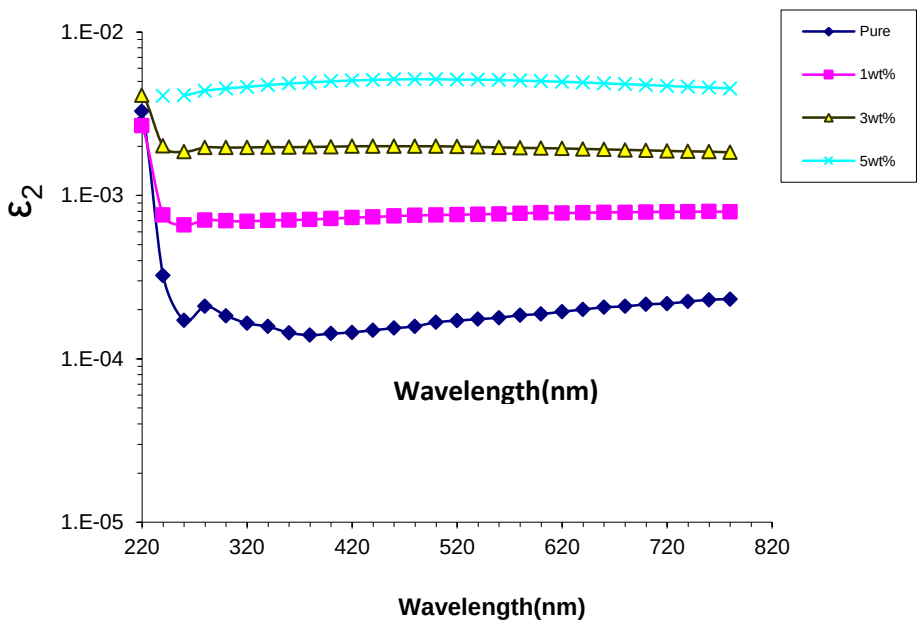


Figure (4-11) : The imaginary dielectric constant (PVA –Al_2O_3) nanocomposite as function wavelength at different percentage.

4.3.8 Optical conductivity

the optical conductivity (σ_{op}) It is defined as the increase in number of charge carriers (electrons or holes) as a result of falling of a light beam of material.

Figure. (4-12) shows that the value of the optical conductivity decreases with increase of wavelength, while it increases at low wavelengths because connection of optical conductivity with absorption coefficient (α).

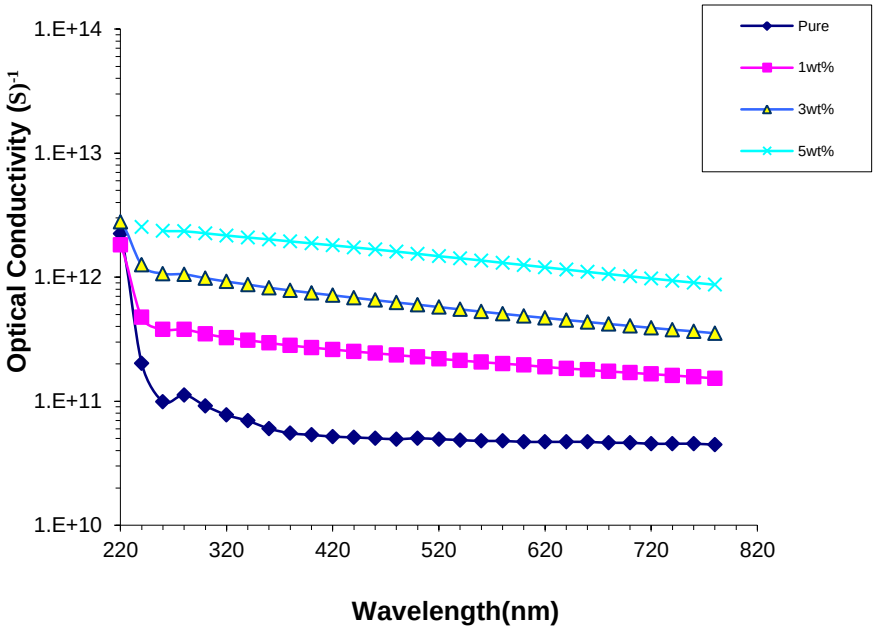


Fig (4-12): The optical conductivity for (PVA –Al_2O_3Nano.) nanocomposite

4.4 The effect of magnetic field on the optical properties :

4.4.1 The Transmittance (T)

Figure (4-13) shows a comparison between the optical transmittance spectrum in the absence of magnetic field and in the presence of magnetic field, where we observe a better displacement of the dipoles of molecules.

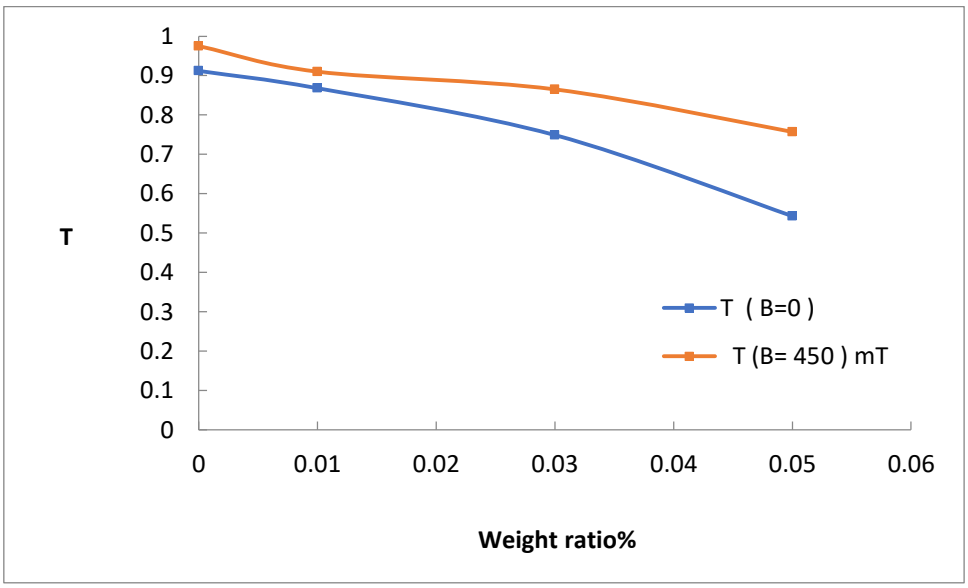


Fig (4-13): The relation between transmittance (T) and the weight ratio of (PVA –Al_2O_3) nanocomposite

We notice from the figure (4-13) that when a magnetic field is applied, the optical permeability increases, and therefore this field will work to polarize the particles of direction of the magnetic field. [100].

4.4.2 The Absorptance (A)

Light has three states within matter. If it is not reflected or transmitted, it will be absorbed by material falling on it [98]

The absorption can be calculated from as in the following form(2-2)

By substituting the transmittance values in this equation, we find that the proportionality between absorption and transmittance is indirect, and it is clear from the figure (4-14) that there is a direct proportion between absorption and doped concentration [100].

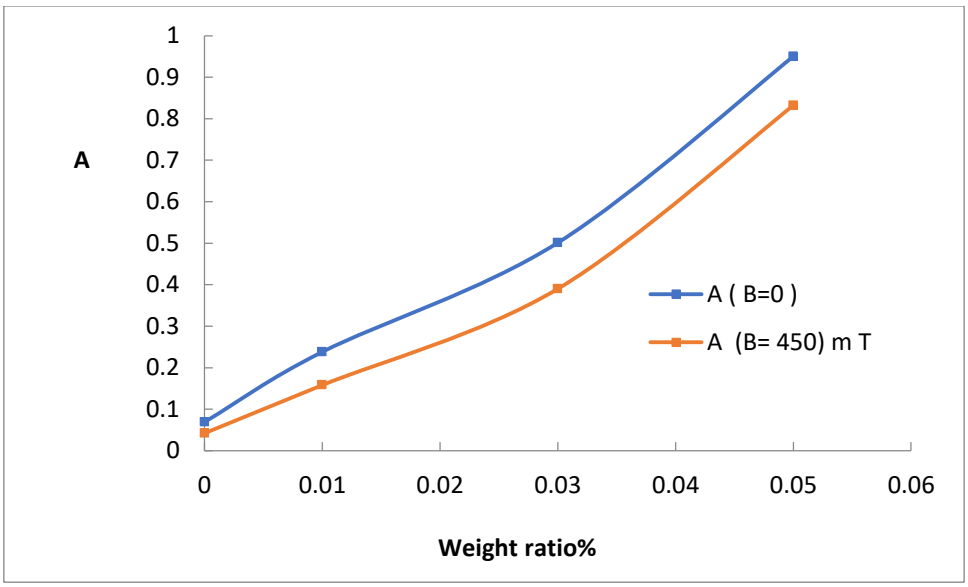


Fig (4-14): The relation between Absorbance and the weight ratio for (PVA–Al_2O_3 nanocomposite

4.4.3The Absorption Coefficient (α)

There is a direct relationship between the concentration and the absorption coefficient. Figure (4-15) shows a direct proportion between both the absorption and concentration coefficients.

We note that the values of the absorption coefficient are low due to the strong effect of the magnetic field, which in turn causes polarity, and therefore we will notice a decrease in the values of the optical absorption coefficient. [101].

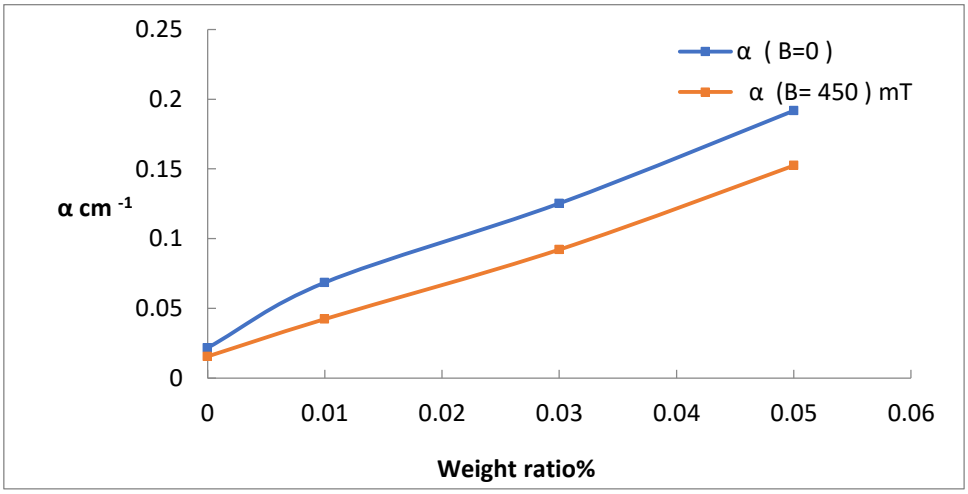


Fig (4-15): The relation between Absorption coefficient (α) and the weight ratio for (PVA – Al_2O_3) nanocomposite

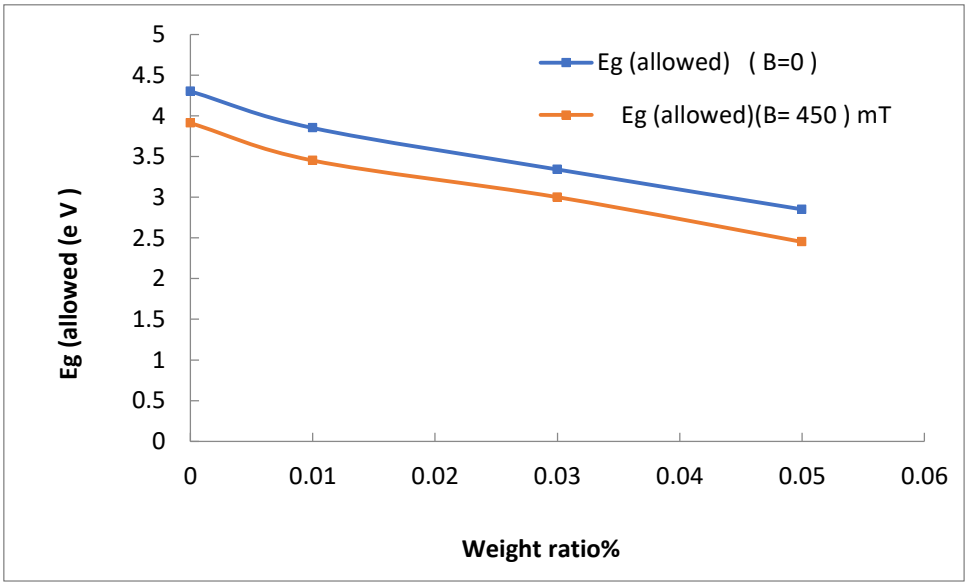


Fig (4-16): The relation between allowed energy gap and the weight ratio for (PVA – Al_2O_3) nanocomposite

4.4.4 The Extinction Coefficient(k)

The behavior of extinction coefficient appears in the form of a direct proportion between of extinction coefficient and concentration of magnetic field that affects the particles, and that is explained in Figure (4-17), and therefore the

decrease in the value of the extinction coefficient is attributed to the decrease in the values of absorption coefficient [102]

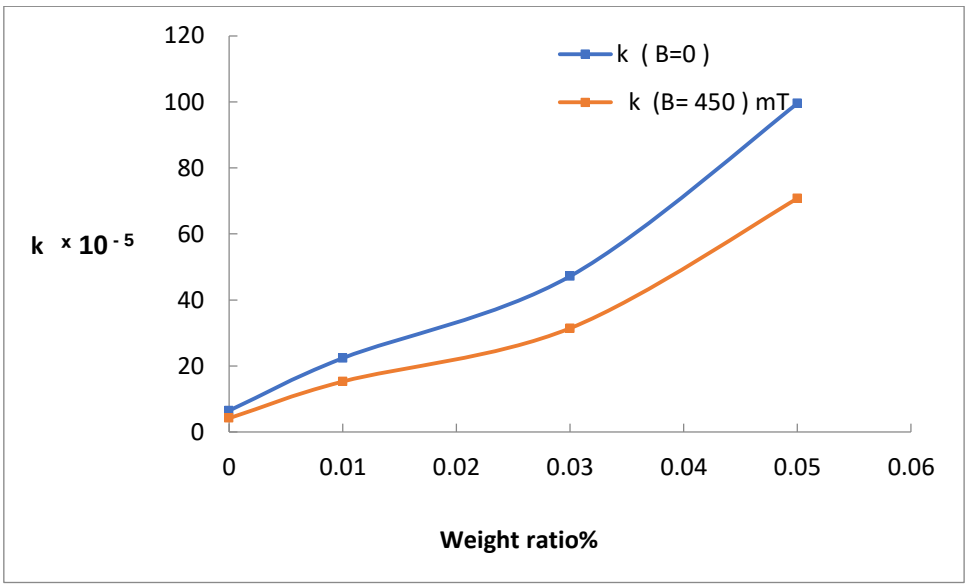


Fig (4-17) : The relation between extinction coefficient (k) and the weight ratio for (PVA – Al_2O_3) nanocomposite

4.4.5 The Refractive index (n)

The figure (4-18) shows the relationship between the values of the refractive index and concentration, which turns out to be directly proportional. The values of the refractive index were decreased, which is due to the effect of the magnetic field, which causes better displacement of the dipoles.

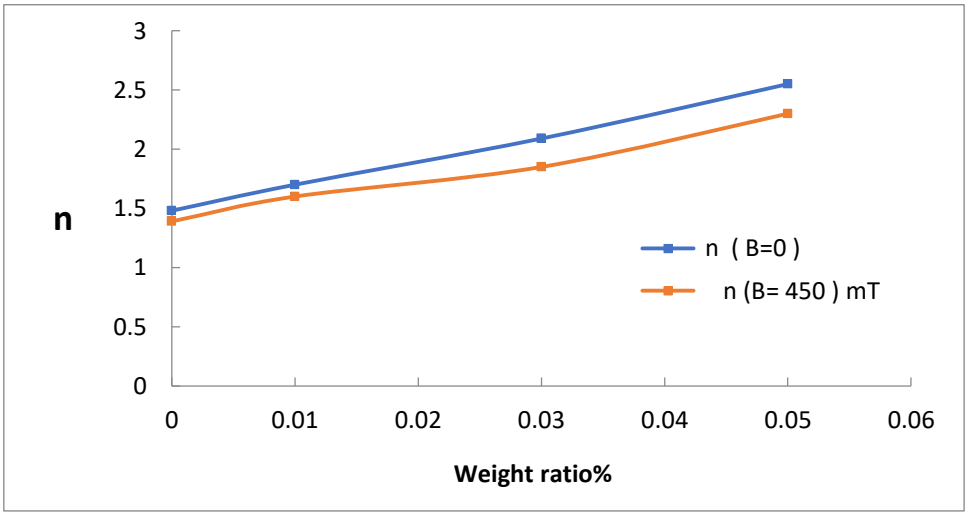


Fig (4-18): The relation between refractive index (n) and the weight ratio for (PVA –Al_2O_3) nanocomposite.

4.4.6 The complex Dielectric

The charges of the material are polarized when the beam falls on the material and it interacts with the charges. This polarization expresses the dielectric constant ε, that is ability electrons of the material to respond to light. We cannot directly calculate each of damping, dielectric and refraction coefficients, except from their respective equations, but we can calculate both absorbance and permeability directly, and the complex dielectric constant can be calculated from the formula (2-14) [103]. Where εr denotes the properties of bound charges, while бop denotes free charges. On the other hand, ε has the following complex (2-15) [103].

The complex isolation function is divided into a real section related to scattering, which is useful for explaining the phenomenon of scattering, and therefore the movement of the actual electrons of the electrons in the material through which the light passes must be taken into account. The second section of the nodal isolation function is the imaginary section, which describes the rate of propagation of electromagnetic devices that disperse through the material.

The real and imaginary parts depend on the energy of the photon and the refractive index, and since the magnetic field caused a decrease in the values of the refractive index, the real and imaginary dielectric constant values will decrease as shown in Figures (4-19) and (4-20) [104].

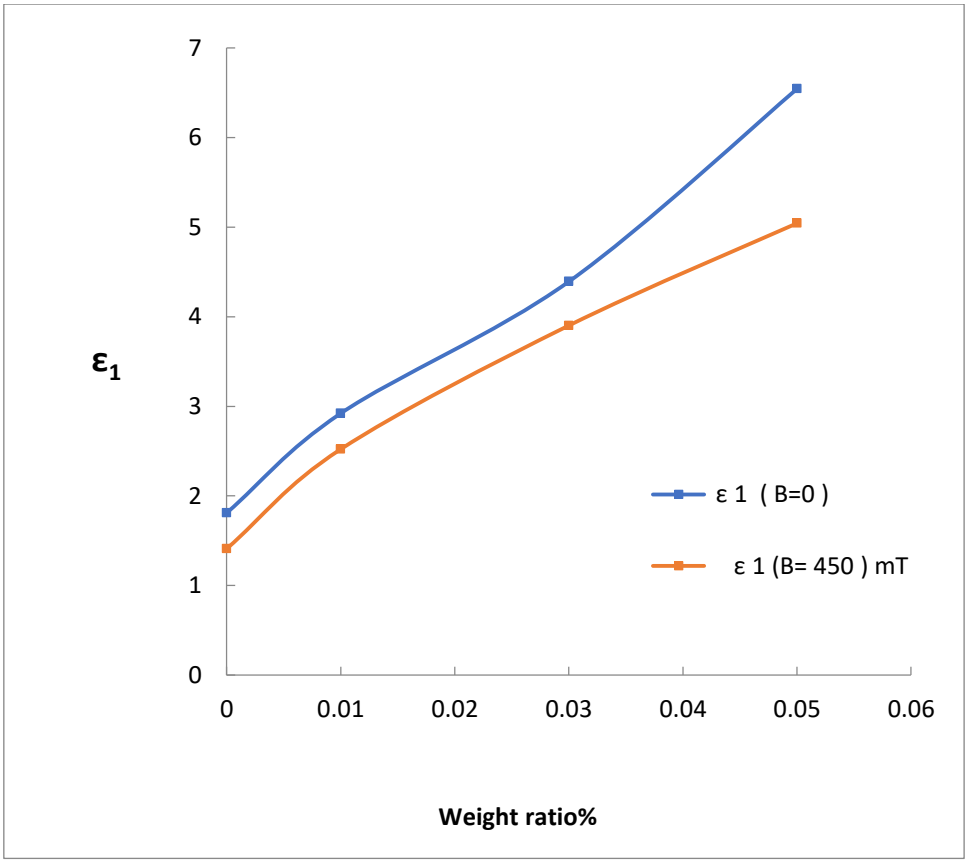


Fig (4-19): The relation between real dielectric constant (ε_1)and the weight ratio for (PVA – Al_2O_3) nanocomposite

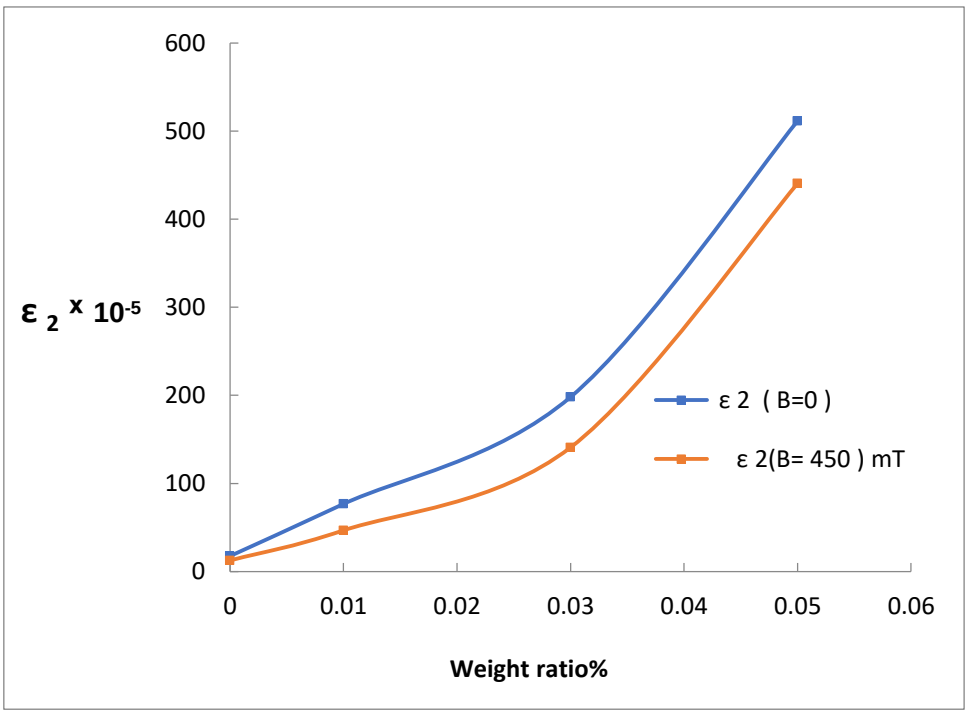


Fig (4-20) **:** The relation between imaginary dielectric constant (ε_2) and the weight ratio for (PVA –Al_2O_3) nanocomposite

Table. (4-2): shows the magnetic field effect data

Weight Ratio	**A B=0**	**A B=450 mT**	**T B=0**	**T B=450 mT**	**α cm $^{-1}$ B=0**	**α cm $^{-1}$ B=450 mT**	**K × 10^{-5} B=0**	**K × 10^{-5} B=450mT**
0	0.069	0.042	0.912	0.975	0.02169	0.01554	6.51	4.212
0.01	0.238	0.158	0.868	0.91	0.06853	0.04234	22.4	15.32
0.03	0.501	0.39	0.749	0.865	0.12528	0.09214	47.2	31.45
0.05	0.95	0.832	0.543	0.757	0.19175	0.1524	99.5	70.75

Weight Ratio	**N B=0**	**N B=450mT**	**ε_1 B=0**	**ε_1 B=450mT**	**ε_2× 10^{-5} B=0**	**ε_2× 10^{-5} B=450mT**	**N B=0**
0	1.48	1.39	1.8101	1.4101	17.5	12.5	1.48
0.01	1.7	1.6	2.9215	2.5215	76.7	46.7	1.7
0.03	2.09	1.85	4.3922	3.9022	198	140.8	2.09
0.05	2.55	2.3	6.5435	5.043	511.4	440.4	2.55

Weight Ratio	E_g (allowed) B=0	E_g (allowed) B=450 m T	E_g (forbidden) B=0	E_g (forbidden) B=450 m T
0	4.3	3.91	3.42	3.2
0.01	3.85	3.45	3.28	3.1
0.03	3.34	3	2.96	2.7
0.05	2.85	2.45	2.62	2.4

4 .5 Conclusions

The results of this study show the optical properties of the composite polymer (PVA-Al_2O_3) nanocomposite, which are as follows:

1. The absorption coefficient(α)of polymer compounds decreases with magnetic field added.
2. The absorption coefficient increases significantly with the increase of the doping concentration ratio especially at high energy, and it changes rapidly near the light absorption edge.
3. the transmittance decreases with increasing doping concentration with aluminum oxide nanoparticles.

4. The value of the optical conductivity decreases by increasing wavelength
5. The magnetic field gives a better chance for all optical properties, as it was noticed that the results improved and the permeability increased due to the effect of the magnetic field and the decrease in the rest of the optical properties .

4 .6 Future Work

For future studies, the following is suggested:

1- Studying the piezoelectric effect on optical properties of (PVA-Al_2O_3) Nanocomposite.

2 -Studying the electric field effect on optical properties of (PVA- Al_2O_3) Nanocomposite.

3 - Studying the temperature effect on optical properties of (PVA-Al_2O_3) Nanocomposite.

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الخلاصة

في هذا العمل تم تحضير أغشية متكونة من بوليمر (PVA) والمطعم بجسيمات(Al_2O_3) وبنسب وزنية %(0، 1، 3، 5) من الوزن المستخدم وبطريقة صب المحلول وباستخدام كحول الكلوروفورم كمذيب في درجة حرارة المختبر.

تمت دراسة الخواص البصرية للعينات باستخدام مقياس طيف الامتصاص ضمن المدى nm (190–1100) اثبت الدراسة أن الخواص البصرية للعينات (الامتصاصية، معامل الامتصاص، معامل الخمود، معامل الانكسار، ثابت العزل الحقيقي والخيالي) لهذه الأغشية قد ازدادت مع زيادة النسب الوزنية لجسيمات(Al_2O_3) النانوية بينما تناقصت النفاذية وفجوة الطاقة حيث سجلت قيم تتراوح بين (3. 9–4.7 ev) عند اعلى نسبة تطعيم مقدارها (5%wt) من الجسيمات النانوية.

استخدم المجهر الضوئي لمعرفة توزيع المادة النانوية (Al_2O_3) داخل الأغشية المحضرة بصورة متجانسة وعدم وجود تكتلات.

وتم استخدام مقياس فورييه للأشعة تحت الحمراء لفحص الأغشية المحضرة وملاحظة عدم وجود تفاعل كيميائي بين مكونات المواد التي حضرت الأغشية منها. تم دراسة تأثير المجال المغناطيسي على الخليط المطعم بنسب وزنية مختلفة حيث لوحظ تحسن الخصائص حيث أصبحت النفاذية كبيرة للضوء الساقط وتناقصت قيم الخواص البصرية(الامتصاصية، معامل لامتصاص، معامل الخمود، معامل الانكسار، ثابت العزل الحقيقي والخيالي).

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

تأثير المجال المغناطيسي على الخصائص البصرية لبوليمر (PVA) المطعم بجسيمات (Al_2O_3) النانوية

رسالة مقدمة

إلى مجلس كلية التربية للعلوم الصرفة في جامعة بابل
وهي جزء من متطلبات نيل درجة الماجستير
في التربية/ الفيزياء

من قبل الطالبة
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جامعة بابل 2009م

بإشراف
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