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Imam Mohammad Ibn Saud Islamic University (IMSIU)
Faculty of Sciences – Department of Physics

Optical properties of Metal Oxide Nano-Polymer Composite

A graduation project submitted to the Department of Physics in partial fulfillment of the requirements for the degree of Bachelor of Science in Applied Physics

By

Ahad Yousef Aljohani

Supervisors

Prof. Wafaa Morsi

Dr. Hanan Akhdar

IMSIU-Riyadh-KSA

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بسم الله الرحمن الرحيم

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﴿وَآخِرُ دَعْوَاهُمْ أَنِ الْحَمْدُ لِلَّهِ رَبِّ الْعَالَمِينَ﴾.

الحمد لله تعالى أولا وآخرا على فضله وتوفيقه لي في إتمام هذا البحث فما كنت لأفعل لولا مكني الله

أهدي هذا النجاح إلى نفسي الطموحه وإلى الأركان العظيمة في الحياة إلى من شاركوني رحلتي الشاقه و سعوا في بناء مستقبل مشرق لي إلى الأعمدة الثابتة في الحياة " عائلتي " شكرا لكم

وبكل حب أهدي ثمرة نجاحي إلى الحبيب والرفيق والسند و الصديق إلى من حصد الأشواك عن دربي ليمهد طريق العلم لي و بذل جهد السنين من أجل أن أعتلي سلالم النجاح إلى أعظم وأعز رجل في حياتي

والدي الحبيب/ يوسف الجهني

إلى من أخذت بيدي طريق العلم والنور وكانت لي ضيء وضياء إلى تلك الدعوات التي رافقتني و كانت بعد عون الله سببا في نجاحي إلى حبيبة قلبي ورفيقة روحي

أمي الحبيبة/ أحلام

كما أتقدم بالشكر الجزيل الى الذين مهدوا لي طريق العلم والمعرفة واشرفوا على تكويني خلال مشواري الجامعي
الى جميع دكاترتنا الأفاضل واخص بشكري الى
البروفيسورة / وفاء مرسي
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اللتان أشرفتا على هذا المشروع من خلال توجيبهم وارشادهم فجزاهم الله عني كل خير وجعلها في ميزان حسناتهم.
ولا أنسى رفيقة الروح التي شاركتني خطوات هذا الطريق وهونت تعبه وكانت بمثابة تشجيع على المثابرة وإكمال المسيرة " حصة السبيعي " ممتنه لك.

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الملخص

تناولت هذه الدراسة تأثير تحميل جزيئات أكسيد الكروم النانوية (Cr_2O_3) بتركيزات مختلفة على أفلام النانو المركبة المصنوعة من بولي فينيل الكحول (PVA). تم دراسة هيكل النطاق الإلكتروني باستخدام طيف الامتصاص في الأشعة فوق البنفسجية والمرئية. لوحظ أن الفجوات الطاقية الغير مباشرة للمصفوفة قد انخفضت، بينما زادت امتصاصية الأشعة فوق البنفسجية والمرئية مع زيادة تركيز الجسيمات النانوية. علاوة على ذلك، تشير القيم المنخفضة لفجوة الطاقة (Eg) للأفلام إلى خصائصها الأفضل، مما يجعلها أكثر فائدة للعديد من الأنظمة والأجهزة البصرية.

Abstract

The present work examined the impact of loading chromium oxide nanoparticles (Cr2O3) with various concentrations on the nanocomposite films which are made of polyvinyl (PVA).The electronic band structure investigation by using Ultraviolet-Visible absorption spectroscopy.

It was observed that the matrix's indirect energy band gaps decreased while its absorbance of ultraviolet-visible radiations increased with an increase the concentration of nanoparticles. Moreover, The low Eg values of the films show that their better characteristics, which makes them becoming more beneficial for various optical systems and devices.

Chapter 1: Introduction

1.1 Polymers

A polymer is a large molecule, or macromolecule, formed by the repetitive linking of smaller, simpler molecules called monomers. These monomers are covalently bonded together through various chemical processes, resulting in a chain-like structure. Polymers can be found in nature (natural polymers) or synthesized in laboratories (synthetic polymers) [1].

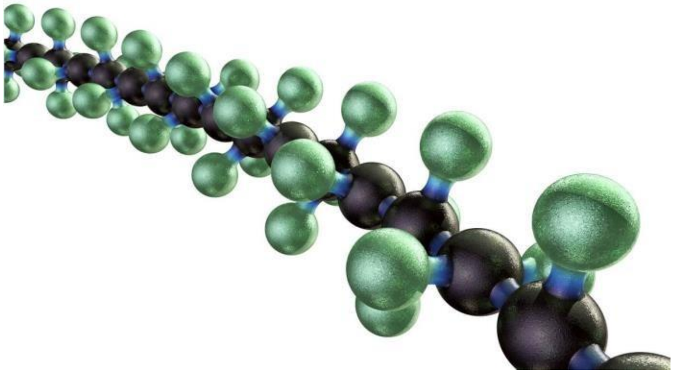

Figure 1.1: Polymer.

1.1.1 Polyvinyl alcohol (PVA)

Polyvinyl alcohol (PVA) is a synthetic polymer widely recognized for its versatility and unique properties. It is created through the hydrolysis of polyvinyl acetate, resulting in a water-soluble polymer that exhibits excellent film-forming capabilities, adhesive strength, and resistance to oils and greases.

PVA is a white, odorless powder that is biodegradable, making it an attractive alternative to traditional plastics in various applications. Its solubility in water allows it to be used in diverse fields, including packaging, textiles, and medical applications.

Due to its non-toxic nature and compatibility with other materials, PVA is often employed in formulations ranging from adhesives to coatings, as well as in specialized applications such as drug delivery systems and agricultural films. As industries seek more sustainable materials, PVA's biodegradability and functional properties position it as a valuable option for future developments. Overall, PVA stands out as a multifaceted material with significant potential across various sectors, promoting both functionality and environmental responsibility [2].

1.2 Nanoparticles

Nanoparticles are tiny particles that have dimensions in the nanometer scale, typically ranging from 1 to 100 nanometers (nm). At this scale, materials exhibit unique physical and chemical properties that differ significantly from their bulk counterparts, leading to a wide range of applications across various fields [3].

1.2.1Nano Oxides

Nano oxides are nanoparticles composed of metal oxides, they are notable for their unique properties and are used in a wide range of applications across various fields, including electronics, catalysis, medicine, and environmental science.

Characteristics of Nano Oxides:

- Size and Surface Area: Nano oxides have a high surface area-to-volume ratio, which enhances their reactivity and interaction with surrounding materials.
- Chemical Properties: The properties of nano oxides can differ significantly from their bulk counterparts, including changes in optical, magnetic, and electronic behaviors.
- Stability: Many nano oxides exhibit good thermal and chemical stability, making them suitable for various applications.
- Functionality: Nano oxides can exhibit photocatalytic activity, magnetic properties, and semiconductor characteristics, which can be tailored by changing their composition or structure [4].

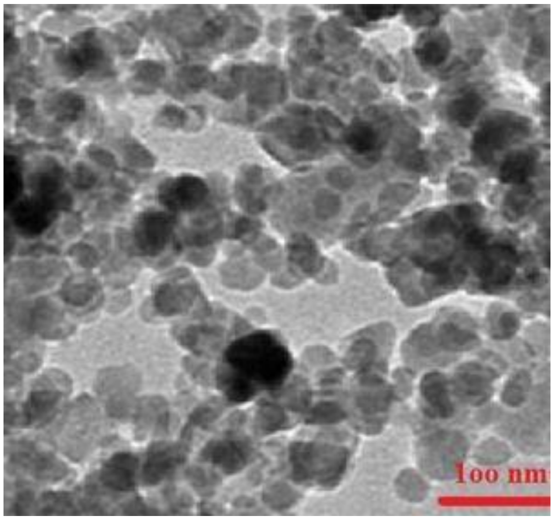

Figure 1.2: Zinc Oxide Nanoparticles.

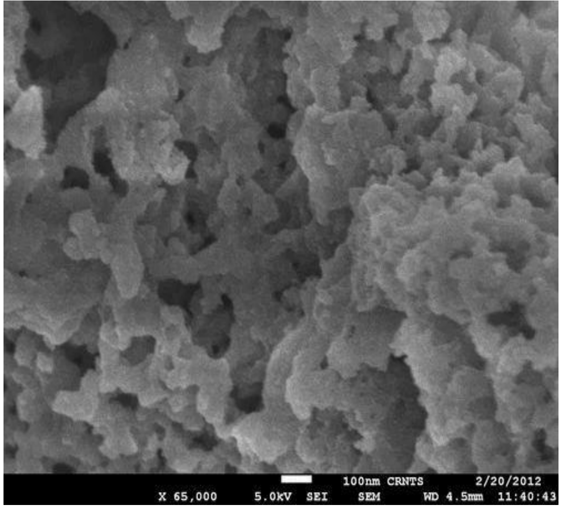

Figure 1.3: Chromium Oxide Nanoparticles.

1.3 Nano Composites with polymer

Polymer nanocomposites are commonly defined as the combination of a polymer matrix and additives that have at least one dimension in the nanometer range. The additives can be one-dimensional (examples include nanotubes and fibers), two-dimensional (which include layered minerals like clay), or three-dimensional (including spherical particles). Over the past decade, polymer nanocomposites have attracted considerable interest in both academia and industry, owing to their outstanding mechanical properties like elastic stiffness and strength with only a small amount of nano additives. This is caused by the large surface area to volume ratio of nano additives when compared to the micro- and macro-additives. Other superior properties of polymer nanocomposites include barrier resistance, flame retardancy, scratch/wear resistance, as well as optical, magnetic, and electrical properties [5].

1.4 Electronic structure of nano particles

The electronic structure of nanoparticles plays a crucial role in determining their physical and chemical
properties, which can differ significantly from those of bulk materials. Here's an overview of the key concepts:

Quantum Confinement

Size Effects: As the size of nanoparticles decreases (typically below 100 nm), quantum confinement occurs. This means that the motion of electrons and holes (electron vacancies) is restricted, leading to quantized energy levels rather than continuous bands.

Band Gap Changes: The reduction in size results in an increase in the band gap energy. Smaller nanoparticles tend to absorb and emit light at shorter wavelengths, which can affect their optical properties. [6]

1.4.1 Absorption

When electromagnetic radiation interacts with matter, it can transfer energy to the material, leading to the excitation of electrons or other energy transitions within the atoms or molecules. This process is termed absorption. There are several possibilities when light encounters an electron. One possibility is that the electronmay absorb a photon and move to an excited state. The photon will only be absorbed if it has an energy corresponding to the energy difference between the current state and the excited state. Conversely, when atomsor molecules in an excited state return to lower energy states or the ground state, they can emit radiant energy inthe form of photons. This emission process can result in the release of photons with characteristic energies as can be seen in figure (1.3). If an electron absorbs a series of photons with the correct energies, the electron can escape from the material. This is likely to occur with photons of high energy. When the electron has escaped the material, the result is the absorption of the light and a current in the material, since a current is the movement of electrons.

The optical band gap reflects the energy difference between the current state (valence band) and excited state (conducting band). It is an important parameter in the selection of a material for a specific application. The optical band gap is equal to the critical absorption edge ε between the states in the valence and conducting band. In a qualitative sense, if a material has a large band gap, it is a good insulator, while if it has a small band gap, it is a semiconductor. The band gap 6 for metals is around zero, as there is no energy difference between the valence and conducting bands. In essence, they overlap [7].

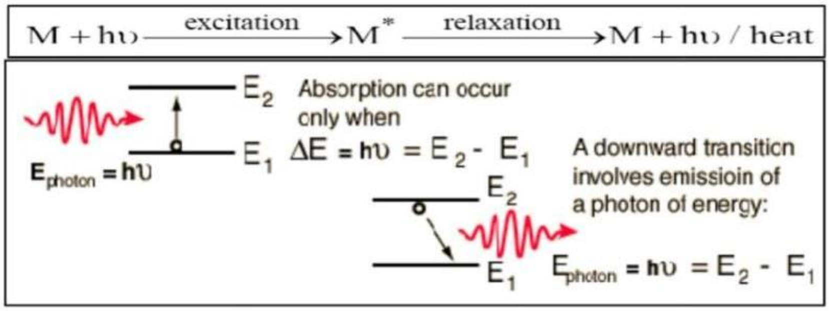

Figure 1.4: Emission-Absorption principle.

1.5 Electronic structure of polymer PVA

Polyvinyl alcohol (PVA) is a synthetic polymer that has garnered significant interest in various fields, including materials science, biomedical applications, and coatings, due to its unique chemical and physical properties. PVA is formed through the polymerization of vinyl acetate, followed by hydrolysis to convert theacetyl groups into hydroxyl groups. This transformation is critical as it imparts the polymer with distinctive characteristics such as hydrophilicity, biocompatibility, and the ability to form strong hydrogen bonds.

Understanding the electronic structure of PVA is essential for elucidating its properties and behaviors. The electronic structure refers to the arrangement of electrons in a molecule, particularly concerning the distribution of electron orbitals, which dictate the chemical reactivity, optical characteristics, and mechanical properties of the polymer [8].

1.6 Optical properties

The study of optical properties is a fascinating and complex field that encompasses how materials interact withlight. These properties are foundational to numerous scientific disciplines, including physics, chemistry, materials science, and engineering, and they play a pivotal role in everyday applications such as imaging, telecommunications, and lighting.

At its core, the optical properties of a material describe its behavior in the presence of electromagnetic radiation, particularly visible light. When light encounters a material, it can be absorbed, reflected, transmitted,or scattered, and the extent and nature of these interactions depend on the intrinsic properties of the material, such as its molecular structure, composition, and surface characteristics [9].

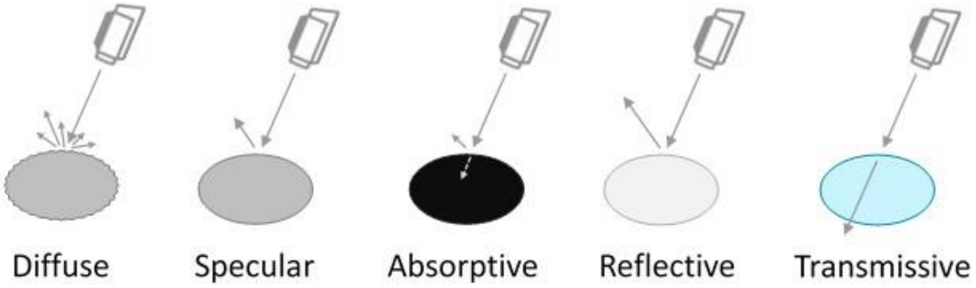

Figure 1.5: The image depicts an overview of the various optical properties of materials described above.

1.7 General applications of polymer nano composites

Polymer nanocomposites are innovative materials that are formed by integrating nanofillers – such as nanoparticles, nanotubes, or nanofibers – into a polymer matrix. This combination enhances the properties of the base polymer, resulting in materials that exhibit improved mechanical, thermal, electrical and barrier properties. The unique features of polymer nanocomposites arise from the high surface area and aspect ratio ofnanofillers, which react at a basic level with PO The diversity of polymer nanocomposites has led to their growing popularity in various industries. In the automotive sector, for example, they contribute to lightweight but powerful components, enhancing fuel efficiency while maintaining safety standards. In aviation applications, its lightweight properties and resistance to extreme conditions make it ideal for advanced structural materials In electronics, polymer nanocomposites are revolutionizing the design of flexible displays and conductive films, promoting the development of thinner and more efficient devices. The packaging industry benefits from the improved barrier properties of these materials, which extend the shelf life of products by reducing moisture Biomedical applications are particularly promising, as polymer nanocomposites can be engineered for drug delivery systems and tissue engineering, taking advantage of their biocompatibility and mechanical strength. In construction, they are used to improve the durability and performance of concrete and other building materials, contributing to sustainable development In addition, polymer nanocomposites are making great strides in environmental applications, such as water treatment, where their high surface area enables efficient absorption of pollutants. Overall, the diverse applications of polymer nanocomposites highlight their ability to drive innovation and efficiency across multiple sectors, making them the focus of ongoing research [10].

1.7.1 Medical applications

Polymer nanocomposites have gained significant traction in the medical field due to theirunique properties and versatility. The integration of nanotechnology into medical applications represents a promising frontier, with the potential to significantly improve treatment outcomes and patient care. Ongoing research continues to explore new ways to harness the benefits of polymer nanocomposites in medicine. Here are some key medical applications:

- Drug Delivery Systems: Polymer nanocomposites can be designed to encapsulatedrugs and release them in a controlled manner. The nanoscale structure allows for improved drug solubility, stability, and targeted delivery to specific tissues, enhancing therapeutic effectiveness.
- Implants and Prosthetics: Polymer nanocomposites are used to enhance the mechanical strength and durability of implants and prosthetics, improving their performance and longevity while maintaining biocompatibility.
- Diagnostic Tools: Nanoscale materials can be utilized in biosensors and imaging applications, enhancing the sensitivity and specificity of diagnostic tests. This can lead to earlier detection of diseases and improved monitoring of health conditions.
- Wound Dressings: Nanocomposite materials can promote faster healing by providing a moist environment, delivering drugs, and preventing infection. Their adjustable properties can be tailored to enhance breathability and absorbency.
- Cancer Treatment: Polymer nanocomposites can be engineered for targeted cancer

therapy, allowingfor localized delivery of chemotherapeutic agents to tumors while minimizing side effects on healthy tissues [11].

1.7.2 Industrial applications

Polymer nanocomposites have found a wide array of applications across various industrial sectors due to their enhanced properties and performance characteristics. Here are somekey industrial applications:

- Automotive Industry: Polymer nanocomposites are used to produce lightweight components that improve fuel efficiency and reduce emissions. They enhance mechanical strength, thermal stability, andimpact resistance in parts like bumpers, dashboards, and under-the-hood components.
- Aerospace: In aerospace applications, these materials contribute to weight reduction while maintainingstructural integrity and resistance to extreme temperatures. They are utilized in components such as panels, wings, and other critical structures.
- Electronics: Polymer nanocomposites are employed in the manufacture of flexible displays, conductive films, and insulation materials. Their improved electrical conductivity and thermal management properties make them suitable for advanced electronic devices and packaging.
- Packaging: The use of polymer nanocomposites in packaging enhances barrier properties against moisture, oxygen, and UV radiation. This results in longer shelf life for food products and improvedprotection for sensitive items.
- Construction Materials: In construction, nanocomposites improve the mechanical properties and durability of concrete and other building materials. They enhance resistance to cracking, reduce waterpermeability, and improve overall longevity.
- Textiles: Polymer nanocomposites are used to create functional textiles with enhanced properties suchas water resistance, UV protection, and antibacterial characteristics. These advancements lead to applications in sportswear, protective clothing, and home textiles.
- Coatings: They are utilized in protective coatings that require enhanced scratch resistance, corrosion protection, and thermal stability. Applications include automotive coatings, industrial finishes, and anti-fogging coatings for various surfaces.

- Energy Storage: In batteries and supercapacitors, polymer nanocomposites improve electrical conductivity and charge storage capacity. This leads to the development of more efficient energy storage solutions.
- Oil and Gas: These materials are applied in drilling fluids and pipe coatings, providing improved resistance to wear, corrosion, and high temperatures, thus enhancing the reliability of equipment in harsh environments [12].

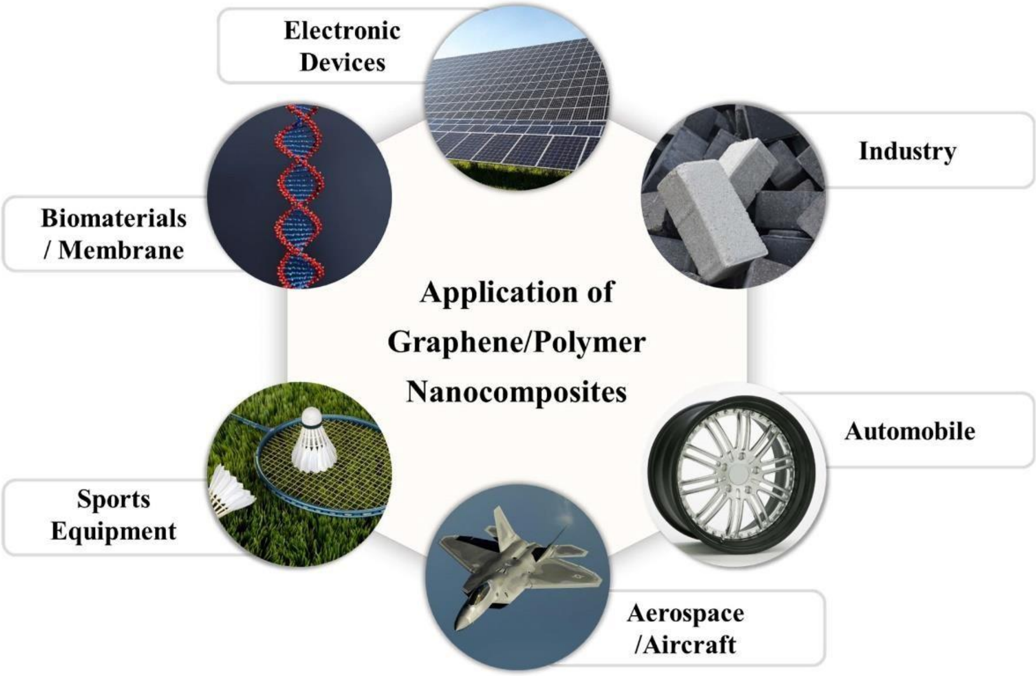

Figure 1.6: Nano Composites in the Polyethylene.

1.7.3 *Optical applications*

These applications highlight the versatility of polymer nanocomposites in advancing optical technologies acrossvarious fields. Here are some notable applications:

- Optical Sensors: Polymer nanocomposites can enhance sensitivity and selectivity in optical sensors. The incorporation of metal or semiconductor nanoparticles can improve the performance of sensors used for detecting gases, biological agents, or environmental pollutants.

- Photonic Devices: These materials are used in photonic devices like waveguides, light-emitting diodes (LEDs), and lasers. Nanocomposites can improve light transmission and efficiency due to their tailored refractiveindices and light-absorbing properties.
- Display Technologies: In liquid crystal displays (LCDs) and organic light-emitting diodes (OLEDs), polymer nanocomposites can be employed to enhance color purity, brightness, and durability, while also reducing weight.
- Anti-Reflective Coatings: Polymer nanocomposites can be used to create anti-reflective coatings that minimize glare on lenses and screens, improving visibility in various lighting conditions.
- Optical Filters: Nanocomposites can be engineered to selectively absorb or transmit specific wavelengthsof light, making them useful for optical filtering applications in photography and telecommunications.
- Solar Cells: In photovoltaics, polymer nanocomposites can enhance light absorption and charge transport,leading to improved efficiency in organic solar cells.
- Biomedical Imaging: Nanocomposites are being explored for use in imaging techniques such as fluorescence imaging, where nanoparticles can serve as contrast agents to improve the visibility of tissues.
- Data Storage: Polymer nanocomposites have potential in optical data storage systems, where they can beused to improve data read/write speeds and storage capacity [13].

Chapter 2: Materials, Devices and Methods

2.1 Samples

In this research, one prepared sample were used (Cr_2O_3), in different proportions were measured and tested on theSpectrophotometer UV-VIS and (FTIR) Devices.

Table 2.1: Samples used in this work.

Sample (Cr_2O_3)	proportions
5-1	0.25
5-2	0.50
5-4	0.75

2.2 Spectrophotometer UV-VIS Device

Figure 2.1: Spectrophotometer UV-VIS Device.

UV-V is spectroscopy (SHIMADZU) was used to investigate the sample. The technique provided insights into the sample's absorbance characteristics across the UV and visible regions. Measurements were conducted to determine the wavelengths corresponding to key absorption peaks, indicating the presence of specific chromophores or electronic transitions. Proper baseline correction was applied, and solvents and cuvettes wereselected to avoid interference. This method ensured accurate detection of optical properties, aiding in the identification and characterization of the sample components.

2.2.1 *UV-Visible Spectrometer-Absorption*

Theory These electronic transitions are typically well associated with changes in the energy levels of the electrons present in an atom, ion, or molecule. This yields absorption spectra characteristic of the atoms and molecules that have taken part in the electronic transitions.

2.2.2 *Beer-Lambert*

The greater the number of molecules that absorb light of a given wavelength, the greater the 9 extent of light absorption and higher the peak intensity in absorption spectrum. If there are only a few molecules that absorb radiation, the total absorption of energy is less, and consequently lower intensity peak is observed. This makes the basis of Beer-Lambert Law which states that thefraction of incident radiation absorbed is proportional to the number of absorbing molecules in itspath [15].

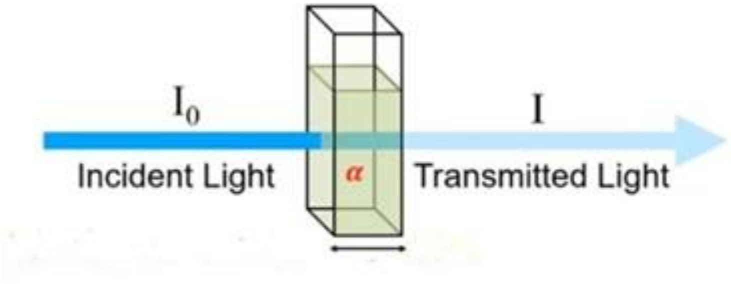

Figure 2.2: Beer-Lambert diagram.

When the radiation passes through a solution, the amount of light absorbed or transmitted is an exponential function of the molecular concentration of the solute and a function of length the of the path of radiation through the sample. Therefore,

$$\frac{I}{I_0} = e^{-\alpha l} \qquad (1)$$

Where Io is the intensity of the incident light, I is the intensity of light transmitted through the sample, l is the thickness of the sample, and α is the absorption coefficient.

$$\log_{10}\frac{I_0}{I} = \alpha l \ \log e \tag{2}$$

he ratio I / Io is known as transmittance T , and the logarithm of the inverse ratio Io / I is known as the absorbance A. Mathematically, absorbance is related to percentage transmittance T by the expression:

$$A = \log_{10}\frac{I_0}{I} = 0.4343\,\alpha l \tag{3}$$

$$\alpha = \frac{A}{l \times 0.4343} = 2.303\frac{A}{l} \tag{4}$$

2.2.3 *Optical band gap*

The calculation of the optical band gap is carried out using two methods. The first method is determined by:

$$E_g = h\nu = \frac{hc}{\lambda} = \frac{1240(eV.nm)}{\lambda\ (nm)} \tag{5}$$

Where ν is the frequency, h is Planck’s constant, and c is the speed of light

The second method is the Tauc equation. The absorption in the UV and visible regions is attributed to direct allowed transitions of electrons from the valence band to the conduction band. The value of the band gap canbe determined from the equation:

$$(\alpha h\nu)^n = \beta(h\nu - E_g) \tag{6}$$

here β is constant, n=0.5, 2, 2/3 ,and 1/3, depending on the nature of the transition for indirect allowed , directallowed, direct forbidden, and indirect forbidden transitions respectively. Plotting a graph of $(\alpha h\nu)$n versus the photon energy $h\nu$. comparing the Tauc equation with the straight- line equation by putting the y-axis equal to zero, and fitting a straight line to the linear part of the graph to give the value of the optical band gap:

$$y = mx + c$$

$$0 = \beta(h\nu - E_g)$$

$$h\nu = E_g \qquad (7)$$

2.2.4 Type of band gaps

Energy gap is direct: electronic transitions occur between the valence and conduction bands with a change in energy or momentum only, without the need for a change in momentum. Thus, a direct band gapmeans that electrons move faster in space.

Energy gap is indirect: electronic transitions between the bands involve a change in momentum, requiring the absorption or emission of photons or phonons to conserve momentum. Therefore, transitionsin this case are less efficient compared to transitions in a direct band gap [16].

2.3 Fourier-transform infrared (FTIR) Device

Figure 2.3: A Fourier-transform infrared (FTIR) Device.

In this study, Fourier Transform Infrared Spectroscopy (FTIR) equipped with an Attenuated Total Reflectance(ATR) accessory was utilized to analyze the sample. The ATR-FTIR technique allows direct measurement without extensive sample preparation, making it suitable for both solid and liquid phases. The spectra were recorded over a wavenumber range of 4000–400 cm^{-1}, with a focus on identifying characteristic peaks.

The sample was placed directly on the ATR crystal, ensuring optimal contact to enhance signal quality. For each measurement, the background spectrum was recorded to eliminate atmospheric interferences, such as water vapor and CO_2. The resolution was set to 4 cm^{-1}, and a minimum of 16 scans were averaged to ensure ahigh signal-to-noise ratio.

This method provided detailed molecular fingerprinting, capturing the vibrational modes associated with functional groups within the sample, particularly the bending and stretching vibrations relevant to the targeted compounds. After each run, the ATR crystal was cleaned thoroughly with an appropriate solvent to avoid cross-contamination between measurements.

Chapter 3: Results and Discussion

3.1 Spectrophotometer UV-VIS Device Result

Absorbance (A) is directly proportional to the concentration of the absorbed species and the path length of thesample, and is inversely proportional to the wavelength of the incident light. In general, absorbance increases as the wavelength decreases, but this can vary depending on the specific characteristics of the absorbed speciesand the medium through which the light passes.

When interpreting the UV-Vis spectrophotometry results for a Cr_2O_3 (chromium(III) oxide) sample, here arethe key aspects absorbance behavior:

- Wavelength Range:
  - 200 to 800 nm: Analysis typically covers this range, capturing both UV and visible light.
- Absorbance Peaks:
  - Near UV Region (200-400 nm): Expect some absorbance peaks due to electronic transitions ofchromium. Peaks might be observed around 250-300 nm.
  - Visible Region (400-700 nm): Significant absorbance is usually noted in the red region (around600-700 nm), correlating with the characteristic green color of Cr_2O_3. The highest absorbance will likely occur here [18].

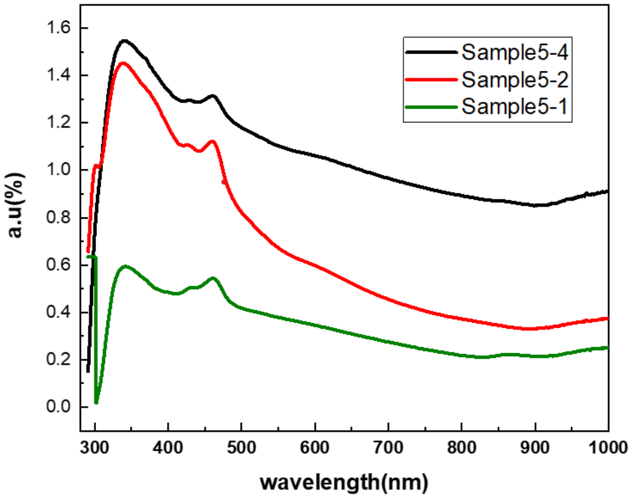

Figure 3.1: Absorbance peaks.

3.1.1 *Calculate the energy gap (Eg) from absorption spectra*

The UV Vis Spectroscopy absorption spectra mean the electrons are absorbing the energy at some specific wavelength means the electrons are going to an excited state from their ground state. The gap between the excited state (conduction band) and the ground state(valence band) is called the band gap. It can be determinedby the edge absorption wavelength where the sharp absorption starts. Mathematically, band gap was calculateddirectly by the first method:

3.1.2 *Tauc plot*

It can be determined the band energy from absorption data using Tauc equation by extrapolation of the linearregion of the plot on to the x-axis gives the band gap (edge energy):

$$(\alpha h\nu)^n = \beta(h\nu - E_g) \tag{8}$$

Absorption coefficient (α) is calculated from Beer-lamber where the thickness of the samples is around 50 mm.

$$\alpha = 2.303\frac{A}{l} = 2.303\frac{A}{5}\ (\mathrm{cm}^{-1}) \tag{9}$$

The (n) is donated to the nature of the transition of electronic transition. Plotting ($\alpha h\nu$)n versus the photonenergy $h\nu$ is a matter of testing n=0.5 or n= 2 which is indirect allowed and direct allowed transitions respectively to compare which provides the better fit and identification the correct type transition.

$$E_g = h\nu = \frac{hc}{\lambda} = \frac{1240(eV.nm)}{\lambda\ (nm)} \tag{10}$$

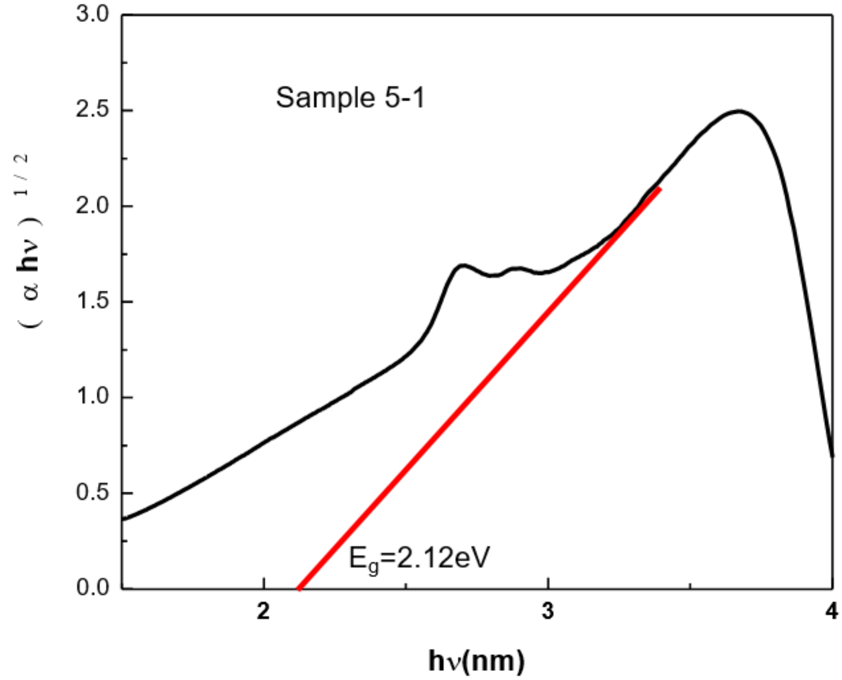

Figure 3.2: band gap calculations Sample 5-1.

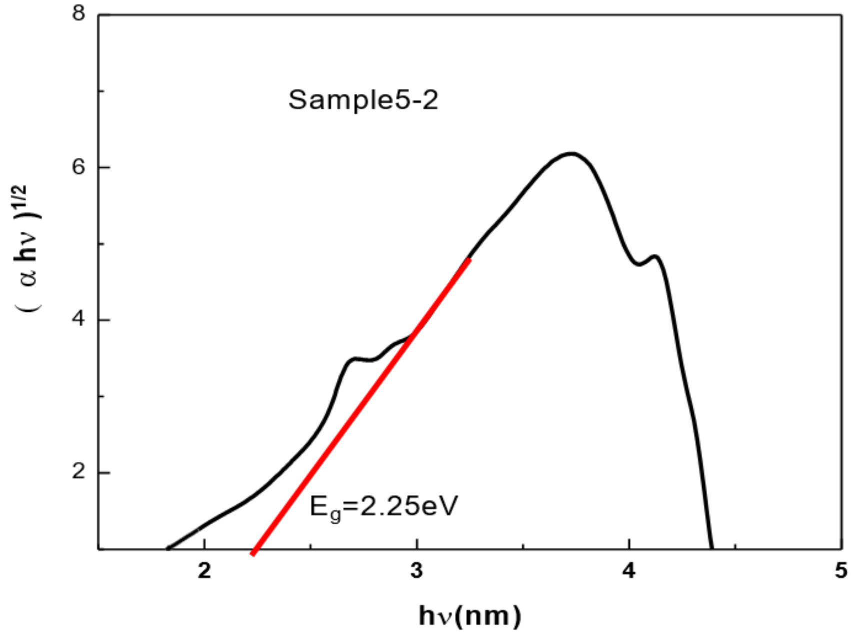

Figure 3.3: band gap calculations Sample 5-2.

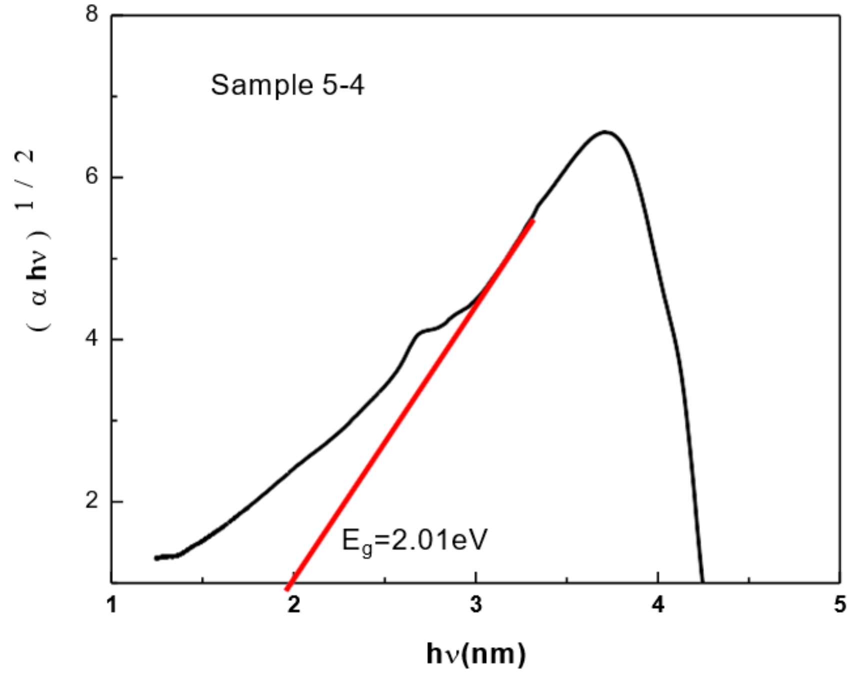

Figure 3.4: band gap calculations Sample 5-3.

3.1.3 *Calculating the indirect band gap by Tauc plot*

lists the calculated band energy for indirect band gap values of the created samples.
Upper frame shows UV–vis spectra of pure PVA film and PVA films loaded with 0.25, 0.50 and 0.75 of Cr2O3 nanoparticles. (b) Lower frame dis plays the extinction coefficient of pure and Cr2O3-doped PVA composite f ilms. potential of the investigated composites within the scope of engineering applications. Using the observed UV-vis spectra, the optical energy band gap (Eg) was determined according to the frequency de pendence of the absorption coefficient,

$$\alpha(v) = \frac{\beta(hv - E_g)^c}{hv}, \tag{11}$$

Where c is an empirical index that is equal to 2 for indirect allowed transitions in the quantum mechanical sense, respon sible for optical absorption, and b is a constant. The plot of (ah)1/2 versus h at room temperature enables us to estimate Eg by extrapolating the linear part of (ah)1/2 to zero The value of Eg for (0.25) was 2.12ev, for (0.50) was 2.25 eV and for (0.75) of Cr2O3-

doped PVA, respectively (Table 3.1). This decrease of Eg with addition of Cr2O3 to PVA may be attributed to increase the occurrence of the interaction between metal ions and the OH groups of PVA, increase the occurrence of the interaction between metal ions and the OH groups of PVA.

Table 3.1: Values for indirect bang gap of (CR_2O_3) in different proportions (0.25, 0.50 and 0.75).

Sample	**Optical band gap (Eg)**
5-1 (0.25)	**2.12 eV**
5-2 (0.50)	**2.25 eV**
5-3 (0.75)	**2.01 eV**

3.2 Fourier-transform infrared (FTIR) Result

The FTIR analysis of Cr_2O_3 provides insight into the vibrational characteristics of the material, which can be essential for understanding its chemical structure and potential applications. To analyze a Cr_2O_3 sample using Fourier-transform infrared (FTIR) spectroscopy, you'll typically look for specific absorption bands that correspond to the molecular vibrations of the material.

The range of 2800-3000 cm^{-1} typically corresponds to C-H stretching vibrations, particularly from aliphatic hydrocarbons.

Here's a brief overview of what you might encounter in that range:

- **2800-2900 cm^{-1}**: This range often shows strong absorption bands due to stretching vibrations of C-H bonds in aliphatic chains (sp^3 hybridized carbons).
- **2900-3000 cm^{-1}**: You may see peaks associated with C-H stretching from more complex molecules, including aromatic compounds. [17].

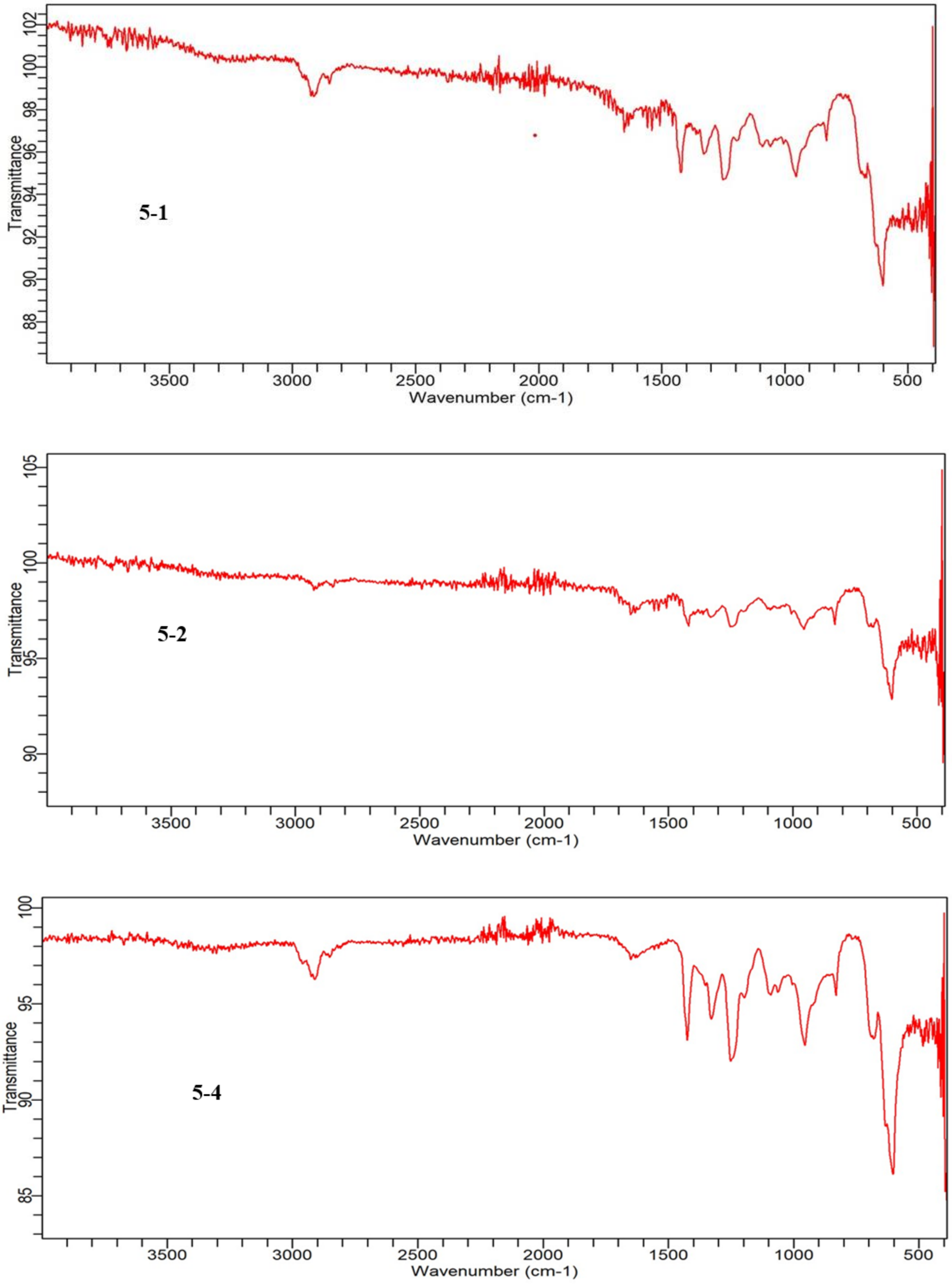

Figure 3.5: FTIR analysis of Cr_2O_3.

Chapter 4: Conclusion

In conclusion, the optical properties of chromium(III) oxide (Cr_2O_3) are characterizedby its unique interactions with light, making it a material of interest in various applications. Key aspects include:

- **Absorption Characteristics**: Cr_2O_3 exhibits strong absorption in specific wavelength ranges, particularly in the ultraviolet and visible spectra, which can be useful for sensors and photodetectors.
- **Band Gap**: The material has a moderate band gap, allowing for tunable optical properties that can be leveraged in optoelectronic devices.
- **Color Properties**: Its distinctive green color, arising from electronic transitions, is beneficial for applications in pigments and coatings.

Overall, Cr_2O_3's optical properties, combined with its stability and durability, position it as a valuable material in fields such as optics, electronics, and coatings. Future research could further explore its potential in advanced technologies

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