

Chapter one

1.1 Introduction :

Optics is the branch of physics which involves the behaviour and properties of light, including its interactions with matter and the construction of instruments that use or detect it. Optics usually describes the behavior of visible, ultraviolet, and infrared light. Because light is an electromagnetic wave, other forms of electromagnetic radiation such as X-rays, microwaves, and radio waves exhibit similar properties. [1].

Most optical phenomena can be accounted for using the classical electromagnetic description of light. Complete electromagnetic descriptions of light are, however, often difficult to apply in practice. Practical optics is usually done using simplified models. The most common of these, geometric optics, treats light as a collection of rays that travel in straight lines and bend when they pass through or reflect from surfaces. Physical optics is a more comprehensive model of light, which includes wave effects such as diffraction and interference that cannot be accounted for in geometric optics. Historically, the ray-based model of light was developed first, followed by the wave model of light. Progress in electromagnetic theory in the 19th century led to the discovery that light waves were in fact electromagnetic radiation.

Some phenomena depend on the fact that light has both wave-like and particle-like properties. Explanation of these effects requires quantum mechanics. When considering light's particle-like properties, the light is modelled as a collection of particles called "photons". Quantum optics deals with the application of quantum mechanics to optical systems.

Optical science is relevant to and studied in many related disciplines including astronomy, various engineering fields, photography, and medicine (particularly ophthalmology and optometry). Practical applications of optics are found in a variety of technologies and everyday objects, including mirrors, lenses, telescopes, microscopes, lasers, and fibre optics.

1.2 Problem :

The studies on the optical properties of potassium permanganate is not enough.

1.3 Significance :

The importance of the study of the optical properties of potassium permanganate because it has the many uses.

1.4 Methodology :

It has been compiled information on the optical properties , potassium permanganate , the preparation of the sample and using the (UV-Vis) spectrophotometry to Study the optical properties of Potassium permanganate .

1.5 Hypotheses :

Identify the optical properties of potassium permanganate .

1.6 Layout :

This research contains four chapters which are arranged as follow:
Chapter one contains the introduction, The Theoretical Background in
Chapter two with the Literature Review, In Chapter three the
experimental part and finally Chapter four contains the results and
discussion .

Chapter two

Theoretical Background

2.1 Introduction :

The aim of this chapter is to present Theoretical Background .

2.1.2 Spectroscopy :

Spectroscopy is the study of the interaction between matter and electromagnetic radiation. [2,3] Historically, spectroscopy originated through the study of visible light dispersed according to its wavelength, by a prism. Later the concept was expanded greatly to comprise any interaction with radiative energy as a function of its wavelength or frequency. Spectroscopic data is often represented by a spectrum, a plot of the response of interest as a function of wavelength or frequency.

2.1.3 Theory :

One of the central concepts in spectroscopy is a resonance and its corresponding resonant frequency. Resonances were first characterized in mechanical systems such as pendulums. Mechanical systems that vibrate or oscillate will experience large amplitude oscillations when they are driven at their resonant frequency. A plot of amplitude vs. excitation frequency will have a peak centered at the resonance frequency. This plot is one type of spectrum, with the peak often referred to as a spectral line, and most spectral lines have a similar appearance.

In quantum mechanical systems, the analogous resonance is a coupling of two quantum mechanical stationary states of one system, such as an atom, via an oscillatory source of energy such as a photon. The coupling of the two states is strongest when the energy of the source matches the energy difference between the two states. The energy (E) of a

photon is related to its frequency (ν) by $E = h\nu$ where h is Planck's constant, and so a spectrum of the system response vs. photon frequency will peak at the resonant frequency or energy. Particles such as electrons and neutrons have a comparable relationship, the de Broglie relations, between their kinetic energy and their wavelength and frequency and therefore can also excite resonant interactions.

Spectra of atoms and molecules often consist of a series of spectral lines, each one representing a resonance between two different quantum states. The explanation of these series, and the spectral patterns associated with them, were one of the experimental enigmas that drove the development and acceptance of quantum mechanics. The hydrogen spectral series in particular was first successfully explained by the Rutherford-Bohr quantum model of the hydrogen atom. In some cases spectral lines are well separated and distinguishable, but spectral lines can also overlap and appear to be a single transition if the density of energy states is high enough. Named series of lines include the principal, sharp, diffuse and fundamental series [4].

2.1.4 Ultraviolet–visible spectroscopy:

Ultraviolet–visible spectroscopy or ultraviolet-visible spectrophotometry (UV-Vis or UV/Vis) refers to absorption spectroscopy or reflectance spectroscopy in the ultraviolet-visible spectral region. This means it uses light in the visible and adjacent (near-UV and near-infrared [NIR]) ranges. The absorption or reflectance in the visible range directly affects the perceived color of the chemicals involved. In this region of the electromagnetic spectrum, molecules undergo electronic transitions. This technique is complementary to fluorescence spectroscopy, in that fluorescence deals with transitions from the excited state to the ground

state, while absorption measures transitions from the ground state to the excited state[5] .

2.1.5 Principle of ultraviolet-visible absorption :

Molecules containing π -electrons or non-bonding electrons (n-electrons) can absorb the energy in the form of ultraviolet or visible light to excite these electrons to higher anti-bonding molecular orbitals. The more easily excited the electrons (i.e. lower energy gap between the HOMO and the LUMO), the longer the wavelength of light it can absorb[5].

2.1.6 Applications :

UV/VIS spectroscopy is routinely used in analytical chemistry for the quantitative determination of different analytes, such as transition metal ions, highly conjugated organic compounds, and biological macromolecules. Spectroscopic analysis is commonly carried out in solutions but solids and gases may also be studied.

Solutions of transition metal ions can be colored (i.e., absorb visible light) because d electrons within the metal atoms can be excited from one electronic state to another. The colour of metal ion solutions is strongly affected by the presence of other species, such as certain anions or ligands. For instance, the colour of a dilute solution of copper sulfate is a very light blue; adding ammonia intensifies the colour and changes the wavelength of maximum absorption (λ_{max}).

Organic compounds, especially those with a high degree of conjugation, also absorb light in the UV or visible regions of the electromagnetic spectrum. The solvents for these determinations are often water for water-soluble compounds, or ethanol for organic-soluble compounds. (Organic solvents may have significant UV absorption; not all solvents are suitable for use in UV spectroscopy. Ethanol absorbs very weakly at most wavelengths.) Solvent polarity and pH can affect the absorption spectrum of an organic compound. Tyrosine, for example, increases in absorption maxima and molar extinction coefficient when pH increases from 6 to 13 or when solvent polarity decreases. While charge transfer complexes also give rise to colours, the colours are often too intense to be used for quantitative measurement.

The Beer-Lambert law states that the absorbance of a solution is directly proportional to the concentration of the absorbing species in the solution and the path length. Thus, for a fixed path length, UV/Vis spectroscopy can be used to determine the concentration of the absorber in a solution. It is necessary to know how quickly the absorbance changes with concentration. This can be taken from references (tables of molar extinction coefficients), or more accurately, determined from a calibration curve.[6]

2.2 Potassium permanganate :

Potassium permanganate is an inorganic chemical compound with the chemical formula KMnO_4 . It is a salt consisting of K^+ and MnO_4^- ions. Formerly known as permanganate of potash or Condy's crystals, it is a strong oxidizing agent. It dissolves in water to give intensely pink or purple solutions, the evaporation of which leaves prismatic purplish-black glistening crystals.[7] In 2000, worldwide production was estimated at 30,000 tonnes. In this compound, manganese is in the +7 oxidation state.

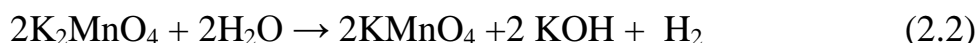
2.2.1 Preparation :

Potassium permanganate is produced industrially from manganese dioxide, which also occurs as the mineral pyrolusite. The MnO_2 is fused with potassium hydroxide and heated in air or with another source of oxygen, like potassium nitrate or potassium chlorate. This process gives potassium manganate:



(Using sodium hydroxide the end product is not sodium manganate but an Mn(V) compound which is one reason the potassium permanganate is more commonly used than sodium permanganate. Furthermore the potassium salt crystallizes better).[8].

The potassium manganate is then converted into permanganate by electrolytic oxidation in alkaline media:



2.2.2 Structure :

KMnO_4 forms orthorhombic crystals with constants: $a = 910.5 \text{ pm}$, $b = 572.0 \text{ pm}$, $c = 742.5 \text{ pm}$. The overall motif is similar to that for barium sulfate, with which it forms solid solutions. In the solid (as in solution), each MnO_4^- centres are tetrahedral. The Mn-O distances are 1.62 \AA .

2.2.3 Uses :

Almost all applications of potassium permanganate exploit its oxidizing properties. As a strong oxidant that does not generate toxic byproducts, KMnO_4 has many niche uses, Such as Water treatment , disinfection , Synthesis of organic compounds and A solution of KMnO_4 in water , Purifying water. Creating an antiseptic solution. As an anti-fungal treatment for the hands and feet.,As a cholera disinfectant ,Treating canker sores ,Marking snow as an emergency signal, And General disinfectant agent [8].

Table: (2.1) shows the Property and Value of Potassium permanganate :

Property	Value
Names	Potassium permanganate
Chemical formula	KMnO ₄
Molar mass	158.034 g/mol
Appearance	purplish-bronze-gray needles magenta–rose in solution
Odor	Odorless
Density	2.703 g/cm ³
Melting point	240 °C (464 °F; 513 K) (decomposes)
Solubility in water	63.8 g/L (20 °C) 250 g/L (65 °C)
Solubility	decomposes in alcohol and organic solvents
Refractive index (n _D)	1.59
Crystal structure	Orthorhombic
Specific heat capacity (C)	119.2 J/mol K

2.3 Optical properties :

2.3.1 Introduction :

The optical properties of materials are useful in different applications. Example.: domestic, medicine, astronomy, manufacturing .optical property of a material is defined as its interaction with electro-magnetic radiation in the visible [9].

2.3.2 Absorption :

Absorption of electromagnetic radiation is the way in which the energy of a photon is taken up by matter, typically the electrons of an atom. Thus, the electromagnetic energy is transformed into internal energy of the absorber, for example thermal energy. The reduction in intensity of a light wave propagating through a medium by absorption of a part of its photons is often called attenuation. Usually, the absorption of waves does not depend on their intensity (linear absorption), although in certain conditions (usually, in optics), the medium changes its transparency dependently on the intensity of waves going through, and saturable absorption (or nonlinear absorption) occurs.[9].

2.3.3Transmission :

Transmission of light is the moving of electromagnetic waves (whether visible light, radio waves, ultraviolet etc.) through a material. This transmission can be reduced or stopped when light is reflected off the surface, or absorbed by the molecules in the material.[10].

2.3.4 Reflection :

Reflection of light. Reflection is when light bounces off an object. If the surface is smooth and shiny, like glass, water or polished metal, the light will reflect at the same angle as it hit the surface. This is called

specular reflection.

2.3.5 Refractive index :

In optics the refractive index or index of refraction(n) of an optical medium is a dimensionless number that describes how light, or any other radiation, propagates through that medium. It is defined as

$$n = c/v \quad (2.3)$$

$$n = \frac{1 + \sqrt{R}}{1 - \sqrt{R}} \quad (2.4)$$

Where (c) is the speed of light in vacuum ,(v) is the phase velocity of light in the medium and (R) is reflection .[10].

Chapter three

Methodology

3.1 Introduction :

The aim of this chapter is to present the Materials and Methods used in this work.

3.2 Materials :

Potassium permanganate was used in powder form, dissolved in a distilled water by assistant of absorbent (10 ml), a pipette (5ml) , Volumetric flask (100ml) and a sensitive scales(model BEL-M124A) in figure 3.1. (UV–VIS) spectrophotometer (model 6505) used to characterization as shown in figures 3.2 and 3.3 below.



Fig. 3.1 Modular Balance Explorer Series .

3.3 Methods :

3.3.1 Preparation of Potassium permanganate solution :

prepare an aqueous solution of potassium permanganate dissolving (0.0079gm) than in (100ml) of distilled water and then being pulled (5ml) solution of record .

3.3.2 Characterization methods :

Initialize spectrophotometer device .

One of the cells fill with distilled water, which is called the Planck cell, At that point the absorption value equal to zero.

The cells on the other container solution (KMnO_4), was in the device and then the absorption of this solution was measure to a range of wavelengths between (270 - 800) nm .

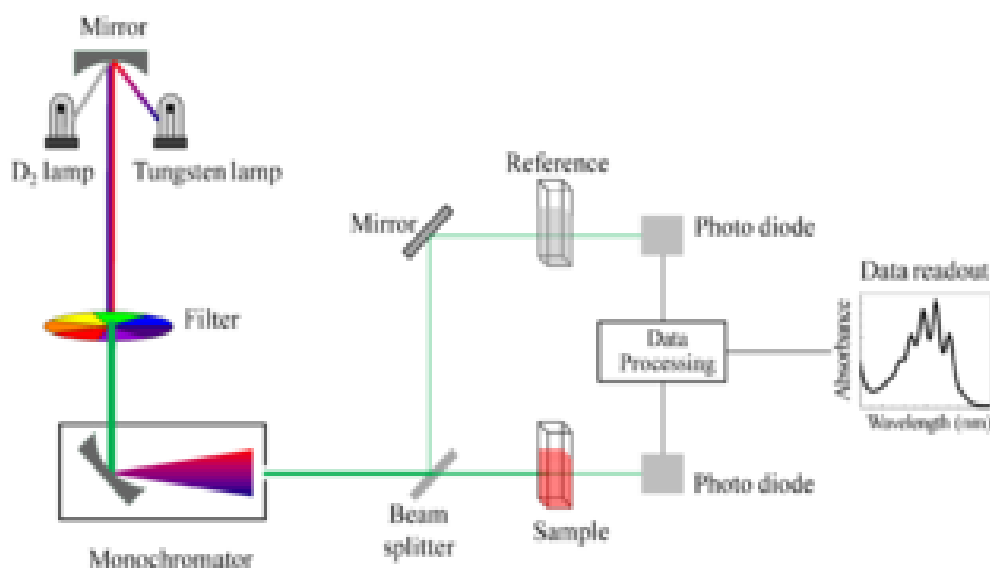


Fig.3.2 schematic diagram of UV-vis spectrophotometer .



Fig.3.3 UV-vis spectrophotometer .

Chapter four

Results and Discussion

4.1 Introduction :

The aim of this chapter is to introduce present the results of the work and to discuss them .

4.2 Results and Discussion :

4.2.1 UV-VIS spectroscopy characterizations :

The solution of the Potassium permanganate was characterized by UV-VIS spectrophotometer and the spectra of absorbance and transmittance of it recorded below in figures 4.1 and 4.2 .

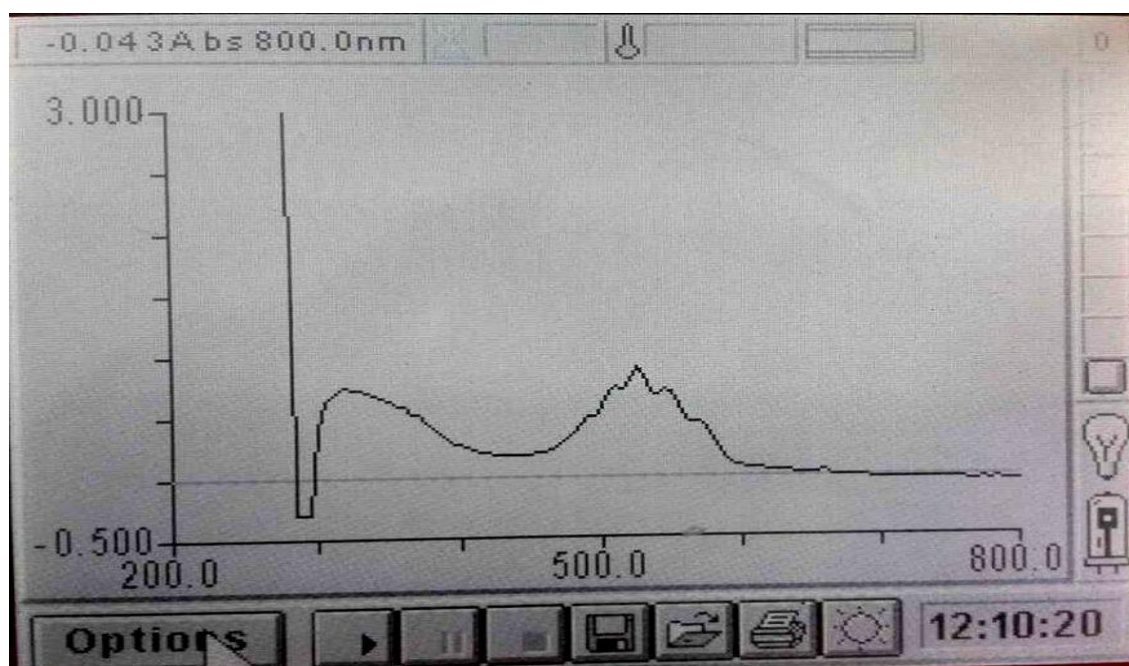


Figure 4.1 Shows the Relationship between the wavelength and absorbance .

The spectrum of absorbance shows high absorption before 300 nm and two broad peaks around 320nm and around 510 nm. This material absorbs UV radiations unless the wavelengths between 390-300 nm.

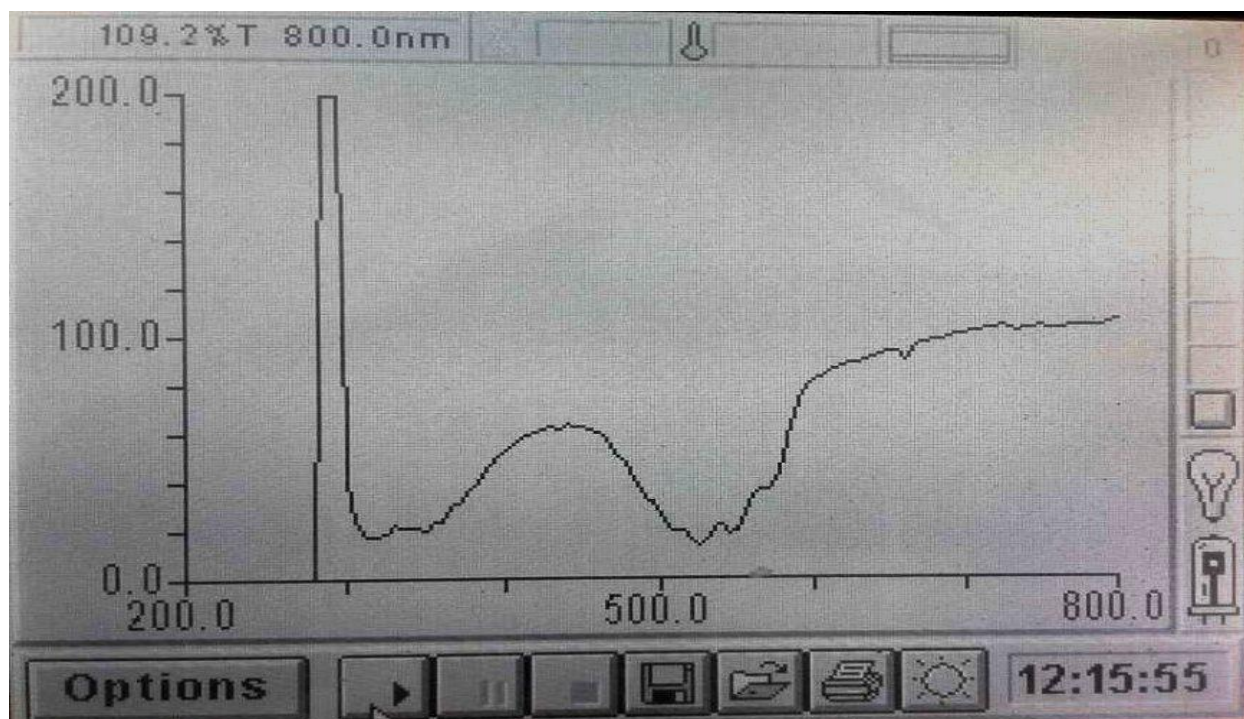


Figure 4.2 Shows the Relationship between the wavelength and transmittance.

The spectrum of transmittance shows high absorption peak before 300 nm and a broad peak from 380nm to 490 nm, wavelengths greater than 560 nm has a good transmittance.

It is obviously seen that this material has good transmittance to a certain wavelengths in the ultra violet and absorbs other ultra violet radiations. The shorter visible light wavelengths transmitted unlike longer once. Infra Red radiations transmits throw this material easily.

Table: (4.1) Shows the measurements of absorption and transmission

#	Wavelength(nm)	Absorption	Transmission
0	310	00.689	19.300
1	315	00.717	18.100
2	320	00.752	18.100
3	325	00.726	19.200
4	330	00.721	22.300
5	520	00.807	16.500
6	525	00.909	13.700
7	530	00.846	15.600
8	540	00.681	22.300
9	550	00.712	20.200

Table: (4.2) Shows the measurements of absorption and transmission and calculations of reflection and Refractive index.

#	Wavelength(nm)	Absorption	transmission	reflection	Refractive index
0	310	00.689	19.300	80.011	1.251
1	315	00.717	18.100	81.183	1.249
2	320	00.752	18.100	81.148	1.249
3	325	00.726	19.200	80.074	1.112
4	330	00.721	22.300	76.979	1.257
5	520	00.807	16.500	82.693	1.247
6	525	00.909	13.700	85.391	1.242
7	530	00.846	15.600	83.554	1.245
8	540	00.681	22.300	77.019	1.257
9	550	00.712	20.200	79.088	1.253

4.3 Conclusion :

We are now concluded that some optical properties of this material carried out from the results above ,and they found to be in conformity with the theoretical and applied results ,and on other hand,The potassium permanganate solution has demonstrated the highest absorbency (0.909) at wavelength 525 nm and the highest permeability (22.300) at wavelengths (330,540) nm. As it has been the expense of reflectiveness and refractive index and found the highest reflectivity (85.391) at the wavelength (525) nm and the highest refractive index (1.257) at the wavelength (540) nm.

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4.4 Recommendations :

Finally we recommended the following:

- * Study of electrical properties of potassium permanganate (KMnO_4).
- * Experimenting with a number of potassium permanganate (KMnO_4) because of its important applications in our daily lives.
- * Study the properties of potassium permanganate (KMnO_4) are available if required hardware.
- * Provision of materials and devices laboratory special postgraduate studies in order to facilitate the practical side.

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