Sudan University of Science and Technology

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Determination of Optical, Electrical and Thermal Properties of Gum Arabic Thin Films and its Applications in a Capacitor

تعيين الخصائص البصرية والكهربية والحرارية لأغشية الصمغ العربي وتطبيقاتها في مكثف

A thesis Submitted for Fulfillment of Requirements for Degree of Doctor of Philosophy in Physics

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Dedication

I dedicate this work to my parents Abbas and Ensaf mohammed Hamza for teaching me to assume I can do anything.

To my husband Mohammed Omer Musa for patient, support and unwavering enthusiasm.

To the joy of life my son Moder Mohammed Omer.

To brothers and sisters: Naser Alden, Montasir , Naser , Entisar and Naba I am truly thankful for having you in my life .

To all my friends

To any one support me.

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First praise be to allah for reconciling me to accomplish this work

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I sincerely hope that this research will play meaningful role to enrich this discipline of study.

Abstract

The aims of **this thesis to** determination of optical, electrical and thermal properties of Gum Arabic (Hashaba, Talha and Neem) Thin Films and Applied as Capacitor. Thin film from three types of Gum Arabic (Hashaba, Neem and Talha) were synthesized using mechanical method (four thicknesses from each type). FTIR used to determine the bond of three gum types while UV-spectrophotometer used to determine some optical properties and thermal properties were obtained through Forbas's method. From FTIR results display that all samples of Hashab and Neem have five bonds but Talha has seven bonds**.** Also reveal that the three types of gum Arabic are similar bonds of (Alkanes, Aromatic and Alkyl halides). UV-VIS results show that the maximal absorbance value equal (0.995 a.u) at wavelengths (257 and 295) nm for Hashaba, but for Neem equal (0.876 a.u) and for Talha equal (1.0029 a.u) at same wavelengths (230 and 287) nm. The value of absorbance increase by increase the thickness of each sample. The maximal value of absorption coefficient (α) for the three types of Gum Arabic (Hashaba, Neem and Talha) equal ($1.6x10^8$) at different wavelengths (258) nm for Hashaba,(229.7) nm for Neem and 230.46nm forTalha , this means that the transition must corresponding to direct electronic transition.The value of the optical energy gap (E_g) of all samples were increased from (3.925eV) to (4.049eV) due to decreased in thickness of the samples, that means these types of the gum Arabic thin film classified as isolator materials. It was found that the maximum value of refractive index (n) is (1.588) for all Gum Arabic (Hashaba, Neem and Talha) samples at wavelengths ranged (310 to 325) nm. The optical properties used to calculate the electrical properties of these types of the gum Arabic. The maximum value of real dielectric constant (ε_1) equal to (19.22) at wavelength 295 nm for the Hashaba Gum Arabic samples, but for the Neem samples equal 7.01 at 288 nm wavelength and for the Talha Gum Arabic samples equal 6.14 at the same wavelength (288 nm).The high magnitude of optical conductivity reached ($1.679x10^{15}$ sec^{-1}) at wavelengths range (303 to 315) nm. For all samples which confirms the highest photo-response of the twelve samples. The maximum value of electrical conductivity for all samples equal 24.3 $(\Omega.cm)^{-1}$ at wavelengths range (304 to 340) nm. The maximal value of thermal conductivity resaved at the maximal samples thickness (176.6 nm) for all types of gum Arabic, for hashaba equal 190W/ (m. k^o), 193.8 W/ (m. K^o) for Neem and 195.7 W/ (m. K^o) for Talha. The capacitor has been Syntheses by using FTO glass and three types of the gum Arabic, the capacitive reactance were calculated as well.

The maximum value of capacitive reactance at minimum thickness (14.40 nm) for all samples, for Hashaba equal to 0.308 Ω, for Talha was 0.317 Ω and 0.313 Ω for Neem.

المستخلص

هدفت هذه الدراسة لتعيين الخصائص الضوئية ،الكهربية والحرارية لأغشية رقيقة من الصمغ العربي (الهشاب ،النيم والطلح) وتطبيقها في مكثف. حضرت طبقات رقيقة (اغشية رقيقة) من الصمغ العربي (الهشاب، النيم ،الطلح) على شرائح زجاجية بطريقة ميكانيكية، أربعة سماكات من كل نوع. **استخدم جهاز تحويلات فورير للاشعة تحت الحمراء** لمعرفة الروابط الكيميائية لهذه الاصماغ وعرضت لجهاز مطيافية الاشعة الضوئية -الفوق بنفسجية لتحديد الخصائص الضوئية والكهربية لها. وكذلك استخدمت طريقة **فوربص** لحساب الموصلية الحرارية لهذه العينات. من نتائج جهاز تحويلات فورير اتضح أن جميع عينات الهشاب والنيم لديها خمسة روابط اهتزازية ولكن الطلح لديه سبعة روابط ، ايضاً اوضحت ان انواع الصمغ العربي الثلاث لديها ثلاث روابط متشابهة وهي (الالكان ،العطرية ، هاليد الالكيل). بينت نتائج جهاز مطيافية الاشعة الضوئية –الفوق بنفسجية ان اعلى قيمة للامتصاصية تساوي (0.995) وحدة كتل ذرية عند الاطوال الموجية (257 و295) نانوميتر للهشاب ،لكن للنيم تساوى (0.876) وحدة كتلة ذرية و (1.009) وحدة كتل ذرية للطلح عند الاطوال الموجية (230 و 287) نانومتر. اعلى قيمة لمعامل الامتصاص (α) لأنواع الصمغ العربي الثلاثة (هشاب ، نيم و طلح) تساوي$1.6x10^{8}$ سم $^{-1}$ عند اطوال موجية مختلفة ، 258 نانوميتر للهشاب ، للنيم 229.7 نانوميتر و 230.46 نانوميتر للطلح ،وهذا يعني ان اغلب الانتقالات تتطابق للانتقالات المباشرة للالكترونات .قيمة فجوة الطاقة الضوئية لجميع العينات زادت من 3.925 إلكترون فولت الي 4.049 إلكترون فولت بسبب نقصان السماكات للعينات وهذا يعني ان الأغشية الرقيقة لانواع الاصماغ الثلاث يمكن تصنيفها كمادة عازلة .وجد أن اعلى قيمة لمعامل الانكسار هي (1.588) لجميع عينات الصمغ العربي (هشاب ،نيم و طلح) عند المدى الطول الموجي من 210 نانومتر الي 225 نانوميتر. استخدمت قيم الخصائص الضوية لحساب قيم الخصائص الكهربية لهذه الانواع من الصمغ العربي .اعلي قيمة لثابت العزل الكهربي الحقيقي يساوي (19.22) عند الطول الموجي 295 نانوميتر لعينات الهشاب ولكن لعينات النيم يساوي 7.01 عند الطول الموجي 288 نانوميتر ولعينات صمغ الطلح يساوي 6.14 عند نفس الطول الموجي 288 نانوميتير .اعلى قيمة للموصلية الضوئية سجلت هي $1.679x10^{15}$ ث$^{-1}$ عند المدى من الطول الموجي من 303 نانومتر الي 315 نانوميتر مما يؤكد انها اعلى استجابة للفوتونات للاثني عشر عينة .اعلى قيمة للموصلية الكهربية لكل العينات تساوي 24.3 اوم . سم $^{-1}$ عند المدى من الطول الموجي 304 نانومتر الي 340 نانوميتر. وأعلى قيمة للموصلية الحرارية عند اكبر سمك للعينانات (176.6) نانوميتر لجميع انواع الصمغ العربي الثلاثة، للهشاب نساوي 190 وات/متر.كلفن و 193.8وات/متر.كلفن للنيم و195.7وات/متر.كلفن للطلح. صمم مكثف كهربي باستخدام زجاج **فلوريد الاينديوم المطعم باوكسيد القصدير** والصمغ العربي (الهشاب ،النيم و الطلح) وحسبت قيمة المفاعلة السعوية لهذه المكثفات. وان أعلى قيمة للمفاعلة السعوية كانت عند اقل سمك (14.40) نانومتر لجميع العينات و كانت للهشاب تساوي 0.308 اوم و 0.317 اوم للطلح بينما للنيم تساوي 0.313 اوم.

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CHAPTER ONE

Introduction

1.1 Introduction:-

Acacia gum, also known as gum arabic, occurs as neutral or slightly acidic salts of complex polysaccharides with some calcium, magnesium and potassium ions (Williams & Phillips, 2000). Play an important role in our day. It is one of the major exported goods from Sudan more than 67% of world product is from Sudan. Gum Arabic has many uses in food stuffs and an adhesive material due to its high viscosity and also used as an additive to make stable suspension mixture for medical surapies, lithography, textiles, paint, inks, and cosmetic.{Leila, 2006}.

Gum arabic is most important commercial poly- saccharides and it is probably the oldest food hydro-colloid in current use. Gum Arabic is high molecular weight polymeric compounds, composed maily of carbon core mixed in heterogeneous manner, including some materials in tonic forms as salts of macromolecules have weak conductive properties {C^{+2}, Mg^{+2}, K^{+} } {FAO, 1990}. It is the most industrially used gum as a protective colloid and emulsifier (Fang, et al, 2010). Gum Arabic is produced from many species of Acacia of African origin.

Chemically, A. Senegal gum is an Arabian galactoy protein composed of arabinose {17-34%}, galactose {32- 50%}, rhamnose {n- 16%}, glu carbonic acid {3- 50%} and protein 1,8- 16%} with an optical rotation of {28° to 32°} {Elassam, 2002}.

Nanotechnology is the ability to measure, design, and manipulate at the atomic, molecular and supramolecular levels on a scale of about 1 to 100 nm in an effort to understand, create, and use material structures, devices, and systems with fundamentally new properties and functions attributable to their small structures.

A **thin film** is a layer of material ranging from fractions of a nanometer (monolayer) to several micrometers in thickness. The controlled synthesis of materials as thin films (a process referred to as deposition) is a fundamental step in many applications. A familiar example is the household mirror, which typically has a thin metal coating on the back of a sheet of glass to form a reflective interface.

1.2 Problem Statement

The materials that used in the electronic devices are very expensive and difficult to obtain in developing countries for all this reasons, for above mentioned local materials (Gum Arabic) was used to fabricate electronic devices with low cost and high efficiency due to availability in local area.

1.3 Objectives

1.3.1 General Objectives

The aim of this work is to Determination of Optical, Electrical and Thermal Properties of Gum Arabic (Hashaba, Talha and Neem) Thin Films and Applied as Capacitor

1.3.2 Specific Objectives

- To study vibration frequencies of the bound using Fourier Transform Infrared Spectroscopy (FTIR)
- To measure absorbance , and calculated some optical properties (transmission ,reflection , absorption coefficient and extinction coefficient)
- To calculate optical constants as (optical energy band gap ,refractive index, rail dialectical constant, imaginary dialectical constant and optical conductivity
- To calculate electrical conductivity by optical method
- To calculate thermal conductivity by Forba's method.
- To fabricate electronic junction (capacitor) and study IV curve of capacitor.
- To calculate reactance capacitive of fabricated capacitor.

1.4 Research methodology

Gum Arabic solution were prepared from different sources (Hashaba, Talha and Neem) , and then to syntheses 12 samples of thin film made by mechanical method with different thickness, The prepared samples were characterized using (FTIR) to investigation bond and function group of samples and UV-VIS 1240 min spectrophotometer to study the optical and electrical properties of thin film of three types gum Arabic. Thermal properties of samples were evaluated through Forba's method, finally the samples were used to fabricate capacitor and study I-V properties of it. Then the reactance captives of the capacitors were calculated. .

1.5 Layout of research

The thesis consists of four chapters. Chapter one is the introduction, chapter two is contain the theoretical of Gum Arabic, thin film and literature review. Chapter three is methodology practical experiments. Chapter four results, discussions, conclusion and references.

CHAPTER TWO

Theoretical Background

2.1 Introduction

This chapter represents of information about the theoretical background of Gum Arabic, nanotechnology, thin films, semiconductor dives (capacitor) and literature review.

2.2 Gum Arabic

Gums in the natural form are often polysaccharides or modified polysaccharideswith high molecular weights. Usually gums have colloidal properties and may produce gels when dissolved in suitable solvents. Commonly, the term gum was applied to the polysaccharide exudates from various plants, which produce viscous mixtures when dissolved in cold or hot water (Roy Lester whistler, 1959).Three-quarters of the weight of the dry plants consists of polysaccharides, but the difficulties in separating the polysaccharides from the plant tissues causes us to look for plants which are rich in polysaccharides (H. S. Blunt 1926). Exudates gums, seaweed gums, seed gums, starch, and cellulose derivatives are all good sources of polysaccharides. Exudates gums are exuded from most plants, but generally only in small amounts, but there are special trees which we choose to produce commercial gums. Gums flow from incisions in the plant as a vermiform or tear shape to form thickened layers.

Starches and cellulose are available polysaccharides and are excellent materials to produce gum; and they can be modified to gum by chemical transformation processes. Natural polysaccharides are found in linear and branch forms, some of them include carboxyl groups. Some polysaccharides contain strong acid groups while others contain basic groups0).Gums in the natural form is often polysaccharides or modified polysaccharides with high molecular weights. Usually gums have colloidal properties and may produce gels when dissolved in suitable solvents. While others contain basic geochemically, GA is a complex mixture of macromolecules of different size and composition (mainly carbohydrates and proteins. Today, the properties and features of GA have been widely explored and developed and it is being used in a wide range of industrial sectors such as textiles, ceramics, lithography, cosmetics and pharmaceuticals, encapsulation, food, etc. Regarding food industry, it is used as a stabilizer, a thickener and/or an emulsifier agent (e.g., soft drink syrup, gummy candies and creams) (Verbeken et al., 2003).

2.2.1 GA Sources and Processing

Acacia Senegal and Acaciaseyal trees are the main sources of GA. These species grow naturally in the semi-arid sub-Saharan regions of Africa. There are over 1000 species of acacia and a summary of their botanical classification was reported by (Phillips and Williams, 1993).

Sudan has traditionally been the main GA producer and its derivatives until the early 60s with a production of 60 kTn/year. Nevertheless, such a production decreased from 60 kTn/year to 20 kTn/year in the '70s and '80s due to extensive drought and unstable government. Most of the gum produced in the Sudan comes from acacia Senegal, which it is found particularly in the district of Kordofan. The best quality of gum comes from acacia Senegal and is known as Hashab in the Sudan and also known as Kordofangurnao. These facts prompted new GA-producing countries such as Chad and Nigeria which produce mainly Acacia seyal (Abdel Nour, 1999). Europe and U.S. are the most important GA markets importing 40 kTn/year, on average, while Japan, the largest Asian consumer, imports about 2 kTn/year.

2.2.2 Chemical Composition and Structure

In recent years, several investigations have been conducted in order to reveal the molecular structure of GA and relate it to its exceptional emulsifying and rheological properties. The chemical composition of GA is complex and consists of a group of macromolecules characterized by a high proportion of carbohydrates (~ 97%), which are predominantly composed of D-galactose and L-arabinose units and a low proportion of proteins (<3%) (Islam et al., 1997). The chemical composition of GA may vary slightly depending on its origin, climate, harvest season, tree age and processing conditions, such as spray dying (Al-Assaf, et al., 2005 (a,b); Flindt et al., 2005; Hassan et al., 2005; Siddig et al., 2005). Therefore, there are some differences between the chemical compositions of the GA taken from Acacia Senegal and Acacia seyal. In fact, both gums have the same sugar residues but Acacia seyal gum has a lower content of rhamnose and glucuronic acid and a higher content of arabinose and 4-O-methyl glucuronic acid than Acacia Senegal gum. Instead, Acacia seyal gum contains a lower proportion of nitrogen, and specific rotations are also completely different. The determination of the latter parameters may clearly spot the difference between the two species (Osman et al., 1993) Gum arabic as a calcium, magnesium, and potassium salt of arabic acid, react with many reagents. A solution of gum arabic will give precipitates or heavy gels if it is treated with the following reagents: borax, ferric chloride, basic lead acetate, mercuric nitrate, gelatin, potassium silicate, sodium silicate, millions reagent. In general trivalent metallic safts will cause precipitation with gum arabic.

2.2.3 Physicochemical properties

The GA is a heterogeneous material having both hydrophilic and hydrophobic affinities. GA physicochemical responses can be handled depending on the balance of hydrophilic and hydrophobic interactions. GA functional properties are closely related to its structure, which determines, for example, solubility, viscosity, degree of interaction with water and oil in an emulsion, micro encapsulation ability, among others.

2.2.3.1 Solubility and Viscosity

GA has high water solubility and a relatively low viscosity compared with other gums. Most gums cannot dissolve in water in concentrations above 5% due to their high viscosity. Instead, GA can get dissolved in water in a concentration of 50% w/v, forming a fluid solution with acidic properties (pH~4.5). The highly branched structure of the GA molecules leads to compact relatively small hydrodynamic volume and, consequently GA will only become a viscous solution at high concentrations. Solutions containing less than 10% of GA have a low viscosity and respond to Newtonian behavior (Williams et al., 1990). However, steric interactions of the hydrated molecules increase viscosity in those solutions containing more than 30% of GA resulting in an increasingly pseudo plastic behavior. Its high stability in acidic solutions is exploited to emulsify citrus oils. The viscosity of GA solutions can be modified by the addition of acids or bases as these ones change the electrostatic charge on the macromolecule. In very acidic solutions, acid groups neutralize so inducing a more compact conformation of the polymer which leads to a decreased viscosity; while a higher pH (less compact molecule) results in maximum viscosity around pH 5.0-5.5.In very basic solutions, the ionic strength increment reduces the electrostatic repulsion between GA molecules producing a more compact conformation of the biopolymer and thus reducing the viscosity of the solution (Anderson et al., 1990; Williams et al., 1990).

2.2.3.2 Molecular Weight:

The molecular weight of gum arabic differs from sample to sample but also depends upon the method of estimation. Anderson and co workers (reported the average molecular weight to lie between 260,000 and 1,160.

2.2.3.4 Surface tension:

The surface tension of the liquid of gum Arabic was studied at different temperatures and concentrations by BANERJI (14w) here he showed the decrease of the surface tension by increasing the temperature, and a decrease of the surface tension by increasing the concentration.

2.2.4 Industrial Uses

GA is being widely used for industrial purposes such as a stabilizer, a thickener, an emulsifier and an encapsulating in the food industry, and to a lesser extent in textiles, ceramics, lithography, cosmetic, and pharmaceutical industry (Verbeken et al., 2003) microencapsulating agent.

Food Industry: A large amount of gum Arabic production is used in the food industry. It is used in the food industry because of its inherent stability; it is non-toxic, odourless, color less, tasteless, and completely water-soluble. It does not affect the flavor, odour, or color of the food Ingredients.

2.2.4.1Confectionery: Because gum Arabic has an ability to prevent the crystallization of the sugars and the thickening the aqueous media. It is used as glaze in candy products and as a component of chewing gum, cough drops, and candy lozenges. Also, gum Arabic plays a role as an emulsifier, keeping the fat uniformly distributed and preventing the floating of the fat on the surface and forming easily oxidizable, greasy film (Roy Lester whistler,1959).

2.2.4.2 Dairy products: Gum Arabic has been used as a stabilizer in frozen products, such as ice cream, ices, and sherbets, because it absorbs the water, and it prevents the growth of ice crystals. It also produces a fine texture from these products. SCHOLD'(L. A. Scholz, 1951) has patented a method using gum Arabic for the preparation of package able milk or cream. WALDER (W. 0. Walder 1949) used gum Arabic to protect the formation of colloids during the preparation of baby food.

2.2.4.3 Baking Industry: Gum Arabic is widely used in the banking industry because of its viscosity and its adhesive property. It is used in glazes and topping and it also gives smoothness when it is used as an emulsion stabilizer. Also, when it is used in a bun glaze, gum Arabic gives stability in conjunction with its free-flowing and adhesive characteristics (Ropert L.,1980).

2.2.4.4 Flavour fixative: The spray-dried technique is used to add different kinds of flavours which may be oxidized or volatile. The gum Arabic forms a thin film around the flavour particle and protects them from oxidation, evaporation and from absorption of moisture from the air (Roy Lester whistler1959).

2.2.4.5 Flavoure mulsifier. Johnstone (C. Johnstone 1939).has mixed a gum Arabic with many flavor emulsions such as orange, lemon, lime, root beer, and cola. The addition of gum Arabic to these materials gave them the required properties and provided smoothness. Citrus oil emulsions consisting of citric acid, lemon oil, glycerol, water, and coloring matter, take on the most convenient properties when mixed with gum Arabic-gum karaya mixtures.

2.2.4.6 Pharmaceuticals: In the pharmaceutical industry, GA is used in pharmaceutical preparations and as a carrier of drugs since it is considered a physiologically harmless substance. Additionally, recent studies have highlighted GA antioxidant properties (Trommer&Neubert, 2005; Ali & Al Moundhri, 2006; Hinson et al., 2004), its role in the metabolism of lipids (Tiss et al., 2001, Evans et al., 1992), its positive results when being used in treatments for several degenerative diseases such as kidney failure (Bliss et al., 1996; Matsumoto et al., 2006; Ali et al., 2008), cardiovascular (Glover et al., 2009) and gastrointestinal (Wapnir et al., 2008; Rehman et al., 2003).

2.2.4.7 Medicine: In 1920 gum Arabic was used for the treatment of low blood pressure caused by hemorrhage or surgical shock. Intravenous saline injection was not successful because the salt escaped rapidly, so the addition of 7% gum arabic solution reduced the dissipation rate of the sodium chloride. In 1933, intravenous injections of gum arabic solution were used for the treatment of nephritic edema. In plastic surgery, a 50% gum Arabic adhesive has been used successfully in grafting destroyed peripheral nerves (Roy Lester whistler,1959).

2.2.4.8 Cosmetics: In cosmetics gum arabic is found in a wide range of applications. In lotions and protective creams, it stabilizes the emulsion, increases the Viscosity, and assists in making a homogenous mixture. It forms a protective coating and it gives the skin a smooth feel. It is also used as a binder in the formulation of the compact cakes. Gum Arabic is used as a foam stabilizer in the production of liquid soap (P. 1. Smith,1996).used in hair creams and as a binder in face powder compact. In protective creams, gum Arabic can be used as a stabilizer and film-former (Roy Lester whistlerm, 1959).

2.2.4.9 Adhesives: Gum Arabic is generally used in a wide range of the adhesives industry. It is mixed with water to form an adhesive solution, and it is sold in powder to make a safe solution for miscellaneous paper products.

2.2.4.10 Inks: Gum Arabic is an important constituent of many special purpose inks. Because it has an excellent protective colloid action. Gum Arabic and lampblack mixed together to form a suitable ink stick which was used in the same process for over 3000 years (Roy Lester whistler, 1959).

2.2.4.11 Lithography: Gums are used as sensitizers for lithography plates. A solution consists of gum Arabic and dichromate and can form water-insoluble substances by the effect of the light.

2.3 Nanotechnology

The reasons why nanoscale has become so important are presented. Historical aspects of nanotechnology are introduced starting with the famous 1959 lecture by R.P. Feynman. It is suggested to name the nanometer scale the Feynman (φ nman) scale after Feynman's great contributions to nanotechnology (1 Feynman [φ] ≡10^{-9}meter =10^{-3}Micron [μ]=10 Angstroms [Å]) (J.C. Phillipsm,1970). Recent inventions and discoveries in atomic and molecular aspects of nanotechnology are presented and the ongoing related research and development activities are introduced (Whitesell and M. Fox 1997), G.A. Mansoori and J.M. Haile, 1983). The shortest and most complete definition of nanotechnology one should refer to the statement by the US National Science and Technology Council (W. Gans and J.C.A. Boeyens, 1998) which states: "The essence of nanotechnology is the ability to work at the molecular level, atom by atom, to create large structures with fundamentally new molecular organization. The aim is to exploit these properties by gaining control of structures and devices at atomic, molecular, and supra molecular levels and to learn to efficiently manufacture and use these devices". In short, nanotechnology is the ability to build micro and macro materials and products with atomic precision. The promise and essence of the nanoscale science and technology is based on the demonstrated fact that materials at the nanoscale have properties (i.e. chemical, electrical, magnetic, mechanical and optical) quite different from the bulk materials. Some of such properties are, somehow, intermediate between properties of the smallest elements (atoms and molecules) from which they can be composed of, and those of the macroscopic materials. Compared to bulk materials, it is demonstrated that nanoparticles possess enhanced performance properties when they are used in similar applications. The Greek word "nano" (meaning dwarf) refers to a reduction of size, or time, by 10^{-9}, which is one thousand times smaller than a micron. One nanometer (nm) is one billionth of a meter and it is also equivalent to ten Angstroms.

Size ranges of a few nanotechnology related objects (like nanotube, single-electron transistor and quantum dot diameters) are also shown in this figure. It is obvious that nanoscience, nanoengineering and nanotechnology, all deal with very small sized objects and systems.

Nanoscale is a magical point on the dimensional scale: Structures in nanoscale (called nanostructures) are considered at the borderline of the smallest of human-made devices and the largest molecules of living systems. Our ability to control and manipulate nanostructures will make it possible to exploit new physical, biological and chemical properties of systems that are intermediate in size, between single atoms, molecules and bulk materials. There are many specific reasons why nanoscale has become so important some of which are as the following (P.L. Huyskens, et all, 1991):

(i) The quantum mechanical (wavelike) properties of electrons inside matter are influenced by variations on the nanoscale. By nanoscale design of materials it is possible to vary their micro and macroscopic properties, such as charge capacity, magnetization and melting temperature, without changing their chemical composition.

(ii) A key feature of biological entities is the systematic organization of matter on the nanoscale. Developments in nanoscience and nanotechnology would allow us to place man-made nanoscale things inside living cells. It would also make it possible to make new materials using the self assembly features of nature. This certainly will be a powerful combination of biology with materials science.

(iii) Nanoscale components have very high surface to volume ratio, making them ideal for use in composite materials, reacting systems, drug delivery, and chemical energy storage (such as hydrogen and natural gas).

(iv) Macroscopic systems made up of nanostructures can have much higher density than those made up of microstructures. They can also be better conductors of electricity. This can result in new electronic device concepts, smaller and faster circuits, more sophisticated functions, and greatly reduced power consumption simultaneously by controlling nanostructure interactions and complexity.

2.4 Thin film

A **thin film** is a layer of material ranging from fractions of a nanometer (monolayer) to several micrometers in thickness. The controlled synthesis of materials as thin films (a process referred to as deposition) is a fundamental step in many applications. Advances in thin film deposition techniques during the 20th century have enabled a wide range of technological breakthroughs in areas such as magnetic recording media, electronic semiconductor devices, Integrated passive devices, LEDs, optical coatings (such as antireflective coatings), hard coatings on cutting tools, and for both energy generation (e.g. thin-film solar cells) and storage (thin-film batteries). It is also being applied to pharmaceuticals, via thin-film drug delivery. A stack of thin films is called a multilayer. In addition to their applied interest; thin films play an important role in the development and study of materials with new and unique properties.

2.4.1 Deposition techniques

Fall into two broad categories, depending on whether the process is primarily chemical or physical (Knoll,et al,(2011). Plating relies on liquid precursors, often a solution of water with a salt of the metal to be deposited. Some plating processes are driven entirely by reagents in the solution (usually for noble metals), but by far the most commercially important process is electroplating. In semiconductor manufacturing, an advanced form of electroplating known as electrochemical deposition is now used to create the copper conductive wires in advanced chips, replacing the chemical and physical deposition processes used to previous chip generations for aluminum wires(IBM.2017,2021).The Langmuir–Blodgett method uses molecules floating on top of an aqueous sub phase. The packing density of molecules is controlled, and the packed monolayer is transferred on a solid substrate by controlled withdrawal of the solid substrate from the sub phase (Arica, (2013).

2.4.1.1 Chemical deposition

Chemical solution deposition (CSD) or chemical bath deposition (CBD) uses a liquid precursor, usually a solution of organ metallic powders dissolved in an organic solvent. This technique is also known as the **sol-gel** method (Hanaor, (2011).Spin coating or spin casting, uses a liquid precursor, or sol-gel precursor deposited on to a smooth, flat substrate which is subsequently spun at a high velocity to centrifugally spread the solution over the substrate. Dip is similar to spin coating in that a liquid precursor or sol-gel precursor is deposited on a substrate, but in this case the substrate is completely submerged in the solution and then withdrawn under controlled conditions. Solution over the substrate (Faustini,et all ,2014).Chemical vapor deposition (CVD) generally uses a gas-phase precursor, often a halide or hydride of the element to be deposited.

In the case of MOCVD, an organ metallic gas is used. Commercial techniques often use very low pressures of precursor gas. Plasma enhanced CVD (PECVD) uses an ionized vapor, or plasma, as a precursor. Unlike the soot example above, commercial PECVD relies on electromagnetic means (electric current, microwave excitation), rather than a chemical-reaction, to produce a plasma. (ALD), and its sister technique molecular layer deposition (MLD), uses gaseous precursor to deposit conformal thin films one layer at a time.

2.4.1.2 Physical deposition

Physical deposition uses mechanical, electromechanical or thermodynamic means to produce a thin film of solid. The material to be deposited is placed in an energetic, entropic environment, so that particles of material escape its surface. Facing this source is a cooler surface which draws energy from these particles as they arrive, allowing them to form a solid layer (Trontl, V. Mikšić, 2005).

2.4.2 Thin Films Types

Types of thin films can be categorized as follows:

- Optical thin films: Used to create reflective coatings, anti-reflective coatings, solar cells, monitors, waveguides and optical detector arrays
- Electrical or electronic thin films: Used to make insulators, conductors, semiconductor devices, integrated circuits and piezoelectric drives
- Magnetic thin films: Usually used to make memory disks

- Chemical thin films: They are used to create resistance to alloying, diffusion, corrosion and oxidation, as well as to make gas and liquid sensors
- Mechanical thin films: Tribological coatings to protect against abrasion, increase hardness and adhesion and use of micro-mechanical properties
- Thermal thin films: They are used to create insulation layers and heat sink

2.5 Electromagnetic Radiation

Electromagnetic radiation consists of oscillating electric and magnetic fields that propagate through space along a linear path and with a constant velocity. Is a form of energy whose behaviors described by the properties of both waves and particles. Some properties of electromagnetic radiation, such as its refraction when it passes from one medium to another. Are explained best by describing light as a wave (Home, et al, (1991). Other properties, such as absorption and emission, are better described by treating light as a particle an electromagnetic wave is characterized by several fundamental properties, including its velocity, amplitude, frequency, phase angle, polarization. Where A is the magnetic field’s maximum amplitude. Other properties also are useful for characterizing the wave behavior of electromagnetic radiation. The wavelength, λ, is defined as the distance between successive maxima (Ball, D. W.1991).

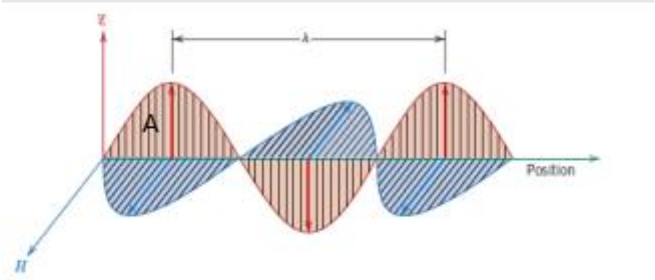

Figure (2.1) an electromagnetic wave showing electric field E and magnetic field H components, and the wavelength λ.

2.5.1 Particle Properties of Electromagnetic Radiation

When matter absorbs electromagnetic radiation it under goes a change in energy. The interaction between matter and electromagnetic radiation is easiest to understand if we assume that radiation consists of a beam of energetic particles called photons. When a photon is absorbed by a sample it is destroyed, and its energy acquired by the sample (Ball, D. W. **1994**). The energy of a photon, in joules, is related to its frequency (v), wavelength, and wave number by the following equation.

$$E = hv = \frac{hc}{\lambda} = hc\breve{v} \qquad (2.1)$$

Where h is Planck's constant, which has a value of 6.626 × 10^{-34}J.s. (Fox, M. 2001)

2.5.2 The Electromagnetic Spectrum

The electromagnetic spectrum—based on the type of atomic or molecular transition that gives rise to the absorption or emission of photons. The boundaries between the regions of the electromagnetic spectrum are not rigid, and overlap between spectral regions is possible. Spectroscopy is the study of the interaction between matter and electromagnetic radiation (Hecht, J., 2008).

2.5.3 Light Interactions with Solids

When light proceeds from one medium into another (e.g., from air into a solid substance), several things happen. Some of the light radiation may be transmitted through the medium, some will be absorbed, and some will be reflected at the interface between the two media. The intensity I_0 of the beam incident to the surface of the solid medium must equal the sum of the intensities of the transmitted, absorbed, and reflected beams, denoted as I_T, I_A, and I_R, respectively, $I_0=I_T+I_A+I_R$

Radiation intensity, expressed in watts per square meter, corresponds to the energy being transmitted per unit of time across a unit area that is perpendicular to the direction of propagation (Gupta, M.C., and J. Ballato, 2007).

Nature of the interactions

- Absorption occurs when energy from the radiative source is absorbed by the material.
- Emission indicates that radiative energy is released by the material.

- Elastic scattering and reflection spectroscopy determine how incident radiation is reflected or scattered by a material
- Impedance spectroscopy studies the ability of a medium to impede or slow the transmittance of energy

2.5.4 Sources of Energy

All forms of spectroscopy require a source of energy. In absorption and scattering spectroscopy this energy is supplied by photons. Emission and photoluminescence spectroscopy use thermal, radiant (photon), or chemical energy to promote the analytic to a suitable excited state (Jiang, S.; Parker., **1981)**.

Colorimeter: In which a sample absorbs visible light, is one example of a spectroscopic method of analysis. At the end of the nineteenth century, spectroscopy was limited to the absorption, emission, and scattering of visible, ultraviolet, and infrared electromagnetic radiation. Since its introduction, spectroscopy has expanded to include other forms of electromagnetic radiation, such as X-rays, microwaves, and radio waves—and other energetic particles, such as electrons and ions.

Absorbance Spectra: There are two general requirements for an analytic's absorption of electromagnetic radiation. First, there must be a mechanism by which the radiations electric field or magnetic field interacts with the analyze. For ultra- violet and visible radiation, absorption of a photon changes the energy of the analyses valence electrons. A bonds vibrational energy is altered by the absorption of infrared radiation. The second requirement is that the photon's energy, must exactly equal the difference in energy (ΔE) between two of the analytes quantized energy states, much of the radiation passes through the sample without a loss in intensity. At selected wavelengths, however, the radiation's intensity is attenuated; this process of attenuation is called absorption.

2.6 Spectroscopy

In principle, a spectrometer is the simplest of scientific instruments. The term spectroscope derives from two root words: the Latin word spectrum, meaning image, and the Greek word skopein, to view, (e.g., microscope, telescope, etc.). So a spectroscope is an instrument that permits visual observation of spectra. Instruments that record a spectral image on a photographic plate (the spectroscope plus the tube plate holder) are commonly called spectrographs. A spectroscope can thus "fingerprint" a material by disclosing what elements the material contains and in what proportions. In certain cases it is not even necessary to touch the object being studied. Almost anything that emits, absorbs, or reflects light Not only can elements be identified (the method is called spectrochemical or elemental analysis), but information can also be obtained on the constituents of the elements — the electrons and atomic nuclei—as well as the atoms and molecules themselves. This aspect is sometimes referred to as atomic or molecular spectroscopy. Spectroscopy has been the means whereby physicists and chemists have learned most of what they now know about the nature of matter. It was originally limited to visible light, but new ways of generating and detecting other kinds of energy are constantly being developed.These are quickly (LLANDÓ, L. & ZUCKER. R. S,1989)

. There are many types of spectroscopy and they are used to detect, identify and quantify data about material samples as gases, liquids and solids. As such, spectroscopy is used to determine both the chemical composition as well as measure the physical properties of matt etc. UV-Vis spectroscopy is an analytical technique that measures the amount of discrete wavelengths of UV or visible light that are absorbed by or transmitted through a sample in comparison to a reference or blank sample. This property is influenced by the sample composition, potentially providing information on what is in the sample and at what concentration. Since this spectroscopy technique relies on the use of light, let's first consider the properties of light. Light has a certain amount of energy which is inversely proportional to its wavelength. Thus, shorter wavelengths of light carry more energy and longer wavelengths carry less energy. A specific amount of energy is needed to promote electrons in a substance to a higher energy state which we can detect as absorption. Electrons in different bonding environments in a substance require a different specific amount of energy to promote the electrons to a higher energy state. This is why the absorption of light occurs for different wavelengths in different substances. Humans are able to see a spectrum of visible light, from approximately 380 nm, which we see as violet, to 780 nm, which we see as red. UV light has wavelengths shorter than that of visible light to approximately 100 nm. Therefore, light can be described by its wavelength, which can be useful in UV-Vis spectroscopy to analyze or identify different substances by locating the specific wavelengths corresponding to maximum absorbance (KHODAKHAH, K. & OGDEN, D 1993).

2.7 UV/VIS SPECTRA FOR ATOMS

The energy of ultraviolet and visible electromagnetic radiation is sufficient to cause a change in an atom's valence electron configuration. Absorption of a photon is accompanied by the excitation of an electron from a lower-energy atomic orbital to an orbital of higher energy. Not all possible transitions between atomic orbital's are allowed.

2.8 Infrared Spectra for Molecules and Polyatomic Ions

The energy of infrared radiation produces a change in a molecules or apolyatomic ion's vibrational energy, but is not sufficient to affect a change in its electronic energy.

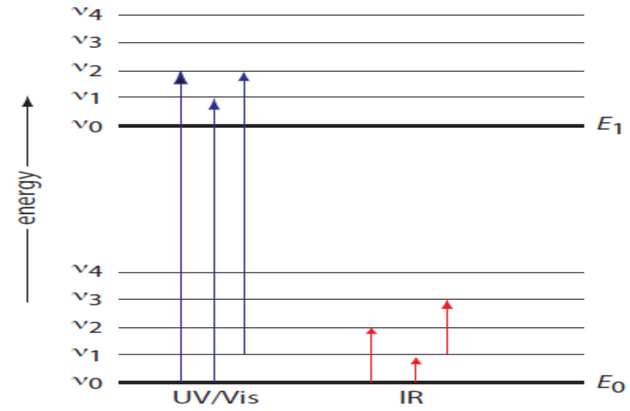

Figure (2.2) Diagram showing two electronic energy levels (E_0 and E_1), each with five vibrational energy levels (ν_0–ν_4).Absorption of ultraviolet and visible, infrared radiation

2.9 Fourier transforms spectrometer

In a Fourier transform infrared spectrometer, or FT–IR, the monochromator is replaced with an interferometer. Because an FT-IR includes only a single optical path, it is necessary to collect a separate spectrum to compensate for the absorbance of atmospheric CO_2 and H_2O vapor. This is done by collecting background spectrum without the sample and storing the result in the instrument's computer memory. The background spectrum is removed from the sample's spectrum by rationing the two signals. In comparison to other instrument designs, an FT–IR provides for rapid data acquisition, allowing an enhancement in signal-to-noise ratio through signal-averaging (Seitz, W. R.. **1984**, Angel, S. M., **1987).**

2.10 Optical Properties

Optical property refers to a material's response to exposure to electromagnetic radiation and in particular, to visible light (Rogers, A, (2008).Saleh, B. E. A., and M. C. Teich, 2007).

2.10.1 Transmittance and Absorbance

As light passes through a sample, its power decreases as some of it is absorbed. This attenuation of radiation is described quantitatively by two separate, but related terms: transmittance and absorbance. **Transmittance** is the ratio of the source radiations power exiting the sample (P_T) to that incident on the sample (P_0) (Svelto, O., 1998).

$$T = \frac{P_T}{P_0} \tag{2.2}$$

An alternative method for expressing the attenuation of electromagnetic radiation is absorbance (A) which we define as:

$$A = -\text{IogT} = -\text{Iog}\frac{P_T}{P_0} \tag{2.3}$$

Absorbance is the more common unit for expressing the attenuation of radiation because it is a linear function of the analyses' concentration.

2.10.2 Absorbance and Concentration: Beer's Law

When monochromatic electromagnetic radiation passes through an infinitesimally thin layer of sample of thickness dx, it experiences a decrease in its power of dP (Strong, F. C. (**2000**); Gilbert, **1991).**

The fractional decrease in power is proportion to the sample's thickness and the analyte's concentration(C) thus

$$-\frac{dp}{p} = \alpha c dx \tag{2.4}$$

Where P is the power incident on the thin layer of sample, and α is proportionality constant. Integrating the left side of equation (2-3) over the entire sample

$$-\int_{P_0}^{P_T} \frac{dp}{p} = \alpha c \int_0^b dx \tag{2.5}$$

$$\ln \frac{P_T}{P_0} = \alpha bc \tag{2.6}$$

Converting from ln to log, and substituting in equation (2.6), gives

$$A = \alpha bc \tag{2.7}$$

Where a is the analytic's absorptivity with units of $cm^{-1}conc^{-1}$. If we express the concentration using molarity, then we replace a with the molar absorptivity, ε, which has units of cm^{-1} M^{-1}.

$$A = \varepsilon \tag{2.8}$$

The absorptivity and molar absorptivity are proportional to the probability that the analytic absorbs a photon of a given energy. As a result, values for both a and ε depend on the wavelength of the absorbed photon (Gupta,M.C., J. Ballato, 2007. Hecht, J. 2008).

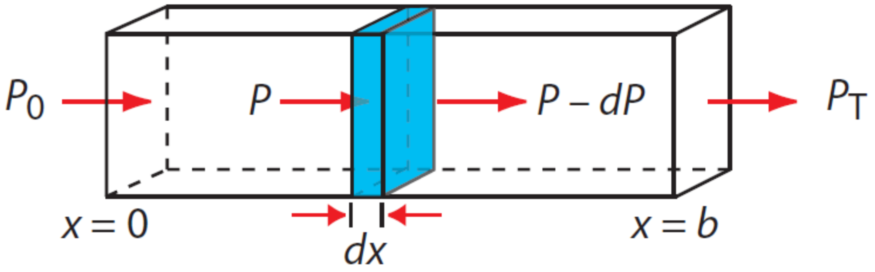

Figure (2.3) Factors used in deriving the Beer-Lambert law.

2.10.3 Refraction

Light that is transmitted into the interior of transparent materials experiences a decrease in velocity, and, as a result, is bent at the interface; this phenomenon is termed **refraction.** The **index of refraction** n of a material is defined as the ratio of the velocity in a vacuum c to the velocity in the medium v.

$$n = \frac{c}{v} \tag{2.9}$$

The magnitude of n (or the degree of bending) will depend on the wavelength of the light reflection when light radiation passes from one medium into another having a different index of refraction, some of the light is scattered at the interface between the two media even if both are transparent. The reflectivity R represents the fraction of the incident light that is reflected at the interface, or

$$R = \frac{I_R}{I_0} \qquad (2.10)$$

Where I_0 and I_R are the intensities of the incident and reflected beams, respectively. If the light is normal (or perpendicular) to the interface, then

$$R = \left(\frac{n_s - n_1}{n_s + n_2}\right)^2 \qquad (2.11)$$

Where n_1 and n_2 are the indexes of refraction of the two media. If the incident light is not normal to the interface, R will depend on the angle of incidence. When light is transmitted from a vacuum or air into a solid s, then

$$R = \left(\frac{n_s - 1}{n_s + 1}\right)^2 \qquad (2.12)$$

Because the index of refraction of air is very nearly unity. Thus, the higher the index of refraction of the solid, the greater the reflectivity. For typical silicate glasses, the reflectivity is approximately 0.05. Just as the index of refraction of a solid depends on the wavelength of the incident light, so also does the reflectivity vary with wavelength reflection losses for lenses and other optical instruments are minimized significantly by coating the reflecting surface with very thin layers of dielectric materials (Rogers, A, (2008). Saleh, B. E. A., and M. C. Teich, 2007).

Reflection calculated from blown relation in this study :

$$R = (1 - T - A) \qquad (2.13)$$

Where:

A≡ the Absorption

T≡ the Transmittance

The refractive index (n) calculated from [Zohal, 2019]

$$n = \left[\left(\left(\frac{1+R}{1-R}\right)^2 - (1 + k^2)\right)^{\frac{1}{2}} + \left(\frac{1+R}{1-R}\right)\right] \qquad (2.14)$$

Where (R) is reflectivity and (k) is Extinction coefficient

2.10.4 Extinction Coefficient

The extinction coefficient is the absorbance divided by the concentration and the path length, according to Beer's Law (epsilon = absorbance/concentration/path length). The units of extinction coefficients are usually $M^{-1}cm^{-1}$, but for proteins it is often more convenient to use $(mg/ml)^{-1}cm^{-1}$ also it's a measure of the rate of diminution of transmitted light via scattering and absorption for a medium. The extinction coefficient describes the loss of wave energy to the material. It is related to the absorption coefficient as: Light loses intensity in an absorbing material according to Beer's Law: Thus, the extinction coefficient relates how quickly light vanishes in a material.

Extinction coefficient (K) [Waleed,2018]

$$k = \frac{\alpha\lambda}{4\pi} \qquad (2.15)$$

Where:

α ≡ the Absorption coefficient

λ ≡ wavelength

2.10.5 Absorption coefficient

The absorption coefficient describes the intensity attenuation of the light passing through a material. It can be understood as the sum of the absorption cross-sections per unit volume of a material for an optical process, the absorption coefficient Calculate by using this formula:

$$\alpha = \frac{2.303\times A}{\tau} \qquad (2.16)$$

Where τ is thickness of layer, A is absorption and α is the absorption coefficient

2.11 Energy Band Structures in Solids

In all conductors, semiconductors, and many insulating materials, only electronic conduction exists, and the magnitude of the electrical conductivity is strongly dependent on the number of electrons available to participate in the conduction process. However, not all electrons in every atom will accelerate in the presence of an electric field.

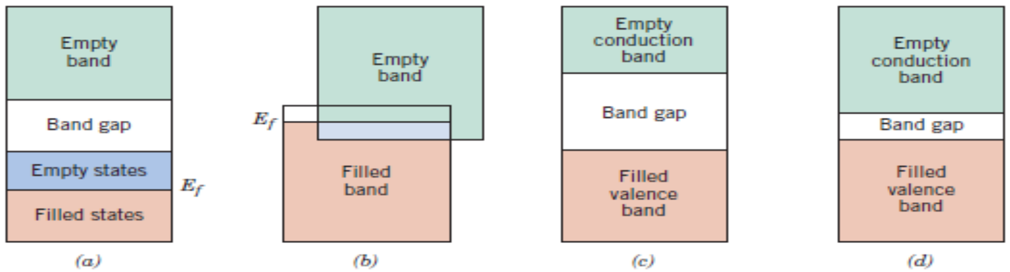

Figure (2.4) the various possible electron band structures in solids at 0 K.

Energy Band Structures in Solids Conduction in Terms of Band and Atomic Bonding Models. The number of free electrons depends on the electron energy band structure of the material. An electron band is just a series of electron states that are closely spaced with respect to energy, and one such band may exist for each electron subshell found in the isolated atom. Electron energy band structure refers to the manner in which the outer most bands are arranged relative to one another and then filled with electrons. There are four different types of band structures are possible at 0 K. In the first (Figure 2.4 a), one outermost band is only partially filled with electrons. The energy corresponding to the highest filled state at 0 K is called the **Fermi energy** E_f, as indicated. This energy band structure is typified by some metals, in particular those that have a singles valence electron. For metals, two band structure types are possible (Figure 2.4 a and 2.4 b) empty electron states are adjacent to filled ones. Band structures for semiconductors and insulators are similar—both have a forbidden energy band gap that, at 0 K, lies between a filled valence band and an empty conduction band. The magnitude of this band gap is relatively wide (>2 eV) for insulators (Figure 2.4 c), and relatively narrow (<2 eV) for semiconductors (Figure 2.4 d).

An electron becomes free by being excited from a filled state to an available empty state at a higher energy. Relatively small energies are required for electron excitations in metals, giving rise to large numbers of free electrons. Greater energies are required for electron excitations in semiconductors and insulators, which accounts for their lower free electron concentrations and smaller conductivity values. (Z. D. Jastrzebski, 1987).

Energy band can be calculated from

energy gap (Eg) [Greene LE, 2005]

relation

$$(\alpha h\upsilon)^2 = C(h\upsilon - Eg) \qquad (2.17)$$

Where:

$\alpha \equiv$ the Absorption coefficient

$h \equiv$ blank constant $=(6.625 \times 10^{-34} \mathrm{J.s})$

$\upsilon \equiv$ frequuence =60Hz

$C \equiv$ speed of light $=3 \times 10^8$ m/s

2.12 Electrical Properties

Consideration of the electrical properties of materials is often important when materials selection and processing decisions are being made during the design of a component or structure. We discussion the phenomenon of electrical conduction: the parameters by which it is expressed, the mechanism of conduction by electrons, and how the electron energy band structure of a material Influences its ability to conduct.

Ohm's Law

Ohm's law relates the current I, or time rate of charge passage to the applied voltage V as follows:

$$V = IR \qquad (2.18)$$

Where R is the resistance of the material through which the current is passing. The units for V, I, and R are, respectively, volts, amperes, and ohms. The electrical resistivity (ρ)is independent of specimen geometry but related to R through the expression

$$\rho = \frac{RA}{l} \qquad (2.19)$$

Where l is the distance between the two points at which the voltage is measured and A is the cross-sectional area perpendicular to the direction of the current. The units for ρare ohm-meters (Ω m).

2.12.1 Electrical Conductivity

Electrical conductivity σis used to specify the electrical character of a material. It is simply the reciprocal of the resistivity.

$$\sigma = \frac{1}{\rho} \qquad (2.20)$$

Solid materials exhibit an amazing range of electrical conductivities, extending over 27 orders of magnitude; probably no other physical property experiences this breadth of variation. In fact, one way of classifying solid materials is according to the ease with which they conduct an electric current; within this classification scheme there are three groupings: conductors, semiconductors, and insulators. **Metals** are good conductors, typically having conductivities on the order of 10^7(Ω .m) at the other extreme are materials with very low conductivities,

ranging between 10^{-10} and 10^{-20} (Ω.m); these are electrical **insulators.** Materials with intermediate conductivities, generally from 10^{-6} to 10^4(Ω.m), are termed **semiconductors.**

2.12.2 Electrical Properties of Polymers

Most polymeric materials are poor conductors of electricity becauseof the unavailability of large numbers of free electrons to participate in the conduction process. The mechanism of electrical conduction in these materials is not well understood, but it is felt that conduction in polymers of high purity is electronic.

2.12.2.1 Conducting Polymers

Polymeric materials have been synthesized that have electrical conductivities on par with metallic conductors; they are appropriately termed conducting polymers. Conductivities as high as 1.5 x 10^7(Ω m)$^{-1}$ have been achieved in these materials; on a volume basis, this value corresponds to one-fourth of the conductivity of copper, or twice its conductivity on the basis of weight.

This phenomenon is observed in a dozen or so polymers, including polyacetylene, polyparaphenylene, polypyrrole, and polyaniline. Each of these polymers contains a system of alternating single and double bonds and/or aromatic units in the polymer chain

A **dielectric** material is one that is electrically insulating (nonmetallic) and exhibitor may be made to exhibit an **electric dipole** structure, there is a separation of positive and negative electrically charged entities on a molecular or atomic level. This concept of an electric dipole. As a result of dipole interactions with electric fields, dielectric materials are used in capacitors.

Real dielectric constant (ε_1) [Emtithal,2019]

$$\varepsilon_1 = n^2 - k^2 \qquad (2.21)$$

Imaginary dielectric constant (ε_2) calculated from the relation [Emtithal, 2019]

$$\varepsilon_2 = 2nK \qquad (2.22)$$

2.13 Optical Conductivity

The optical conductivity is the property of a material which gives the relationship between the induced current density in the material and the magnitude of the inducing electric field for arbitrary frequencies (J. Robert Schrieffer; J.S. Brooks 2007). This linear response function is a generalization of the electrical conductivity, which is usually considered in the static limit, i.e., for time-independent or slowly varying electric fields. While the static electrical conductivity is vanishingly small in insulators (such as diamond or porcelain), the optical conductivity always remains finite in some frequency intervals (above the **optical gap** in the case of insulators). The total **optical weight** can be inferred from sum rules. The optical conductivity is closely related to the dielectric function, the generalization of the dielectric constant to arbitrary frequencies. The optical conductivity is most often measured in optical frequency ranges via the reflectivity of polished samples under normal incidence (in combination with a Kramers–Kronig analysis) or using variable incidence angles (Hari Singh Nalwa, ed. 2000). For samples that can be prepared in thin slices, higher precision is obtainable using optical transmission experiments

The relation of optical conductivity δ_{opt} andThe electrical conductivity δ_{ele} can be estimated using the following relation [T. Brouri, 2011 and F. A.1995]

$$\delta_{opt} = \frac{\alpha n c}{4\pi} \tag{2.23}$$

$$\delta_{ele} = \frac{2\lambda\delta_{opt}}{\alpha} \tag{2.24}$$

Where (c) is light velocity

2.14 Thermal properties

Thermal property refers to the response of a material to the application of heat. As a solid absorbs energy in the form of heat, its temperature rises and its dimensions increase. The energy may be transported to cooler regions of the specimen if temperature gradients exist, and ultimately, the specimen may melt. Heat capacity, thermal expansion, and thermal conductivity are properties that are often critical in the practical utilization of solids.

2.14.1 Heat capacity

A solid material, when heated, experiences an increase in temperature signifying that some energy has been absorbed. **Heat capacity** is a property that is indicative of a material's ability to absorb heat from the external surroundings; it represents the amount of energy required to produce a unit temperature rise. In mathematical terms, the heat capacity C is expressed as follows:

$$C = \frac{dQ}{dT} \tag{2.25}$$

Where dQ is the energy required to produce a dT temperature change. Ordinarily, heat capacity is specified per mole of material (e.g., J/mol K, or cal/mol K). **Specific heat** (often denoted by a lowercase c) is sometimes used; this represents the heat capacity per unit mass and has various units (J/kg_K, cal/g.K)

2.14.2 Thermal conductivity

Thermal conduction is the phenomenon by which heat is transported from high- to low-temperature regions of a substance. The property that characterizes the ability of a material to transfer heat is the **thermal conductivity.** It is best defined in terms of the expression

$$q = -k\frac{dT}{dx} \tag{2.26}$$

Where q denotes the heat flux, or heat flow, per unit time per unit area (area being taken as that perpendicular to the flow direction), k is the thermal conductivity, and dT/dx is the temperature gradient through the conducting medium. The units of q and k are W/m K.

2.15 Capacitor

A **capacitor** is a device that stores electrical energy in an electric field. It is a passive electronic with two terminals. The effect of a capacitor is known as capacitance. While some capacitance exists between any two electrical conductors in proximity in a circuit, a capacitor is a component designed to add capacitance to a circuit. The capacitor was originally known as a **condenser** or **condensator** (Duff, Wilmer (1999)).The physical form and construction of practical capacitors vary widely and many types of capacitor are in common use. Most capacitors contain at least two electrical conductors often in the form of metallic plates or surfaces separated by a dielectric medium. A conductor may be a foil, thin film, sintered bead of metal, or an electrolyte. The no conducting dielectric acts to increase the capacitor's charge capacity. Materials commonly used as dielectrics include glass, ceramic, plastic film, paper, mica, air, and oxide layers.

2.15.1Capacitance

When a voltage is applied across a capacitor, one plate becomes positively charged, the other negatively charged, with the corresponding electric field directed from the positive to the negative. The capacitance C is related to the quantity of charge stored on either plate Q by:

$$c = \frac{Q}{V} \tag{2.27}$$

Where V is the voltage applied across the capacitor. The units of capacitance are coulombs per volt, or farads (F).

Figure (2.5) Aparallel-plate capacitor (a) when a vacuum is present and (b) when a dielectric material is present.

Now, consider a parallel-plate capacitor with a vacuum in the region between the plates (Figure **2.5** a).The capacitance may be computed from the relationship

$$C = \varepsilon_0 \frac{A}{l} \tag{2.28}$$

Where A represents the area of the plates and l is the distance between them. The parameterε_0, called the permittivity of a vacuum, is a universal constant having the value of 8.85 x 10^{-12} F/m. If a dielectric material is inserted into the region within the plates (Figure. **2.5** b), then

$$C = \varepsilon \frac{A}{l} \tag{2.29}$$

Where ε is the permittivity of this dielectric medium, which will be greater in magnitude than ε_0. The relative permittivityε_r, often called the dielectric constant, is equal to the ratio:

$$\varepsilon_r = \frac{\varepsilon}{\varepsilon_0} \tag{2.30}$$

This is greater than unity and represents the increase in charge storing capacity by insertion of the dielectric medium between the plates. The dielectric constant is one material property that is of prime consideration for capacitor design.

2.15.2 capacitive reactance (X_C):

In electrical circuits, **reactance** is the opposition presented to alternating current by inductance or capacitance (Veley, Victor F. C. (1997). Greater reactance gives smaller current for the same applied voltage. Reactance is similar to resistance in this respect, but differs in that reactance does not lead to dissipation of electrical energy as heat. Instead, energy is stored in the reactance, and a quarter-cycle later returned to the circuit, whereas a resistance continuously loses energy. Reactance is used to compute amplitude and phase changes of sinusoidal alternating current (AC) going through a circuit element. Like resistance, reactance is measured in ohms, with positive values indicating inductive reactance and negative indicating capacitive reactance.

An ideal resistor has zero reactance, whereas ideal inductors and capacitors have zero resistance. As frequency increases, inductive reactance increases and capacitive reactance decreases.

The term reactance was first suggested by French engineer M. Hospitalier in L'Industrie Electrique on 10 May 1893. It was officially adopted by the American Institute of Electrical Engineers in May 1894 (Charles Proteus Steinmetz, Frederick Bedell,1994).

Capacitive reactance is an opposition to the change of voltage across an element. Capacitive reactance (X_C) is inversely proportional to the signal frequency (f) (or angular frequency (ω)) and the capacitance (c) (Irwin, D. (2002).

There are two choices in the literature for defining reactance for a capacitor. One is to use a uniform notion of reactance as the imaginary part of impedance, in which case the reactance of a capacitor is the negative number (Irwin, D. 2002, Hayt, W.H., Kimmerly J.E. 2007. Glisson, T.H. 2011)

$$\mathbf{X_C = \frac{1}{\omega c} = -\frac{1}{2\pi f c}} \qquad (2.31)$$

Another choice is to define capacitive reactance as a positive number (Horowitz P., Hill W. 2015, Hughes E.et al 2012, Robbins, A.H., Miller W. 2012)

$$\mathbf{X_C} = \frac{\mathbf{1}}{\boldsymbol{\omega}\mathbf{c}} = \frac{\mathbf{1}}{\mathbf{2\pi fc}} \qquad (2.32)$$

In this case however one needs to remember to add a negative sign for the impedance of a capacitor A graph of I against V should give a straight line. Thus V/I= const showing that ohms low was verified also the ratio gives the capacitive reactance (Xc) in the circuit.

$$\frac{V}{I} = \frac{OB}{AB} = \frac{1}{2\pi fC} \qquad (2.33)$$

$$C = \frac{1}{2\pi f} \cdot \frac{AB}{OB} \qquad (3.34)$$

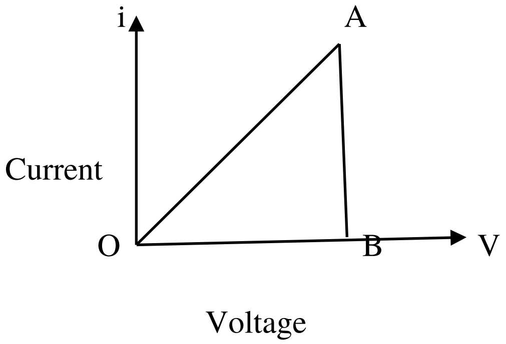

Figure (2.6): current–voltage, I–V curve

2.16 I-V curves

The current (I) - voltage (V) relationship of electrical components can often provide insight into how electronic devices are used. More specifically, many non-linear devices such as diodes and transistors are used in operating regions in which they behave like ideal components—such as current sources, voltage regulators, and resistors.

An understanding of I-V curves often provides insight into knowing how the device operates and helps us know how to operate a device in a way that enables the required functionality.

2.16.1 Obtaining I-V Curves

Method 1: Voltage Sweeps

The current-voltage (I-V) relationship for a device is a current measured for a given voltage. For devices that do not supply power, I-V curves are obtained by using linear voltage sweeps. Voltage sweeps involve the linear variation of the voltage, to obtain the corresponding measured output current. Because it is impossible to physically sweep through all the voltages in an instant, it is important to understand that these measurements are made with respect to time as well.

Figure 1.1 illustrates the translation of voltage sweep with respect to time (V vs t) onto the X-axis of the current-voltage graph (I vs V). It is important to understand that the V vs t information is implicitly present in the I vs V curve. The notion of time is relevant for components that respond to a change in voltage (such as a capacitor) rather than the instantaneous voltage (as with a resistor).

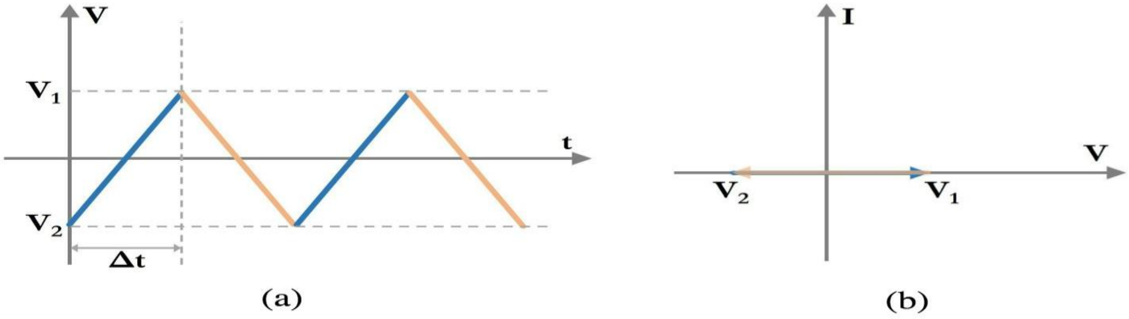

Figure (2.7): A linear sweep of voltage (V) with respect to time (t); **(b)**: the corresponding voltage sweep in the current (I) - voltage (V) curve.

Method 2: Load Switching

Load switching is a method that involves measuring the current supplied by the power source for varying load resistance. The load is the device that electrical power is being delivered to, where power (p) is defined as

$$P = V \times I \tag{2.35}$$

I-V Curves of Ideal Components

Using linear voltage sweeps and load switching, we will now look at the I-V curves of ideal components. In general, if the device requires power to operate, the voltage sweep method is used.

On the other hand, if the device acts as a source of power, the load switching method is used. Based on their basic definitions, we can derive the I-V curves of ideal passive components (resistors, capacitors, and inductors) using the concept of linear voltage sweeps. We will use the concept of load switching for the I-V curves of an ideal voltage source and an ideal current source.

2.16.2 Ideal Resistor

Let's start with one of the more familiar ideal components: the resistor.

The resistor is a component that represents a linear relationship between voltage and current as dictated by Ohm's law

$$V = R \times I \tag{2.36}$$

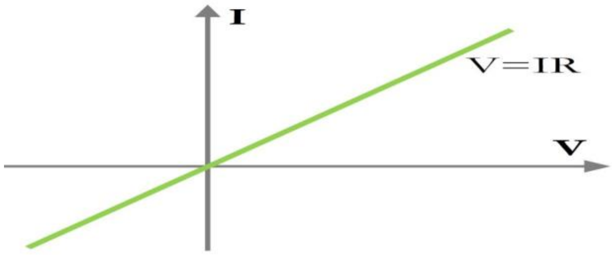

Figure (2.8) shown the I-V curve of the Ohm's law equation is a straight line passing through the origin.

2.16.3 I-V Characteristic Curves

The **I-V Characteristic Curves**, which is short for **Current-Voltage Characteristic Curves** or simply **I-V curves** of an electrical device or component, are a set of graphical curves which are used to define its operation within an electrical circuit. As its name suggests, I-V characteristic curves show the relationship between the current flowing through an electronic device and the applied voltage across its terminals.

I-V characteristic curves are generally used as a tool to determine and understand the basic parameters of a component or device and which can also be used to mathematically model its behaviour within an electronic circuit. But as with most electronic devices, there are an infinite number of I-V characteristic curves representing the various inputs or parameters and as such we can display a family or group of curves on the same graph to represent the various values.

For example, the “current-voltage characteristics” of a bipolar transistor can be shown with various amounts of base drive or the I-V characteristic curves of a diode operating in both its fBut the static current–voltage characteristics of a component or device need not be a straight line. Take for example the characteristics of a fixed value resistor, we would expect them to be reasonably straight and constant within certain ranges of current, voltage and power as it is a linear or ohmic device.

There are however, other resistive elements such as LDR’s, thermistors, varistor’s, and even the light bulb, whose I-V characteristic curves are not straight or linear lines but instead are curved or shaped and are therefore called non-linear devices because their resistances are non-linear resistances.

If the electrical supply voltage, V applied to the terminals of the resistive element R above was varied, and the resulting current, I measured, this current would be characterised as: I = V/R, being one of Ohm’s Law equations.

We know from Ohm’s Law that as the voltage across the resistor increases so too does the current flowing through it, it would be possible to construct a graph to show the relationship between the voltage and current as shown with the graph representing the the volt-ampere characteristics (its i-v characteristic curves) of the resistive element. Consider the circuit below.

I-V Characteristic Curves of an Ideal Resistor

orward and reverse regions.

The above i-v characteristic curves defines the resistive element, in the sense that if we apply any voltage value to the resistive element, the resulting current is directly obtainable from the I-V characteristics. As a result, the power dissipated (or generated) by the resistive element can also be determined from the I-V curve.

If the voltage and current are positive in nature, then the I-V characteristic curves will be positive in quadrant I, if the voltage and therefore the current are negative in nature then the curve will be displayed in quadrant III as shown.

In a pure resistance the relationship between voltage and current is linear and constant at a constant temperature, such that the current (i) is proportional to the potential difference V times the constant of proportionality 1/R giving i = (1/R) x V. Then the current through the resistor is a function of the applied voltage and we can demonstrate this visually using an I-V characteristics curve.

In this simple example, the current i against the potential difference V, is a straight line with constant slope 1/R as the relation is linear and ohmic. However, practical resistors may exhibit non-linear behaviour under certain conditions for example, when exposed to high temperatures.

There are many electronic components and devices which have non-linear characteristics, that is their V/I ratio is not constant. Semiconductor diodes are characterized by non-linear current–voltage characteristics as the current flowing through a forward-biased common silicon diode is limited by the ohmic resistance of the PN-junction.

I-V Characteristic Curves of Semiconductors

Semiconductor devices such as diodes, transistors and thyristors are all constructed using semiconductor PN junctions connected together and as such their I-V characteristics curves will reflect the operation of these PN junctions. Then these devices will have non-linear I-V characteristics, as opposed to resistors which have a linear relationship between the current and voltage.

So for example, the primary function of a semiconductor diode is rectification of AC to DC. When a diode is forward biased (the higher potential is connected to its Anode), it will pass current. When the diode is reverse biased (the higher potential is connected to its Cathode), the current is blocked. Then a PN junction needs a bias voltage of a certain polarity and amplitude for current to flow. This bias voltage also controls the resistance of the junction and therefore the flow of current through it. Consider the diode circuit below.

2.17 FTO Glass

FTO (Fluorine-doped Tin Oxide) glass is a transparent conductive metal oxide that can be used in the fabrication of transparent electrodes for thin film photovoltaics, such as: organic photovoltaic, amorphous silicon, cadmium telluride, dye-sensitized solar cells, and hybrid perovskites. FTO glass also has a varied range of other applications, including touch screen displays, electromagnetic interference/radio frequency interference shielding, heated glass, anti-static coatings, and light-emitting diodes. There are several properties of FTO glass that make it suitable for the fabrication of a wide range of optoelectronic devices: these include low surface resistivity, high optical transmittance, scratch and abrasion resistant, thermally stable up to high temperatures, and inert to a wide range of chemicals.

Ossila supply four types of FTO-coated glass for sale: these are TEC 7 (2.2mm), TEC 8 (2.2mm thick glass), TEC 10 (1mm/1.1mm/3.2mm thick glass), and TEC 15 (2.1/2.2mm thick glass). Each offer different conductivities and surface roughness to suit a variety of applications.

- TEC 8 FTO offers the highest conductivity for applications where low series resistances are crucial.

- TEC 10 FTO offers both high conductivity and high surface uniformity where both properties are crucial for the fabrication of high performance electronic devices.
- TEC 15 FTO offers the highest surface uniformity for applications where thin films are to be used.

Specifications and data files for Ossila's range of FTO-coated glass can be seen below, along with processing guides for the etching and cleaning of the FTO coating.

Fluorine Tin Oxide conductive glass (FTO coated glass) has been developed and used as a replacement for ITO conductive glass; It can be widely used in LCD panels, photo catalysis, thin film solar cell substrates, and some Fields such as electro chromic glass. Recently, with the breakthrough progress of perovskite solar cells, FTO conductive glass has become the best transparent electrode material for perovskite solar cells due to its excellent high temperature resistance. Our FTO coated glass substrate/slide has good temperature resistance and transmittance; we can customize the size and etching pattern according to your requirements.

Figure (2.9) showing slits of FTO glass

2.18 literature review

2.18.1 An experimental investigation of electrical conductivities in biopolymers

In this study Samples were prepared with Acacia arabicapowder (supplied by LOBA CHEMICAL, Bombay) of 98% purity grade by pressing it in pellet form. Samples were also prepared using naturally collected raw bio-product from Acacia plant. The powdered solid gum sample was cast as an experimental specimen by preparing a thick viscid bubble free water solution and then allowed it to dry for 3 to 5 days depending on specimen thickness (for 1 mm specimen 48 h was sufficient).using thermal analysis of the specimen to Detection of conducting, In the thermo gravimetric analysis (TGA) of the powdered sample the percentage loss of weight of the sample was recorded by a TGA analyzer (CGCRI, CSIR Facilities).Figure 1 shows experimental results of the thermal analysis. It has been estimated from the experimental data that on an average gum Arabica contains 2% of free water (H2O). Thermal analysis results show that gum Arabica is thermally stable up to 80°C, TGA measurement restricted to temperature range 25–125°C(H MALLICK and A SARKAR,2000).

2.18.2Diffusivity and electrical properties of gum arabic, carbon black/kbro3 composite material

In this study the Porous Gum Arabic (GA) doped with carbon black (Soot) was prepared using solid state chemical method. Potassium spectroscopy (IS) scanning electron microscope (SEM) and Energy-dispersive X-ray Spectroscopy (EDS) were used in order to investigate the electrical properties of Gum Arabic, the diffusion coefficient, dielectric constant and the existence of elements, respectively. The results of diffusion coefficient and dielectric showed direct proportionality with the logarithmic frequency. The porosity of the sample was found to be directly proportional to the dielectric constant. The effect of temperature was profound as diffusivity and conductivity were found to increase with temperature **(A. Elhadi H. M. Ishage, 2015)**

2.18.3 Analytical Study on Three Types of Gum from Sudan

In this research the properties of three types of Gum grown in Sudan i.e. Gumminesinaolibanum, Guar Cyamopsisteyragonlobus and CombretumCombertaceae were investigated. The tested physicochemical parameters were: moisture and ash contents, nitrogen, protein, pH, equivalent weight, uronic acid, tannin content, specific rotation and viscosity. The analysis results showed: 5.35, 6.70 and 9.10 % moisture content, 1.77, 0.63 and 4.33 % ash , 0.27, 0.71 and 0.96 % nitrogen, 1.68, 4.18 and 6.45 % protein, - 40.31, + 75.87 and -38.10 specific rotation, 3.85, 5.62 and 5.25 pH values, 1.335, 1.336 and 1.338 refractive indices, 0.150, 0.233 and 0.079 % tannin, 3.23, 0.46 and 2.49 viscosity for olibanum, guar and combretum respectively. The main sugars present were 6.10, 2.05 and 8.23 % arabinose and 6.93, 39.22 and 48.79 % galactose for olibanum, guar and combretum respectively. Low percent of manose, rhamnoe and D-glucuronic acid were reported. The elemental content of sodium, calcium, potassium, magnesium, copper and phosphorus was determined. The water holding capacity was found to be: 65.15, 60.35 and 65.40 for olibanum, guar and combretum respectively. While the emulsifying stability was found to be: 1.046, 0.037 and 1.006 for olibanum, guar and combretum respectively. The FTIR spectra supported the existence of sugar moiety in the composition of gum. The findings indicated that combertum has good gum properties close to those of gum Arabic (K. K.Taha,et al ,2012**)**.

2.18.4 Optical Properties of Gum Arabic doping by Different Concentration of Iodine Using UV- Spectroscopy

In this work study the optical Properties of Gum Arabic(Talha) Nano-material doping by Different Concentration(0.1 ,0.3 ,0.5 ,0.7 and 0.9) m Molar of Iodine measured by using the UV-Spectroscopy min 1240. The effaced of different concentration on the optical parameters. Forall samples the absorbance increases upon increasing the concentration, while the transmission decreases. The value of Energy band gap (Eg) was decreased from (4.420) eV to (4.323) eV. Also this work obtained value of the absorption coefficient α = 5.59x103 cm^{-1} for Talha Gum 0.9 m Molarbut for Talha Gum 0.1 m Molar sample equal 3.22x103 cm^{-1} at the same wavelength. The Extinction coefficient (K) for Talha Gum 0.9 m Molar s have value at wavelength 250 nm equal $1.12x10^{-5}$ while for other sample Talha Gum 0.1 m Molar at the same wavelength equal $6.39x10^{-5}$.the maximum value of refractive index equal (2.158) for all samples at tow area the first one in ranged (213 to 223) nm the second (273 to 283) nm,the maximum value of realdielectric constant (ε_1) equal to (4.64), The imaginary dielectric constant (ε_2) equal to (4.64),(H. Mustafa,et al 2020).

2.18.5 Investigation of Arabic gum optical properties as UV-Blue light down conversion for light emitting diode application

In this study, two experiments were conducted using Gum Arabic Malaysia and Gum Arabic Sudan in several annealing temperature (150°C and 200°C) and different time 20, 40, 60, 80 and 100 minutes and using different mass, 100mg and 150mg.the gum power encapsulated in 0.7ml silicone gel and dried to do remote phosphor using for light conversion. The Gum Arabic from Sudan and Malaysia were measured using HPC-2 light source colorimeter. The measured result show that the gum Arabic has high value in rendering index, CRI (colour rendering index) if the gum annealed at longer time and at the optimal temperature. The CCT (correlated colour temperature) value that show the best result or positive values are below 2500. The gum Arabic with melting process also shows improvement in result. The mass of the powder used give high concentration thus the CRI value is nearest to the 80 as references value.

The absorption spectrum of gum Arabic Sudan, with mass 100mg exhibits fluctuate peaks. But the maximum absorption occurs at 293 nm. For gum Arabic Sudan with mass 150mg the maximum peak at 285 nm (Hayder, et al, 2019)

2.18.6 Electrical and optical properties of two types of Gum Arabic

this work study two types of solution with different concentration of Gum Arabic (Acacia Senegal and Seyal), by use X-ray fluorescence (XRF) and Fourier Transformation infrared spectroscopy (FTIR) were used as analytical techniques. The XRF results indicated that, Gum Arabic (Acacia Senegal and Seyal) contained Calcium (Ca), Iron (Fe), Copper (Cu), Lead (Pb), and Strontium (Sr).The FTIR spectra of both typesof Gum Arabic showed broad and strong absorption band in the range of 600 to 3000 cm–1. These absorptions were assigned to the different stretching vibrations..(HajerAdam,et al,2014)

2.18.7 Physical and Electrical Properties of Gum Arabic

This research is focused on the optical and electrical properties of towtypes of gum Arabic (GA)

Acacia seyal (talha) and (neem),using Fourier-transform infrared spectroscopy (FTIR) and UV-visible spectroscopy of UV-visible devices to investigation this propertiesThe values of the energy band gap have been gradually decreasing from Acacia seyal (talha) to Azadirachtaindica (neem) (5.13–5.05 eV), and this phenomenon gives the insulator behavior. The extinction and absorption coefficients were derived as a wavelength function to determine the refractive index, which laid down between n = 1.28–1.16 for A. seyal (talha) to A. indica (neem). Also, the gum thickness and their wavelength values were affected from the full width at half of the maximum,(abdelrahman,et al,2016)

2.18.8 Optical, Electrical, Magnetic, and Structural Properties of Talha and Hashab Gum Doped with Iodine

In this work use Gum in solar cells and electronic circuits by doping it with suitable compounds to act as a semiconductor. This will minimize the cost of electronic circuits and solar cells. Two cultivars of Gum (Talha and Hashab) were used in this study five samples from Talha Gum and other five samples from Hashab Gum were doped with iodine having concentrations (0.1, 0.2, 0.3, 0.4, 0.5 ppm) by thermo chemical method. The optical properties and band positions were studied using Ultraviolet –Visible (UV-VIS) spectroscopy and Fourier Transform Infrared (FTIR) Spectroscopy. The crystal parameters and the crystal nano sizes were studied using Scanning Electron Microscope (SEM) and X-Ray Diffraction (XRD). Upon increasing iodine concentration to be (0.1, 0.2, 0.3, 0.4and 0.5 ppm) the Talhanano crystal sizes decrease taking values(98.60 , 85.52, 69.28, 60.59, and 53.46 nm) .The Hashabnano crystal sizes decrease also with corresponding values(96.63 , 82.98, 76.41, 67.11, and 52.57 nm). The increase of iodine concentrations increases absorption also for both Talha and Hashab .For Talha the increase of iodine concentration decreases the energy gap to take the values (2.364, 2.356, 2.352, 2.345, and 2.339 eV).For Hashab the energy gap increases assuming the values (2.453, 2.467, 2.473, 2.482, and 2.493 eV).The results of FTIR Spectrometer shows the existence of nine chemical bonds in Talha and six in Hashab. The bonds O-H , H-O-H ,C-O and C=C are common in Talha and Hashab. This explains that Talha Gum properties as semiconductor is better than Hashab Gum since its energy gap is narrower and can become narrower by doping (Osman,2021)

2.18.9 Physicochemical Properties of Acacia PolyacanthaGum

fourty samples of gum nodules were collectedFrom Kadogli and Eldamazine areas in Sudan using in this study ,The specific rotation of Kadogli samples was -19.6, while that of Eldmazine was -14. Intrinsic viscosities were 9.9 and 10.2 ml/g for Kadogli and Eldamazine samples, respectively. Refractive index of all samples from the two different locations showed the same value of1.3354.The two samples gave approximately the same moisture (10.5 %) and ash (3.4 %) contents. Nitrogen content of Kadogli samples ranged from 0.30 to 0.42% (1.88 to 2.63% protein content), while that of Eldamazine samples varied from 0.36 to 0.48% (2.30 to 2.90% protein content). The pH value for Kadogli samples and Eldamazine samples was 4.96 and 5.23, respectively. The concentration of reducing sugars was 0.23 and 0.16% for Kadogli and Eldamazine samples, respectively. Uronic acid contents of Kadogli samples ranged from 12.02% to 17.30% and that of Eldamazine samples ranged from 12.10% to 19.48% and significantly ($P \leq 0.05$) affected by location (Ahmed, 2009).

2.18.10 Structural characterization and emulsifying properties of polysaccharides of Acacia mearnsii de Wild gum

Polysaccharides (GNF) from Acacia mearnsii de Wild gum exudates, collected from trees growing in the south of Brazil, were characterized (13C and HSQC NMR, GC–MS, colorimetric assays). A commercial gum arabic (GAC) was analyzed similarly and compared with GNF. There were differences, consistent with distinct behavior in densitometry tests and as emulsion stabilizer. GNF had a higher protein content than GAC, with small differences in the monosaccharide composition, the greater one being the lower uronic acid content of GNF (4%), compared with GAC (17%). GNF had a much broader molecular mass distribution, Mw/Mn, and a lower Mw. GNF was more efficient in lowering the surface tension of water and saline solutions and was more efficient in emulsifying castor oil droplets. Results were discussed taking into account structural and molecular differences between the studied gums. It was concluded that polysaccharides from A. mearnsii de Wild are candidates as substitutes of currently commercialized arabic gums (Acacia senegal and Acacia seyal) having, depending on their application, improved properties (AlineGrein,et al,2013).

2.18.11 Utilization of gum arabic forIndustries and human health

Gum Arabic, a natural polysaccharide derived from exudates of Acacia senegaland Acacia seyaltrees, is acommonly used food hydrocolloid. The highlight of this study was to review the utilization of gum Arabic for industries and human health. Gum Arabic has a unique combination of excellent emulsifying properties and low solution viscosity. These properties make gum Arabic very useful in several industries but especially in the food industry where it is used as a flavor and stabilizer of citrus oil emulsion concentrates in soft drinks (**EqbalDauqan and Aminah Abdullah, 2013**).

2.18.12 Microstructure Examination, Elemental Composition Analysis of Gum Arabic Bonded RhizophoraSpp. Particleboards and Their Potential as Tissue Equivalent Material

Macroscopic examination of the fabricated particleboard showed smooth homogeneous surface and strong rigid texture.gum Arabic (GA) has been used as a bio-adhesive in particleboard manufacturing. For the first time, GA is used in this study as a binder in Rhizophoraspp. Particle boards. The fabricated particleboards were evaluated in terms of field emission scanning electron microscopic (FESEM) surface features and carbon, hydrogen, nitrogen, and sulfur (CHNS) elemental composition to study their potential as tissue equivalent substitute. The FESEM Showed the gum Arabic distributing homogeneously within the cells either coating or filling up in between compressed fibres. No spaces were found in the GA bonded particleboards which justifies the macroscopic smooth surface as seen by naked eyes. Furthermore, the CHNS analysis revealed that Rhizophorasppparticleboards have all the required major elements found normally in tissues and in closely comparable amounts to those in tissues. Rhizophorasppparticleboard samples have the potential to be good representatives of human tissues and more specifically human breast tissue (Ali. Abuarra et al 2014).

2.18.13 Rheological properties and surface tension of Acacia tortuosagum exudate aqueous dispersions

Steady shear flow properties of Acacia tortuosa gum aqueous dispersions at different concentrations (15–40% w/v) were studied at20 C^{o} using a controlled shear rate Couetterheometer and Mooney–Ewart sensor systems. Flow curves showed shear thinning non-Newtonian behaviour with a tendency to a Newtonian plateau at high-shear rate. The results obtained fitted the Sisko model very well. The influence of temperature (5–40 _C) on the flow curves was studied at given gum concentration (40% w/v). The infinite-shear rate Newtonian

viscosity derived from the Sisko model fitted an Arrhenius-type equation. A controlled stress rheometer was used to conduct small amplitude oscillatory shear tests with the double cone geometry on A. tortuosa gum dispersion (40% w/v). It was clearly observed that the gum dispersion exhibited viscoelastic properties in a given temperature range (5–25 _C). The elastic component was always higher than the viscous one. The frequency dependence of the dynamic moduli and the failure of the Cox–Merz rule supported the existence of a soft gel-like structure which weakened with temperature. The surface tension of A. tortuosa aqueous solutions was measured in a concentration range (0.01–1.5% w/v). The equilibrium value reached at (0.5% w/v) was (42.6 mN/m), which is significantly lower than the corresponding to A. senegal gum (46.9 mN/m). The rheological behaviour and surface tension of A. tortuosagum suggest that it may compete with Arabic gum in some industrial applications (J. Mun˜oz et al, 2007).

2.18.14 Effects of γ-Irradiation on Some Properties of Gum Arabic (Acacia Senegal L)

This work study the effects of gamma radiation with variable doses on some properties of gum Arabic (Acaciasenegal) obtained from Blue Nile State, in Sudan season Doses of 5.5, 6.5, 7.5,

8.5, 9.5, and 10.5 KGy were used respectively for irradiation of gum Arabic samples. The properties studied include the emulsifying stability, viscosity and absorption. It was found that the best emulsifying stability, highest relative viscosity and highest absorbance were obtained with the highest radiation dose (10.5 KGy).The absorption of gum Arabic wasmeasured by UV-VIS 1240 spectrophotometer from SHIMATZO Company in Japan. This spectrometer allows for scanning wavelength from 190 nm to1100nm. Aqueous gum Arabic (Acacia senegal) 20% was prepared overnight at room temperature for thispurpose.Absorbance increased drastically compared with the control sample (not irradiated sample). Redshift in the peak absorption wavelength was also observed. Change in the color of irradiated samples occurred from white to red colour. It was concluded that gamma radiation is capable of enhancement of the properties of gum Arabic material (Siddig T. et al 2010).

2.15.15 Physicochemical Properties of Arabic Acid and Arabate Salts

Arabic acid was prepared from Acacia senegalgum by the removal of metal ions using ion exchange chromatography. Arabate salts of (Na, K, Ca and Mg) were prepared using arabic acid by adding respective cations. Scanning electron microscope (SEM) proved successful production of arabic acid and arabate salts. pH values were 2.6, 6.9, 6.5, 4.9, 4.5 for arabic acid, Na, K, Ca and Mg arabate salts respectively. Intrinsic viscosities of arabic acid, Na, K, Ca and Mg arabatesalts in 1M NaCl were determined. The measured viscosities were 8.53, 2.47, 0.11, 0.05 and 1.24 ml g-1 for arabic acid, Na, K, Ca and Mg arabate salts respectively and 10.82, 14.33, 12.9, 10.12 and 9.38 ml g-1 for arabic acid, Na, K, Ca and Mg arabate salts respectively in 0.5M NaCl where they were 18.47, 45.82, 30.72, 11.76 and 10.83 ml g-1 for arabic acid, Na, K, Ca and Mg arabate salts respectively in deionized water. The equivalent conductivities of the Arabic acid and arabate salts have been measured in water at 25°C. The results showed a very sharp nonlinear increase with decreasing polyelectrolyte concentration. The overall results of the present work showed that; the bonding of metal ions to Arabic acid decreases the viscosity of Arabic acid with variation in pH values among arabate salts where the results of equivalent conductivities showed a sharp increase with dilution (Zulfa, 2014).

2.18.16 Diode Laser (532 nm) Induced Grafting of Polyacrylamide onto Gum Arabic

Initiation of graft copolymerization of acrylamide (AAm) on Gum Arabic (GA, Acacia Senegal) using diode laser (532 nm) was investigated. The results showed that the optimum conditions to achieve efficient graft copolymerization were: 60 min laser irradiation time and 0.5 gm of GA, 0.142 gm of acrylamide (monomer). The percentage of graft efficiency and percentage of graft yield were 27.40% and 97.40%, respectively. The graft copolymers were characterized using Fourier-transform infrared spectroscopy (FTIR), X-ray diffraction (XRD) and scanning electron microscope (SEM) which proved a successful production of GA-g-Acrylamide (GA-g-AAm). The results proved that copolymerization by laser can be considered as a new, effective and clean method for producing GA-g-AAm(Nafie et al,2012).

2.18.17 Applications of Natural Polymer Gum Arabic

GA Has vatil role in industrial manufacturings, spanning from food, pharmaceutics, paint, textile, printing industries. It has proved itself indispensable as stabilizer, emulsifier, bulking agent, shelf-life enhancer, encapsulating agent for bioactive components, satiating agent. Its anti-inflammatory effects on multiple organs have elevated its status as a safe food additive. GA is increasingly being implicated in nano-medicines and biosensors. Among other effective uses, controlled drug delivery and better bio dispersion of nanopaticles are most pronounced. On the other hand, its agro-forestry is facing steep competition from cash crops. Incentive or subsidies from authorities may motivate farmers to stick to Acacia plantations. The dwindling GA production must be bolstered for sustainable economic growth of cash-strapped and unemployment-ridden African countries (Seema Patela & Arun Goyal, 2014).

2.18.18 Application of dielectric barrier discharge plasma to hydrophobically modification of gum arabic with enhanced surface properties

The aim of the present study was to evaluate the effect of cold atmospheric-pressure plasma (CAP) on the structural aspects and some physicochemical properties of gum arabic (GA), with emphasis on its surface properties. GA was treated at dielectric barrier discharge (DBD) plasma with ambient air for different times (20, 40, and 60 min). The optical emission spectroscopy (OES) was utilized to scope present active species in the plasma. Upon treatment, the structural, thermal and morphological variations, as well as changes in water contact angle, surface and interfacial tension, molecular weight, solubility, moisture content and color of the treated gums, were studied. Compared with GA, overall significant changes in the spectra of all treated gums were recognized, particularly in the range of 1200-1750 cm-1. Elemental analysis of surface demonstrated that both oxygen and nitrogen content of treated gum increased time-dependently. Plasma had no pronounced effect on the amorphous nature of GA. Water contact angle data showed that plasma treatment was surprisingly capable of transforming GA hydrophilic nature into hydrophobic. The surface roughness of the treated gums powder time-dependently decreased after CAP treatment. The thermal properties and color of the treated 26 gums changed after CAP treatment. In total, this study confirmed that the CAP treatment was an efficient approach to improve surface properties of gum arabic. increased. The molecular weight, solubility, and moisture content of treated gum nonlinearly decreased with increasing treatment duration. The surface and interfacial tension significantly (W. Rashmi a b et all 2012).

2.18.19 Viscosity and thermal conductivity of dispersions of gum arabic capped MWCNT in water: Influence of MWCNT concentration and temperature

Experiments were carried out on the measurement of viscosity and thermal conductivity of multi-walled carbon nanotubes (MWCNT)-water nanofluids prepared using gum arabic as dispersant. The influence of temperature (28–60 8C), MWCNT concentration (0.14–0.24 vol%) on viscosity and effective thermal conductivity has been investigated. Our results on the effect of MWCNT concentration on relative viscosity and thermal conductivity ratio are in qualitative agreement with those reported in literature. Thermal conductivity ratios increase strongly with temperature, especially above 45 8C. Relative viscosities too increased with temperature above 45 8C at relatively higher MWCNT concentration indicating the potential role of Brownian motion (Indhuja, K.S. Suganthi, S. Manikandan, K.S. Rajan, 2013).

2.18.20 Effects of Ultraviolet Irradiation on the Physicochemical and Functional Properties of Gum Arabic

The impact of ultraviolet (UV) irradiation on the physicochemical and functional properties of gum arabic was investigated. Gum arabic samples were exposed to UV irradiation for 30, 60, 90, and 120 min; gum arabic was also treated with formaldehyde for comparison. Molecular weight analysis using gel permeation chromatography indicated that no significant changes occurred on the molecular structure on the samples exposed to UV irradiation. Free amino group analysis indicated that mild UV irradiation (30 min) could induce cross-linking on gum arabic; this result was comparable with that of samples treated with formaldehyde. However, viscosity break down was observed for samples exposed to UV irradiation for longer times (90 and 120 min). All irradiated and formaldehyde-treated samples exhibited better emulsification properties than unirradiated samples. These results indicate that UV-irradiated gum arabic could be a better emulsifier than the native (unmodified) gum arabic and could be exploited commercially (Yau-hoong kuan,et all 2009).

2.18.22 Thermal behavior of gum arabic in comparison with cashew gum

Thermal behavior of gum arabic and cashew gum, the exudate polysaccharides from Acacia and Anacardium occidentale L., containing different gum/water concentrations: 100/0, 80/20, 60/40, 50/50, 40/60, 20/80 and 5/95% w/w, were studied by differential scanning calorimetry (DSC) and thermo gravimetry (TG). DSC thermal pro®les for gum arabic with low water content (0±40%) showed an endothermic event at about 908C (Tonset) and with increasing water content (50±80%) multiple melting endotherms and associated enthalpies were observed. Similar behavior was found in the DSC curves of cashew gum with Tonset of about 978C. TG curves show two decomposition stages, the major decomposition occurred at 2528C (Tonset) to arabic and cashew gums pure (C.G. Mothe, M.A. Rao, 2000).

CHAPTER THREE

Material and Method

3.1 introductions

This chapter consist of all material which used to prepare the samples of gum Arabic and all equipments were used to syntheses the thin film layers , in addition to the instruments that used to analysis the samples and determine the optical and electrical properties by using U-V spectrometer ,also investigation the wavenumber ,bond and function group of three types of gum Arabic (Hashaba, Neem and Talha) by using FTIR and preparing the capacitor from FTO glass and gum Arabic ,and measure the capacitive reactance by using I-V characteristic circuit respectively.

3.2 Materials

3.2.1 Hashab Gum Arabic

The gum Arabic material was collected from Hashaba trees (acacia SENEGAL) from Kordofan in the east Sudan. Gum samples were collected from Arabic company of gum.

3.2. 2 Neem Gum Arabic

The **Neem** gum Arabic material was collected from olds neem trees (acacia SENEGAL) from Khartoum. Samples were collected from local tress directly.

3.2. 3 Talha Gum Arabic

The **Talha**gum Arabic material was collected from Talha trees from Kordofan in the east SUDAN. Gum samples were collected from Arabic company of gum.

Figure (3.1): showing Gum Arabic image

3.2.4 Distillation Water

Distilled water is water that has been boiled into vapor and condensed back into liquid in a separate container. Impurities in the original water that do not boil below or near the boiling point of water remain in the original container. Thus, distilled water is a type of purified water (H_2O).

3.2.5 Microscope slide

Prepared are all amounted on good quality glass .A microscope slide is a thin flat piece of glass, typically 75 by 26 mm (3 by 1 inches) and about 1 mm thick, used to hold objects for examination under a microscope. Typically the object is mounted (secured) on the slide, and then both are inserted together in the microscope for viewing. This arrangement allows several slide-mounted objects to be quickly inserted and removed from the microscope, labeled, transported, and stored in appropriate slide cases or folders etc. Microscope slides are often used together with a cover slip or cover glass, a smaller and thinner sheet of glass that is placed over the specimen.

Figure (3.2): image of Microscope slide

3.2.6 FTO Glass

Fluorine Tin Oxide conductive glass (FTO coated glass) size (5cmx5cmx.3cm) has been developed and used as a replacement for ITO conductive glass, It can be widely used in LCD panels, photocatalysis, thin film solar cell substrates, and some Fields such as electrochromic glass. In this research using FTO for substance of two plats of capacitor.

3.3 Characterization Techniques

The Materials Characterization Lab has a wide variety of characterization techniques in the areas of min 1240 UV- Spectroscopytechniques and FTIR (Fourier Transform Infrared Spectrophotometer which help to increase the different degrees of understanding why different materials show different properties and behaviors.

To investigate the optical and electrical properties of three types of gum, Gum Arabic (Hashaba, Neem and Talha) different thickness, some precise techniques have been used in our study. The following characterizations have been potentially performed for the analytical of the synthesized samples.

3.3.1 Ultraviolet -visible spectroscopy (UV-Vis)

UV spectroscopy or **UV–visible spectrophotometer** (**UV–Vis** or **UV/Vis**) refers to absorption spectroscopy or reflectance spectroscopy in part of the ultraviolet and the full, adjacent visible regions of the electromagnetic spectrum. This means it uses light in the visible and adjacent ranges. The absorption or reflectance in the visible range directly affects the perceived color of the chemicals involved. In this region of the spectrum, atoms and molecules undergo electronic transitions. Absorption spectroscopy is complementary to fluorescence spectroscopy, in that fluorescence deals with transitions of electrons from the excited state to the ground state, while absorption measures transitions from the ground state to the excited state. (Skoog, et al 2007)

The basic parts of a spectrophotometer are a light source, a holder for the sample, a diffraction grating in a monochromator or a prism to separate the different wavelengths of light, and a detector. The radiation source is often a Tungsten filament (300–2500 nm), a Deuterium arc lamp, which is continuous over the ultraviolet region (190–400 nm), Xenon arc lamp, which is continuous from 160 to 2,000 nm; or more recently, light emitting diodes (LED) (Skoog,et al 2007)for the visible wavelengths. The detector is typically a photomultiplier tube, a photodiode, a photodiode array or a charge-coupled device (CCD). Single photodiode detectors and photomultiplier tubes are used with scanning monochromators, which filter the light so that only light of a single wavelength reaches the detector at one time. The scanning monochromator moves the diffraction grating to "step-through" each wavelength so that its intensity may be measured as a function of wavelength. Fixed monochromators are used with CCDs and photodiode arrays. As both of these devices consist of many detectors grouped into one or two dimensional arrays, they are able to collect light of different wavelengths on different pixels or groups of pixels simu

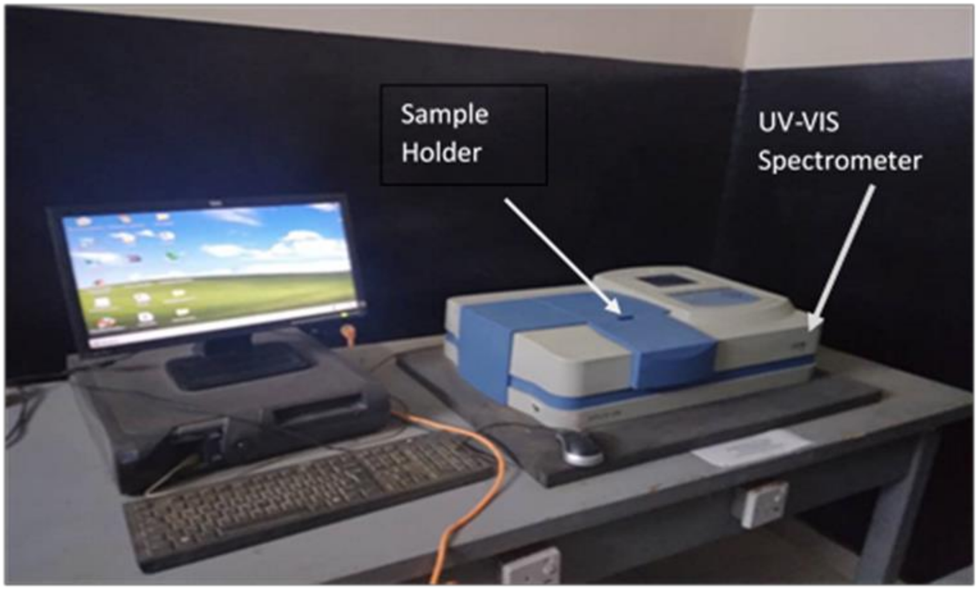

Figure (3.3): UV mini 1240 spectrometer shimadzu

3.3.2 Fourier transport infrared spectroscopy (FTIR)

Fourier transforms spectrometer. In a Fourier transform infrared spectrometer, or FT–IR, the monochromator is replaced with an interferometer (Figure 10.13). Because an FT-IR includes only a single optical path, it is necessary to collect a separate spectrum to compensate for the absorbance of atmospheric CO_2 and H_2O vapor. This is done by collecting a background spectrum without the sample and storing the result in the instrument's computer memory. The background spectrum is removed from the sample's spectrum by rationing the two signals. In comparison to other instrument designs, an FT–IR provides for rapid data acquisition, allowing an enhancement in signal-to-noise ratio through signal-averaging.

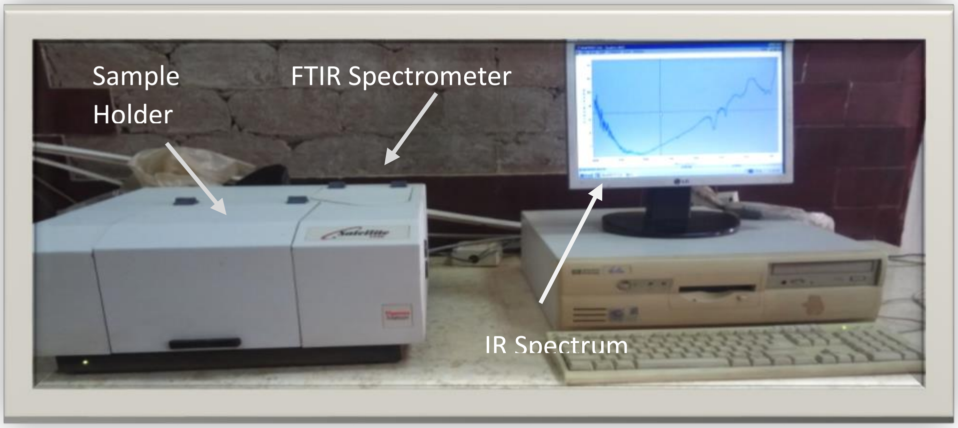

Figure (3.4): FTIR (Mattson, model 960m0016) spectroscopy.

3.3.3 I-V Characteristic Circuit

A current–voltage characteristic or I–V curve (current–voltage curve) is a relationship, typically represented as a chart or graph, between the electric current through a circuit, device, or material, and the corresponding voltage, or potential difference across it. In electronics, the relationship between the direct current (DC) through an electronic device and the DC voltage across it's terminals is called a current–voltage characteristic of the device. Electronic engineers use these charts to determine basic parameters of a device and to model its behavior in an electrical circuit. These characteristics are also known as I–V curves, referring to the standard symbols for current and voltage. The simplest I–V curve is that of a resistor, which according to Ohm's law exhibits a linear relationship between the applied voltage and the resulting electric current; the current is proportional to the voltage, so the I–V curve is a straight line through the origin with positive slope. The reciprocal of the slope is equal to the resistance. The I–V curve of an electrical component can be measured with an instrument called a curve tracer. The transconductance and early voltage of a transistor are examples of parameters traditionally measured from the device's

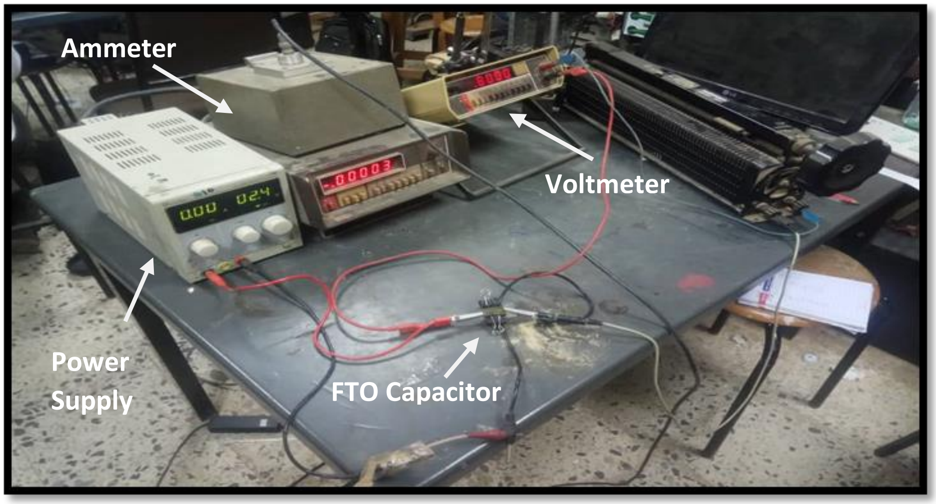

Figure (3.5): current–voltage characteristic or I–V curve of capacitor

3.4 Method

In this work, thin film of three types of gum Arabic (Hashaba, Talha and Neem) was prepared made by mechanical method in different thicknesses. The precursor used in the synthesis gum Arabic (GA) (5g) of Gum dissolved in 50 ml of distillation water and stirred for 10 min at room temperature. After that, the gum Arabic solution was ready to be used to prepare as layers by mechanical method in different thicknesses. The Arabic Gum solution was made on glass substrate. The glasses substrate was firstly cleaned by ethanol and distilled water. Then, washed substrate glass by deionizer water. Then the Arabic Gum was deposited on substrate glass manner mechanical method, the coating on glass was performed at room temperature, with suitable at different thicknesses (174.6, 56.0, 37.07 and 14.4) nm. four groups thin film Gum Arabic samples was syntheses, used UV 1240 min spectrophotometer to study the electrical properties like absorbance, transmission, reflection, absorption coefficient , energy band gap, extinction coefficient, refractive index (n), real dielectric constant (ε_1), Imaginary dielectric constant (ε_2), optical and electrical conductivity by optical methods.to calculated the thermal conductivity use the principle of Forbss's method is that steady state, the quantity heat passing through samples of gum Arabic will be equal to the quantity of heat lost by radiation by the remaining part of the bar **Preparing capacitor** Cleaning the FTO class and inserting the samples solution which prepared already as sandwich between the slides of FTO to construct capacitor with different isolator of the three types of gum Arabic (Hashaba, Talha and Neem) and leaved under normal condition for one week. To execute the I-v characteristic low voltage AC source was used as in previous experimental voltmeter for checking output voltages and capacitor C which sensitized. Ac ammeter of suitable range. Connect up the circuit as shown in figure (3.) and starting with the low value of transformer secondary voltage across the circuit read current I record the ammeter A, repeat with successively higher voltages to the limit of voltage range .record the current values against the appropriate voltage values these voltage having been checked at each stage by the Ac voltammeter.

CHAPTER FOUR

Results and Discussion

4.1 Introduction

In this part of research contains from the main results that have been obtained from the experiments made of three samples of Gum Arabic (Hashaba, Talha and Neem) at different thicknesses (176.6, 56.0, 35.07 and14.40) nm in addition to the discussion of these results, discussion and conclusion and recommendations.

4.2 FTIR Results for three types of Gum Arabic

Fourier transformed Infrared Spectroscopy (FTIR) was carried out to investigate the vibrational frequencies and functional groups presence in the prepared samples, FTIR spectrum of the samples were shown from fig (4.1) to fig (4.3) and the functional groups were displayed from table (4.1) to table (4.3).

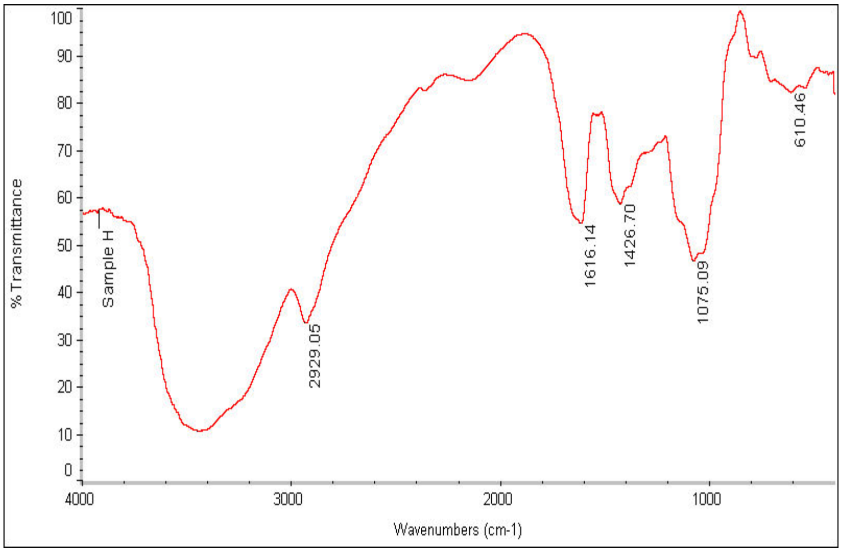

Figure (4.1) Fourier transport infrared spectroscopy (FTIR) of Hashaba gum Arabic

Table (4.1) Wavenumber, Bond and Funcation groupe of Hashaba gum Arabic

Wavenumber	**Bond**	**Funcation groupe**
610.16	C-Br stretch	Alkyl hakdes
1075.09	C-N stretch	Aliphatic amines
1426.70	C-C stretch (in-ring)	Aromatic
1616.14	N-H bend	1^0amines
2929.05	c-H stretch	Alkenes

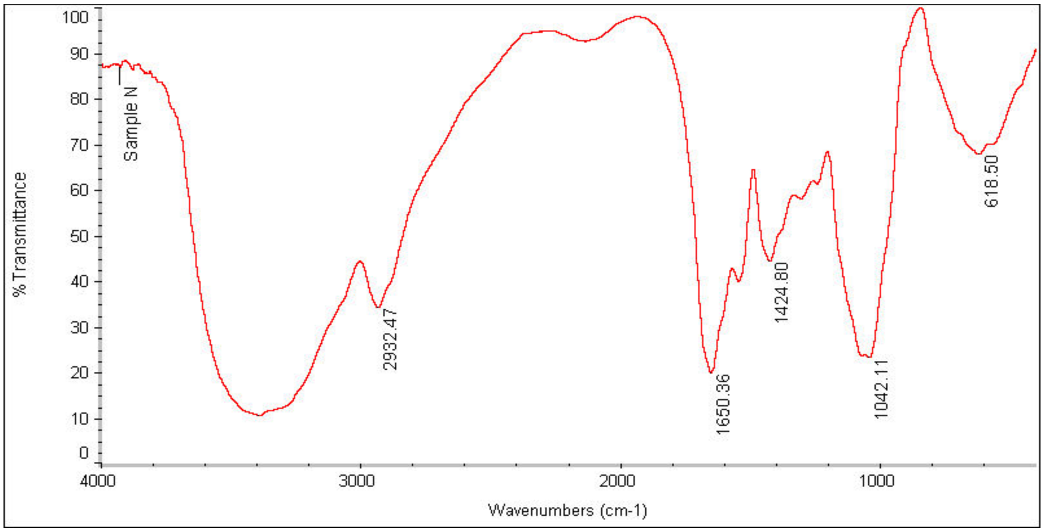

Figure (4.2) Fourier transport infrared spectroscopy (FTIR) of Neem gum Arabic

Table (4.2) Wavenumber, Bond and Funcation groupe of TalhaGum Arabic

Wavenumber	**Bond**	**Funcation groupe**
611.51	C-Br stretch	Alkyl hakdes
1071.37	C-D stretch	Alcohools, carboxlic, acids, esters ethers
1259.88	C-H wag(- C H_2 X)	Alkyl halides
1426.78	C-C stretch (in-ring)	Aromatic
1613.18	N-H bend	1^0amines
2142.43	-C ≡ C- stretch	Alkynes
2930.42	C -H stretch	Alkanes

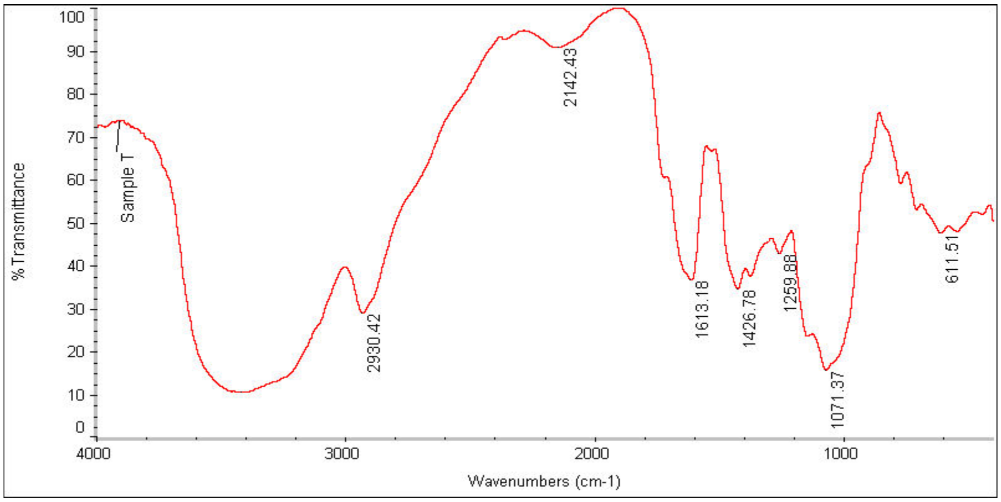

Figure (4.3) Fourier transport infrared spectroscopy (FTIR) of Talha Gum Arabic

Table (4.3) Wavenumber, Bond and Funcation groupe of Neem gum Arabic

Wavenumber	**Bond**	**Funcation groupe**
618.50	C-Br stretch	Alkynes
1042.11	C-N stretch	Aliphatic amines
1424.80	C-C stretch (in-ring)	Aromatic
1650.36	-C=C-stretch	Alkenes
2932.47	c-H stretch	Alkanes

Figure (4.1), Figure (4.2) and Figure (4.3) show that Hashab and Neem have five **Funcation group** but Talha have seven **Funcation group**. From these figures all types of gum Arabic contained the (Alkanes) it bond (c-H stretch) at wavenumber (2929, 2930 and 2932) cm^{-1}, (Aromatic) itsbound (C-C stretch (in-ring)) with wavenumber (1426.70, 1426.78, and1424) cm^{-1} with wavenumber (610.50, 611.51, 618.50) cm^{-1}. Also the types of Hashab and Neem contained Aliphatic amines with bond (C-N stretch) at wavenumbers (1075.09 cm^{-1} for hashaba and 1042 cm^{-1}.11 cm^{-1}for talha).also samples for hashab and talha involve (1^{0}amines) with wavenumber (1616.14and 1613.18) cm^{-1}. The AlkenesFuncation group was found for neem gum Arabic just with wavenumber (1650.36) cm^{-1} and bond (-C=C-stretch). While talha contained (Alcohools, carboxlic, acids, esters ethers) its bond (C-D stretch) with wavenumber (1071.37) cm^{-1} and Funcation groupe of Alkynes have bond (-C ≡ C- stretch) at wavenumber (2142.43) cm^{-1} see tables (1,2and 3). From FTIR results the three types of gum Arabic are similar function group of (Alkanes, Aromatic and Alkyl hakdes).

4.3 Optical Results of gum Arabic (Hashaba, Neem and Talha) at different thicknesses

Three groups thin film Gum Arabic (Hashaba, Talha and Neem) samples have been prepared at different thicknesses (174.6, 56.0, 37.07 and 14.4) nm, the optical properties results are illustrated in the figures below.

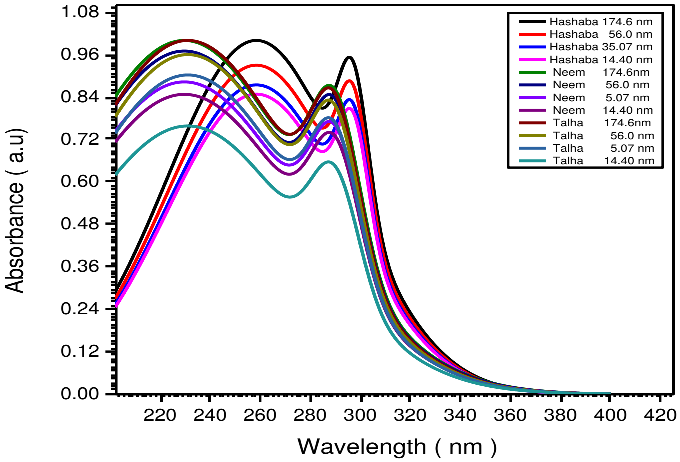

Figure (4.4) the relation between absorbance and wavelengths of three types of Gum Arabic (Hashaba, Neem and Talha) at different thicknesses

From the above figure we can notice the maximal absorbance value for the three Gum Arabic types at the same thickness 174.6nm, but with different wave lengths .for Hashab the maximal absorbance value is (0.995 a.u) at wave length (257 and 295) nm, while the Neem and Talha have the same wave lengths range (230 and 287) nm, but with different absorbance values, (0.876 a.u) for Neem and (1.0029 a.u) for Talha.

Beside that the figure illustrates the increase in the absorbance value with thickness increase for all samples.

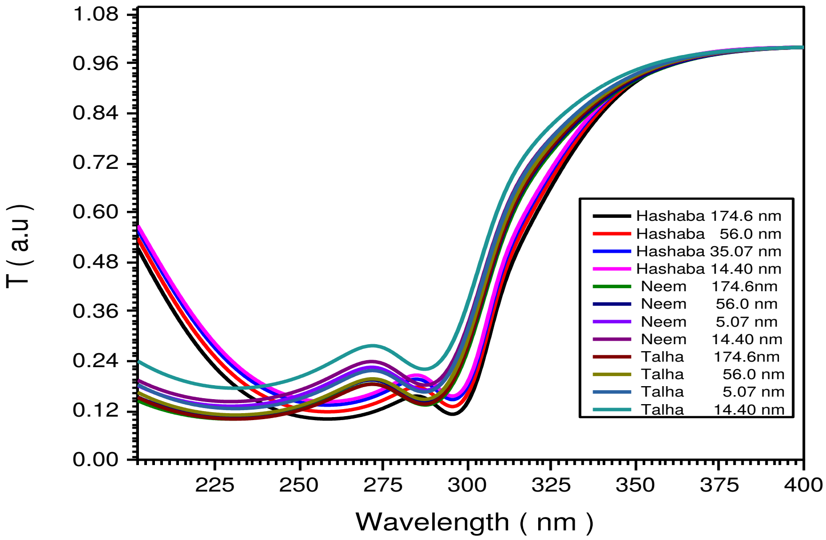

Figure (4.5) the relation between transmission and wavelengths of three types of Gum Arabic (Hashaba, Neem and Talha) at different thicknesses

Figure (4.5) shows the transmission of three Gum Arabic samples at different thicknesses. The figure reveals the minimal transmission value for Neem and Talha at same wavelengths (230 and 287) nm,while for the Hashaba sample it found at wavelengths (257 and 295) nm,and all the value recorded at the same thickness

From the same figure we can notice that the increase in the transmission depends on the decrease of the thicknesses of the samples.

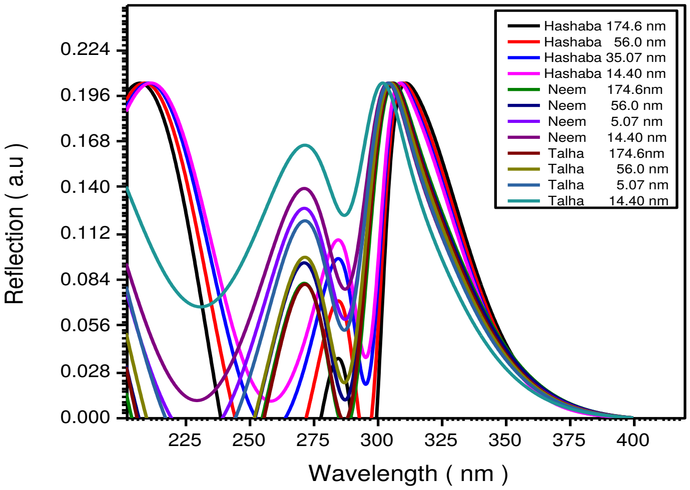

Figure (4.6) the relation between reflection and wavelengths of three types of Gum Arabic (Hashaba, Neem and Talha) at different thicknesses

The reflection of three samples Gum Arabic at different types and thicknesses shows in fig (4.6), the maximal reflection value for all samples in the maxial thickneess (174.6nm) but at the different wavelengthes. In the Hashaba type the range of wavelengths for maximal reflection value at (305 to 313) nm. While for the range of wavelengths is (300 to 307) nm for Neem and Talha. That means the samples become mirror at the maximal reflection value.

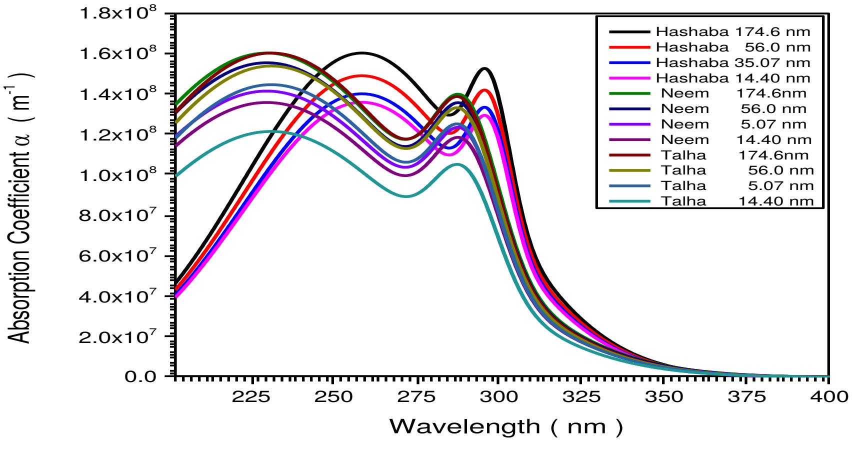

Figure (4.7) the relation between absorption coefficient and wavelengths of Gum Arabic (Hashaba, Neem and Talha) at different thicknesses

The absorption coefficient (α) of the three groups of the Gum Arabic (Hashaba, Neem and Talha) at different thicknesses were found from the relation (2.16). Figure (4.7) shows the plot of (α) with wavelength (λ) of all samlples of Gum Arabic at different thicknesses, which obtained the maximal value of α ($1.6x10^8$) for all types of the Gum Arabic at thicknesse174.6nm but at different wavelengths, (258)nm for Hashaba, (229.7) nm for Neem and 230.46nm for Talha.While the absorption coefficient (α) equal ($1.36x10^8$) for (Hashaba &Neem) at 14.4nm thickness but at different wavelengthes: 258.6nm for Hashaba and 229.7 nm for Neem, and it equle $1.22x10^8$forTalha(thicknesses 14.4nm) at wavelength 230.46nm.

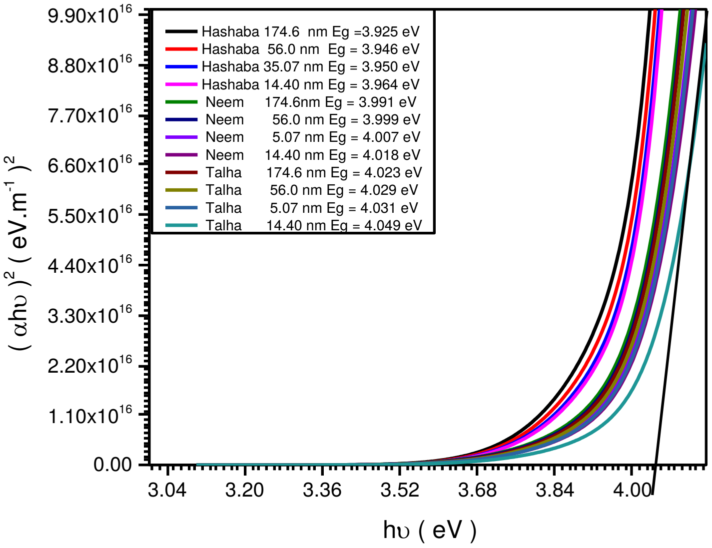

Figure (4.8) optical energy band gap of three types of Gum Arabic (Hashaba, Neem and Talha) at different thicknesses

The optical energy gap (Eg) has been calculated from the relation (2.17) . By plotting $(\alpha h\upsilon)^2$ vs photon energy (hυ) as shown in figure.(4.8), at the maxmal thickness 174.6 nm the energy gap equal (3.925) eV for Hashaba , (3.991) eV for the Neem and equal 4.023 eV for the Talha, but at the minimumm thickness (14.4nm) the energe gab egual (3.964) eV for Hashaba Gum Arabic sample , but Neem sample recorded 4.018 eV and Talha recieves 4.049 eV . The value of (Eg) increased from (3.925) eV to (4.049) eV. The increasing of (Eg) related to decrease of the thicknesses of samples [H.mustafa,2020]. It was observed that the different thicknesses of Gum

Arabic (Hashaba, Neem and Talha) samples confirmed the reason for the bad gap shifts. This fact can classefied the thin film gam Arabic to isollater materials.

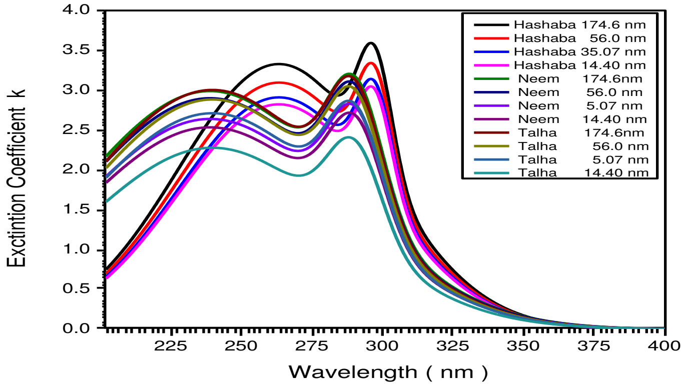

Figure (4.9) the relation between extinction coefficient and wavelengths of Gum Arabic (Hashaba, Neem and Talha) at different thicknesses

Extinction coefficient (K) has been calculated by using the releation (2.15).The variation of the (K) values as a function of (λ) are shown in figure(4.9) for Gum Arabic sampleses at different thicknesses, and it is observed that the spectrum shape of (K) as the same shape of (α). The Extinction coefficient (K) for three types of Gum Arabic (Hashaba, Neem and Talha) at different thicknesses obtains diffrent value of (K) at the same wavelength, four samples of Hashaba recieves values of K at wavelength 295 nm, the Extinction coefficient equal (3.589) for thickness sample (174.6nm), while (K) equal 3.025 at thickness sample(14.4nm). Neem and Talha Gum Arabic records Extinction coefficient (K) values at same wavelength (287nm), (K) is equal (3.206 & 2.870) for Neem Gum Arabic, and (2.809 & 2.389) for Talha Gum Arabic, at the same samples thicknesses (174.6 & 56)nm. Also fig (6) shows the effects of different thicknesses of Gum Arabic (Hashaba, Neem and Talha) increasing to increasing Extinction coefficient (k) value.

4.4 Electrical properties

After prepared three groups of Gum Arabic thin films samples at different thicknesses, the optical absorbance by UV 1240 min spectrophotometer in wavelengths range (190-420) nm.as show in figure (4.4), then the electrical properties was calculated as monitoring below.

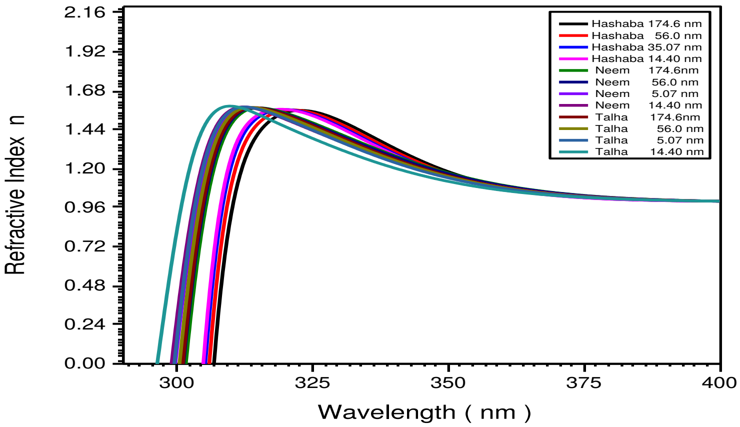

Figure (4.10) the relation between refractive index and wavelengths of Gum Arabic at different thicknesses

The refractive index (n) is the relative between speeds of light in vacuum to its speed in material which does not absorb this light. The value of n was calculated from the equation (2.14). The variation of (n) vs (λ) for 12 samples was treatment by Gum Arabic (Hashaba, Neem and Talha) at different thicknesses samples is shown in figure (4.10), which shows that the maximum value of (n) is (1.588) for all types of Gum Arabic at wavelengths ranged (310 to 325) nm, the point was agreement with red shift by increase for the samples thickness. Also we can notice that the value of (n) begin to decrease before 310 nm and after 325 nm on the spectrum.

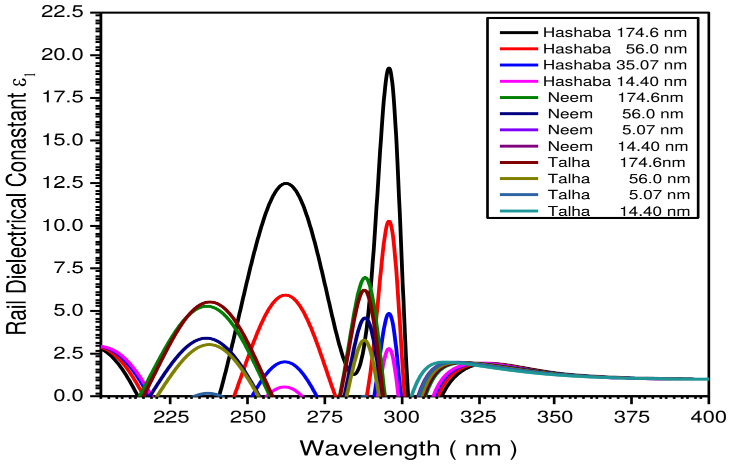

Figure (4.11) the relation between real dialectical constant and wavelengths of Gum Arabic at different thicknesses

Figure (4.11) shows the variation of the real dielectric constant (ε_1) with wavelength of three types of Gum Arabic at different thicknesses samples, which calculated from the relation(2.21). From figure (4.11) the variation of (ε_1) is follow the refractive index, where at wavelengths ranged (262 to 295) nm for all samples of Hashaba Gum Arabic, and (238 and 288) nm for (Neem and Talha) Gum Arabic samples, where the absorption of the samples at these wavelength is small, but the polarization was increase. The maximum value of (ε_1) recorded at maximal samples thickness174.6nm for three types of Gum Arabic but at different wavelength. (ε_1) equal to (19.22) at wavelength 295 nm for the Hashaba Gum Arabic, but for the Neem Gum Arabic equal 7.01, while for the Talha Gum Arabic equal 6.14,which were measure at the same wavelength (288nm) for both Neem & Talha. The effect of treatment samples on the (ε_1) were increase when the thickness increase.

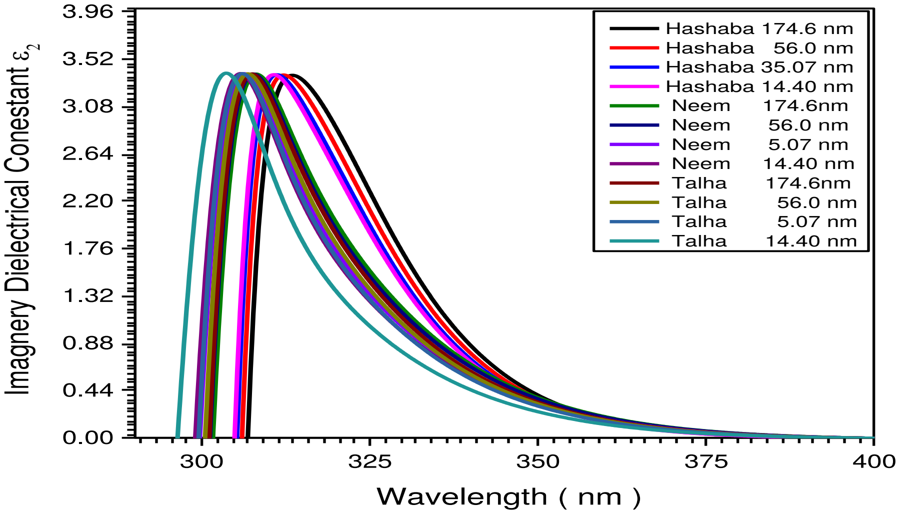

Figure (4.12) the relation between imaginary dialectical constant and wavelengths of Gum Arabic) at different thicknesses

The imaginary dielectric constant (ε_2) vs (λ) was shown in figure (4.12) this value calculated from the relation (2.22), (ε_2) represent the absorption associated with free carriers. As shown in figure (4.12) for the Gum Arabic at different thicknesses samples, the shape of (ε_2) is not the same as (ε_1), this means that the refractive index was dominated in these behavior. The maximum values of (ε_2) are different according to the treatment operation, so the maximum value of (ε_2) equal to (3.408) at wavelengths ranged (303 to 315) nm for all Gum Arabic types at different thicknesses samples, the point was agreement with blue shift by increase for the samples thickness. Also we can show that the value of (ε_2) begin to decrease before 303 nm and after 315nm on the spectrum, these behavior may be related to the different absorption mechanism for free carriers.

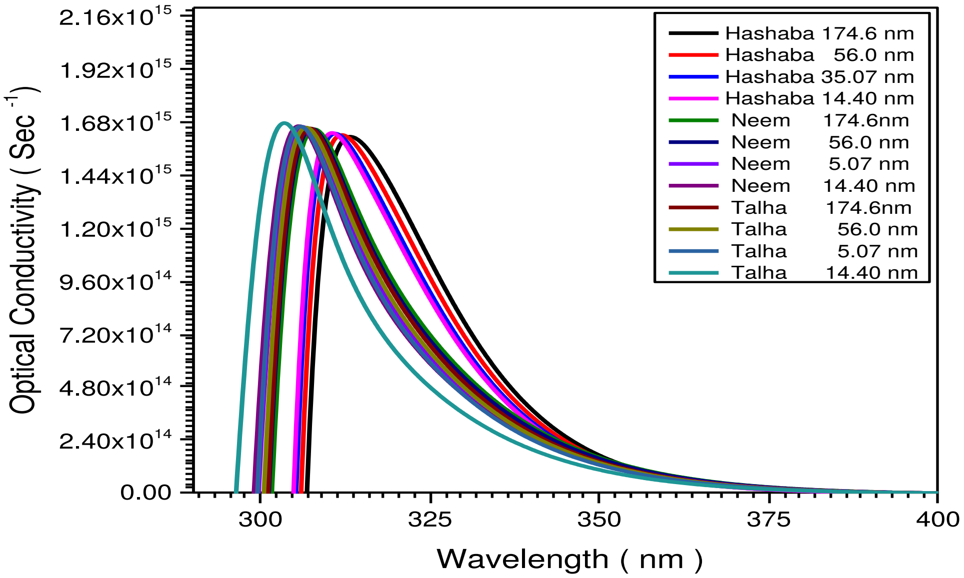

Figure (4.13) the relation between optical conductivity and wavelengths of Gum Arabic at different thicknesses.

The optical conductivity is a measure of frequency response of material when irradiated with light, which is determined by using the relation (2.23) .The high magnitude of optical conductivity (1.679x10^{15} sec^{-1}) at wavelengths range (303 to 315) nm for all Gum Arabic samples confirms the presence of very high photo-response of the 12 samples prepared by Gum Arabic. The increased of optical conductivity at high photo generation is due to the high absorbance of Gum Arabic samples, and may be due to electron excitation by photon energy.

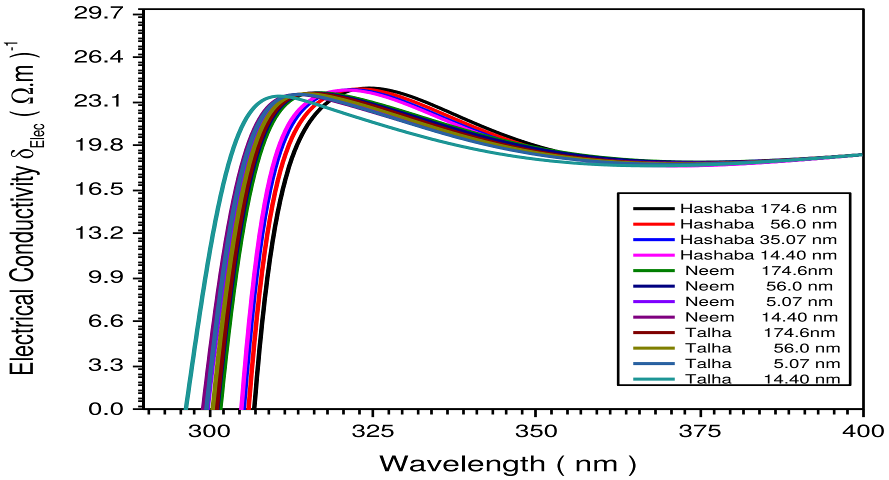

Figure (4.14) the relation between electrical conductivity and wavelengths of Gum Arabic at different thicknesses.

The electrical conductivity is the measure of a materials ability to allow the transport of an electrical charge, which is determined by using the relation (2.24). The relation between electrical conductivity and wavelengths of Gum Arabic at different thicknesses shows in Figure (4.14). The effect of Gum Arabic thin films at different thicknesses was blue shift on electrical conductivity by decreeing thin film thickness , the maximal value of electrical conductivity for all samples equal 24.3 (Ω.cm)$^{-1}$ at wavelengths range (304 to 340) nm. According to these results of electrical conductivity, the Gum Arabic thin films can be classified as weak semiconductor materials.

4.5 Thermal Properties

Forba’s method was used to determined the thermal properties (thermal conductivity) of three types Gum Arabic((Hashaba, Neem and Talha)) samples shown below.

Table (4.4) the thermal experiment results of Hashaba Gum Arabic samples using forbas’s method

No	Time (second)	T of Hashaba 459.3 nm (^{O}C)	T of Hashaba 56 nm (^{O}C)	T of Hashaba 35.07 nm (^{O}C)	T of Hashaba 14.4 nm (^{O}C)
1	0	185.2132	164.83975	148.35577	129.06952
2	50.04485	87.46126	77.84052	70.05647	60.94913
3	100.59484	47.51161	42.28533	38.0568	33.10942
4	151.14484	31.43238	27.97482	25.17734	21.90428
5	201.69483	24.96069	22.21502	19.99352	17.39436
6	252.24483	22.35592	19.89677	17.90709	15.57917
7	302.79482	21.30753	18.96371	17.06733	14.84858
8	353.34482	20.88557	18.58816	16.72934	14.55453
9	403.89481	20.71574	18.43701	16.5933	14.43617
10	454.44481	20.64738	18.37617	16.53855	14.38854
11	504.9948	20.61987	18.35168	16.51651	14.36937

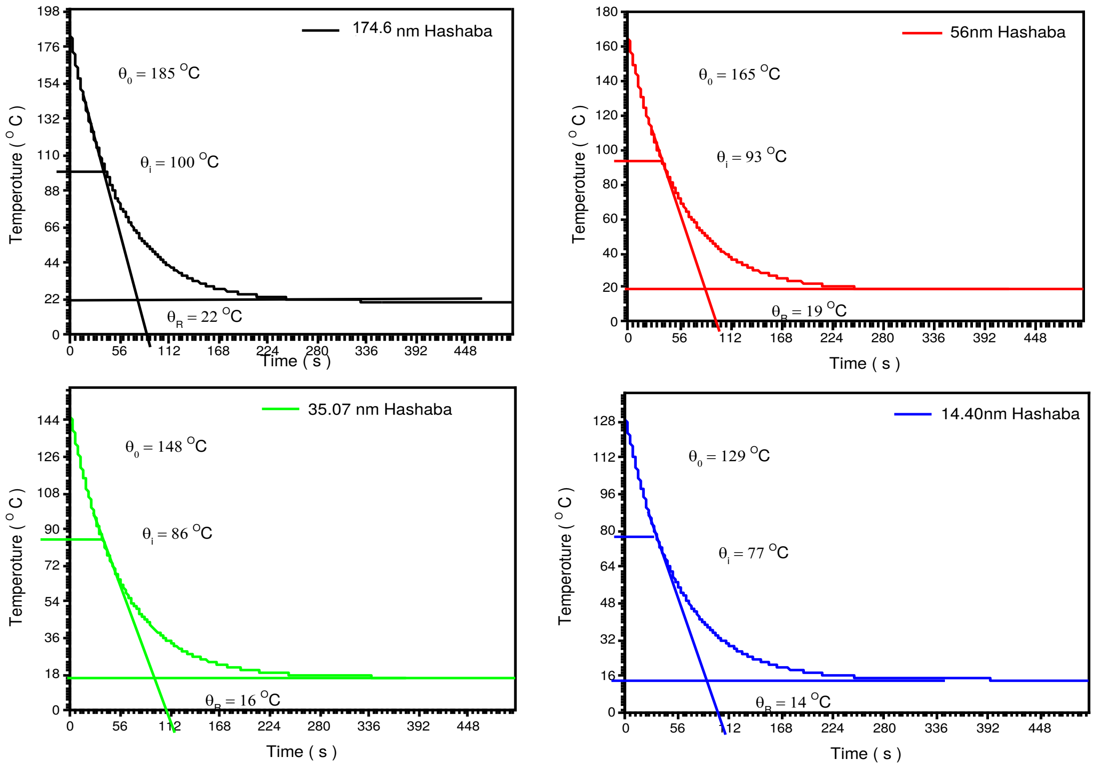

Figure (4.15) time Vs Temperature of Hashaba Gum Arabic samples at different thicknesses

Table (4.5) thermal conductivity of Hashaba Gum Arabic samples

Samples	L (10 $^{-9}$ m)	ΔT(k^{o})	K (W/ (m. k^{o})
Hashaba 174.6nm	174.6	351	190
Hashaba 56 nm	56.00	347	177
Hashaba 35.07 nm	35.07	343	166
Hashaba 14.4 nm	14.40	336	161

Figure (4.15) shown the relation between time and Temperature of Hashaba Gum Arabic samples the maximum value of thermal conductivity equal 190 (W/ (m. k^{o}) resaved at the maximum thickness 174.6nm but the minimum value equal 161(W/ (m. k^{o}) at minimum sample thickness 14.4

Table (4.6) the thermal experiment results of Neem Gum Arabic samples using forbas's method

No	Time (second)	T of Neem 174.6 nm (^{O}C)	T of Neem 56 nm (^{O}C)	T of Neem 35.07 nm (^{O}C)	T of Neem 14.4 nm (^{O}C)
1	0	188.91746	168.13655	151.32289	131.65091
2	50.04485	89.21049	79.39733	71.4576	62.16811
3	100.59484	48.46184	43.13104	38.81794	33.77161
4	151.14484	32.06103	28.53432	25.68089	22.34237
5	201.69483	25.4599	22.65932	20.39339	17.74225
6	252.24483	22.80304	20.29471	18.26523	15.89075
7	302.79482	21.73368	19.34298	17.40868	15.14555
8	353.34482	21.30328	18.95992	17.06393	14.84562
9	403.89481	21.13005	18.80575	16.92517	14.72489
10	454.44481	21.06033	18.74369	16.86932	14.67631
11	504.9948	21.03227	18.71871	16.84684	14.65676

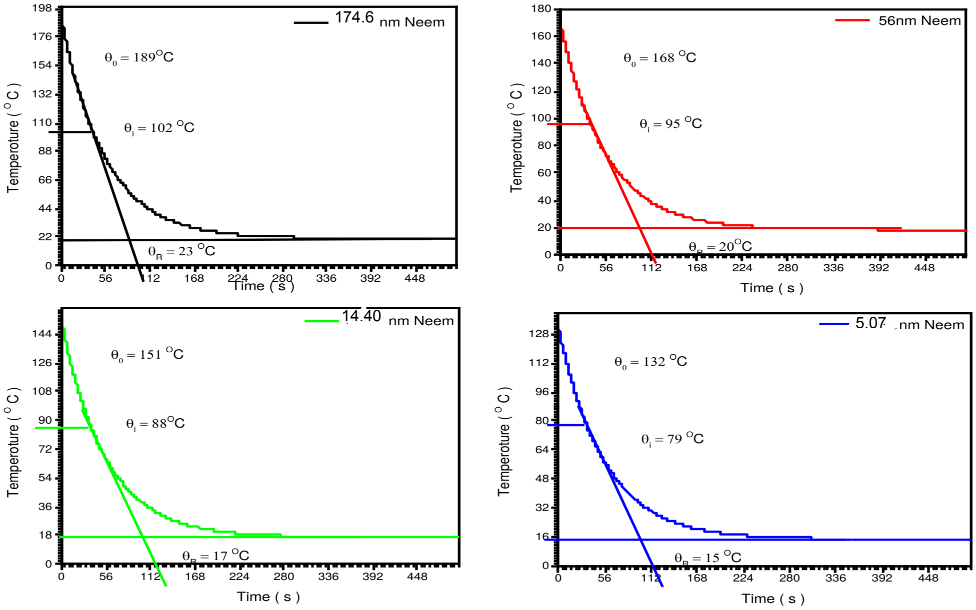

Figure (4.16) time Vs Temperature of Neem Gum Arabic samples at different thicknesses

Table (4.7) thermal conductivity of Neem Gum Arabic samples

Samples	L (10^{-9} m)	ΔT(k^{o})	K (W/ (m. k^{o})
Neem 174.6 nm	174.6	352	193.8
Neem 56 nm	56.00	348	180
Neem 14.4 nm	35.07	344	169
Neem nm 5.07	14.40	337	163

Figure (4.16) display relation between time and Temperature of Neem Gum Arabic samples different thickness. The maximum value of thermal conductivity equal 193.8 (W/ (m. k^{o})at maximum thickness sample 174.6nm while minimum value of it equal 163(W/ (m. k^{o}) at minimum thickness sample 5.07nm.that means where the thickness increase the thermal conductivity increase .

Table (4.8) the thermal experiment results of Talha Gum Arabic samples using forbas's method

No	Time (second)	T of Talha 459.3 nm (^{O}C)	T of Talha 56 nm (^{O}C)	T of Talha 35.07 nm (^{O}C)	T of Talha 14.4 nm (^{O}C)
1	0	190.7696	169.78494	152.80644	132.94161
2	50.04485	90.0851	80.17574	72.15816	62.7776
3	100.59484	48.93696	43.55389	39.1985	34.1027
4	151.14484	32.37535	28.81406	25.93266	22.56141
5	201.69483	25.70951	22.88147	20.59333	17.91619
6	252.24483	23.0266	20.49367	18.4443	16.04655
7	302.79482	21.94676	19.53262	17.57935	15.29404
8	353.34482	21.51214	19.1458	17.23122	14.99117
9	403.89481	21.33721	18.99012	17.0911	14.86926
10	454.44481	21.2668	18.92746	17.03471	14.8202
11	504.9948	21.23847	18.90223	17.01201	14.80045

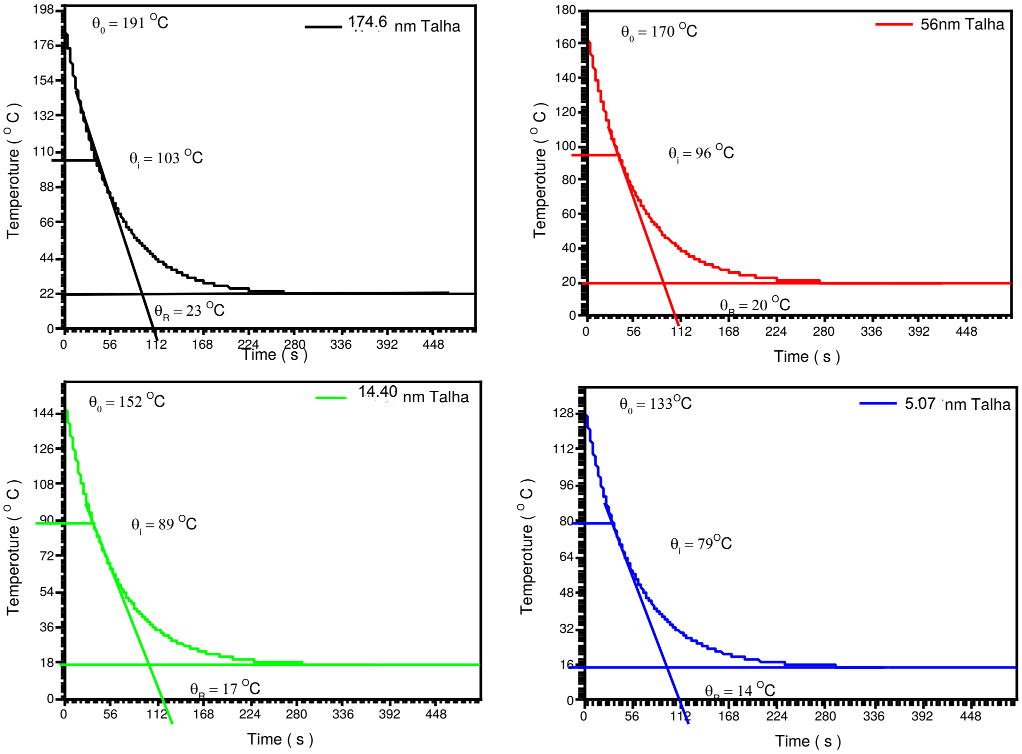

Figure (4.17) time Vs Temperature of Talha Gum Arabic samples at different thicknesses

Table (4.9) thermal conductivity of Talha Gum Arabic samples

Samples	L (10^{-9} m)	ΔT(k^o)	K (W/ (m. k^o)
Talha 176.4 nm	176.4	353	195.7
Talha 56 nm	56.00	349	182
Talha 14.40nm	14.40	345	171
Talha 5.07 nm	5.07	338	166

Figure (4.17) shown relation between time and Temperature of Talha Gum Arabic samples different from this Fig calculated the thermal conductivity of each samples at the maximum thickness 174.6nm the thermal conductivity equal maximum value for this type , in the minimum thickness 5.07 nm equal 166(W/ (m. k^o)

4.6 The Results of measured reactance capacitive (Xc):

Table (4.10) I-V results for Hasaba Gum Arabic at different thickness

Volt 10^{-5} (mV)	Current 10^{-5}(A) of sample 174.6 nm	Current 10^{-5}(A) of sample 56.0 nm	Current 10^{-5}(A) of sample 5.07 nm	Current 10^{-5}(A) of sample 14.4 nm
2.19009	0.454292	0.521241	0.595705	0.67454
4.4023	0.981576	1.04775	1.19743	1.35591
6.61451	1.50886	1.57425	1.79915	2.03727
8.82673	2.03614	2.10076	2.40087	2.71863
11.0389	2.56343	2.62727	3.00259	3.39999
13.2512	3.09071	3.15377	3.60431	4.08135
15.4634	3.61799	3.68028	4.20603	4.76272
17.6756	4.14528	4.20679	4.80776	5.44408
19.8878	4.67256	4.73329	5.40948	6.12544
22.1	5.19985	5.2598	6.0112	6.8068

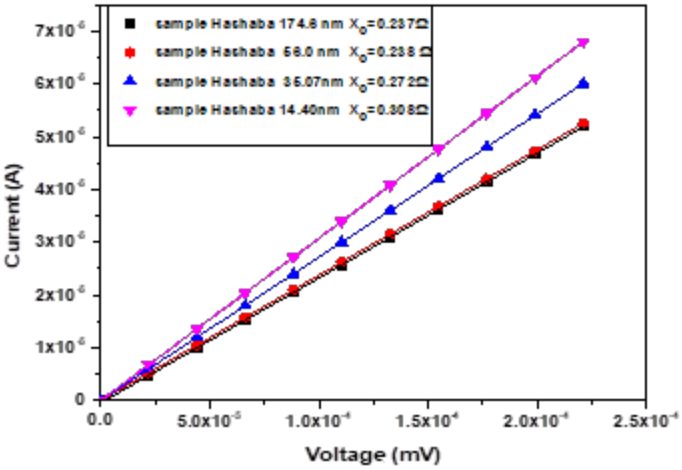

Figure (4.18) the capacitive reactance (Xc) of Hshaba gum Arabic

The capacitive reactance (Xc) of Hshaba gum Arabic shown in Figure (4.18).the maximum thickness sample of Hashaba (174.6) have minimum value (0.237Ω) of capacitive reactance (Xc), while equal maximum value (0.308Ω) at the minimum thickness sample (14.40 nm). That means the capacitive reactance inversely proportional with sample thicknesses.

Table (4.11) I-V results for Talha Gum Arabic at different thickness

Volt 10^{-5} (mV)	Current10^{-5} (A) of sample 174.6 nm	Current10^{-5} (A) of sample 56.0 nm	Current10^{-5} (A) of sample 5.07 nm	Current10^{-5} (A) of sample 14.4 nm
2.19009	0.687688	0.689878	6.92068	6.94259
4.4023	1.38232	1.38673	1.39113	1.39553
6.61451	2.07696	2.08357	2.09019	2.0968
8.82673	2.77159	2.78042	2.78925	2.79807
1.0389	3.46623	3.47727	3.4883	3.49934
13.2512	4.16086	4.17411	4.18736	4.20061
15.4634	4.8555	4.87096	4.88642	4.90189
17.6756	5.55013	5.56781	5.58548	5.60316
19.8878	6.24477	6.26465	6.28454	6.30443
22.1	6.9394	6.9615	6.9836	7.0057

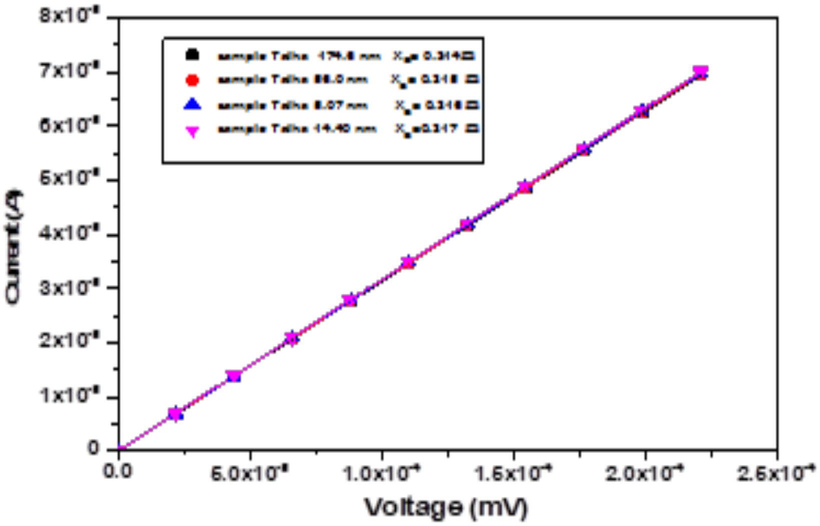

Figure (4.19) the capacitive reactance (Xc) of Talha gum Arabic

Figure (4.19) showing the capacitive reactance (Xc) of four samples for Talha gum Arabic at different thicknesses. The maximum value of Xc (0.318Ω) recorded at minimum sample thickness (5.07nm), while the minimum value of Xc (0.314Ω) received at maximum thickness sample (174.6nm).

Table (4.12) I-V results for Neem Gum Arabic at different thickness

Volt 10^{-5} (mV)	Current 10^{-5}(A) of sample 174.6 nm	Current 10^{-5}(A) of sample 56.0 nm	Current 10^{-5}(A) of sample 5.07 nm	Current10^{-5} (A) of sample 14.4 nm
0	0	0	0	0
2.19009	0.678928	0.681118	0.683308	0.685498
4.4023	1.36471	1.36912	1.37352	1.37792
6.61451	2.0505	2.05711	2.06373	2.07034
8.82673	2.73629	2.74511	2.75394	2.76277
11.0389	3.42207	3.43311	3.44415	3.45519
13.2512	4.10786	4.12111	4.13436	4.14761
15.4634	4.79364	4.80911	4.82457	4.84003
17.6756	5.47943	5.4971	5.51478	5.53246
19.8878	6.16521	6.1851	6.20499	6.22488
22.1	6.851	6.8731	6.8952	6.9173

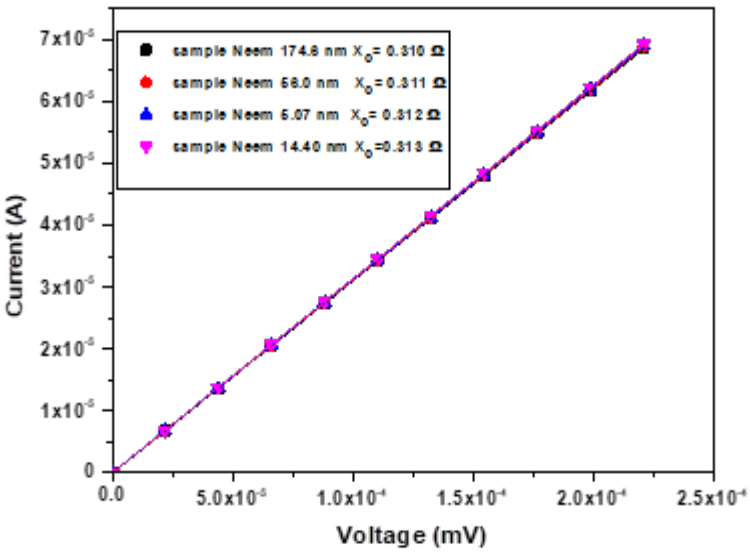

Figure (4.20) the capacitive reactance (Xc) of Neem gum Arabic

The capacitive reactance (Xc) for four samples of Neem gum Arabic shown in Figure (4.20). in this type of gum Arabic also the sample have maximum thickness (174.6nm) record minimum value of capacitive reactance(0.310Ω) and the maximum vlue of Xc (0.313Ω) received at minimum sample thickness (5.07nm). For the three types of gum Arabic (Hashab, Talha and Neem) the talha recorded maximum capacitive reactance (Xc) that means the capacitance of talha capacitor is minimum in this type, while the type of hashab recorded minimum values of capacitive reactance (Xc) this result means the capacitance of hashaba capacitor is the best one.

4.7 Discussion

Twelve samples from three types of Gum Arabic (Hashaba, Talha and Neem) were prepared at different thicknesses (176.6, 56.0, 35.07 and14.40) nm. FTIR results display that all types of gum Arabic contained same three function group at different wave number and all types of gum Arabic have function group of aromatic (bond C-C stretch (in-ring)) also appear that all bond of hashaba is single and stretch and Talha have one triple bond while Neem all bonds were stretch but one of them have double bond.The optical results display that the absorbance, absorption coefficient and extinction coefficient of Gum Arabic (Hashaba, Talha and Neem) samples decrease when the thickness of the sample decrease for all Gum Arabic types, it was noted that all samples have same value of reflection but at different regions and this due to the differences in polarization of each sampleThe optical energy band gap increases when the thickness of the sample decrease, all obtained values for optical energy band gap for all samples greater than 3.5 eV, according to that this material can be classified as isolator material. All samples have same value of refractive index at different wavelength range with red shift by increase for the samples thickness. The variation of real and imaginary dielectric constants follows the variation in refractive index, the real dielectric constants increase when the thickness increase while all samples have same value of imaginary dielectric constant with blue shift as thickness increase. The high magnitude of optical conductivity at wavelengths range for all Gum Arabic samples this confirms with the presence of very high photo-response of prepared by Gum Arabic. The increased of optical conductivity at high photo generation is due to the high absorbance of Gum Arabic samples, and may be due to electron excitation by photon energy. Thermal conductivity of all thin films of Gum Arabic samples were obtained using Forbes method, the type of Hashab resaved minimum value of thermal conductivity after that the type of Neem and the type of Talha have maximum values of thermal conductivity from I-V curve of capacitor fabricated from all samples, the maximum value of reactance capacitive come from maximum thickness of all samples. In general, the Hashaba samples have minimum reactance capacitive than other samples (Neem and Talha) .The variations of all properties (optical, electrical and thermal) refer to differences on functional group of each type of Gum Arabic, single ponds on Hasaba samples made it has high absorption, low (band gap , thermal conductivity and of reactance capacitive) and this properties have been increased according to bonds increased(Neem contains double bond and Talaha contains triple bonds), the type of Talha have maximum value of absorbance this agree with result of FTIR for Talha.

4.7 Conclusion

The synthesis of n12 samples of three group's thin films Gum Arabic (Hashaba, Talha and Neem) at different thickness (174.6, 56.0, 37.07 and 14.4) nm has been conducted to measure the optical properties. The absorbance of all samples at UV region and the value of absorbance increase by samples thickness increase. The value of energy band Gap (Eg) of Hashaba Gum Arabic increased from 3.925 eV to 3.964 eV, for the Neem Gum Arabic also increased from 3.991 eV to 4.018 eV, while for Talha Guam Arabic is increased from4.023 eV to 4.049 eV. In all samples the value of (Eg) was increased from (3.925) eV to (4.049) eV, the increasing related to decreased the of the samples'thickness.The Electrical properties were calculated by optical method. The maximum value of refractive index (n) equal (1.588) for all samples. Electrical conductivity of all samples equal 24.3 $(\Omega.\text{cm})^{-1}$ at wavelengths range (304 to 340) nm with blue shift by increase for the samples thicknesses.

4.8 Recommendation

* Applied this study for another types of gum Arabic.

* The thin film prepared from gum Arabic so brittle, recommended solving this problem.

*To study the effect of temperature on gum Arabic the thin film.

*To study which span the optical and electrical properties don’t modification.

* Change the substrate material from FTO to other material with gum Arabic.

* To study effect of temperature in efficiency of the capacitor.

* comparing the efficient of the capacitor FTO glass and gum Arabic with common capacitor

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