Sudan University of Science and Technology
College of Graduate Studies

Determination of Optical and Structural Properties of Gum Arabic Doped by Aluminum Oxide to be used in Diode Multilayer

تحديد الخصائص الضوئية والتركيبية للصمغ العربي المشوب بأكسيد الالمونيوم لإستخدامه فى الثنائي متعدد الطبقات

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

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بسم الله الرحمن الرحيم

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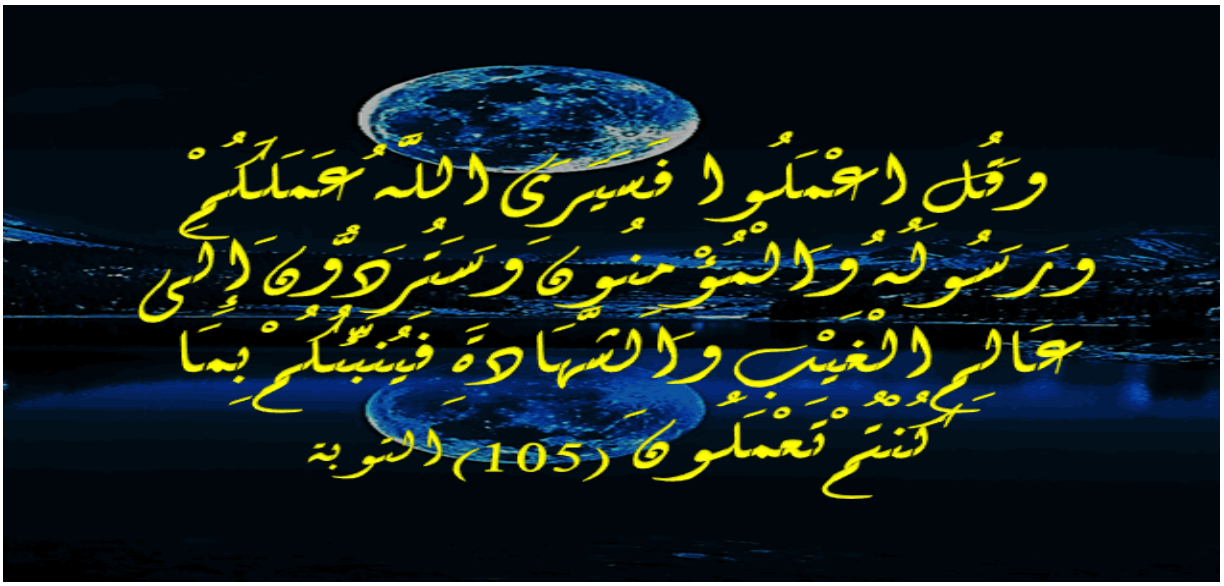

صدق الله العظيم

Dedication

First, I dedicate this work

To everyone who loves me and pray for me

In this world

To my great

Mother& Father

MY supportive brothers and sisters

My beautiful kids

My friend

And special Dedication to my beloved husband

And every person who helped me to finish this work.

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First and last thanks to **Allah** who gives me the power to go forward in a way illuminated with His merciful guidance. My thanks to Dr. Rawia Abdelgani supervisor who introduced me to this research and helped me throughout this project, and special thanks for Dr. AbdAlsaki Suleiman Mohammed.

I owe a lot to everybody in the department of Physics, lab technicians and all the staff of Al-Neelain University Faculty of Sciences and Technology Physics Department.

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Last but not least, my grateful thanks to my husband Amro Mohamednoor.

Abstract

This research discussed how use the local materials in the felid of manufacture semiconductors material by determining the optical and structural properties of Gum Arabic doped by aluminum oxide made by sol gel and chemo-thermal methods and to be used in diode multilayers. Four samples of Gum Arabic doping by aluminum oxide were prepared by sol gel method and other four samples which were prepared by using chemo -thermal method, after that the multi-layers were prepared by spin coating technique. The optical properties and structural parameter were found using UV-vis spectrometer and FTIR and XRD respectively.

The XRD results showed the crystal structure for Gum Arabic Made by sol gel method was (Hexagonal- Primitive), while (Cubic – Primitive) for the chemo-thermal method .There were different optical properties result for the two method, for sol gel sample the maximal absorption at wavelength 465 nm corresponding to photon energy 2.667 eV, and for chemo-thermal sample the chemo-thermal maximal absorption at wavelengths 576 nm corresponding to photon energy 2.605 eV. An optical conductivity for sol gel sample equal to (9.63x108 Sec^{-1}) at 435 nm and (9.61x108 Sec^{-1}) at 510 nm, and for chemo-thermal were (9.58x108 Sec^{-1}) at 442 nm and (9.55x108 Sec^{-1}) at 520 nm , the change of optical conductivity at high photo -generation due to the high absorbance of all samples prepared according to electron excitation by photon energy. The I-V characteristic results of diode multilayer carried out it showed the relation between the number of layers and (Charge Injection Voltage and Turn on Voltage), voltage increases as the number of layers increases, while the density of current decreases in the two cases , so the I-V curve which was obtain is similar to the silicon I-V curve.

المستخلص

في هذا البحث تمت مناقشة كيفية استخدام المواد المحلية في مجال تحسين المواد التي تصنع منها اشباة الموصلات حيث يتم ذلك من خلال تحديد الخصائص البصرية والتركيبية عن طريق تشويب الصمغ العربي بأكسيد الألومنيوم والتي تم تحضيرها بطريقتين سول جل والطريقة الكيميائية الحرارية واستخدامها في عمل الثنائي متعدد الطبقات. تم تحضير أربع عينات من الصمغ العربي المشوب بأكسيد الألمنيوم بطريقة سول جل وأربع عينات أخرى تم تحضيرها بالطريقة الكيماوية الحرارية ، وبعد ذلك تم عمل طبقات متعددة من الصمغ العربي المشوب باكاسيد الالمونيوم مع Poly [2-methoxy-5-(2'-ethylhexyloxy)-1,4-phenylene vinylene] (MEH-PPV) بتقنية الطلاء المغزلي. حيث تم الحصول على الخصائص البصرية والتركيب البلوري والزمر الوظيفية باستخدام (مطياف الأشعة فوق البنفسجية , XRD و FTIR) على التوالي.

أوضحت النتائج التي تم الحصول عليها من جهاز حيود الأشعة السينية (XRD) ، أن العينات المحضرة بطريقة سول جل أعطت تركيب بلوري او خلية وحدة (سداسية) و (مكعبة) للطريقة الكيميائية الحرارية. أما بالنسبة للخصائص البصرية فالامتصاصية القصوى كانت عند الطول الموجي 465 نانومتر مقابلة لطاقة الفوتون 2.667 الكترون فولت للعينات المحضرة بطريقة سول جل ,أما العينات المحضرة بالطريقة الكيميائية الحرارية اعطت امتصاصية قصوى عند الطوال الموجي 576 نانومتر مقابلة لطاقة الفوتون 2.605 الكترون فولت. اما الموصلية الضوئية لعينة سول جل تساوي (9.63×108 ثانية$^{-1}$) عند 435 نانومتر و (9.61×108 ثانية$^{-1}$) عند 510 نانومتر، وبالنسبة للعينة المحضرة بالطريقة الكيميائية الحرارية كانت (9.58×108 ثانية$^{-1}$) عند 442 نانومتر و (9.55×108 ثانية$^{-1}$) عند 520 نانومتر, هذا التغيرفي الموصلية الضوئية نتج عن الامتصاصية العالية لجميع العينات المحضرة وفقًا لإثارة الإلكترون بواسطة طاقة الفوتون الممتص . النتائج المتحصل عليها من منحنى I-V والتي تمثل العلاقة بين عدد الطبقات و (Charge Injection Voltage و Turn on Voltage) ،وجد أن الزيادة في عدد الطبقات تؤدي الى زيادة الجهد ، بينما تنخفض كثافة التيار وذلك في الحالتين الجهد الحاجز وجهد التشغيل،وبالتالي فإن المنحنى I-V الذي تم الحصول عليه مشابه لمنحنى الصمام الثنائي الضوئي للسيليكون.

Table of Contents

List of Tables

Table of Figures

Abbreviation list

1- X-ray Powder Diffraction (XRD)
2- Fourier transport infrared spectroscopy (FTIR)
3- Ultraviolet -visible spectroscopy (UV-Vis)
4- Indium Tin Oxide Glass (ITO)
5- Poly [2-methoxy-5-(2'-ethylhexyloxy)-1, 4-phenylene vinylene] (MEH-PPV)
6- Current- voltage characteristic (I-V curve)

CHAPTER ONE
INTRODUCTION

1.1 Introduction

Gum Arabic is an exudates natural gum. It is an important commercial polysaccharide which was used at least 4000 years ago. The term gum was applied because the material has gummy characteristics, and the name "gum Arabic "because the origin of export was an Arab area [1].

Gum Arabic is being widely used for industrial purposes such as a stabilizer, a thickener, an emulsifier and to a lesser extent in textiles, ceramics, and lithography, cosmetic and pharmaceutical industry. In the food industry, GA is primarily used in confectionery, bakery, dairy, and beverage and as a microencapsulating agent [2]. It is mostly used in food industry, but other sectors such as textile, pottery, lithography, cosmetics and pharmaceutical industries also make use of it. Several researchers are also studying the application of GA in the development of controlled drug delivery systems, and carriers for the microencapsulation of oils and other bioactive molecules. Recently, the use of GA has been extended to the nanotechnology and Nano medicine fields, due to its biocompatibility for in vivo applications, as well as its stabilization of nanostructures [3].GA has also found wide applications in nanotechnology, where it has been used as a cross linking agent to produce chitosan/gum Arabic nanoparticles for sustained drug release [4]. Gum acacia is an important substance in medicine and bacteriology. It has been reported that inorganic salt complex of gum acacia exhibits an electrical conduction like super ionic conductor [5]. Biopolymer used for the production of nanoparticles (NPs) has attracted increasing attention. In the presence article we use aqueous solution of polysaccharide commonly known as guar gum (GG), from plants. GG acts as reductive preparation of silver nanoparticles which are found to be <10 nm in size

[6].Nanotechnology have a Various definitions of the fields of Nano science and nanotechnology have been widely debated in the literature .The traditional definition of "materials with at least one dimension between 1 and 100 nm" is based on the size at which many materials exhibit size-dependent characteristics not evident at bulk scales [7].Nanotechnology is generally defined as the design, production, and application of structures, devices, and systems through control of the size and shape of the material at the 10^{-9} of a meter scale. Nanotechnology is truly an interdisciplinary field that stretches across a whole spectrum of science including physics, chemistry, and biology as well as engineering including micro-fabrication techniques. The physical, chemical, and biological properties of structures and systems at Nano scale are substantially different than the macro-scale counterparts due to the interactions of individual atoms and molecules thereby offering unique and novel functional applications [8]. Many scientific fields—such as chemistry, materials science, biology, physics, and engineering—study and apply nanotechnology; the goal is to create materials as well as devices and systems that have fundamentally new properties or functions Nanomaterial's come in a variety of forms, based on both their chemical composition and their physical structure. Material properties differ significantly from those of larger scales. The properties of matter at Nano scale are different from those at a larger scale. When the dimensions of a material are reduced from a large size, the properties remain the same at first, and then small changes occur. Finally, when the size drops below 100 nm, dramatic changes in properties can occur. The unique physical and chemical properties of nanomaterial's can be exploited for commercial applications and for novel performance that benefits society. The discovery of novel materials, processes, and phenomena at the Nano scale and the development of new experimental and theoretical techniques for research at the end of the 20th century provide fresh opportunities for the development of innovative Nano systems and nanomaterial's. Manufacturing at the Nano scale,

referred to as nonmanufacturing, is accomplished by using either a “bottom-up “or “top down” approach to the production of nanomaterial’s, structures, devices, and systems [9]. In recent years semiconductor nanostructures have become the model systems of choice for investigations of electrical conduction on short length scales. This development was made possible by the availability of semiconducting materials of unprecedented purity and crystalline perfection [10]. The developments in semiconductor nanotechnology have led to new materials having specific properties, which can be considered for electronic applications because of their strong quantum size confinement effects. Incorporating QDs into organic optoelectronic components make them promising candidates for light-emitting diodes and photovoltaic cells [11].There is considerable ongoing research and development into military applications of nanotechnology. Some of these applications include Nano-electronics. Nanotechnology combines with information and communications technology (ICT) to yields smaller, lighter, faster, and much more energy-efficient and easily deployable devices that enable real-time situational and information dominance that integrates the battlefield and strategic command. Nano-electronics are substantially enhancing everything from information operations (IO), data processing and flow, precision guidance of munitions, manned and unmanned vehicles, to individual human cognition and motor control [12].Semiconductor devices operate on the basis of the basic principle that the conducting and optical properties of semiconductors can be altered easily and rapidly. One way this can be done is through the use of junctions between dissimilar materials. Junctions can form between n−type and p−type materials, between materials with different band gaps, and between metals and semiconductors. The p-n junction is one of the most important junctions in solid-state electronics. The junction is used as a device in applications such as rectifiers, waveform shapers, variable capacitors, lasers, detectors, etc. The key ingredient

of the bipolar transistor, which is one of the most important electronic devices, is a p-n junction.

Doped of bulk semiconductors, the process of intentional insertion of impurity atoms into a crystal, was introduced in the 1940s and is the basis for the widespread application of semiconductors in electronic and electro-optic components. Controlling the size and dimensionality of semiconductor structures is an additional way to tune their properties via quantum confinement effects [13].

1.2 Research Problem

The developments in semiconductor nanotechnology led to new materials having specific properties, which can be considered for electronic applications such as diodes, transistors and solar cells. These materials used in this field in our country are not available, due to synthesis difficulty and high cost. Alternative abundant local material with low cost, easy treatment such as gum Arabic is chosen for this study.

1.3 Objectives

1.3.1 Ganeral Objectives

Determination of optical and structural properties of gum Arabic made by (sol gel and chemo thermal) methods and doped with aluminum oxide to be used in diode multilayer.

1.3.2 Specific Objectives

- To prepare gum Arabic by (sol gel and chemo thermal) methods and doped with aluminum oxide.
- To calculate optical properties and electrical conductivity such as (absorbance, absorption coefficient etc.) by UV spectrometer.

- To compare the optical properties of all samples that made (sol gel and chemo thermal) method.
- To determine the structure parameter by using XRD and FTIR
- To fabricate thin film multilayer by using spin coating technique.
- To find out the IV curve of diode multilayer.

1.4 Methodology

Four sampels of gum Arabic doped by aluminume oxide were perepared by sol gel method and other four sampels were perepared by using chemo -thermal method .The optical propreties and sturcural parameter were found by using (UV-spectrometer and FTIR, XRD) respectively.Finally multilayer were prepered by spin coating technique.

1.5 Thesis Layout

This theses contains five chapters, chapter one includes introduction , research problems and objectives .Theoretical background for the topic of research and previous studies were discussed in chapter two , while chapter three includes the materials and the methods used, the results and the discussion are displayed in chapter four. Chapter five contains conclusion and recommendations.

CHAPTER TWO
THEORETICAL BACKGROUND AND PERVIOUS STUDIES

2.1Introduction

This chapter represents of information about the theoretical background of researches of gum Arabic, nanotechnology, semiconductor and doping lastly previous studies which is related to this work.

2.2 Gum Arabic

Gum Arabic is the natural form, it is an important commercial polysaccharide which was used at least 4000 years ago. The term gum was applied because the material has gummy characteristics, and the name "gum Arabic" because the origin of export was an Arab area, the republic of Sudan is one of the most important countries producing gum. Most of the gum produced in the Sudan comes from acacia Senegal which growth to about 15-20 ft. tall and has a life of about 25-30 years. It grows in poor, sandy, reddish soil. 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 Kordofan gum90% of the gum produced in the Sudan is from these kinds of trees and about10% of the gum comes from the Seyal variety of acacia which is known in the Sudan western part of the country and in the Nile region. The gum from Seyal trees is exuded naturally. During the rainy season, no gum is formed by the trees. So, the gum is collected during the dry season between October and May or June. A suitable age for trees which can be tapped is 6-7 years. Attempts to extract gum from trees younger than this causes death of the trees. After a few weeks, the gum form in the cuts which is depending on the weather conditions is collected every 10 days during the season [1].Gum Arabic (GA) or Acacia gum is an edible biopolymer obtained as exudates of mature trees of Acacia senegal and Acacia seyal which grow

principally in the African region in Sudan. The exudates is a non-viscous liquid, rich in soluble fibers, and its emanation from the stems and branches usually occurs under stress conditions such as drought, poor soil fertility, and injury. GA found its way to Europe and it started to be called "gum Arabic" because was exported from Arabian ports [14].Most commercial gum Arabic is derived from Acacia Senegal locally known as hashab gum (in the Sudan) and as Kordofan gum in the world. Gum Arabic has been known for many thousands of years and there are no artificial substitutes that match it for quality or cost of the production [15].Composition And Structure of Gum Arabic is a complex polysaccharide, comprised mostly of glactose, arabinose, rhamnose and glucoronic acid, with ~2 % proteins as an integral part of its structure [16]. Gum Arabica has been found from different species of Acacia e.g. Acacia Arabica, *Acacia babul* etc. The gum Arabica specimen under investigation has a complex molecular structure in which chain of L-arabinose (24%), L-galactose (67%) and L-rhamnose (7%) are interlinked with D-galacturonic acid (~ 2%) unit. Its melting point is around 160°C. It is important to mention here that gum Arabica produces salt complexes with inorganic materials like $FeSO_4$, [K_2SO_4, $Al_2(SO_4)_3$, $24H_2O$], $LiClO_4$, iodine etc. [17].Gum Arabic consists mainly of high-molecular weight polysaccharides made up of rhamnose, arabinose, and galactose, glucuronic and 4-o-methoxylglucuronic acid, and the salts of calcium, magnesium, potassium, and sodium of the two acids. The Sudanese, major gums of economic importance are gum Arabic, gum Talha and Acacia polyacantha gum. The source of gum Arabic is Acacia Senegal varSenegal [15].

2.2.1 The Properties of Gum Arabic

Physical Properties: Gum Arabic is amber, amorphous, highly viscous material when it is in fresh form and it is solid after contact with the atmosphere, it is light in color with shades of yellow, red or brown, depending on the sort of acacia trees,

the4countries of origin and the condition of storage. It is nontoxic, odorless, tasteless, and soluble in water giving a homogeneous colloidal and colorless system).Molecular weight: The molecular weight of gum Arabic differs from sample to sample but also depends upon the method of estimation. Anderson and coworkers (m reported the average molecular weight to lie between 260,000 and1, 160,000 Melting point. The melting point, measured between (190-200) C^{O}. Solubility of Gum Arabic is completely soluble in cold or in hot water and in some oils, but it is insoluble in most of the well-known organic solvents. The solubility of the gum was tested in aliphatic and aromatic alcohols, ketones, ethers, esters, halogen derivatives, glycols, pyridine, hydrocarbons, and liquid ammonia. It is only dissolved in ethylene glycols and glycerol with low-viscosity. The viscosity of gum Arabic is studied carefully by varying different factors such as concentration, temperature, electrolytes, pH, solvents other than water, the time of measuring the viscosity, mechanical treatment, and the effects of ultrasonic vibrations and ultraviolet irradiation on viscosity. The pH of the solution of the gum Arabic between 4.58 and 6.30 which the viscosity started to decrease gradually in between pH values of 5 to 10. Gum Arabic is a suitable medium for microorganism growing.

The surface tension of the liquid gum Arabic was studied at different temperatures and concentrations the decrease of the surface tension by increasing temperature, and concentration.

Chemical Properties: 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 and Millions reagent. A solution of gum Arabic can be coagulated by ruthenium red, hexol nitrate, ordesogen Geigy. Gum Arabic can be hydrolized when it is treated with dilute acidsto give a mixture of L-arabinose, L-rhamnose,

D-galactose, and D-glucuronic Acid. It also reacts with nitric acid to give music. Solubility of the acacia mucilage solution with concentrated and dilute hydrochloric acid, concentrated and dilute acetic acid, concentrated and dilute ammonium hydroxide and dilute sodium hydroxide. The acacia mucilage is soluble in all these reagents. Also it is soluble in 10%solutions of sodium chloride, mercuric chloride, bismuth chloride, and silver nitrate, but it is not soluble in a 10% solution of chloride and concentrated sodium hydroxide.

Enzymes: Oxidases and peroxidases are found in gum Arabic and are both inactivated by the heating of the gum to 800 C for 1 hour [1].

2.2.3 Applications of Gum Arabic

Gum Arabic is used as an emulsifier, thickener, stabilizer in a wide range of food and other industrial applications

Industrials uses

- **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 and because it is non-toxic, odorless, color less, tasteless, and completely water-soluble. It does not affect the flavor, odorless, or color of the food ingredients.
- **Confectionery**: Because gum Arabic has an ability to prevent the crystallization of the sugars and the thickening the aqueous media. It is used as a glaze in candy products and as a component of chewing gum, cough drops, and candy.
- **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. WALDER used gum Arabic to protect the formation of colloids during the preparation of baby food.
- **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.

- **Flavor fixative**: The spray-dried technique is used to add different kinds of flavors which may be oxidized or volatile. The gum Arabic forms a thin film around the flavor particle and protects them from oxidation, evaporation and from absorption of moisture from the air.
- **Flavor emulsifier**. JOHNSTONE 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.
- **Pharmaceuticals:** Because the gum Arabic has inherent emulsifying and demulcent and emollient characteristics, it is used in many applications in the pharmaceuticals area, from the stabilization of emulsions to the formation of tablets. Also, because the solution of gum Arabic can retain its viscosity over a wide range. Gum Arabic is mixed with sodium benzoate, vanillin tincture and sucrose for use as a flavor vehicle because of its demulcent affect and its protective colloid action. Good syrup of diabetic foods is prepared from gum Arabic, saccharin, methyl-p-hydroxy benzoate and water.
- **Suspending agent:** OSBORN and DEKAY04f) and that gum Arabic is a convenient emulsifier and suspender for calamine suspensions, kaolin suspensions, liquid petroleum emulsions and cod liver oil emulsions. It has been found that it is an excellent medium for preparing a stable, non-setting magnesia suspension. Poorly soluble medicinal substances, such as steroids, fat-soluble vitamins, and barbitureates that are suspended in gum Arabic can be facilities by the incorporation of wetting agents or other emulsifiers).

Antiseptic preparation has been made with a mixture of colloidal silver bromide and gum arabion. Silver arabate has antiseptic properties which are suitable for use as a substitute for silver nitrate and organic silver compounds in the treatment of ophthalmic infections. Silver compounds for the internal treatment of mucous membranes have been patented by VON NEERGAARDM. These compounds swell and liquefy in contact with moist tissues and are prepared from water-soluble silver compounds such as the nitrate.

- **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 chloridev-110In. 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.
- **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 give the skin a smooth feel. It is also used as a binder in the formulation of the compact cakes, rouges, and as an adhesive in the preparation of facial masks. Gum Arabic has also entered the prescriptions which are used in hair creams and fixatives and as a binder in face powder compact.
- **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. Employed gum Arabic with sodium hydroxide as an adhesive agent for paper products. The glue of gum Arabic is desirable because one finds it easy to prepare, light in color and very stable. These glues can be improved by the addition of metal

salts such as calcium nitrate and Aluminum Sulphate, Gum Arabic is also used as a glue for cellophane. Also, a good transparent cement can be made with gum Arabic. Sometime gum Arabic is used as a binder for water cements such as gray and iron cement.

- **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).Many of the inks use gum Arabic in the formula, including record ink, which sis used in government writings. Soluble inks, used just to mark the cloth in the textile area. Gum Arabic is a suitable binder for water color inks because it has excellent suspending properties where this kind of ink must remain in suspension. Gum Arabic is used with ethanol as a thickener and suspension agent in fast drying inks, also it is used in fabric and laundry marking inks. In typographic ink gum Arabic is used as a binder to keep the ink out of separation. The Conductive inks have a range of application in the electronic area. The most important use of this Ink is in preparing printed circuits. The most conductive Inks are based on carbon black, powdered graphite. Powdered silver or copper are used and the suspension agent can be a lacquer or gum Arabic [1].
- **Lithography**: Gums are used as sensitizers for lithography plates. A solution consists of gum Arabic and dichmmates and can form water-insoluble substances by the effect of the light. A layer of this mixture can be formed on plastic, paper, metallic and stone surfaces and unexposed material can be removed easily by water or dilute acids. Gum Arabic for this use must be of the best quality and be prepared in a special way for this purpose [1].

2.3 Aluminum Oxide

Aluminum, the second most abundant metal in the earth's crust, exhibits only the trivalent state in the compound and in solution [18]. Metal oxides are widely used

in adsorption technology as adsorbent surfaces because of their efficiency, low cost and unique physical properties. .One of the renowned oxides is Aluminum oxide (Al_2O_3) which is an amphoteric oxide known as alumina and found in many crystalline structures like 'α- Al_2O_3, γ- Al_2O_3, θ- Al_2O_3, η- Al_2O_3' etc. Aluminum oxide is characterized by its non-toxic, easy used, chemical stability and has many hydroxide groups all these property mad it efficient adsorbent. From 1923 Aluminum oxide had usage as adsorbed to remove Pigments, antibiotics, heavy metals, dissolved organics etc. In the light of the continuous development in the field of nanotechnology and its use in treatment pollution of the environment, interest increasing in the use of metal oxides as nanoparticles as absorbers to remove pollutants from the environment, especially Aluminum oxide nanoparticles inasmuch to it inexpensive, high surface area, surface reactivity, well adsorption ability, surface acidity and thermal stability [19].

Nanostructured aluminum oxide is the most important metal oxide material which is used widely in many industrial applications, such as catalyst, surface passivation, ant-reflection coating, sensors, gas diffusion barrier, abrasive materials and Nano laminates. $Al_2O_3$is a wide band-gap (*6 eV at 300 k for bulk material) dielectric material which can exist in different crystalline forms such as gamma, delta, theta and alpha phases. There are many techniques to prepared aluminum oxide nanoparticles powder including ball milling, hydrothermal, sol-gel, co-precipitation, pyrolysis, laser ablation, vapor phase reaction and combustion methods [20].

2.4 Nanotechnology

Nano is the Greek word (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 [21].

Nano science is a new discipline concerned with the unique properties associated with nanomaterials, which are assemblies of atoms or molecules on a Nano scale. Nano science is actually the study of objects/particles and its phenomena at a very small scale, ranging roughly from 1 to 100 nm. "Nano" refers to a scale of size in the metric system.

Nano sciences a new discipline concerned with the unique properties associated with Nanomaterials, which are assemblies of atoms or molecules on a Nano scale. Nano science is actually the study of objects/particles and its phenomena at a very small scale, ranging roughly from 1 to 100 nm. "Nano" refers to a scale of size in the metric system size range.

Nano-object: Material confine in one, two, or three dimensions at the Nano scale. This includes nanoparticles (all three dimensions in the Nano scale), Nano fiber (two dimensions in the Nano scale), and Nano plates (one dimension in the Nano scale). Nano fiber are further divided into nanotubes (hollow Nano fiber) Nano rods (solid Nano fiber) and nanowire (electrically conducting or semiconducting Nano fiber) However, the term Nano-object is not very popular.

Particle: It is a minute piece of matter with define physical boundaries. A particle can move as a unit. This general particle definition applies to Nano-objects.

Nanoparticle: It is a Nano-object with all three external dimensions in the Nano scale. Nanoparticles can have amorphous or crystalline form and their surfaces can act as carriers for liquid droplets or gases.

Nano particulate matter: It refers to a collection of nanoparticles, emphasizing their collective behavior.

Agglomerate: It is a group of particles held together by weak forces such as van der Waals forces, some electrostatic forces, and surface tension. It should be noted that agglomerate will usually retain a high surface-to-volume ratio.

Aggregate: It is a group of particles held together by strong forces such as those associated with covalent or metallic bonds. It should be noted that an aggregate may retain a high surface-to-volume ratio.

Nanotechnology is the construction and use of functional structures designed from atomic or molecular scale with at least one characteristic dimension measured in nanometers. Their size allows them to exhibit novel and significantly improved physical, chemical, and biological properties, phenomena, and processes because of their size. Thus, nanotechnology can be define as research and development that involves measuring and manipulating matter at the atomic, molecular, and supramolecular levels at scales measured in approximately 1–100 nm in at least one dimension. When characteristic structural features are intermediate between isolated atoms and bulk materials in the range of approximately 1–100 nm, the objects often display physical attributes substantially different from those displayed by either atoms or bulk materials. The term "nanotechnology" is by and large used as a reference for both Nano science and nanotechnology especially in the public domain. We should distinguish between Nano science and nanotechnology. Nano science is a convergence of physics, chemistry, materials science, and biology, which deals with the manipulation and characterization of matter on length scales between the molecular and the micron size. Nanotechnology is an emerging engineering discipline that applies methods from Nano science to create products [22].

Nano-coatings. Applications of Nano-coatings are used to stabilize highly explosive materials, making it much safer to handle nuclear and other warheads. **Nano-coatings** can also stabilize biological and chemical agents, making them longer lasting and diversifying their means of delivery. Radio-frequency shield coatings could provide privacy and security to shield buildings and wireless networks from radio waves.

Nano-optics. Nano-engineered negative index met materials are moving stealth technology toward cloaking and invisibility, based on their ability to deflect light away from around an object rather than reflect it. Optical fibers married with Nano wires portend the advent of solar-rechargeable, portable and wearable electronic devices [23].

2.5 Simple Lattices

Although no semiconductors crystallize into simple lattice they form the basis for understanding the more complicated semiconductors structure. We will use them to illustrate some of the more important concepts involved in forming a mathematical description of the crystal lattice.

A concept most useful in specifying the underlying geometry of crystal structure is the Bravais Lattice. A Baravais lattice is the infinite matrix of points which, together with the atoms or molecules situated at the points, form the crystal structure it has the property that arrangement of Lattice sites around any given lattice site is the same as that around any other site mathematically, A Bravais Lattice consist of all poivrts generated by the vectors.

$$R= \sum n_i, a_i, \quad i= 1, 2, 3 \qquad (2.1)$$

Where $a_i$is noncoplanow vectors and n_i take on all integral values. The a_i which generate the Bravais Lattice is known as primitive vectors.

In the simple cubic structure, which has an atom at each corner of a cube of dimension the Bravais Lattice can be determined by three mutually orthogonal vectors.

a_1=ax, a_2 =ay, a_3=az

Where x,y, and z are Cartesian unit vectors. This set of vectors demonstrates the basic symmetry of the structure and it is easy to see that the entire Bravais Lattice can be constructed with these vectors this set of primitive vectors is not unique, however, in defining the simple cubic Brava's can also be used to construct the Lattice as well as an infinite number of other sets.

The body center cubic structure has an atom at each corner of cubic dimension and one at the point determined by the intersection of the cubic body diagonals, another Lattice of interest in semiconductor crystal structure is the hexagonal close packed Lattice. Although not a Baravais Lattice, because the Lattice sites are not equivalent it consist of two interpenetrating simple hexagonal Lattices which are Bravais Lattice. The simple hexagonal Lattice consist of Lattice site at each corn of an equilateral triangle of side a, with an additional set of points on triangle at a distance above the first [24].

2.6 Crystal Structure

The performance semiconductor devices are based on crystalline materials. Crystals are periodic structures made up of identical building blocks. While in "natural" crystals the crystalline symmetry is fixed by nature, new advances in crystal growth techniques are allowing scientists to produce artificial crystals with modified crystalline structure. These advances depend upon being able to place atomic layers with exact precision and control during growth, leading to "low dimensional systems". To define the crystal structure, two important concepts are introduced. The lattice represents a set of points in space forming a periodic structure. The lattice is by itself a mathematical abstraction. A building block of atoms called the basis is then attached to each lattice point yielding the physical crystal structure. To define a lattice one defines three vectors a1, a2, a3, such that any lattice point R_ can be obtained from any other lattice point R by a translation

$$R\_ = R + m1a1 + m2a2 + m3a3 \quad (2.2)$$

Where m1, m2, m3 are integers. Such a lattice is called a Bravais lattice. The crystalline structure is now produced by attaching the basis to each of these lattice points.(Lattice + basis = crystal structure) the translation vectors a1, a2, and a3 are called primitive if the volume of the cell formed by them is the smallest possible. There is no unique way to choose the primitive vectors. It is possible to define more than one set of primitive vectors for a given lattice, and often the

choice depends upon convenience. The volume cell enclosed by the primitive vectors is called the Primitive unit cell. Because of the periodicity of a lattice, it is useful to define the symmetry of the structure. The symmetry is defined via a set of point group operations which involve a set of operations applied around a point. The operations involve rotation, reflection and inversion. The symmetry plays a very important role in the electronic properties of the crystals. For example, the inversion symmetry is extremely important and many physical properties of semiconductors are tied to the absence of this symmetry. As will be clear later, in the diamond structure (Si, Ge, C, etc.), inversion symmetry is present, while in the Zinc Blende structure (GaAs, AlAs, InAs, etc.), it is absent. Because of this lack of inversion symmetry, these semiconductors are piezoelectric, i.e., when they are strained an electric potential is developed across the opposite faces of the crystal. In crystals with inversion symmetry, where the two faces are identical, this is not possible [25].The size of the unit cell and the arrangement of atoms in a crystal may be determined from measurements of the diffraction of X-rays by the crystal.

2.7 X-Ray Powder Diffraction (XRD)

X-ray diffract meters consist of three basic elements: an X-ray tube, a sample holder, and an X-ray detector. X-rays are generated in a cathode ray tube by heating a filament to produce electrons, accelerating the electrons toward a target by applying a voltage, and bombarding the target material with electrons. When electrons have sufficient energy to dislodge inner shell electrons of the target material, characteristic X-ray spectra are produced. These spectra consist of several components, the most common being Kα and Kβ. Kα consists, in part, of Kα1 and Kα2. Kα1 has a slightly shorter wavelength and twice the intensity as Kα2. The specific wavelengths are characteristic of the target material (Cu, Fe, Mo, and Cr). Filtering, by foils or crystal monochrometers, is required to produce monochromatic X-rays needed .for diffraction. Kα1and Kα2 are sufficiently close

in wavelength such that a weighted average of the two is used. Copper is the most common target material for single-crystal diffraction, with CuKα radiation = 1.5418Å. These X-rays are collimated and directed onto the sample. As the sample and detector are rotated, the intensity of the reflected X-rays is recorded. When the geometry of the incident X-rays impinging the sample satisfies the Bragg Equation, constructive interference occurs and a peak in intensity occurs. A detector records and processes this X-ray signal and converts the signal to a count rate which is then output to a device such as a printer or computer monitor. The geometry of an X-ray diffractometer is such that the sample rotates in the path of the collimated X-ray beam at an angle θ while the X-ray detector is mounted on an arm to collect the diffracted X-rays and rotates at an angle of 2θ. The instrument used to maintain the angle and rotate the sample is termed a goniometer [26].

2.8 Fourier Transport Infrared Spectroscopy (FTIR)

Infrared (IR) spectroscopy is a one-photon effect and the photon absorption results in a vibrational motion of a molecule. Infrared spectra originate from the vibrational motions of atoms in chemical bonds within the molecular structure. When a beam of light containing the (IR) radiation interacts with a sample [27]. Fourier spectroscopy" is a general term that describes the analysis of any varying signal into its constituent frequency components, Fourier Transform Infrared Spectroscopy (FTIR) is a reliable method of infrared spectroscopy and offers several analytical opportunities in academic, analytical and forensic labs, FT-IR spectroscopy includes the absorption, reflection, emission, or photoacoustic spectrum obtained by Fourier transform of an optical interferogram [28].

The infrared region (10-14000 cm-1) of the electromagnetic spectrum is divided into three regions: the near-, mid-, and far-IR. The mid-IR (400-4000 cm-1) is the most commonly used region for analysis as all molecules possess characteristic

absorbance frequencies and primary molecular vibrations in this range. Mid-infrared spectroscopy. Methods are based on studying the interaction of infrared radiation with samples. As IR radiation is passed through a sample, specific wavelengths are absorbed causing the chemical bonds in the material to undergo vibrations such as stretching, contracting, and bending. Functional groups present in a molecule tend to absorb IR radiation in the same wave number range regardless of other structures in the molecule, and spectral peaks are derived from the absorption of bond vibrational energy changes in the IR region. Thus there is a correlation between IR band positions and chemical structures in the molecule. In addition to providing qualitative information about functional groups, IR spectra can provide quantitative information, such as the concentration of bacteria in a growth medium. An IR spectrum is measured by calculating the intensity of the IR radiation before and after it passes through a Sample and the spectrum is traditionally plotted with Y-axis units as absorbance or transmittance and the X-axis as wave number units. For quantitative purposes it is necessary to plot the spectrum in absorbance units [29].

FT-IR absorbance spectra follow Beer‘s law, which relates concentration to absorbance as in Eq. (3.1)

$$A_\lambda = L\ {}_\lambda C \qquad (2.3)$$

Where A_λ_= Absorbance, L = Path length, ε_λ = Absorptivity, c = Concentration

Transmittance is not directly proportional to the concentration and is defined in Eq. (2.4)

$$T = \frac{I_S}{I_R}\% \qquad (2.4)$$

Where I_S= Intensity of I_R beam after passing through the sample, I_R= Intensity of IR beam before passing through the sample, T= Transmittance

2.9 Preparation of Nanoparticles

Synthesis of Nano metal and metal oxide (MO) materials involves substantial synthetic ingenuity. Although one can develop a balanced method to the synthesis of Nano materials, there is continually an element of serendipity. A verity of nanomaterial's has been synthesized in the last several decades by the old-style ceramic method, which includes mixing and crushing powders of the constituent oxides, carbonates, and other compounds and heating them at elevated temperatures with transitional grinding when necessary. Some of the important chemical methods of synthesis of oxides are coprecipitation and precursor methods, ion exchange and sol-gel technique, topochemical methods, hydrothermal/solvothermal approaches, combustion technique (self-propagating high- and low-temperature method and solution combustion method), microwave-assisted and liquid-liquid interface method, etc. Some of them have been briefly described in the following sections [30].

2.9.1 Sol – gel method

A sol-gel is a colloidal suspension of solid particles in liquid. In sol gel process, the precursors (starting compound) for preparation of a colloid consist of metal or metalloid element surrounded ligands common precursors for Aluminum oxide include inorganic (containing no carbon) salts such as $AL(NO_3)_3$ and organic compound such as $AL(OC_4H_9)_3$ Transition metal oxide gels include one of the most successful sol-gel products. Transition metal oxide gels are also the basis of several important thin –film ferroelectric such as Barium titanate as well as semiconducting V_2O_5 films, electrochromic W_3O films, or particles. Recently transition metal oxide gels have been used extensively in chemical routes to high-temperature superconducting ceramic. Sol-gel methods have been recognized as interesting procedures to prepare catalysts. The versatility of the sol-gel techniques allows control of the texture, composition, homogeneity and structural properties

of solids, and makes possible production of tailored materials such as dispersed metals, oxidic catalysts and chemically modified supports [31]. The sol-gel process has emerged as a standard production technique for engineering materials. Unlike the more conventional methods, the sol-gel technique allows for preparing porous materials in a "one-pot" with a homogeneous distribution of components on the atomic scale through a technology of low temperature synthesis and with full control of the finite product microstructure. The sol-gel chemistry involves two distinct phases: solution and gelation: a sol is a colloidal suspension of solid particles, whereas a gel is an interconnected network of solid phase particles that form a continuous entity throughout a secondary, usually liquid, phase. The advantages of sol-gel methods include: high yield, low operation temperatures, and low production costs. Even more, the sol-gel synthesis resulted in possessing unique features, namely the possibility of control over the physico–chemical properties of the resulting compounds through a careful variation of the parameters affecting the various synthesis steps. The sol-gel process is generally considered as "soft chemistry" in contrast to more classical industrial techniques for glass and ceramic manufacturing, which require very high temperatures. Nowadays, the term 'sol-gel' is used more broadly as covering the synthesis of solid materials, such as metal oxides, from solution-state precursors. The development of technologically advanced synthesis routes that overcome the obstacles that are encountered in the most traditional procedures allowed the sol-gel technique to become a unique tool in the design of metal oxides with controlled architecture. [32].

2.9.2 Chemo Thermal method

The method of precipitation from solution under hydrothermal conditions is one among the soft chemical routes; at comparatively low temperatures, current attention is engaging for the direct preparation of crystalline ceramic particles.

Generally, hydrothermal reactions were conducted in an autoclave at temperatures between the boiling and significant points of water (100–374 C) at raised pressure (up to ca. 15 MPa). Recently, the ultra-fine powders of various ceramics nanoparticles are prepared by the hydrothermal techniques. Results have excellent consistency and particle uniformity. Important benefits of synthesis techniques under hydrothermal conditions over alternative chemical synthesis are as follows: It is simple to regulate morphology and particle size by various synthesis conditions. Next numerous materials are continually prepared directly within the anticipated crystalline state at low temperature. Lastly, an elemental oxidation state material may be produced in a very sol form [33].

2.10 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, its Greek word, (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 [34]. 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.[1] 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 [35].

2.10.1 Ultraviolet-Visible Spectroscopy (UV-Vis)

Ultraviolet and Visible Spectroscopy is absorption spectroscopy uses electromagnetic radiations between 190 nm to 800 nm and is divided into the ultraviolet (UV, 190-400 nm) and visible (VIS, 400-800 nm) regions. Since the absorption of ultraviolet or visible radiation by a molecule leads transition among electronic energy levels of the molecule, it is also often called as electronic

spectroscopy. When radiation interacts with matter, a number of processes can occur, including reflection, scattering, absorbance, Fluorescence/phosphorescence (absorption and reemission), and photochemical reaction (absorbance and bond breaking). In general, when measuring UV-visible spectra, we want only absorbance to occur. Because light is a form of energy, absorption of light by matter causes the energy content of the molecules (or atoms) to increase. The total potential energy of a molecule generally is represented as the sum of its electronic, vibrational, and rotational energies [36].

In the UV-Vis spectral range transitions between electronic energy levels can be observed, which determine the absorption bands in the UV-Vis region. An electron is excited when the frequency of the incident electromagnetic radiation is the same as the difference of energy between two electronic states. This difference of energy depends on the electronic structure of the molecule and of its "environment". For a transition to happen after absorption of radiation it is necessary to have a dislocation of charge and some rules [37].

2.11Optical Properties

Optical methods are very useful for the quantitative determination of the electronic band structure of martial. In this study optical absorbance, reflectivity, transmission and refraction provide the way to determine the dielectric constant of sample, which is related to the band structure. The dielectric constant is related to the optical conductivity. The term "optical conductivity" means the electrical conductivity in the presence of an alternating electric field [38].

2.11.1 Absorption

The intensity of the net absorbed radiation is dependent on the character of the medium as well as the path length within. The intensity of transmitted or non-absorbed radiation continuously decreases with distance x that the light traverses:

$$I_T = I_o e^{-\beta x} \qquad (2.5)$$

Where is the intensity of the non-reflected incident radiation and ß the absorption Coefficient (in mm^{-1}), is characteristic of the particular material; furthermore, varies with wavelength of the incident radiation. The distance parameter x is measured from the incident surface into the material. Materials that have large values are considered highly absorptive [38].

2.11.2 Transmission

The phenomena of absorption, reflection, and transmission may be applied to the passage of light through a transparent solid. For an incident beam of intensity I_0 that impinges on the front surface of a specimen of thickness l and absorption coefficient, the transmitted intensity at the back face I_T is

$$I_T = I_o(1 - R)^2 e^{-\beta l} \quad (2.6)$$

Where R is the reflectance; for this expression, it is assumed that the same medium exists outside both front and back faces. Thus, the fraction of incident light that is transmitted through a transparent material depends on the losses that are incurred by absorption and reflection. Again, the sum of the reflectivity R, absorptivity A, and transmissivity T, is unity according to Equation (2.2). Also, each of the variables R, A, and T depends on light wavelength. This is demonstrated the transmission [38, 39].

2.11.3 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

$$R = \frac{I_R}{I_o} \quad (2.7)$$

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

$$R = \left(\frac{n_2 - n_1}{n_{2+} n_1}\right)^2 \quad (2.8)$$

Where n_1 and n_2 are the indices 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

$$R = \left(\frac{n_s - 1}{n_s + 1}\right)^2 \quad (2.9)$$

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 [40, 41, and 38].

2.11.4 Absorption Coefficients

Much of the information about the properties of materials is obtained when they interact with electromagnetic radiation. When a beam of light (photons) is incident on a material, the intensity is expressed by the Lambert-Beer- law as Equation (2.4). If this condition for absorption is met, it appears that the optical intensity of the light wave, (I), is exponentially reduced while traveling through the film. If the power that is coupled into the film is denoted by I0, gives the transmitted intensity that leaves the film of thickness d.(α) Is called "absorption coefficient". From Equation (2.9) it follows that

$$\alpha = -\frac{1}{d} \operatorname{Lin}\left(\frac{I}{I_o}\right) \quad (2.10)$$

It is clear that α must be a strong function of the energy hν of the photons. For hν<Eg (direct), no electron hole pairs can be created, the material is transparent and α is small. For hν ≥ Eg (direct), absorption should be strong. All mechanisms other than the fundamental absorption may add complications (e.g. "sub band gap

absorption" through exactions), but usually are not very pronounced. Optical transmission measurements were carried out to determine the film thickness, the wavelength dependence of the refractive index and optical absorption coefficient. The optical constants were determined from the optical transmission measurements using the method described by Swanepoel [42].

The transparent substrate has a thickness several orders of magnitude larger than (d) and has index of refraction (n) and absorption coefficient ($\alpha = 0$). The index of refraction for air is taken to be $n_0 = 1$. In the transparent region ($\alpha = 0$) the transmission is determined by n and s through multiple reflections. In the region of weak absorption α is small and the transmission begins to decrease. In the medium absorption region α is large and the transmission decreases mainly due to the effect of α. In the region of strong absorption, the transmission decreases drastically due almost exclusively to the influence of α. If the thickness d is uniform, interference effects give rise to the spectrum [40, 43 and 44].

2.11.5 Refractive Index

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 or

$$n = \frac{c}{\upsilon} \qquad (2.11)$$

The magnitude of n (or the degree of bending) will depend on the wavelength of the light. This effect is graphically demonstrated by the familiar dispersion or se parathion of a beam of white light into its component colors by a glass prism. Each color is deflected by a different amount as it passes into and out of the glass, which results in the separation of the colors. Not only does the index of refraction affect the optical path of light, but also, as explained shortly, it influences the fraction of incident light that is reflected at the surface. Just as Equation (2.10) defines the

magnitude of c, an equivalent expression gives the velocity of light in a medium as

$$\nu = \frac{1}{\sqrt{c\mu}} \tag{2.1}$$

Where ν and are, respectively, the permittivity and permeability of the particular substance. From Equation (2.12), we have

$$n = \frac{c}{\nu} = \frac{\sqrt{\epsilon\mu}}{\sqrt{\epsilon_o \mu_o}} = \sqrt{\epsilon_r\ \mu_r} \tag{2.13}$$

Where and are the dielectric constant and the relative magnetic permeability, respectively. Because most substances are only slightly magnetic, and

$$n \cong \sqrt{\epsilon_r} \tag{2.14}$$

Thus, for transparent materials, there is a relation between the index of refraction and the dielectric constant [45].

2.12 Conductivity

How superconductivity emerges from a strongly correlated normal state is one of the most important problems in the field of strongly correlated electron systems. One of the most powerful bulk probes of carrier dynamics is the optical conductivity. For example, the changes of the integral of the optical conductivity upon super fluid condensation [45, 46] can be linked to the kinetic energy change, and therefore gives a direct probe of the origin of the condensation energy. Much effort was recently devoted to measure this kinetic energy difference between normal and superconducting state [3–5] using sum rule, by integrating careful measurements of the optical conductivity up to large enough cutoff of the order of 1 eV in both normal and superconducting state. It has been shown that in the over doped regime, the absolute value of the kinetic energy decreases, while in the under doped regime the system gains kinetic energy. These surprising

experimental results have been the subject of lively controversy [42, 43, and 47] but have by now been obtained by at least three experimental groups. It is well known that the approach to a Mott transition causes a dramatic reduction of the low energy spectral optical weight. In this paper we address the more refined issue of how the difference between the optical conductivity in the normal and superconducting state, and the consequent difference in kinetic energy are affected by the proximity to the Mott transition.

2.12.1 Optical Conductivity

The optical conductivity of an electronic model governed by a Hamiltonian H consisting of a band with dispersion ε_k and gauge invariant interaction terms obeys the f-sum rule [49, 50]

$$\int_0^\infty \delta(x)d(x) = -\frac{\pi e^2}{4}\langle T\rangle \qquad (2.15)$$

The conductivity $\hat{\delta}$ is given by the current-current correlationfunction obtained by Peierls substitution coupling vector potential A to the Hamiltonian H = (j =$\delta H/\delta A$, T =$\delta^2 H/\delta A^2$) and the bracket $\langle..|..\rangle$denotes thethermal average with respect to H. T is given by$T = -\sum_{k,\delta,\alpha=(x,y)}[\frac{d^2\varepsilon_k}{dk^2}]n_{k\alpha}$. In the Hubbard modelnk is the electron momentum distribution function while in the t-J model nk is the momentum distribution of the electron operator projected to the subspace without the double occupancy. For model lattice Hamiltonians with nearest neighborhopping, T is the kinetic energy operator. The experimental inference of $\langle T\rangle_{super} - \langle T\rangle_{normal}$is thereforeextremely important for understanding the mechanismof high temperature superconductivity. Here $\langle T\rangle_{super}$and $\langle T\rangle_{normal}$are kinetic energy in superconductingand normal state, respectively. Notice that this quantity requires the evaluation of $\langle T\rangle_{normal}$ below the superconductingtransition, a quantity which is well defined andcan be calculated only in a mean field framework. Onlymean field theory provides the possibility of defining the

continuation of the normal state below Tc. This is the procedure done in BCS theory, and our approach represents the extensions of these ideas to correlated systems. Experimentally it is estimated by an extrapolation procedure from the normal state data as described [48] which necessarily involves additional approximations. In the Hubbard model, the optical conductivity has two contributions: a low energy contribution due to a motion of holes and a high energy feature at an energy scale of order U due to transitions to the upper Hubbard band involving doubly occupied sites. Hence the operator on the right hand side of eq. (2.14) is the sum of the two different contributions which cannot be separated. It has been shown in ref. [49] that entering the superconducting state results in a reduction of kinetic energy of the Hubbard model, in stark contrast with the BCS theory where the kinetic energy increases upon entering the superconducting state. The reduction of the kinetic energy was also found in the t-J model treated within the separately approximation [50, 52]. Here we use the t-J model to evaluate separately the two physically different contributions, motion of holes and super exchange contribution. This allows us to make direct contact with optical experiments which measure the kinetic energy of the holes since the cutoffs which are used are such that the transitions into the upper Hubbard band, or the inter band transitions, are not included. Used the Cluster Dynamical Mean Field method on a plaquette. This approach has been used by several groups [45, 51] to elucidate several qualitative aspects of the physics of the cup rates such as their phase diagram [53, 54, 55, and 59] and the variation of the spectral function and the electron lifetime along the Fermi surface [56 to 59]. Show that this approach clearly captures the striking feature that doping induces a sign change of the difference between normal state and the superconducting state kinetic energy.

2.12.2 Electrical Conductivity

The electrical conductivity of foods is of relatively recent interest to researchers. Little literature exists on this topic, since electrical conductivity was not critical in food applications prior to the late 1980s. Recent attention on electrical resistance heating of foods and pulsed electrical field in pasteurizing foods has necessitated the need for information on the electrical conductivity of foods. Electrical conductivity is a critical parameter for both the Ohms heating and pulsed electrical field processes. Knowledge of a food's electrical conductivity while under Ohmic heating or pulsed electrical field conditions are essential for process design. Electrical conductivity is the reciprocal of resistance through a unit cross-sectional area. A over a unit distance L, or the reciprocal of resistivity.

$$\sigma = (\frac{L}{AR}) \tag{2.16}$$

Or

$$\sigma = \left(\frac{I}{V}\right)\left(\frac{L}{A}\right) \tag{2.17}$$

where, A is the area of cross section of the sample (m^2), I is the current through the sample (A), L is the electrode gap or length of sample (m), R is the resistance of the sample (Ω), V is the voltage across the sample (V), and σ is the specific electrical conductivity (S/m).The definition above has been used to design experiments for measuring the electrical conductivity of foods. Standard methods and commercial conductivity meters are available for electrical conductivity measurements. Some researchers have used a commercial electrical conductivity meter (YSI model 30, YSI Incorporated, Yellow Springs, OH) to determine the conductivity of various food groups. In addition to temperature, the electrical conductivity of foods is strongly affected by ionic content, moisture mobility, and physical structure, as well as the heating process. Some researchers have studied the changes in electrical conductivity of foods during Ohmic and conventional heating. They concluded that the behavior of electrical conductivity during both

treatments was different. As a result, a device was developed to determine the electrical conductivity of foods under Ohmic or conventional heating conditions. The device consists of a cylindrical sample chamber made of steel tube that contains a Teflon sleeve inside with a thermocouple opening at the center and rhodium plated stainless steel electrodes at both ends. The tube is fitted with a metallic jacket with a thermocouple opening and an inlet and outlet for circulating heat exchange fluids. A T-type copper-constantan, Teflon® coated thermocouple, with a compression fitting, is used to measure the temperature at the geometric center of the sample. Voltage and current transducers are used to measure the voltage across and the current through the samples. Experimental data on electrical conductivity measured for several food groups have been expressed in mathematical relationships. These models are useful in estimating the electrical conductivity of food materials. Some are presented in the following. Researchers have reported that electrical conductivity is a linear function for temperature and presented the following model to predict the conductivity of solid foods:

$$\sigma_T = \sigma_{P25} [\, 1 + k\,(T - 25)] \qquad (2.18)$$

Where σ_T= electrical conductivity (S/m) at any temperature T (°C), σ_{p25} = electrical conductivity of particulate at 25°C, and K = temperature compensation constant.

In this section to observe the electrical conductivity of various pure liquids, ionic solids, metals and aqueous solutions using a conductivity probe and LED conductivity indicator [60].

- **Electrical conductivity of molten compounds**: Ionic compounds, in the solid state, are composed of ions that are not free to move. The ions become mobile after the compound is heated to its melting temperature, becomes fluid, and the ions are freed from their positions in their crystalline lattice. The large number

of mobile ions then causes the molten compounds to become good electrical conductors. Covalent compounds do not conduct electricity even when molten because the resultant mobile particles are neutral molecules. Their movement cannot be used to carry an electric charge [60, 61].

- **Electrical conductivity of metallic solids:** Metals conduct electricity in the solid state because the valence electrons of the atoms generate a mobile "sea" of electrons.
- **Electrical conductivity of compounds in aqueous solutions**: Water is a good solvent for many covalent and ionic compounds. Substances that dissolve in water to form electrically conducting solutions are electrolytes.

Substances that dissolve to form no conducting solutions are known as non-electrolytes. All soluble ionic compounds are electrolytes. Water molecules are able to pull the positively and the negatively charged ions away from each other in the solid state, and carry them along to be distributed throughout the solution[61].

$$NaCl(S) \xrightarrow{H_2O} Na^+ + Cl^-(aq) \qquad (2.19)$$

Most covalent compounds are nonelectrolytes. When dissolved, molecules of covalent compounds are separated from each other by water molecules. The separated molecules are not charged species and will not conduct electricity. However, some covalent compounds actually react with water to form ions. The process of forming ions in this manner is known as ionization [61].

$$HCl(g) + H_2O\ (1) \ \rightarrow \ H_3O^+(aq) + Cl^-(aq) \qquad (2.20)$$

If all dissolved molecules react to form ions, the solution becomes strongly conducting and the solutes are referred to as strong electrolytes. If only a fraction of the dissolved molecules ionizes the solution becomes weakly conducting and the compound is known as a weak electrolyte [61].

$$HC_2H_3O(aq) + H_2O(1)H_3O^+(aq) + C_2H_3O_2^-(aq) \quad (2.21)$$

2.13 physics of Thin Films

Thin films have become increasingly important in physics and engineering due to their uses in semiconductors, mirrors, lens coatings, and many other applications. In industry, there are applications in areas including optical electronics, communications, a variety of coatings, energy generation, and energy conservation1. Thin Films are also heavily used in microelectronics and semiconductor devices. The thin film industry is growing as quickly as scientist and engineers can find applications for them. This field will become even more vibrant as we try to make appliances and systems smaller and thinner. One of the beauties of thin film physics is that it is a very multidisciplinary subject. Through thin films we can explore areas in solid state physics, surface science, chemistry, vacuum science, crystal growth, and still more. The reason for this is that we are dealing with layers from millimeters of material to nanometers and beyond. With such small amounts of material, the structure and material properties become very important. Questions arise about discrepancies between effects in the thin films and effects in bulk properties of the same material. By investigating these abnormalities. After thin films were produced, the thickness is an important quality of thin films; it became necessary to find a way to measure the thickness of the films so that BYU—Idaho can begin developing thin films with specific applications in mind. Measuring the thickness will also be important to ensure that the deposition method which is used can produce films with consistent properties and quality [62].

2.14 Semiconductor Materials

Solid-state materials can be categorized into three classes - insulators, semiconductors, and conductors. A semiconductor usually defined rather loosely as a material with electrical resistivity lying in the range of 10^{-2} _10^{9} o cm.

alternatively, it can be defined as a material whose energy gap for electronic excitations lies between zero and about 4 electron volts (eV). Materials with zero band gap are metals or semimetals, while those with an energy gap larger than 3 eV are more frequently known as insulators. There are exceptions to these definitions. For example, terms such as semiconducting diamond (whose energy gap is about 6 eV) and semi-insulating GaAs (with a 1.5 eV energy gap) are frequently used. GaN, which is receiving a lot of attention as optoelectronic material in the blue region, has a gap of 3.5 eV. Semiconductors occur in many different chemical compositions with a large variety of crystal structures. They can be elemental semiconductors, such as Si, carbon in the form of C_{60} or nanotubes and selenium (Se) or binary compounds such as gallium arsenide (GaAs). Many organic compounds, e. g. polyacetylene (CH)*n*, are semiconductors. Some semiconductors exhibit magnetic (Cd1_*x*Mn*x*Te) or ferroelectric (SbSI) behavior. Others become superconductors when doped with sufficient carriers (GeTe and $SrTiO_3$) [63].

Based on the energy band model, we can now understand the differences among semiconductors, insulators, and conductors. A semiconductor has a nearly filled valence band and a nearly empty conduction band separated by a band gap as illustrated in Fig. 2–1a. The band diagram of an insulator is similar to that of a semiconductor except for a larger E_g, which separates a completely filled band and a completely empty band (see Fig. 2–1b). Totally filled bands and totally empty bands do not contribute to current conduction, just as there can be no motion of liquid in totally filled jars and totally empty jars. A conductor has a quite different energy band diagram. As depicted in Fig. 2–1c, a conductor has a partially filled band. This is the conduction band of the conductor and it holds the conduction electrons. The abundance of the conduction electrons makes the resistivity of a typical conductor much lower than that of semiconductors and insulators.

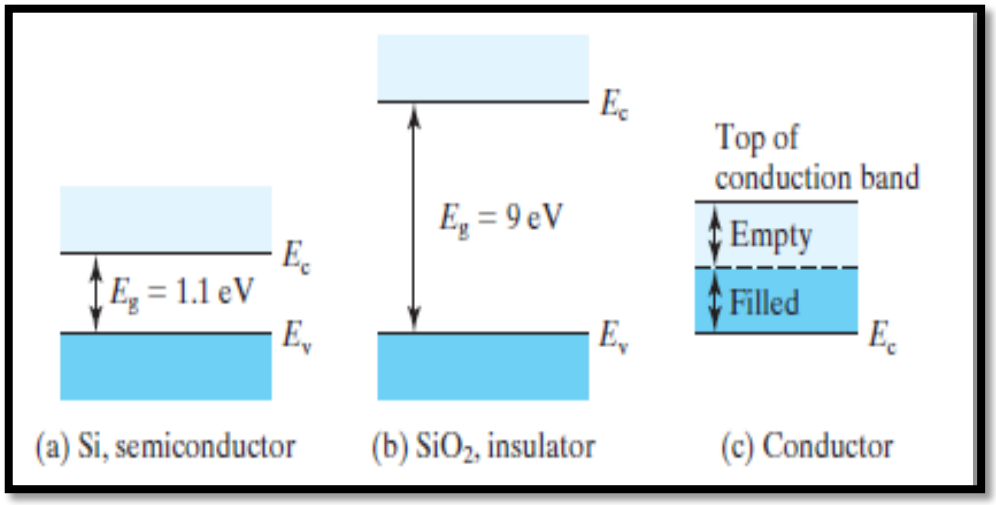

Figure (2.1): Energy band model semiconductors, insulators, and conductors

The elemental solids with odd atomic numbers (and therefore odd numbers of electrons) such as Au, Al, and Ag are conductors. Elements with even atomic numbers such as Zn and Pb can still be conductors because a filled band and an empty band may overlap in energy, thus leaving the combined band partially filled. These elements are known as semimetals. An insulator has a filled valence band and an empty conduction band that are separated by a larger E_g. However, even diamond, with $E_g \sim 6$ eV exhibits semiconductor characteristics. It can be doped N type and P type, and electronic devices such as rectifiers and transistors have been made with diamond. One may say that semiconductors differ from insulators in that semiconductors can be made N type or P type with low resistivity through impurity doping. This characteristic of the semiconductors is very important for device applications [64].

2.14.1 Electron movement in a crystal

Because the thermal energy causes the electron to jump to the higher energy level of the conduction band, it leaves behind a “hole”, that is, a place devoid of an electron. Now that the hole exists, it provides a place for another electron to “fall into”. The higher the temperature, the greater the number of freed electrons and the greater the number of corresponding holes. We now have thermally-induced

electron movement. We can also look at this from the opposing perspective, namely that we have an equal magnitude but opposite direction "hole flow". The electron moves into this hole it fills it in a process called electron-hole recombination. The movement of electrons as a movement of negative charge, then the movement of holes can be thought of as a movement of positive charge. We can say that the electron is the carrier of negative charge while the hole is the carrier of positive charge [65].

2.14.2 Energy Band Diagram

Fig (2.2) is the energy band diagram of a semiconductor; it shows the top edge of the valence band, denoted by Ev, and the bottom edge of the conduction band, denoted by Ec. The difference between Ec and Ev is the band gap energy or energy gap, Eg. Clearly, Eg= Ec–Ev. For silicon, the energy gap is about 1.1 eV. The electrons in the valence band are those associated with the covalent bonds, and the electrons in the conduction band are the conduction or mobile electrons. The band-gap energy has strong influence on the characteristics and performance of optoelectronic devices, the band-gap energy can be precisely tuned to desired values. This is widely practiced for optical semiconductor devices .The band-gap energy can be determined by measuring the absorption of light by the semiconductor as a function of the photon energy, hv. The light is strongly absorbed only when hv is larger than E_g. The absorbed photon energy is consumed to create an electron–hole pair. As hv is reduced below E_g, the specimen becomes transparent to the light. E_g can be determined by observing this critical hv [63].

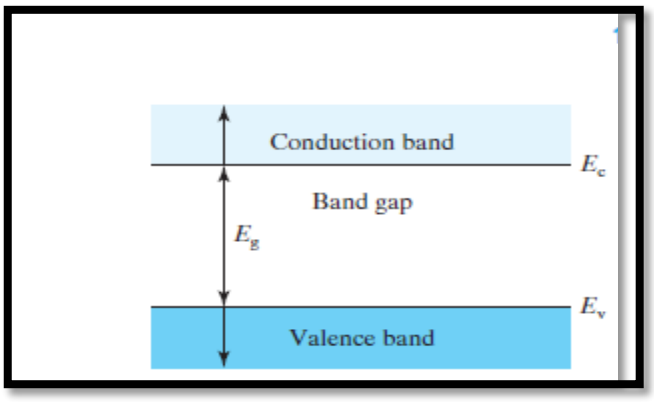

Figure 2.2 the energy band diagram of semiconductor

2.14.3Type of Semiconductor materials

- **Metal Oxides**

Although most oxides are good insulators, some, such as CuO and Cu_2O, are well-known semiconductors. Since cuprous oxide (Cu_2O) occurs as a mineral, it is a classic semiconductor whose properties have been studied extensively. In general, oxide semiconductors are not well understood with regard to their growth processes, so they have limited potential for applications at present. One exception is the II–VI compound zinc oxide (ZnO), which has found application as a transducer and as an ingredient of adhesive tapes and sticking plasters. However, this situation has changed with the discovery of superconductivity in many oxides of copper. The semiconductor lanthanum copper oxide (La_2CuO_4), which has a band gap of about 2 eV Carriers in the form of holes are introduced into La_2CuO_4 when trivalent lanthanum (La) is replaced by divalent barium (Ba) or strontium (Sr) or when an excess of oxygen is present. When sufficient carriers are present the semiconductor transforms into a superconducting metal [63].

- **Layered Semiconductors**

Semiconducting compounds such as lead iodide (PbI_2), molybdenum disulfide (MoS_2) and gallium selenide (GaSe) are characterized by their layered crystal structures. The bonding within the layers is typically covalent and much stronger

than the van der Waals forces between the layers. These layered semiconductors have been of interest because the behavior of electrons in the layers is quasi-two-dimensional. Also, the interaction between layers can be modified by incorporating foreign atoms between the layers in a process known as.

- **Organic Semiconductors**

Many organic compounds such as polyacetylene [$(CH_2)n$] and polydiacetylene are semiconductors. The advantage of organic over inorganic semiconductors is that they can be easily tailored to the applications. For example, compounds containing conjugate bonds such as –C=C–C= have large optical nonlinearities and therefore may have important applications in opt-electronics. The band gaps of these compounds can be changed more easily than those of inorganic semiconductors to suit the application by changing their chemical formulas. Recently new forms of carbon, such as C_{60} (fullerene), have been found to be semiconductors. One form of carbon consists of sheets of graphite rolled into a tube of some nanometers in diameter known as nanotubes. These carbon nanotubes and their "cousin", BN nanotubes, hold great promise as nanoscale electronic circuit elements. They can be metals or semiconductors depending on their pitch [63].

2.14.4 Doping in Semiconductors materials

To introduce electrons and holes in a semiconductor the material is doped with dopants. The electrons (holes) created by the dopants are used in device design. Donors are dopants which can donate an electron to the conduction band and acceptors are dopants which can accept an electron from the valence band and thus create a hole. The donor atom replaces a host atom in the crystal and contains one (or more) extra electrons in its outer shell. The donor atom could be a pentavalent atom in Si or a Si atom on a Ga site in GaAs. Focusing on the pentavalent atom in Si, four of the valence electrons of the donor atom behave as they would in a Si atom; the remaining fifth electron now sees a positively charged ion to which it is

attracted, as shown in fig (2.3). The ion has a charge of unity and the attraction is simply Coulombic suppressed by the dielectric constant of the material. The problem is now that of the hydrogen atom case, except that the electron mass is the effective mass at the band edge. The attractive potential is

$$U(r) = \frac{-e2}{4\pi\epsilon r} \qquad (2.21)$$

Where ε is the dielectric constant of the semiconductor; i.e. , the product of ε_0 and the relative dielectric constant [25].

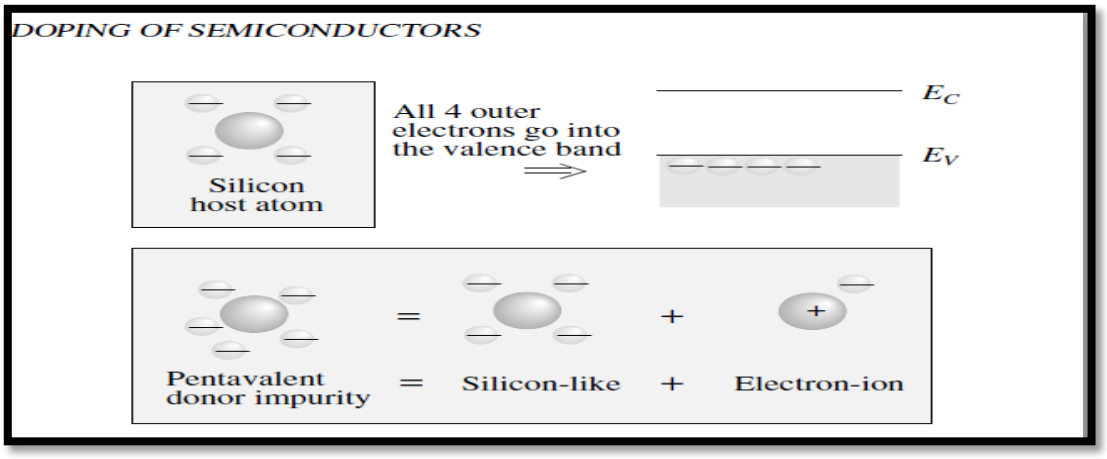

Figure (2.3): A schematic showing the approach we can take to understand donors in semiconductors

2.14.5 Semiconductor Devices

All the electronic devices are based on semiconductors. Semiconductor structures have also provided the stages for exploring questions of fundamental physics. As technology advances the number of semiconductors that are used in technology steadily increases. Indeed many innovations have arisen as a result of using new materials and their hetero structures. Thus while Si, GaAs and InP have been most widely used, other materials like InAs, GaN, InN etc. are finding important uses as well. It is important to recognize that the ability to examine fundamental physics issues and to use semiconductors in state of the art device technologies depends critically on the purity and perfection of the semiconductor crystal. Semiconductor structures can operate at their potential only if they can be grown with a high

degree of crystallinity and if impurities and defects can be controlled. For high structural quality it is essential that a high quality substrate be available. This requires growth of bulk crystals which are then sliced and polished to allow epitaxial growth of thin semiconductor regions including hetero structures [65].

2.14.6 P-n Junction Diodes

The basic device physics, the ideal static and dynamic characteristics, the operation principles, and practical applications of p-n junctions will be described. A p-n junction diode is known as a minority carrier device since the current conduction is controlled by the diffusion of minority carriers (i.e., electrons in the p region and holes in the region) in a p-n junction diode. A p-n junction diode can be fabricated by doping the semiconductor material with opposite doping impurities (i.e., acceptor or donor impurities) to form the p and n regions of the diode. If a p-n junction is formed on the same semiconductor it is referred to as a p-n homo junction diode. On the other hand, if a p-n junction is formed using two semiconductor materials of different band gaps and with opposite doping impurities, then it is referred to as a p-n hetero-junction diode. The p-n junction plays an important role as the basic device structure for fabricating a wide variety of electronic and photonic devices. For example, p-n junction structures have been used in fabricating switching diodes, diode rectifiers, solar cells, light emitting diodes (LEDs), laser diodes (LDs), photo detectors, bipolar junction transistors (BJTs), hetero-junction bipolar transistors (HBTs), junction field-effect transistors (JFETs), metal–semiconductor field-effect transistors (MESFETs), high-electron mobility transistors (HEMTs), tunnel diodes, multi quantum well (MQW) and super lattice (SL) devices. The p-n hetero junctions can be formed from a wide variety of elemental and compound semiconductors suchas n-Si/p-SiGe, n-ZnSe/p-GaAs, p-AlGaAs/n-GaAs, p-Ge/n-GaAs, n-InGaAs/n- InP, p-InAlAs/n-

InGaAs, p-GaN/n-InGaN, and p-AlGaN/n-InGaN semiconductor hetero junction devices[66].

If we were to create a region of N material abutting a region of P material in a single crystal, an interesting situation occurs. Assuming the crystal is not at absolute zero, the thermal energy in the system will cause some of the free electrons in the N material to "fall" into the excess holes of the adjoining P material. This will create a region that is devoid of charge carriers (remember, electrons are the majority charge carrier in N material while holes are the majority charge carrier in P material). In other words, the area where the N and P materials abut is depleted of available electrons and holes, and thus we refer to it as a depletion region. This is depicted in Fig (2.4).The excess electrons of the N material are denoted by minus signs while the excess holes of the P material are denoted with plus signs. At the interface, the free electrons have recombined with holes. When an electron recombines, it leaves behind a positive ion in the N material (shown here as a circled plus sign) and produces a negative ion in the P material (shown as a circled minus sign [65].

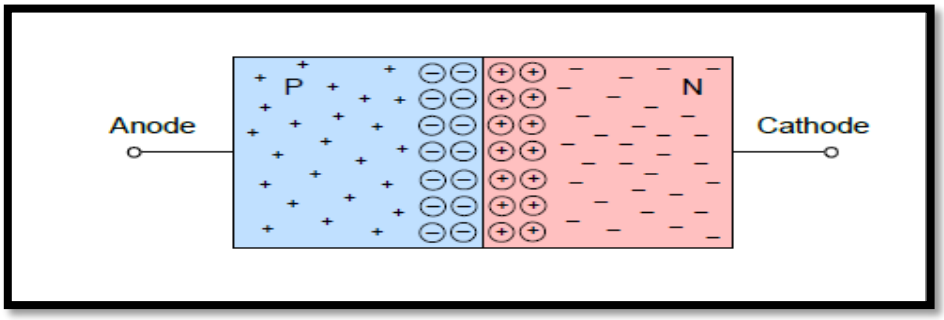

Figure (2.4) : PN junction

We now have a region depleted of charge carriers and this will have an effect on the ability to establish a flow of current through the device. We have, in essence, created an energy hill that will need to be overcome. To understand the concept of the energy hill, recall that in the prior chapter it was discovered that doping an intrinsic crystal would shift the Fermi level. For N material, the Fermi level is

shifted up, toward the conduction band. In contrast, for P material the Fermi level is shifted down, nearer to the valence band. When two dissimilar regions adjoin, as in the case here, the energy bands will adjust so that the Fermi levels are consistent. Effectively, these cause the bands of the P material relative to the bands of the N material. The interface between the two appears as a hill, and this is the aforementioned depletion region. This situation is depicted graphically in Fig (2.5) Compare this energy diagram to the energy diagrams for N material and P material presented in the prior chapter. By simply aligning the Fermi levels, it should be clear how we arrive at the new energy diagram. We now have a region depleted of charge carriers and this will have an effect on the ability to establish a flow of current through the device. We have, in essence, created an energy hill that will need to be overcome. For N material, the Fermi level is shifted up, toward the conduction band. In contrast, for P material the Fermi level is shifted down, nearer to the valence band. When two dissimilar regions adjoin, as in the case here, the energy bands will adjust so that the Fermi levels are consistent. Effectively, this causes the bands of the P material relative to the bands of the N material. The interface between the two appears as a hill, and this is the aforementioned depletion region. This situation is depicted graphically in Fig (2.5) Compare this energy diagram to the energy diagrams for N material and P material presented in the prior chapter. By simply aligning the Fermi levels, it should be clear how we arrive at the new energy diagram [65].

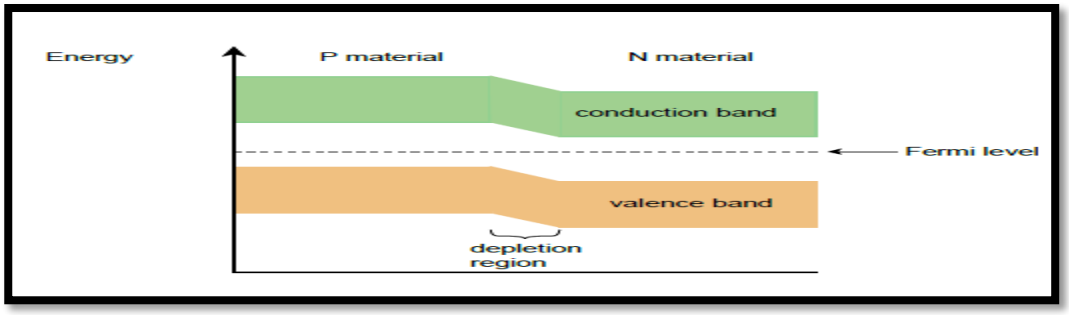

Figure 2.5 Energy bands in PN junction.

Now let's consider what happens if we were to connect this device to an external voltage source as shown in Fig 2.6. Obviously, there are two ways to orient the PN junction with respect to the voltage source. This version is termed forward-bias.

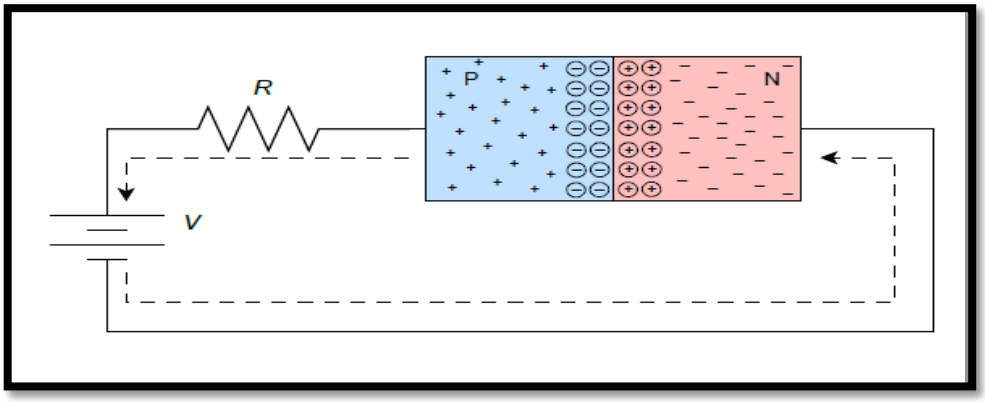

Figure (2.6) PN junction connected to external voltage source

2.14.6 .1 Forward--Bias

The dotted line of Fig (2.7) shows the direction of electron flow (opposite the direction of conventional flow). First, electrons flow from the negative terminal of the battery toward the N material. In N material, the majority carriers are electrons and it is easy for these electrons to move through the N material. Upon entering the depletion region, if the supplied potential is high enough, the electrons can diffuse into the P material where there are a large number of lower energy holes. From here, the electrons can migrate through to the positive terminal of the source; completing the circuit (the resistor has been added to limit maximum current flow). The "trick" here is to assure that the supplied potential is large enough to overcome the effect of the depletion region. That is, a certain voltage will be dropped across the depletion region in order to achieve current flow. This required potential is called the barrier potential or forward voltage drop. The precise value depends on the material used. For silicon devices the barrier potential is usually estimated at around 7 volts. For germanium devices it is closer to 3 volts while LEDs may exhibit barrier potentials in the vicinity of 1.5 to 3 volts, partly

depending on the color. Another way of thinking about this is that the addition of the voltage source “flattens” the inherent energy hill of the junction. Once the applied forward-bias voltage is at least as big as the hill, current can flow easily [65].

2.14.6.2 Reverse--Bias

If the voltage source polarity is reversed in Fig (2.7), the behavior of the PN junction is altered radically. In this case, the electrons in the N material will be drawn toward the positive terminal of the source while the P material holes will be drawn toward the negative terminal, creating a small, short-lived current. This has the effect of widening the depletion region and once it reaches the supplied potential, the flow of current ceases. In essence, we have increased the size of the energy hill. Further increases in the source voltage only serve to make the situation worse. The depletion region simply expands to fill the void, so to speak. Ideally, the PN junction acts like an open circuit with an applied reverse-bias voltage. This asymmetry in response to a supplied potential turns out to be extra ordinarily useful. Perhaps the simplest of all semiconductor devices is the diode. In its basic form a diode is just a PN junction. It is a device that will allow current to pass easily in one direction but prevent current flow in the opposite direction. Shockley Equation .We can quantify the behavior of the PN junction through the use of an equation derived by William Shockley.

$$I = I_S \left(e^{V_D q n k T} - 1\right) \qquad (2.22)$$

Where

I is the diode current

I_S is the reverse saturation current

V_D is the voltage across the diode

q is the charge on an electron, 1.6E-19 Coulombs

$n$is the quality factor (typically between 1 and 2)

$k$is the Boltzmann constant, 1.38E-23 joules/Kelvin

T is the temperature in Kelvin

At 300 Kelvin, *q*/*kT* is approximately 38.6. Consequently, for even very small forward (positive) voltages, the "-1" term can be ignored. Also, *IS* is not a constant. It increases with temperature, approximately doubling for each 10 C° rise (more on this in a moment). If we plot the Shockley equation using typical values for a silicon device, we arrive at the curve shown in Fig 2.7. This plots the junction current as a function of the forward (positive) device voltage. It is a representative curve only. While all silicon diodes will exhibit this same general shape, the precise value of current for a specific voltage will vary depending on the device design [65].

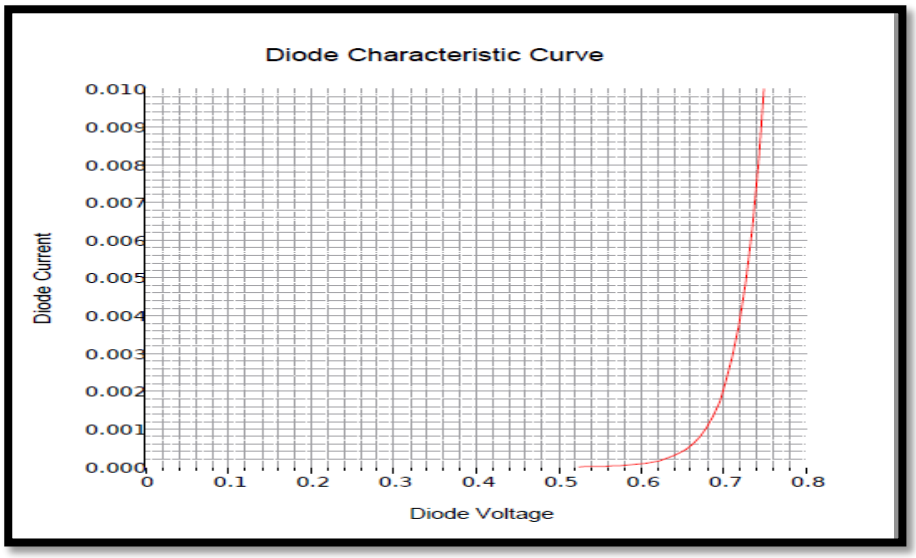

Figure 2.7 Characteristic curve of forward-biased silicon PN junction.

For potentials below about 5 volts, the current is virtually non-existent. Above this value, the current rises rapidly, coming nearly vertical after approximately 7 volts. If the plot was recreated using a higher temperature, the effect would be to shift the curve to the left (i.e., a higher current for a given voltage). If we were to alter the graph to use a logarithmic current scale rather than a linear scale, the graph of Fig 2.8 results. The resulting straight line plot shows clearly the logarithmic relationship between the diode's voltage and current.

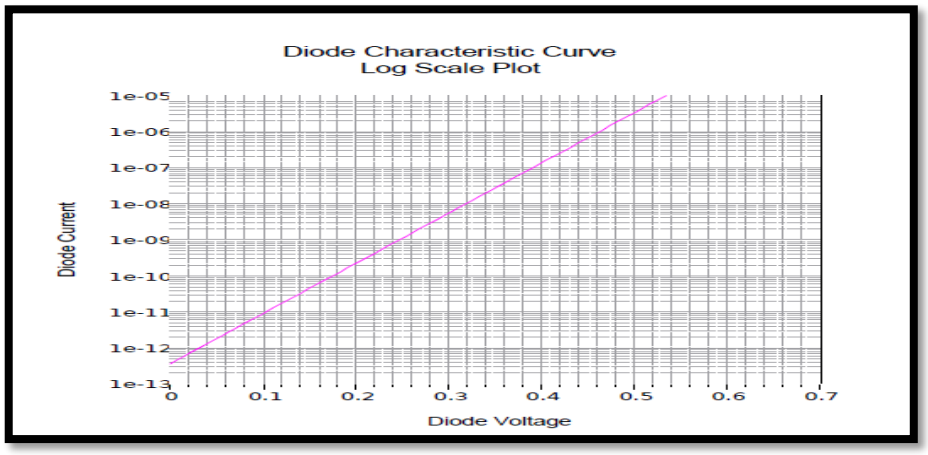

Figure (2.8) Characteristic curve of forward-biased silicon PN junction using log scale.

For negative voltages (reverse-bias) the Shockley equation predicts negligible diode current. This is true up to a point. The equation does not model the effects of breakdown. When the reverse voltage is large enough, the diode will start to conduct. This is shown in Fig 2.9. In the first quadrant we see the same general shape we found in Fig2.9. VF is the forward "knee" voltage (roughly 7 volts for silicon). IR is the reverse saturation current (ideally zero but in reality a very small amount of current will flow). VR is the reverse breakdown voltage. Note that the current increases rapidly once this reverse voltage is reached [65].

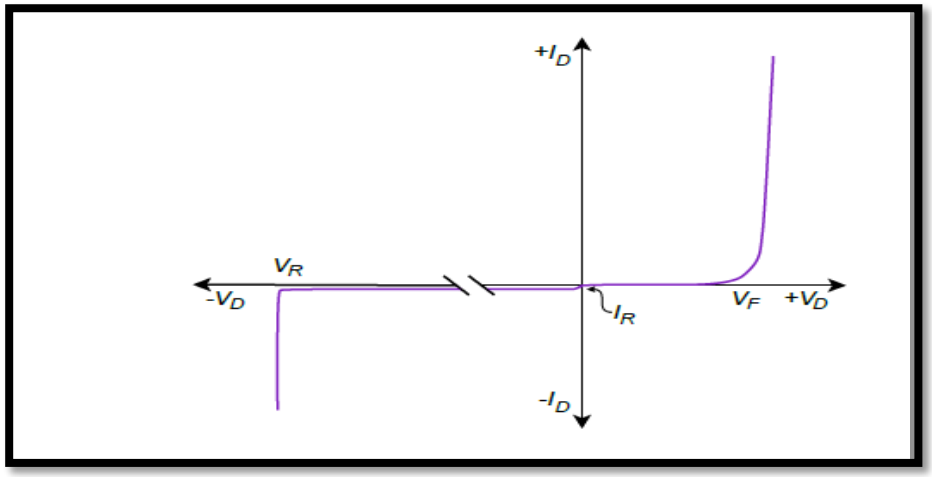

Figure 2.9 Simplified forward and reverse I-V curve for diode.

In general, diodes should not be operated in the breakdown region (the exception being Zener diodes). There are two mechanisms behind this phenomenon. The Zener effect, named after Clarence Zener, predominates when the doping levels are high and produces breakdown voltages below roughly five or six volts. It is due to the production of a very high electric field across the depletion region which then results in the production of a high current through electron tunneling. In devices using lower levels of doping, avalanche dominates. In this instance, a high electric field accelerates the free electrons to the point where they can impact surrounding atoms and create new electron-hole pairs, thus creating new free electrons that can repeat the process, resulting in a rapid increase of current [65].

2.15 Literature Review

2.15.1Analytical Study on Three Types of Gum from Sudan

This work done by K. K. Taha; the study assess the physicochemical properties and the functionality of three types of gum in comparison with Gum Arabic in an attempt to use them as an alternative or substituent to it. the properties of three types of Gum grown in Sudan i.e. Gumminesina olibanum, Guar Cyamopsis teyragonlobus and Combretum Combertaceae were investigated , after the tested physicochemical parameters were done 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 indeces, 0.150, 0.233 and 0.079 % tannin, 3.23, 0.46 and 2.49 viscosity for olibanum, guar and combretum respectively.

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. The FTIR spectra supported the existence of sugar moiety in the composition of gum. The

findings indicated that combertum has good gum properties closely to those of gum Arabic [67].

2.15.2 Physicochemical Properties of Acacia Polyacantha Gum

This work done by Ahmed Adam Elnour, gum samples collected from two areas in sudan (kadogli and aldamazine), the functional properties showed similar refractive index value and the same moisture, and ash levels. Kadogli samples were found to have insignificantly ($P \leq 0.05$) higher specific optical rotation, molecular weight, reducing and sugars compared to Eldamazine gum samples. Eldamazine samples showed insignificantly ($P \leq 0.05$) higher intrinsic viscosity, emulsifying stability, water holding capacity compared to Kadogli gum samples. Lastly gum samples obtained from Eldamazine showed significantly ($P \leq 0.05$) higher nitrogen, uronic acid and pH levels, whereas that from Kadogli showed significantly ($p \leq 0.05$) higher equivalent weight [15].

2.15 .3 Utilization of Gum Arabic for Industries And Human Health

Eqbal Dauqan reviewed the utilization of gum Arabic in industries and human health. An excellent emulsifying properties and low solution viscosity 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 [2].

2.15 .4 Electrical and optical properties of two types of Gum Arabic

The study done by Hajer Adam in two types of Gum Arabic namely; Acacia Senegal and Seyal. X-ray fluorescence (XRF) and Fourier transformation infrared spectroscopy (FTIR) were used as analytical techniques. The XRF results showed that, Gum Arabic (Acacia Senegal and Seyal) contained Calcium (Ca), Iron (Fe), Copper (Cu), Lead (Pb), and Strontium (Sr). The FTIR spectra of both types of Gum Arabic appeared absorption band in the range of 600 to 3000 cm^{-1} which is broad and strong. These absorptions were assigned to the different stretching

vibrations. The conductivity was found to increase with frequency. In dielectric the versa behavior observed. The absorption was found to increase with the increase of concentration [68]

2.15.5 Improving the Properties of Gum Arabic to Act as Semiconductor

This paper done by H. Mustafa. Gum Arabic by iodine of different concentrations at room temperature) 25oC) was prepared. The effect of vaccination of iodine on the distance between atoms and the angles between them and the absorption and energy gap of the treated samples using Easy Scan device and (UV-VIS) spectroscopy respectively. The distance and angles between the atoms in Gum Taleh highest Distance between atoms was 70.8 nm when the focus 1.52mg and what can be when the distance is less focus. 1.22mg / L In gum Hashab distance increases between atoms then be fixed between(1.2 - 2.0) mg / L where 68.3nm after that increasing. The angles between atoms in Gum Taleh angles between the atoms of the biggest gum Hashab. The gap energy affected by a concentration of gum. When Gum Taleh was preparing of 1ggum theenergy gap was 3.04 eV and, 2g was 3.09eV and when you add 5 ml of distilled water to the gum solution 1 g wigs affected by the energy gap. In Hashab the sample was prepared 1g gum the gap energy was 3.04eV When the concentration of gum 2g was energy gap 2.99V eV and 5 ml of distilled water the energy gap became 3.1eV [69].

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

This study done by H. Mustafa .in this study Gum Arabic (Talha) Nano-material samples were prepared with different Concentration (0.1, 0.3, 0.5, 0.7and 0.9) m Molar by doping with Iodine. Optical Properties of Gum Arabic doping by Different Concentration of Iodine measured by using the UV- Spectroscopy mini 1240. In this work study the effaced of different concentration on the optical parameters. For all samples the absorbance increases upon increasing the

concentration, while the transmission decreases. The value of Energy band gap (E_g) was decreased from (4.420) eV to (4.323) eV [70].

2.15.7 Determination of the Energy Gap of Gum Arabic Doped with Zinc Oxide Using the UV-VIS Technique

This work done by Elkhatem Elmhdy Ali Mohamed .In this work ,Zinc Oxide Nano particle (Zn O) were successfully synthesized by a sol-gel method, then the solution of the gum Arabic was also prepared and powred by the mortar method. The samples were characterized by UV-VIS spectroscopy technique. The energy gap (E_g) equal (2.760) eV, for both samples. Which prove that it is a real semiconductor and its conductivity increases with the increasing of the dopants Zinc Oxide (Zn O). The conclusion of this work is the defrosting of citric acid on the zinc-oxide polymer led to reducing the energy gap [71].

2.15.7 Effects of ã-Irradiation on Some Properties of Gum Arabic (Acacia Senegal

This work done by Siddig T. KafiIn this work Properties of gun Arabic (Acacia senegal) were studied using variable doses of gamma radiation of 5.5, 6.5, 7.5, 8.5, 9.5, and 10.5 KGy, respectively. It was found that the highest dose of gamma radiation used achieved the best emulsification, viscosity and absorbance. The only drawback is the change of the color of gum Arabic from white to dark red. Finally the gamma radiation is capable of enhancement of the properties of gum Arabic material [16].

2.15.8 Diffusivity and Electrical Properties of Gum Arabic, Carbon Black/Kbro3 Composite Material

This Work Done by A. Elhadi H. M. Ishage the Aim of This Work Is improve the properties of Gum Arabic (GA) by doping it with carbon black (soot) and potassium bromide. Sample of GA doped with Carbon black/KBrO3 was prepared using solid state chemical method. The effect of doped and effect of different temperature on the properties of GA was investigated using different analyses .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. Such results might be attributed to the increase in grains surface to volume ratio obtained in our sample and being the good evident for porosity formation [72].

2.15.9 The Effect of Transparency and Replacing Gum by Dye Layer on Solar Cell Efficiency When Doped By Cobalt Oxide

This work done by Alobid Ali Khalid Awad Elkareem In this work the Gum Arabic doped by Cu O based Dye Sensitized Solar Cells (DSSC) with different type of dyes (Coumarin 500, Ecrchrom Black, Rhodamine B, DDTTc and Nile blue) were fabricated on ITO glass Microstructure and cell performance of the solar cells with (ITO/ Gum Arabic / dye /ITO+ graphite and Iodine) structures were investigated. Photovoltaic devices based on the Gum Arabic +CuO/ (C Coumarin 500, Ecrchrom Black, Rhodamine B, DDTTc and Nile blue) dye hetro-junction structures provided photovoltaic properties under illumination. Absorption and energy gap measurement of the Coumarin 500, Ecrchrom Black, Rhodamin B, DDTTc and blue Nile were studied by using UV-VS mini 1240 spectrophotometer, The five (ITO/ dye / Gum Arabic /ITO+ graphite and Iodine) solar cells were produced and characterized, Another 5 samples were also prepared by replacing Gum Arabic layer by dye, such that the gum layer is above the dye one (ITO + graphite + Iodine). The analysis shows that the efficiency of the solar cell increases when the upper layer is more transparent [73].

2.15.10 Using Gum Arabic in Making Solar Cells by Thin Films Instead Of Polymers

This study done by Abdalsakhi .S .M.H in this study the microstructure and cell performance of the solar cells with ITO/ Rhodamine 6G/ Gum Arabic structures were investigated three sample of Gum solar cells were made by depositing the Gum Arabic solution on ITO a glass manner Spin Coating, and another layer was deposited from day on a layer of Gum Arabic .Gold was fabricated on the layers to represent the anode and ITO Cathode , The formed devices were characterized by Ultra violet-visible spectroscopy. Absorption and energy gap measurement of the Rhodamine 6G / Gum Arabic hetro-junction were studied by using UV-VS mini 1240 spectrophotometer and light current-voltage characteristics the efficiency (η) is (3.8 - 5.1 and 5.2) %. Fill factor (FF) is (0.964 - 0.9462 and 0.973), current density (Jsc) is (2.22 - 4.31 and 4.4) mAcm-2 and Open – circuit voltage (Voc) is (1.22 -1.25 and 1.209) V. This could be used at larger scale in promoting efficiency of solar cells [74].

2.15.11 Investigating the Electric Conductivity, Magnetic Inductivity, and Optical Properties of Gum Arabic Crystals

This paper represented by Elhadi M. I. Elzain. In this study Samples of Gum crystals of different thicknesses were prepared by drying Gum solution. A special Capacitor was designed, to be used. The maximum value of electric permittivity was 2.8×10-4 C/Nm2.Themaximum value of electric conductivity was 9.88×10-7 ohm-1 cm^{-1}. The results indicated that; Gum Arabic crystals could be considered as weak semiconductors. The light intensity has slight effect on the conductivity, permittivity, and the current passing through the crystals. The results from this study also encourage more researches in this field. The Conclusions of this work was the electrical properties of gum Arabic indicate that; its behavior resembles that of a semiconductor with a large band gap. A new technique based or taking more than 100 readings for (V) and (I) is recommended to be used, to find the

values of the energy gap. The refractive index is found to be in the range comparable with that of some previous studies [75].

2.15.12 The Effect of Optical Energy Gaps on the Efficiency for Dye Sensitized Solar Cells(DSSC) by using Gum Arabic Doped by CuO and (Coumarin 500,EcrchromBlack, Rhodamin B and DDTTc) Dyes

This work done by Mubarak Dirar Abd-allain this work the Gum Arabic based Dye Sensitized Solar Cells (DSSC) with five types of dyes (Coumarin 500, Ecrchrom Black, Rhodamin B, DDTTc and Nile blue) were fabricated on ITO glass. Microstructure and cell performance of the solar cells with (ITO/ Gum Arabic / dye /ITO+ graphite and Iodine) structures were investigated. Photovoltaic devices based on the Gum Arabic / dye hetrojunction structures provided photovoltaic properties under illumination. Absorption and energy gap measurement of the (Coumarin 500, Ecrchrom Black, Rhodamin B, DDTTc and Nile blue) were studied by using UV-VS mini 1240 spectrophotometer and light current-voltage characteristics. The five (ITO/ Gum Arabic / dye /ITO+ graphite) solar cells were produced and characterized, which provided efficiency (η) and Energy gap 4.92 % for E_g = 1.436 eV ,1.9 % for E_g = eV ,2.01, 0.44% for E_g = 2.641 eV and 0.37 % for E_g = 4.197 respectively. It is very interesting to note that the efficiency increases as the energy gap decreases. However for Ecrchrom Black the efficiency is high which may be related to high transparency that allows more photons to liberate electrons from gum layer. The efficiency of solar cells formed from gum Arabic doped with copper oxide and dyes are affected by the energy gap and transparency of dyes [76].

2.15.13 Heavily Doped Semiconductor Nano crystal Quantum Dots

This study done by David Mocatta in this study developed a method to dope semiconductor Nano crystals with metal impurities, enabling control of the band gap and Fermi energy. A combination of optical measurements, scanning tunneling spectroscopy, and theory revealed the emergence of a confined impurity

band and band-tailing. His method yields n- and p-doped semiconductor Nano crystals, which have potential applications in solar cells, thin-film transistors, and optoelectronic devices [13].

2.15.14 Dielectric Properties and Crystal Structure of Aluminum Oxide (Al_2O_3) at Different Molar

The optical transmittance and reflectance of the (Al_2O_3) samples were measured as a function of wavelength by UV-visible spectroscopy, and other optical constant was calculated. The crystal structure of all samples characterized at room temperature using a Philips PW1700 X-ray diffract meter (operated at 40 kV and current of 30 mA) and samples were scanned between 20o and 90o at a scanning speed of 0.06 C°/s using Cu Kα radiation with λ = 1.5418Å*P* This work done by Rawia Abdelgani Elobaid in this work the Al_2O_3 samples were prepared by the sol-gel method with different molar, samples was prepared using Aluminum nitrate (0.1M, 0.2 M and 0.3 M) dissolved in 300 ml of ethanol in the glass beaker. Then the solution was stirred for 60 min at 80°C until we get milky solution. The optical properties of the (Al_2O_3) samples were investigated. In particular, optical parameters such as the optical band gap, absorption coefficient, refractive index and extinction coefficient, real and imaginary dielectric constant were comprehensively studied. It is found that the optical absorbance wavelength range was (370–390) nm. Also the morphology characteristics of crystal structure of samples have been investigated by XRD and using optical method to investigate the electrical properties; and the results were as follow: the existence of the (022) at 34.87O, (111) at 38.35O, (202) at 45.23O, (020) at 54.53O, (113) at 58.59O and (311) at 61.48O Major lattice planes in the XRD patterns confirms the formation of spinal Monoclinic, Miller indices provided in the figure and all peaks determine transformation of dried .The results indicate the sample have good characteristics for optoelectronic applications [77].

2.15.15 Effect of difference concentrations of Al on the optical properties of AZO thin films

This study done by Aldesogi Omer Hamed in this study the Zn O thin films deposited by Sol-gel method shows band gap 3.69eV which under AZO 1% concentration was found to be 3.29eV and3.28eV at AZO 2% concentration. Under these treatment the film shows a shift of 0.41eV for AZO 2% concentration and3.04eV for AZO 3% concentration in its optical spectra .Such dependence has been attributed to the structure of the film. The extinction coefficient value was increased in the UV region with treatment. The films give refractive index value equal to 2.13 in the 345.39 (UV-region).Hence, these treatment for thin film give a best optical properties to be used for optoelectronic Applications [78].

2.15.16 Optical and Electrical characteristics of LEDs based on a single organic layer

This work done by S. Cheylana. In this work a study of Optical and electrical characterization of a single layer structure LED with MEH-PPV as the active organic layer. The LED structure used was ITO/MEHPPV/Al and exhibited bright red electroluminescence visible to the naked eye. A thermal treatment upon completion of the device was shown to improve drastically the efficiency of the device. The current-voltage (I/V) characteristics were measured with an Agilent Parameter Analyzer. The electroluminescence spectra were collected by an optical fiber linked to a spectrometer (OCEANOPTICS) onto a CCD camera, connected to a computer. Such effect is believed to result from a better adhesion interface between the conjugated polymer layer and the cathode [79].

2.15.17 Enhancement of current-voltage characteristics of multilayer organic light emitting diodes by using nanostructured composite films

This study done by Nguyen Nang Dinh .The aim of improving the photonic efficiency of an organic light emitting diode _OLED_ and its display duration, both the hole transport layer _HTL_ and the emitting layer _EL_ were prepared

as nanostructured thin films. For the HTL, Nano composite films were prepared by spin-coating a homogeneous solution of low molecular weight. The resulting multilayer OLED had the following structure of samples Characterization of the Nano composite films showed that both the current-voltage _I-V_ characteristics and the photo luminescent properties of the Nano composite materials were significantly enhanced in comparison with the standard polymers. OLEDs made from these layers would exhibit a large photonic efficiency [80].

2.15.18 Optical Properties of MEH-PPV and MEH-PPV/ [6, 6]-Phenyl C61-butyric Acid 3-ethylthiophene Ester Thin Films

This study done by B.M.Omer. In this study thin films of Poly [2-methoxy-5-(2ethylhexyloxy)-1, 4-phenylenevinylene] (MEH-PPV) were prepared from chloroform, 1,2-dichlorobenzene and toluene solutions by spin coating technique on quartz substrates. The spectra for MEH-PPV were examined as a function of solvent, to determine the change in optical properties upon different solvents. All the spectra show a narrow low intensity peak at 334, 324 and 333 nm for the films prepared from chloroform, 1,2-dichlorobenzene and toluene, respectively. The optical band gaps (E_g^{opt}) were calculated from the onset wave lengths (λonset).The λonset and the corresponding E_g^{opt} of MEHPPV thin film fabricated from chloroform,1,2dichlorobenzene and toluene are 590 nm (2.10 eV), 588 nm (2.11 eV) and 620 nm (2.0 eV), respectively [81].

CHAPTER THREE

MATERIAL AND METHOD

3.1Introduction

This chapter consist of all materials were used to preparation the samples of gum Arabic doped by aluminum oxide and all equipment were used to syntheses the thin film layers , in addition to the instruments to analysis the samples to determine the optical properties , structure and I-V curve by Using U-V spectrometer ,(FTIR and XRD) and I-V circuit respectively.

3.2 Materials

3.2.1 Hashab Gum Arabic

Acacia gum is a natural agricultural resource from the gum Acacia Senegal and locally known as hashab. The gum Arabic material was collected from HASHAB trees (acacia SENEGAL) from KORDOFAN area of SUDAN. Gum samples were collected from local markets.

Figure (3.1) Hashab Gum Arabic sample

3.2.2 Aluminum Oxide

Aluminum oxide is a chemical compound of aluminum and oxygen with the chemical formula Al_2O_3. It is the most commonly occurring of several aluminum oxides, and specifically identified as aluminum (III) oxide naturally in its crystalline polymorphic phase α-Al_2O_3 as the mineral corundum, varieties of which form the precious gemstones ruby and sapphire. Al_2O_3 is significant in its use to produce aluminum metal, as an abrasive owing to its hardness, and as a refractory material owing to its high melting point The samples of Al_2O_3 were prepped from Aluminum nitrate (monohydrate) extra pure $Al(NO_3)_3.9H_2O$.

3.2.3 MEH- PPV

Poly [2-methoxy-5-(2'-ethylhexyloxy)-1, 4-phenylene vinylene] (MEH-PPV) is a PPV derivative that is particularly favorable for device fabrication due to its great solubility in most of the common organic solvents owing to its asymmetric side chains. To date, MEH-PPV is possibly one of the most celebrated and studied polymer semiconductors, recognizing its applications in OPV, OFETs, polymer light-emitting diodes (PLED) and solar cells.

3.2.4 Ethanol

Ethanol is a natural byproduct of plant fermentation and also can be produced through the hydration of ethylene. Ethanol, also called alcohol with chemical formula C_2H_6O, ethyl alcohol and grain alcohol which is molarity 46 mole, is a clear, colorless liquid and the principle ingredient in alcoholic beverages like beer, wine or brandy. Because it can readily dissolve in water and other organic compounds, ethanol also is an ingredient in a range of products, from personal care and beauty products to paints and varnishes to fuel.

3.2.5 Methanol

Methanol, also known as methyl alcohol amongst other names, is a chemical and the simplest alcohol, with the formula CH_3OH (a methyl group linked to a hydroxyl group, often abbreviated MeOH). It is a light, volatile, colorless, flammable liquid with a distinctive alcoholic odour similar to that of ethanol (potable alcohol)

3.2.6 Dimethyle Aldehyde

A group is an alkyl derived from methane , containing one carbon atom bonded three hydrogen atoms Diethyl aldehyde An organic compound, especially etha e, containing two methyl groups with chemical formula $C_5H_{10}O$ —often used in combinationa colorless, odorless, flammable gas, illuminating gas, and crude pet roleum: us d chiefly in organic synthesis and as a fuel gas .

3.2.7 Distilled 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).

3.2.8 ITO Glass

ITO (Indium Tin Oxide) Coated Glass - 50mm x 50mm. This is a very interesting and fun material, also used in scientific research and LCD/OLED manufacture! One side of the glass is coated in ITO, you can use the flat of a blade or similar to scrape away some of the film to create 'traces' - just be careful because as it is glass, any nick-lines will cause it to break on the line (that's how a glass cutter works) It may also be possible to use a laser cutter to pattern it.

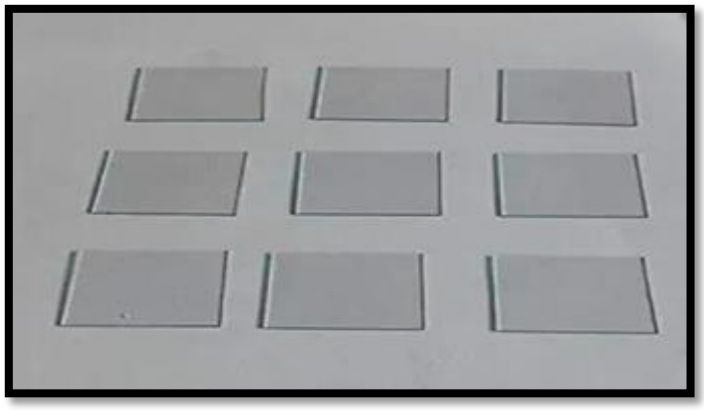

Figure (3.2): The ITO (Indium Tin Oxide) Glass

3.2.9 Spin Coating

Spin coating is a procedure used to deposit uniform thin films onto flat substrates. Usually a small amount of coating material is applied on the center of the substrate, which is either spinning at low speed or not spinning at all. The substrate is then rotated at speed up to 10,000 rpm to spread the coating material by centrifugal force. A machine used for spin coating is called a spin coater, or simply spinner. Rotation is continued while the fluid spins off the edges of the substrate, until the desired thickness of the film is achieved. The applied solvent is usually volatile, and simultaneously evaporates. The higher the angular speed of spinning, the thinner the film. The thickness of the film also depends on the viscosity and concentration of the solution, and the solvent. Spin coating is widely used in micro fabrication of functional oxide layers on glass or single crystal substrates using sol-gel precursors, where it can be used to create uniform thin films with Nano scale thicknesses. It is used intensively in photolithography, to deposit layers of photoresist about 1 micrometer thick. Photoresist is typically spun at 20 to 80 revolutions per second for 30 to 60 seconds. It is also widely used for the fabrication of planar photonic structures made of polymers. One advantage to spin coating thin films are the uniformity of the film thickness. Owing to self-leveling, thicknesses do not vary more than 1%. However, spin coating thicker

films of polymers and photoresists can result in relatively large edge beads whose planarization has physical limit.

Figure (3.3): The spin coating technique

3.4 Characterization Techniques

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

To investigate the optical properties of Gum Arabic (Hashaba) doped by aluminum oxide made by two methods, some precise techniques have been used. The following characterizations have been potentially performed for the analytical of the synthesized samples.

3.4.1Fourier Transport Infrared Spectroscopy (FTIR)

A technique used to obtain an infrared spectrum of absorption or emission of a solid, liquid or gas. An FTIR spectrometer simultaneously collects high-resolution spectral data over a wide spectral range. This confers a significant advantage over a dispersive spectrometer, which measures intensity over a narrow range of wavelengths at a time. The goal of absorption spectroscopy techniques

(FTIR, ultraviolet-visible ("UV-Vis") spectroscopy, etc.) is to measure how much light a sample absorbs at each wavelength. The most straightforward way to do this, the "dispersive spectroscopy" technique, is to shine a monochromatic light beam at a sample, measure how much of the light is absorbed, and repeat for each different wavelength. (This is how some UV–Vis spectrometers work**.**Fourier transport infrared (FTIR) spectra of samples were detected by (Mattson, Model 960m0016) spectra with transmission from 4000 to 400cm^{-1}, by using KBr pellets seen .

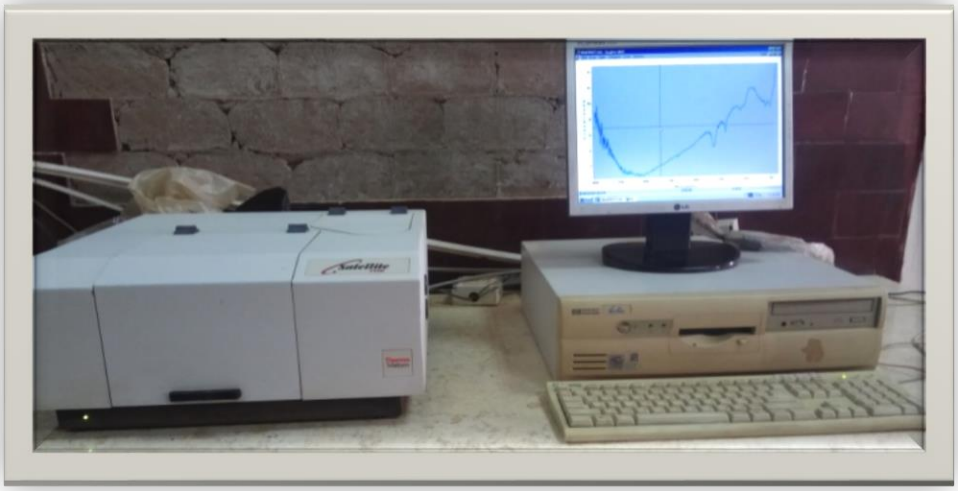

Figure (3.4): FTIR (Mattson, model 960m0016) spectroscopy.

3.4.2 Ultraviolet -visible Spectroscopy (UV-Vis)

Absorption of light in the UV/Visible part of the spectrum (210 – 900 nm). The transitions that result in the absorption of electromagnetic radiation in this region of the spectrum are transitions between electronic energy levels. Generally, the most probable transition is from highest occupied molecular orbital (HOMO) to lowest occupied molecular orbital (LUMO).Light in the UV-VIS part of the spectrum is used to promote electrons from the ground state to various excited states. The particular frequencies at which light is absorbed are affected by the structure and environment of the chromophore (light absorbing species). Excited

electrons can return to the ground state by vibrational transitions through smaller energy increments. Absorbed energy appears ultimately as heat in solution. The absorption spectra of prepared nanoparticles were measured using shimadzu spectrophotometer (UV mini 1240) in 190-800nm range see Figure (3.2)

Figure (3.5): UV mini 1240 spectrometer shimadzu

3.4.3 X-ray Powder Diffraction (XRD)

X-ray powder diffraction (XRD) is a rapid analytical technique primarily used for phase identification of a crystalline material and can provide information on unit cell dimensions. The analyzed material is finely ground, homogenized, and average bulk composition is determined. (XRD) is a non-destructive technique for analyzing the structure of materials, primarily at the atomic or molecular level. It works best for materials that are crystalline or partially crystalline (i.e., that have periodic structural order) but is also used to study non-crystalline materials. XRD relies on the fact that X-rays are a form of light, with wavelengths on the order of nanometers. When X-rays scatter from a substance with structure at that length scale, interference can take place, resulting in a pattern of higher and lower

intensities. This is qualitatively similar to the colorful patterns produced by soap bubbles, in which different colors are viewed in different directions. XRD produces a diffraction pattern, which does not superficially resemble the underlying structure, and provides information about the internal structure on length scales from 0.1 to 100 nm. A beam of X-rays is directed towards a sample, and the scattered intensity is measured as a function of outgoing direction. By convention, the angle between the incoming and outgoing beam directions is called 2θ. For the simplest possible sample, consisting of sheets of charge separated by a distance *d*, constructive interference (greater scattered intensity) is observed when Bragg's Law is satisfied: $n\lambda = 2d\sin\theta$ Here *n* is an integer (1, 2, 3 ...) λ is the wavelength of the x-ray beam, and θ is half the scattering angle 2 θ shown above. Real materials are more complicated, of course, but the general result holds that there is a relationship between inter particle distances within the sample and the angles at which the scattered intensity is the highest, with larger distances *d* corresponding to smaller scattering angles 2θ. The data collected by using X-Ray diffract meter: XRD (wavelength 1.54 A°) in the figure below

Figure (3.6) X-Ray diffract meter: XRD (wavelength 1.54 A°)

3.4.4 I-V Circuit

The current-voltage, (I-V) Characteristics Curves define the operating characteristics of an electronic device .The most important parameters of diode multilayer can be determined by the I–V characteristic which is shown in figure below. These parameters include the short-circuit current (I_{sc}), open-circuit voltage (V_{oc}), voltage at maximum power point (V_{mp}), current at maximum power point (I_{mp}) and maximum output power (P_{mp}).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 its 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. A straight line through the origin represents a linear circuit element, while a curved line represents a nonlinear element. For example, resistors, capacitors, and inductors are linear, while diodes and transistors are nonlinear.

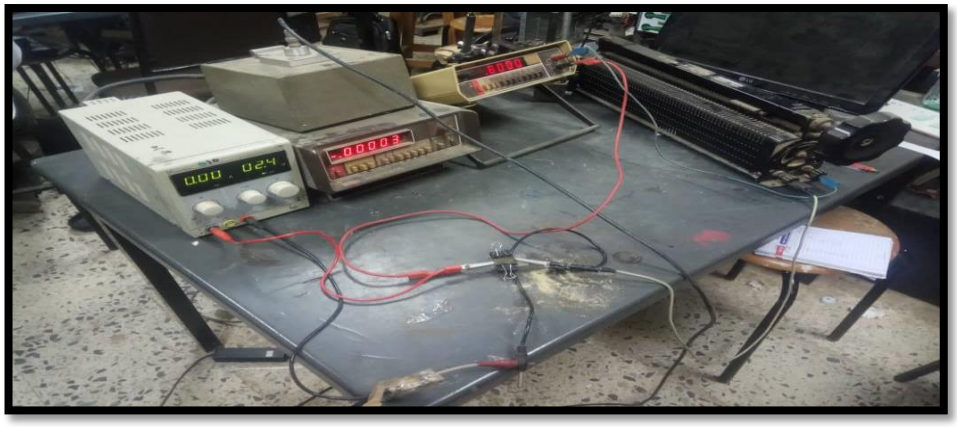

Figure (3.7): current–voltage characteristic or I–V curve

3.5 Method

Gum Arabic prepared by two methods (sol gel and chemo thermal), .The precursor used in the synthesis gum Arabic (GA) and Aluminum Oxide (Al_2O_3). For the sol-gel process used Gum Arabic and Aluminum nitrate monohydrate, (5g) Hashab Gum Arabic dissolved in 50 ml of distillation water then 1ml ammonia added to solution. The solution was stirred for 60 min at 80°C. Moreover (2g) aluminum nitrate monohydrate Al $(NO_3)_3.9H_2O$ was dissolving in (110 ml) Ethanol C_2H_5OH in the glass beaker. Then dropped 1ml Dimethyl 2- methyl the solution was stirred for 60 min at 80°C. After that, the two solutions are mixed and put the mixture at room temperature for 24 hours, and we obtained the Sol ready to be used to prepare as layers by spinner (spin coating).In the second method Chemo thermal has been used to prepare Gum Arabic and Aluminum nitrate monohydrate. 17 ml acid added 34 ml ethanol (C_2H_5OH) slowly and the solution was stirred for 5 min , then added (5g) Hashab Gum Arabic , the solution was stirred for 60 min at 70°C. In addition (2g) Aluminum Nitrate monohydrate Al $(NO_3)_3.9H_2$ O dissolved in 110 ml Ethanol C_2H_5OH, and then 2 ml 2 Dimethyl methyl dropped, the solution was stirred for 60 min at 100°C. After that, two solutions were mixed in ice bath with stirred for 60 min. The mixture has been leave in lab's temperature about one day. After syntheses Gum Arabic by (Sol Gal and chemo-thermal) Method and doped with Aluminum Oxide samples used UV-VS mini 1240 spectrophotometer to study the optical parapets (absorbance, transmission, reflection, absorption coefficient, extinction coefficient and optical energy band gap) as showing in the results below , the curves we found the behavior of Gum Arabic Made by (Sol Gal and chemo - thermal) Method and doped with Aluminum Oxide samples studied using UV-VS min 1240 spectrophotometer . After obtained Gum Arabic Made by (Sol Gal and chemo-thermal) Method and doped with

Aluminum Oxide, samples were ready to be used to prepare as layers by spinner (spin coating). The Arabic Gum doped with Aluminum Oxide was made on ITO glass. The ITO glasses were firstly cleaned by ethanol and distilled water. then, were washed ITO glass by deionized water ,then used that mixture to deposited on ITO a glass manner Spin Coating, the coating on glass was performed at room temperature, with suitable speed rate for 60 s, for 0.02 A and 1.9V for 60 s and another layer was deposited from MEH-PPV polymer on Gum Arabic that synthesis layer. Every layer was coated with MEH-PPV. Four samples were prepared with Gum Arabic doped by Aluminum Oxide (Al_2O_3) single layer sample, double layer sample, triple layer and quadruple layers sample as showing in fig (3.8), the thicknesses of the thin layer were about (16 nm for mixture layer and the MEH-PPV polymer layer was 48 nm so the single layer was equivalent 64 nm) by using mass approximation method. After syntheses four thin film Gum Arabic by (Sol Gel) Method and doped with Aluminum Oxide and MEH-PPV samples, used to study the crystal structure, and used Fourier Transform Infrared spectroscopy (FTIR) to measure the vibrational of bonds as showing in the results below .

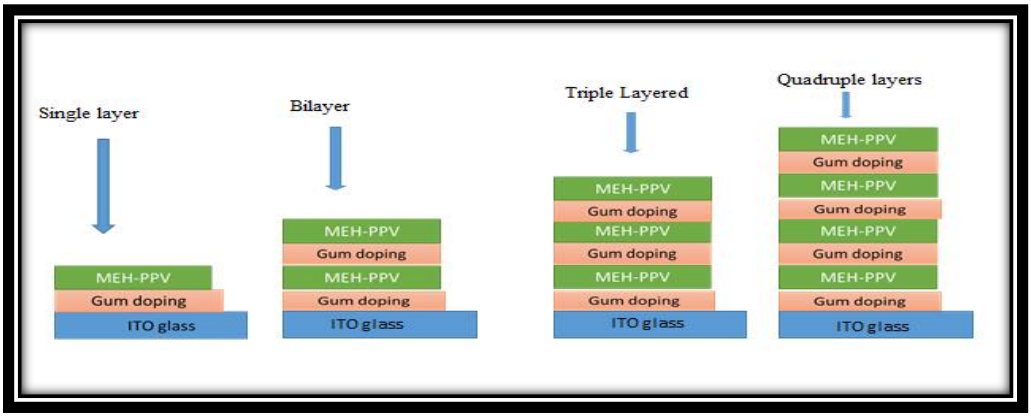

Figure (3.8) schematic structure of four thin film samples syntheses by Gum Arabic (Sol Gel) Method and doped with Aluminum Oxide sample and MEH-PPV

3.6 Preparation of Thin Films

Thin films of the selected compositions were prepared by the most widely used technique known as thermal evaporation technique of bulk samples on to glass substrates for both optical and dc conductivity measurements. In order to prepare well-formed and homogeneous films onto glass substrates and homogenous glass substrate with low surface roughness the following steps were carried out:

- Cleaning the substrate the substrates were washed several times using hot distilled water and soap.
- Then substrates were exposed to ultrasonic waves using Branson-120 device for 15 minutes in a solution of distilled water and ethyl alcohol.
- Finally the substrates were washed with distilled water and ethyl alcohol separately and then, dried in an oven.

Measuring the thickness will also be important to ensure that the deposition method which is used can produce films with consistent properties and quality.

3.6.1 Film Measurement Techniques

There are different techniques such as X-Ray Diffraction, Spectrometric Technique, Geometry and Beer's Law, Ellipsometry/ Reflectometry, Mass Approximations……..etc. In this research we focused in mass approximations techniques.

If deposition occurs with a known metal composition, and the mass of the metal applied is measurable, an approximation on the thickness of the produced film can be made. The first is dependent on measuring how much mass is evaporated form the source. The second method involves measuring the mass increase of the slide after deposition.

3.6.1.1 Mass Evaporated

If we assume that the mass evaporated proceeds from the source spherically, we can approximate the thickness as

$$\tau = \frac{m}{4\pi \mathrm{K} \rho h^2} \tag{3.1}$$

The thickness is t, m is the mass evaporated (mass difference in the pellet), p is the density of the metal, and h is the height of the slide from the basket. The mass evaporated can easily be measured by simply weighing the crucible and the metal to be evaporated before and after deposition. The difference in these masses is what was evaporated out of the crucible. This formula assumes that the evaporation radiates out spherically.

3.6.1.2 Mass Added to the Slide

One should be able to weigh the slide before the film is applied and weigh the slide afterwards and figure out approximately how thick the film is by way of the formula

$$\tau = \frac{m}{\rho A} \tag{3.2}$$

This gives the thickness with respect to the mass (m), density (p), and area of the slide's filmed surface (A) [62].

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

In this chapter the main results that have been obtained from the experiments made of Gum Arabic doped by Aluminum Oxide with two methods (sol gel and chemo-thermal). The data of X-ray diffraction (XRD) have been analyzed by to gated crystal structure and lattice parameters of samples, the FTIR data have been carried to investigate the chemical bonds within atoms and the data of UV-visible used to evaluate the band gap. After obtaining all data from UV-Spectrometer, FTIR and I-V Curve we need to analyze and interpret the data by using origin and the data from XRD analyzed by MDI Jade 5.

4.2 The Result

4.2.1 XRD Results of Gum Arabic Made by (Sol Gel and chemo - thermal) Method and doped with Aluminum Oxide samples

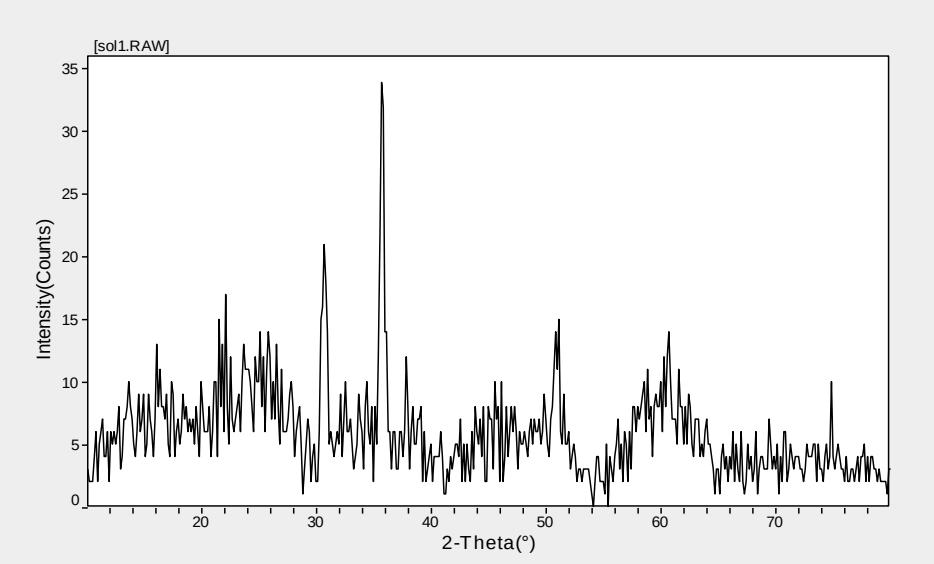

Figure (4.1) XRD spectrum of Gum Arabic doped by Aluminum Oxide sol gal method sample 1

Table (4.1) Calculate Lattice Constants from Peak Locations and Miller Indices [Hexagonal- Primitive] of Gum Arabic doped by Aluminum Oxide sol gal method sample 1

2Ɵ	d (nm)	h k l	Xs(nm)
30.656	2.9139	0 11	22.5
35.688	2.5137	401	23.2

Average Lattice Constants = 2.9479

a= b= 11.66 c= 15.68 $\alpha = \beta = 90^{O}$ $\gamma = 120^{O}$

Density = 0.0108 $mg.cm^{-3}$

Crystal Form: Hexagonal- Primitive

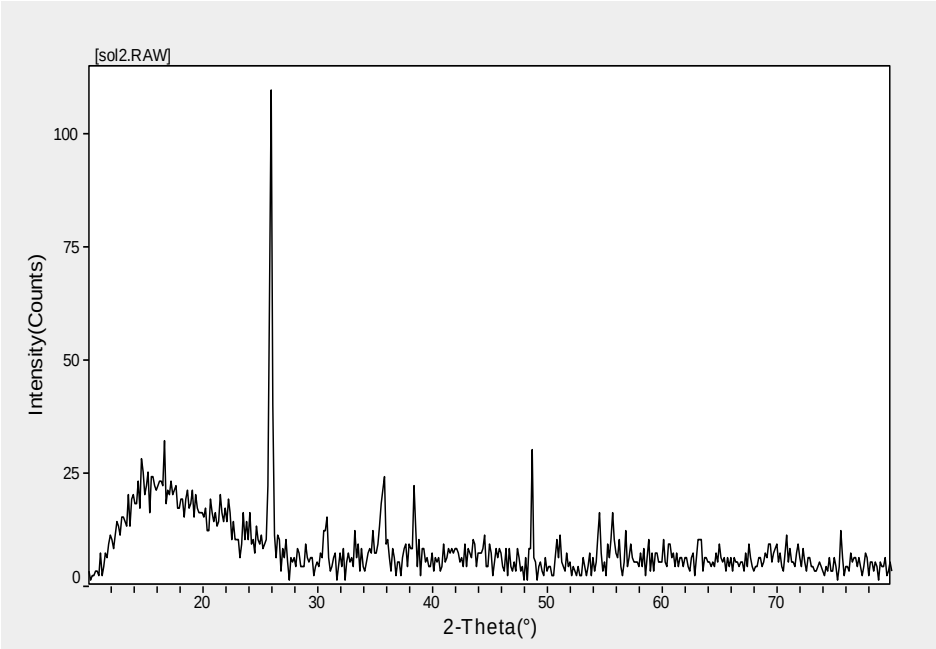

Figure (4.2) XRD spectrum of Gum Arabic doped by Aluminum Oxide sol gel method sample 2

Table (4.2) Calculate Lattice Constants from Peak Locations and Miller Indices [Hexagonal- Primitive] of Gum Arabic doped by Aluminum Oxide sol gel method sample 2

2Ɵ	d (nm)	h k l	Xs(nm)
35.726	2.5111	401	27.7

Average Lattice Constants = 2.9479

a= b= 11.66 c= 15.68 $\alpha = \beta = 90^{O}$ $\gamma = 120^{O}$

Density = 0.0106mg.cm^{-3}

Crystal Form: Hexagonal- Primitive

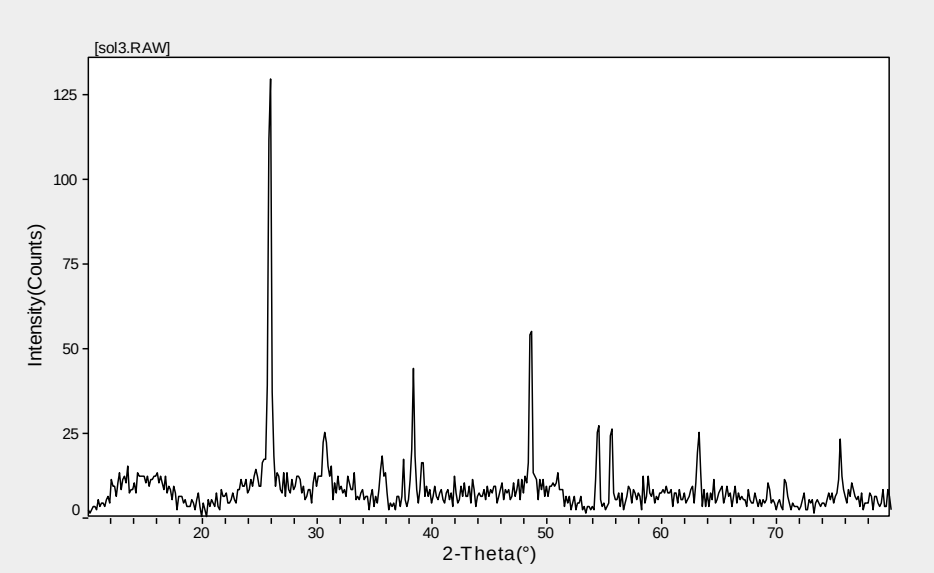

Figure (4.3) XRD spectrum of Gum Arabic doped by Aluminum Oxide sol gel method sample 3

Table (4.3) Calculate Lattice Constants from Peak Locations and Miller Indices [Hexagonal- Primitive] of Gum Arabic doped by Aluminum Oxide sol gel method sample 3

2Θ	d (nm)	h k l	Xs(nm)
25.873	3.4408	3 0 0	37.4
30.656	2.9139	0 1 1	25.6
35.688	2.5137	4 0 1	26.5
48.604	1.8717	0 3 1	44.4

Average Lattice Constants = 2.9479

a= b= 11.66 c= 15.68 $\alpha = \beta = 90^{O}$ $\gamma = 120^{O}$

Density = 0.0105mg.cm^{-3}

Crystal Form: Hexagonal- Primitive

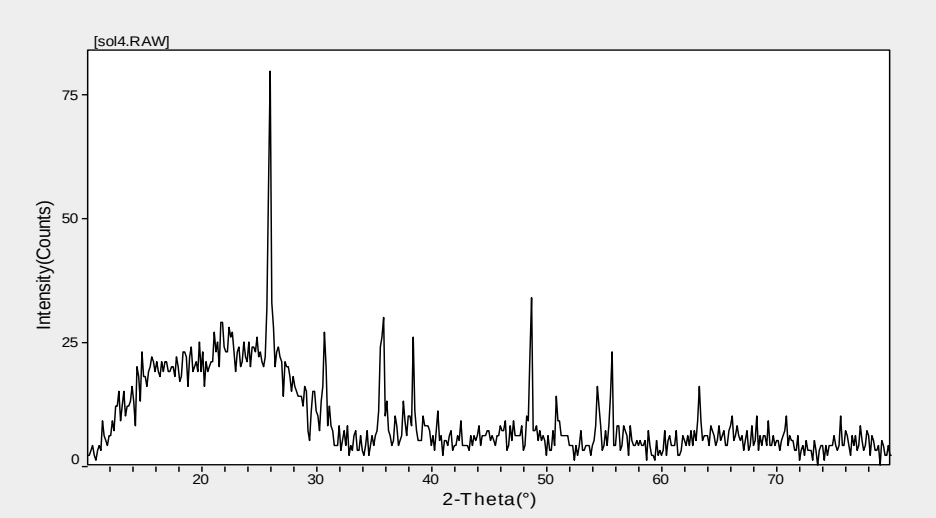

Figure (4.4) XRD spectrum of Gum Arabic doped by Aluminum Oxide sol gal method sample 4

Table (4.4) Calculate Lattice Constants from Peak Locations and Miller Indices [Hexagonal- Primitive] of Gum Arabic doped by Aluminum Oxide sol gel method sample 4

2Θ	d (nm)	h k l	Xs(nm)
35.688	2.5129	4 0 1	37.7

Average Lattice Constants = 2.9479

a= b= 11.66 c= 15.68 $\alpha = \beta = 90^{O}$ $\gamma = 120^{O}$

Density = 0.0102mg.cm^{-3}

Crystal Form: Hexagonal- Primitive

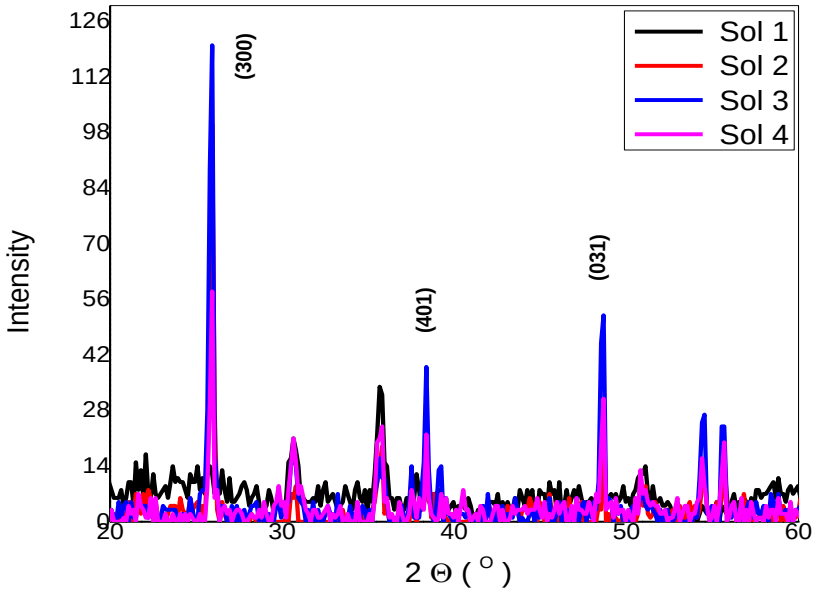

Figure (4.5) XRD spectrum of all sample that made from Gum Arabic doped by Aluminum Oxide sol gel method

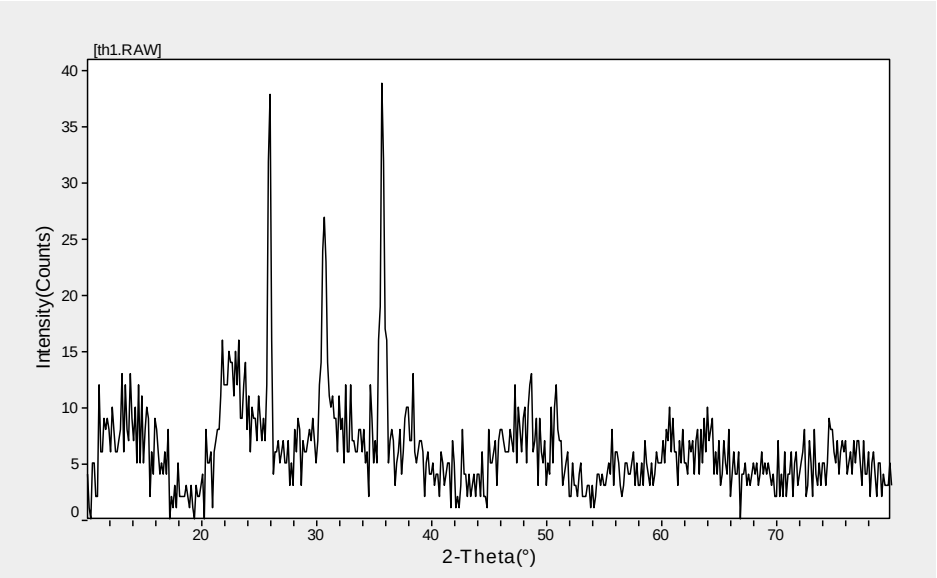

Figure (4.6) XRD spectrum of Gum Arabic doped by Aluminum Oxide made by chemo-thermal method sample 1

Table (4.5) Calculate Lattice Constants from Peak Locations and Miller Indices [Cubic - Primitive] of Gum Arabic doped by Aluminum Oxide made by chemo-thermal method sample 1

2Ɵ	d (nm)	h k l	Xs(nm)
30.684	2.9114	1 1 1	19.7
35.691	2.5135	2 0 0	29.7

Average Lattice Constants = 5.0349

A =b=c= 5.05518 $\alpha = \beta = \gamma = 90^{O}$

Density = 4.5938 $mg.cm^{-3}$

Crystal Form: Cubic – Primitive

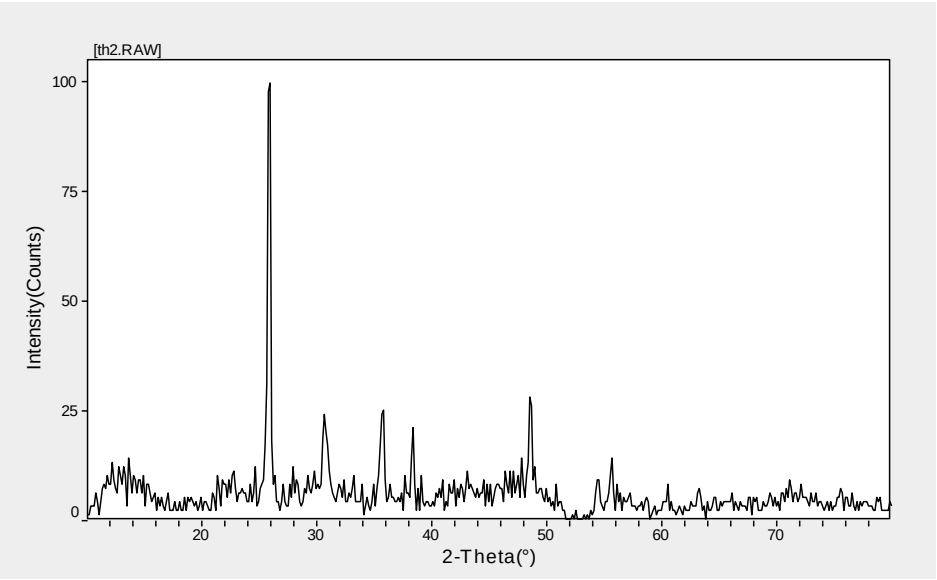

Figure (4.7) XRD spectrum of Gum Arabic doped by Aluminum Oxide made by chemo-thermal method sample 2

Table (4.6) Calculate Lattice Constants from Peak Locations and Miller Indices [Cubic - Primitive] of Gum Arabic doped by Aluminum Oxide made by chemo-thermal method sample 2

2Θ	d (nm)	h k l	Xs(nm)
25.858	3.4427	1 0 1	31.3
35.675	2.5146	1 1 0	26.0

Average Lattice Constants = 5.0293

A =b=c= 5.05518 $\alpha = \beta = \gamma = 90^{O}$

Density = 4.5938 $mg.cm^{-3}$

Crystal Form: Cubic – Primitive

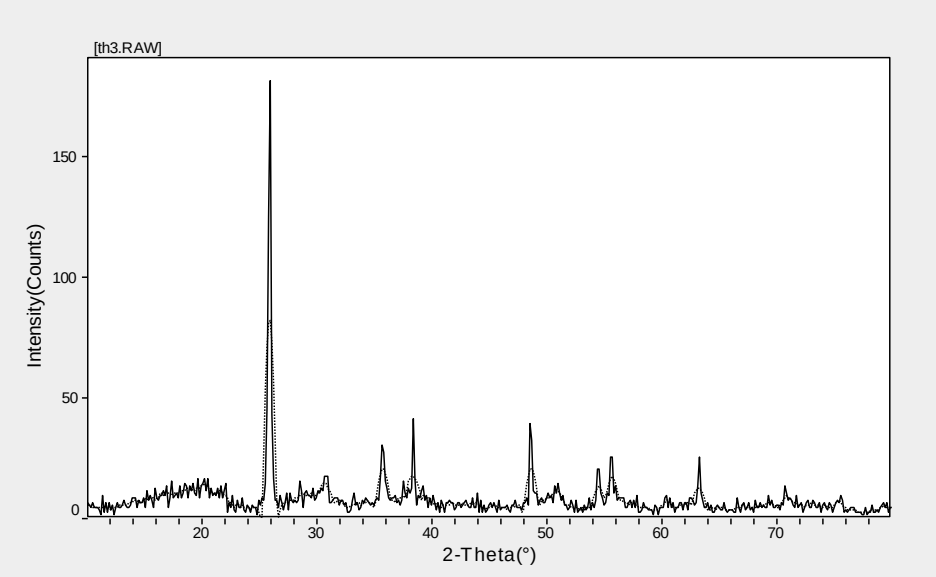

Figure (4.8) XRD spectrum of Gum Arabic doped by Aluminum Oxide made by chemo-thermal method sample 3

Table (4.7) Calculate Lattice Constants from Peak Locations and Miller Indices [Cubic - Primitive] of Gum Arabic doped by Aluminum Oxide made by chemo-thermal method sample 3

2Θ	d (nm)	h k l	Xs(nm)
25.877	3.4402	1 01	35.3
35.711	2.5122	1 1 0	22.3
48.587	1.8723	1 1 2	36.0

Average Lattice Constants = 5.0349

A =b=c= 5.05518 $\alpha = \beta = \gamma = 90^{O}$

Density = 4.5938 $mg.cm^{-3}$

Crystal Form: Cubic – Primitive

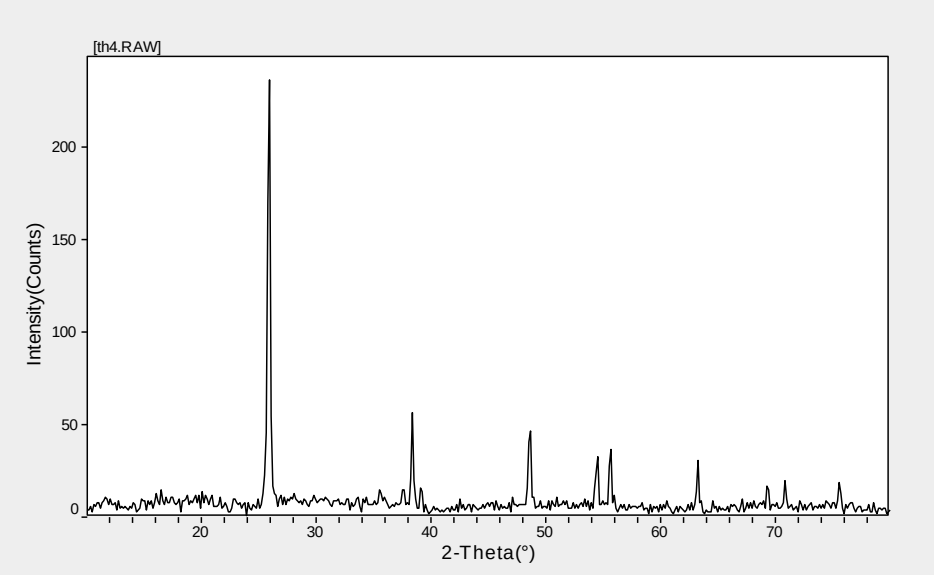

Figure (4.9) XRD spectrum of Gum Arabic doped by Aluminum Oxide made by chemo- thermal method sample 4

Table (4.8) Calculate Lattice Constants from Peak Locations and Miller Indices [Cubic - Primitive] of Gum Arabic doped by Aluminum Oxide made by chemo_ thermal method sample 4

2Θ	d (nm)	h k l	Xs(nm)
25.877	3.4402	1 0 1	35.3
35.711	2.5122	1 1 0	22.3
48.587	1.8723	1 1 2	36.0

Average Lattice Constants = 5.0349

A =b=c= 5.05518 $\alpha = \beta = \gamma = 90^{O}$

Density = 4.5938 $mg.cm^{-3}$

Crystal Form: Cubic – Primitive

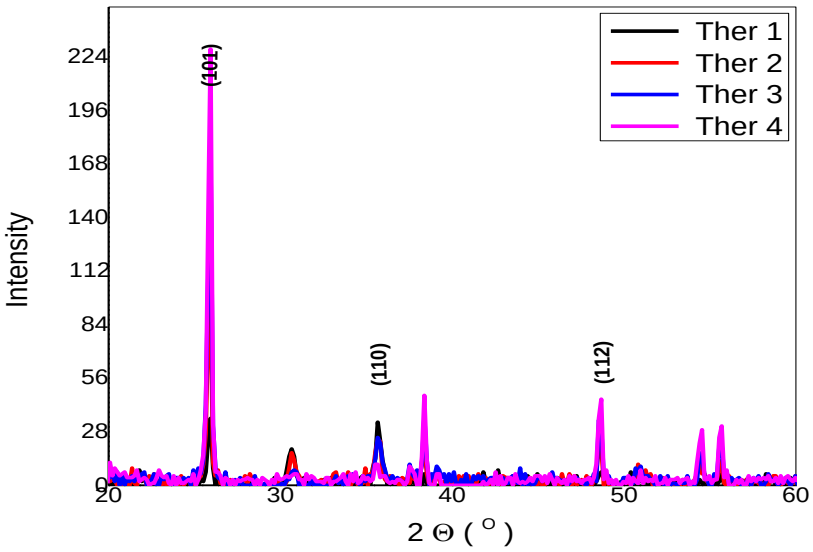

Figure (4.10) XRD spectrum of all sample of Gum Arabic doped by Aluminum Oxide made by chemo-thermal method

Table (4.9) Calculate Lattice Constants from Peak Locations and Miller Indices of Gum Arabic doped by Aluminum Oxide made by chemo -thermal method

No sample	d (A^0)	X_s (nm)	FWHM	δ ($mg.cm^{-3}$)
Chemo thermo 1	3.4402	35.3	25.877	2.1587
Chemo thermo 2	2.5122	22.3	35.711	3.7849
Chemo thermo 3	1.8723	36.0	48.587	4.1522
Chemo thermo 4	1.8723	36.0	48.587	6.4267

Table (4.10) Calculate Lattice Constants from Peak Locations and Miller Indices of Gum Arabic doped by Aluminum Oxide sol gel method

No sample	d (A^0)	FWHM	Xs (nm)	δ (mg.cm-3)
Sol Gel 1	3.4246	0.198	47.7	2.3145
Sol Gel 2	3.4685	0.180	54.4	3.7849
Sol Gel 3	3.8655	0.732	61.2	4.1522
Sol Gel 3	3.8655	0.732	61.2	5.3423

4.2.2 XRD Discussion of Gum Arabic Made by (Sol Gel and chemo - thermal) Method and doped with Aluminum Oxide samples

The crystal structure of all samples characterized at room temperature using a Philips PW1700 X-ray diffract meter (operated at 40 kV and current of 30 mA) and samples were scanned between 5^O and 25^O at a scanning speed of 0.06 C°/s using Cu Kα radiation with λ = 1.5418Å. The representative XRD charts of Gum Arabic Made by (sol Gel, chemo- thermal) methods and doped By Aluminum Oxide samples as show from fig (4.1) to fig(4.5) for sol gel method and fig (4.6) to fig (4.9) that samples made by chemo-thermal method . Miller indices provided in the fig (4.5) and all peaks determine transformation of Gum Arabic Made by (sol Gel, chemo-thermal) method and doped By Aluminum Oxide. Molar crystallites with (Hexagonal- Primitive) crystal structure for Gum Arabic Made by (sol Gel) method samples and Cubic – Primitive for the Gum Arabic Made by (chemo-thermal) method samples. Table (4.10) and table (4.11) show the XRD parameters of Gum Arabic Made by (sol Gel, chemo-thermal) method samples at various crystalline orientations. The relation between the number of layers and density showed that increase the density by increasing the number of layers, and

other increases the crystals size as calculated from table (4.10) for Gum Arabic Made by (sol Gel) method samples and table (4.11) for the Gum Arabic Made by (chemo thermal) method samples. And for the representative XRD charts of all Gum Arabic made by (sol Gel) method samples. The miller indices provided in the figure (4.5)[at 25.873 (3 0 0) , at 30.656 (0 1 1) , at 35.688 (4 0 1) and at 48.604 (0 3 1)] for Gum Arabic made by (sol Gel) method samples and in fig (4.9) [at 25.877 (1 0 1) , at 35.711 (1 1 0) and at 48.587 (1 1 2)] for the Gum Arabic made by (chemo thermal) method samples . Table (4.10) and table (4.11) shows the XRD parameters of Gum Arabic Made by (sol gel and chemo- thermal) method samples at various crystalline orientations. Due to treatment method of samples crystal structure change, it's clear that the d-spacing increases with layers. When to compare all results obtained by the chemo thermal and sol gel in grain size the value of sol gel greater than chemo thermal due to enthalpy of formation.

4.3.1 FTIR Results of Gum Arabic Made by (Sol Gal and chemo - thermal) Method and doped with Aluminum Oxide samples

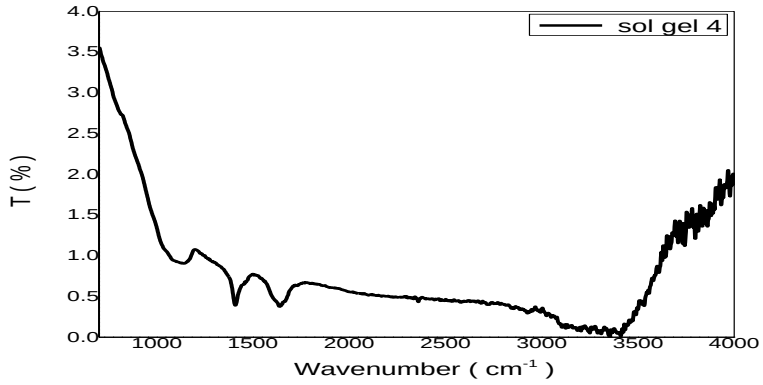

Figure (4.11) FTIR spectrum of Gum Arabic Made by sol gel and doped by Aluminum Oxide sample 4

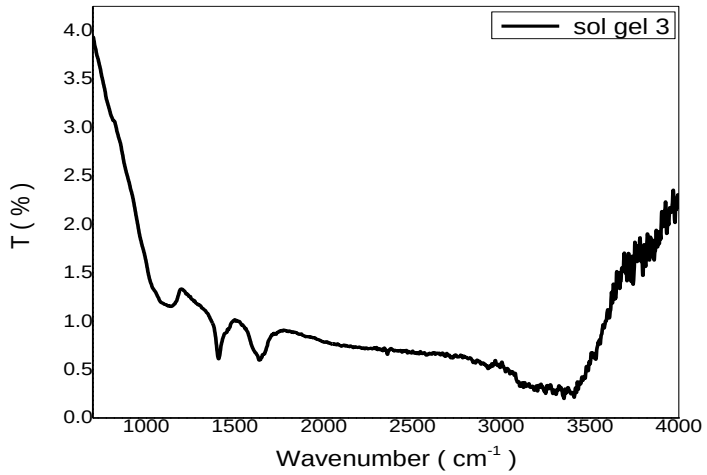

Figure (4.12) FTIR spectrum of Gum Arabic Made by sol gel and doped by Aluminum Oxide sample 3

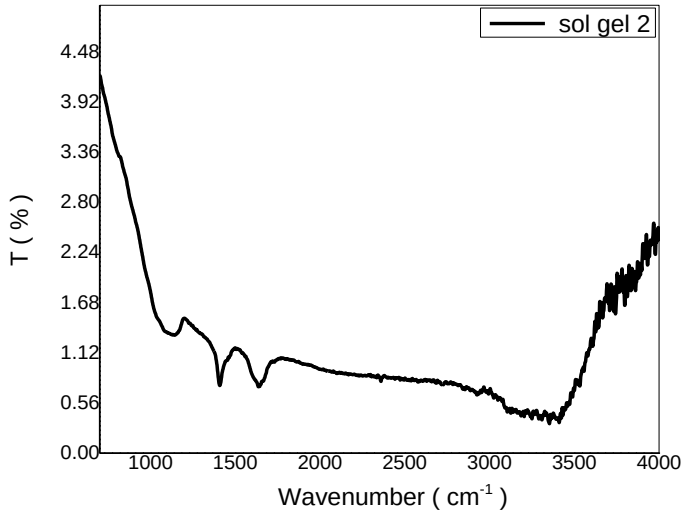

Figure (4.13) FTIR spectrum of Gum Arabic Made by sol gel and doped by Aluminum Oxide sample 2

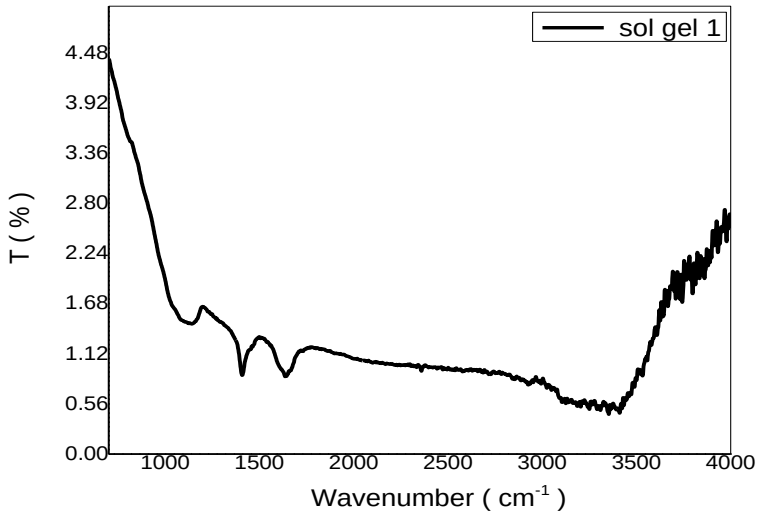

Fig (4.14) FTIR spectrum of Gum Arabic Made by sol gel and doped by Aluminum Oxide sample 1

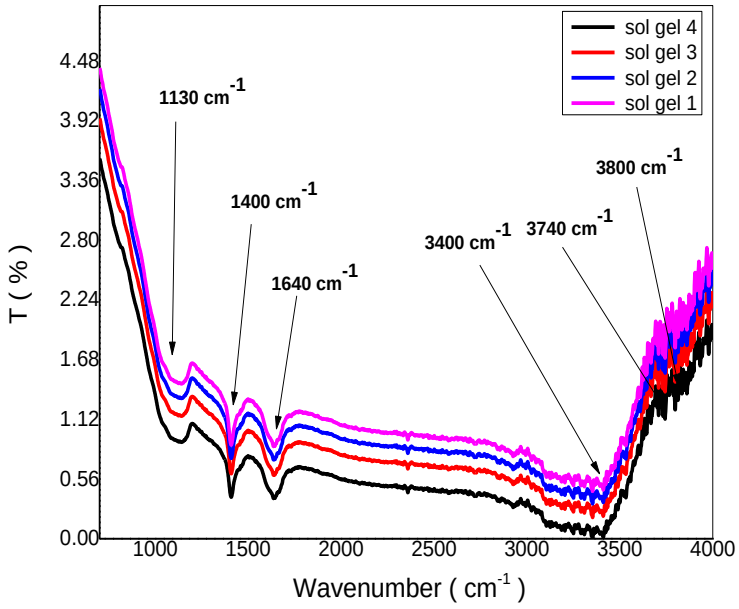

Figure (4.15) FTIR spectrum of Gum Arabic Made by sol Gel doped By Aluminum Oxide

Table (4.11) Table of Characteristic FTIR of Gum Arabic Made by sol Gel doped by Aluminum Oxide

no	Wavenumber	bond	Funcation groupe
1	1130	C–N stretch	aliphatic amines
2	1400	C–C stretch (in–ring)	aromatics
3	1640	–C=C– stretch	alkenes
4	3400	N–H stretch	1°, 2° amines, amides
5	3740	O-H strech	Alcohoal
6	3800	O-H strech	Water

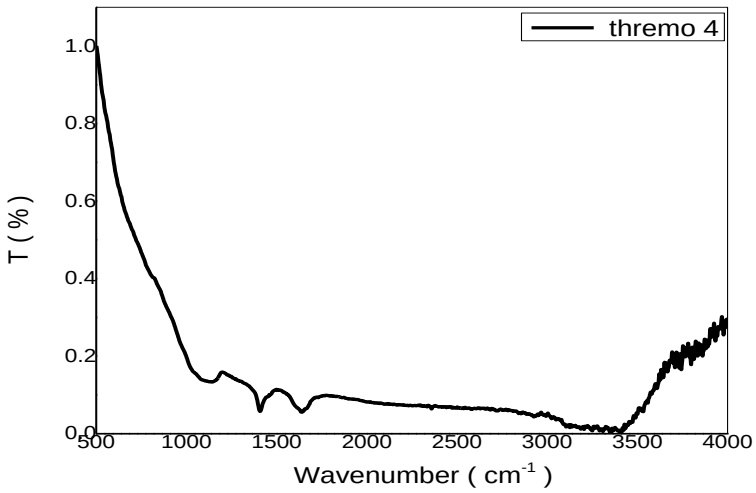

Figure (4.16) FTIR spectrum of Gum Arabic Made by chemo-thermal doped by Aluminum Oxide sample 4

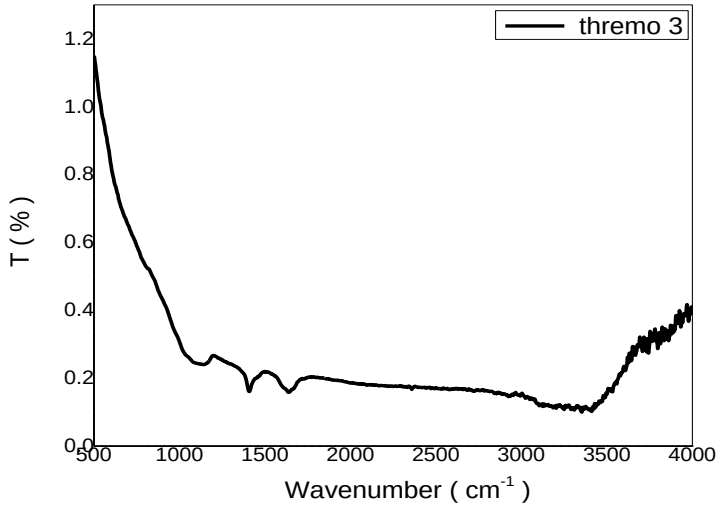

Figure (4.17) FTIR spectrum of Gum Arabic Made by chemo-thermal and doped by Aluminum Oxide sample 3

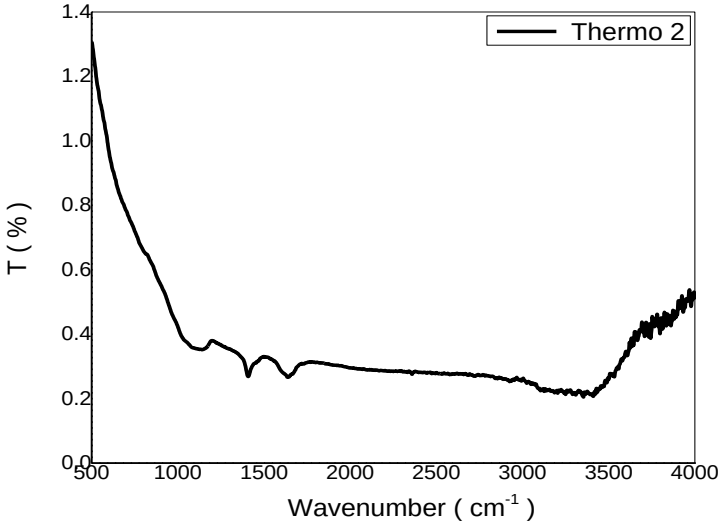

Figure (4.18) FTIR spectrum of Gum Arabic Made by thermal and doped by Aluminum Oxide sample 2

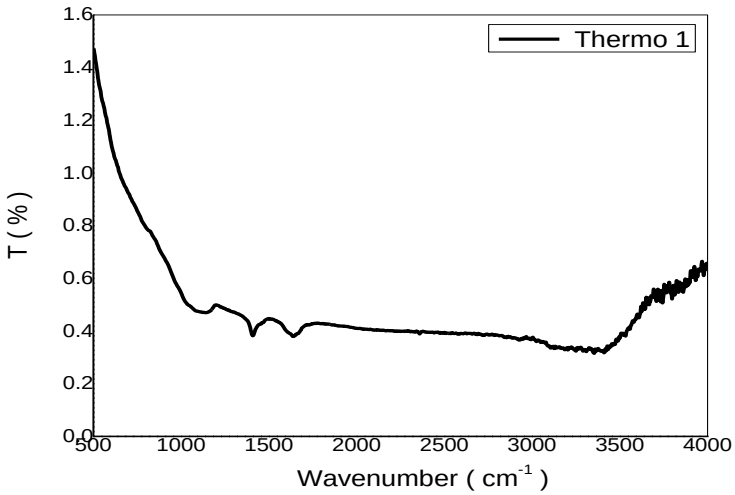

Figure (4.19) FTIR spectrum of Gum Arabic Made by chemo-thermal and doped by Aluminum Oxide sample 1

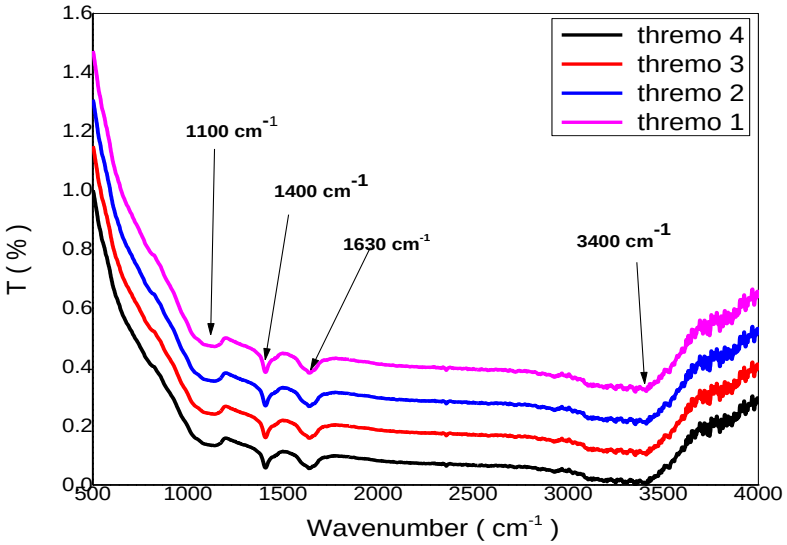

Figure (4.20) FTIR spectrum of Gum Arabic Made by Chemo-thermal method doped by Aluminum Oxide

Table (4.12) Table of Characteristic FTIR of Gum Arabic Made by Chemo-thermal method doped By Aluminum Oxide

no	Wavenumber	bond	Funcation groupe
1	1100	C–O stretch	alcohols, carboxylic acids, esters, ethers
2	1400	C–C stretch (in–ring)	aromatics
3	1630	N–H bend	1° amines
4	3400	N–H stretch	1°, 2° amines, amides

4.3.2 FTIR Discussion of Gum Arabic Made by (Sol Gel and chemo - thermal) Method and doped with Aluminum Oxide samples

Fourier Transform Infrared spectroscopy is a technique used to measure the vibrational frequencies of bonds in the molecule. The FTIR spectra of Gum Arabic Made by sol Gel and doped By Aluminum Oxide samples is shown from Fig (4.11) to fig (4.15). The strong intensity peak at 3800 cm^{-1} assigned to water O-H stretch, at 3740 cm^{-1} assigned to O–H stretch vibration of alcohol group, the band at 3400 cm^{-1} assigned to 1°, 2° amines, amides (N–H stretch) vibration. Peak at 1640 cm^{-1} assigned to alkenes (–C=C– stretch) while the very intense peak positioned at 1400 cm^{-1} revealed the presence of (C–C stretch (in–ring)) stretching for aromatics. In addition, while the very intense peak positioned at 1130 cm^{-1} revealed the presence of (C–N stretch) stretching for aliphatic amines. All this results as showing in table (4.11) .And the FTIR spectra of Gum Arabic Made by Chemo- thermal method and doped By Aluminum Oxide samples is shown from Fig (4.16) to fig (4.20). The strong intensity peak at 3400 cm^{-1} assigned to 1°, 2° amines, amides N–H stretch , at 1630 cm^{-1} assigned to N–H bend vibration of 1° amines group, the band at 1400 cm^{-1} assigned to aromatics (C–C stretch (in–

ring)) vibration. The peaks positioned at 1100 cm^{-1} observed due to C–O stretch vibration of alcohols, carboxylic acids, esters, ethers Compounds. Moreover, all this results were show in table (4.11).

4.4.1 Optical Results of Gum Arabic Made by (Sol Gal and chemo - thermal) Method and doped with Aluminum Oxide samples

After syntheses Gum Arabic Made by (Sol Gal and chemo - thermal) Method and doped with Aluminum Oxide samples used UV-VS mini 1240 spectrophotometer to study the optical parapets (absorbance, transmission, reflection, absorption coefficient, extinction coefficient and optical energy band gap) as showing in the results below , the curves we found the behavior of Gum Arabic Made by (Sol Gal and chemo - thermal) Method and doped with Aluminum Oxide samples studied using UV-VS min 1240 spectrophotometer

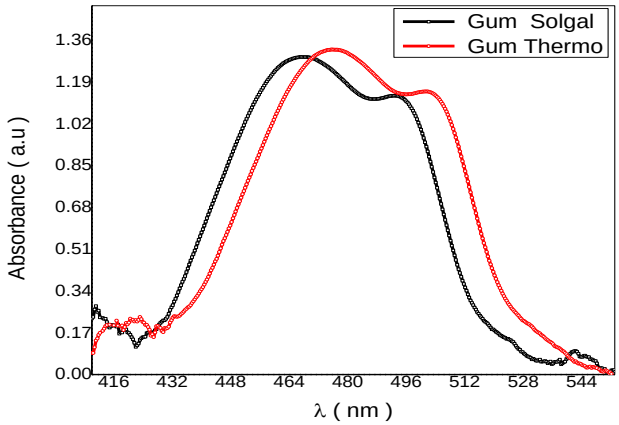

Figure (4.21) The relation between absorbance and wavelengths of Gum Arabic Made by (Sol Gel and chemo - thermal) Method and doped with Aluminum Oxide samples

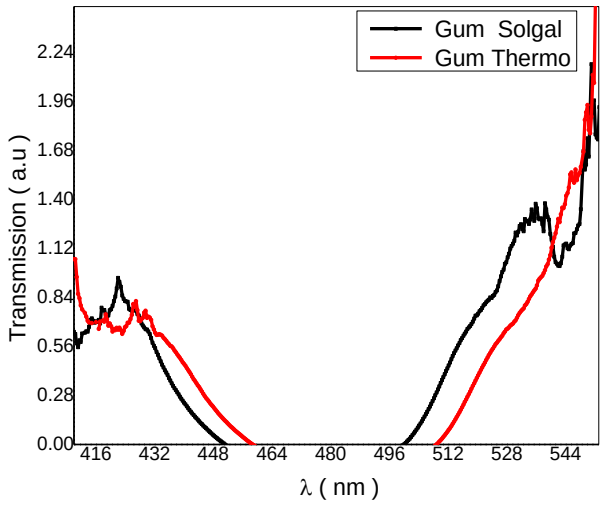

Figure (4.22) The relation between transmission and wavelengths of Gum Arabic Made by (Sol Gel and chemo - thermal) Method and doped with Aluminum Oxide samples

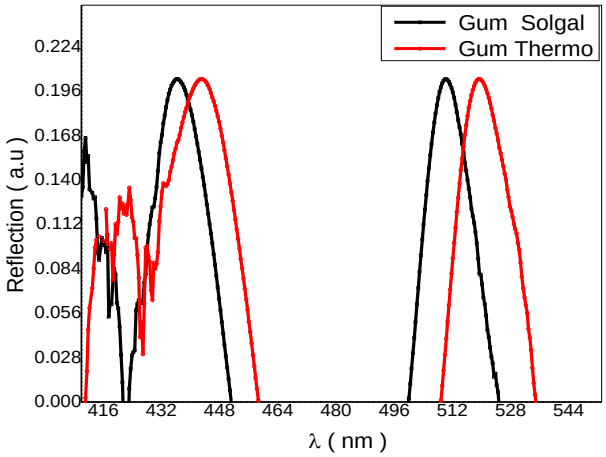

Figure (4.23) The relation between reflection and wavelengths of Gum Arabic Made by (Sol Gel and chemo - thermal) Method and doped with Aluminum Oxide samples

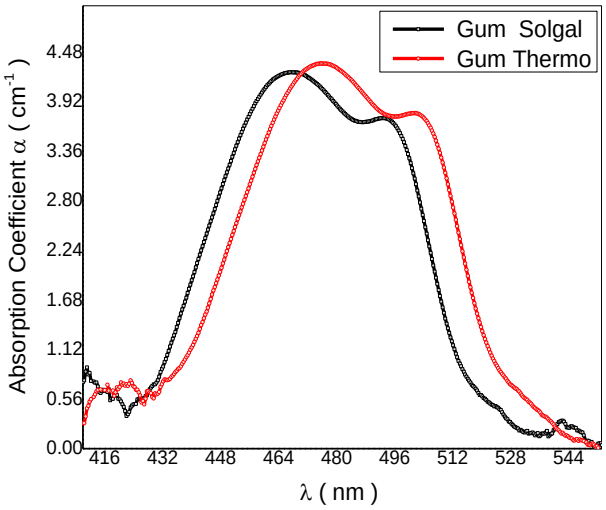

Figure (4.24) The relation between absorption coefficient and wavelengths of Gum Arabic Made by (Sol Gel and chemo - thermal) Method and doped with Aluminum Oxide samples

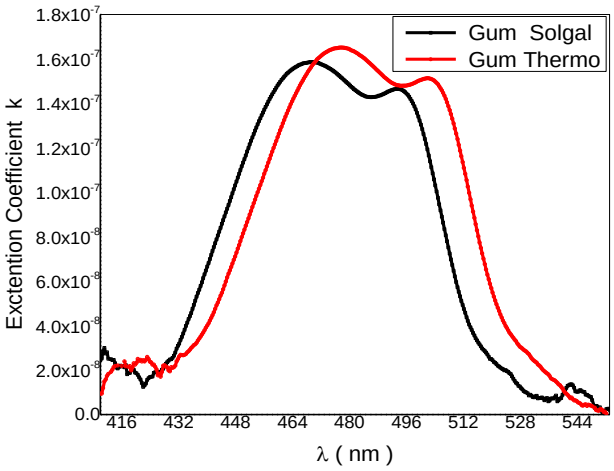

Figure (4.25) The relation between extinction coefficient and wavelengths of Gum Arabic Made by (Sol Gel and chemo - thermo) Method and doped with Aluminum Oxide samples

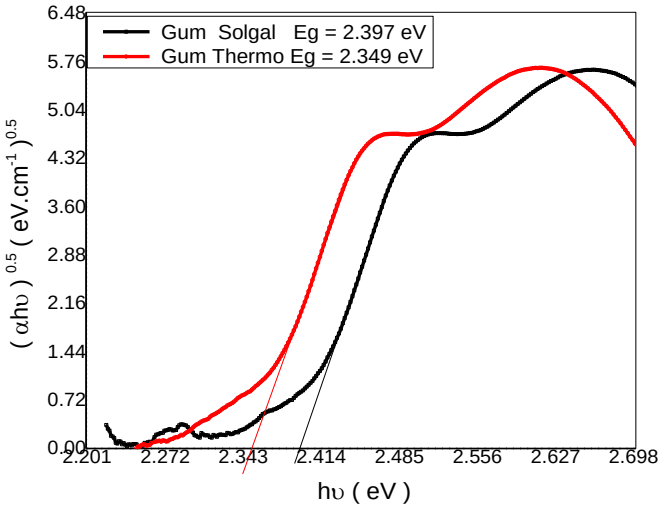

Figure (4.26) optical energy band gap of Gum Arabic Made by (Sol Gel and chemo - thermal) Method and doped with Aluminum Oxide samples

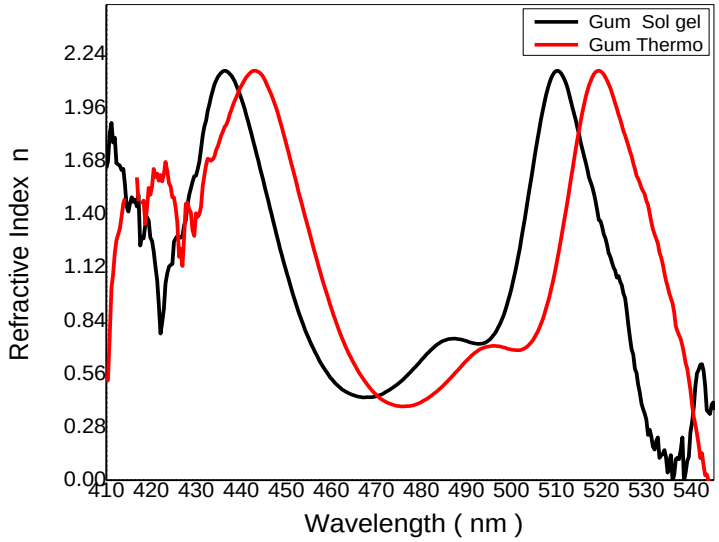

Figure (4.27) relation between refractive index and wavelengths of Gum Arabic Made by (Sol Gal and chemo - thermal) Method and doped with Aluminum Oxide samples

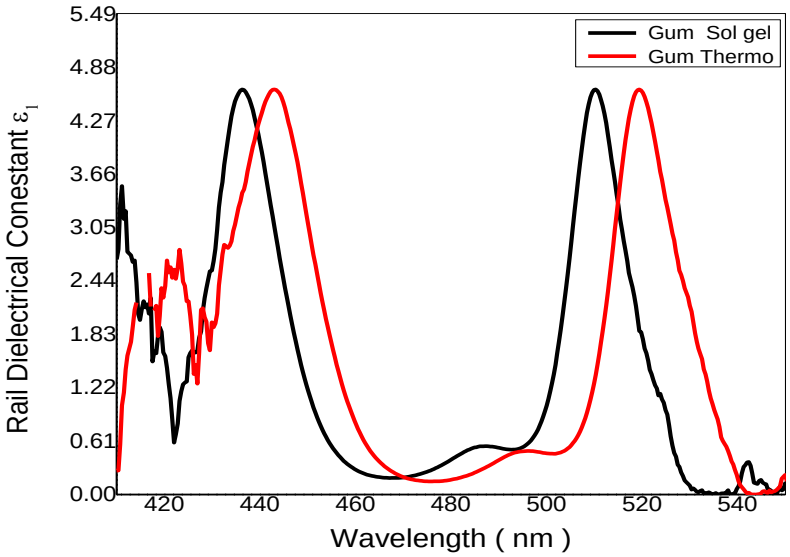

Figure (4.28) Relation between rail dialectical constant and wavelengths of Gum Arabic Made by (Sol Gal and chemo - thermal) Method and doped with Aluminum Oxide samples

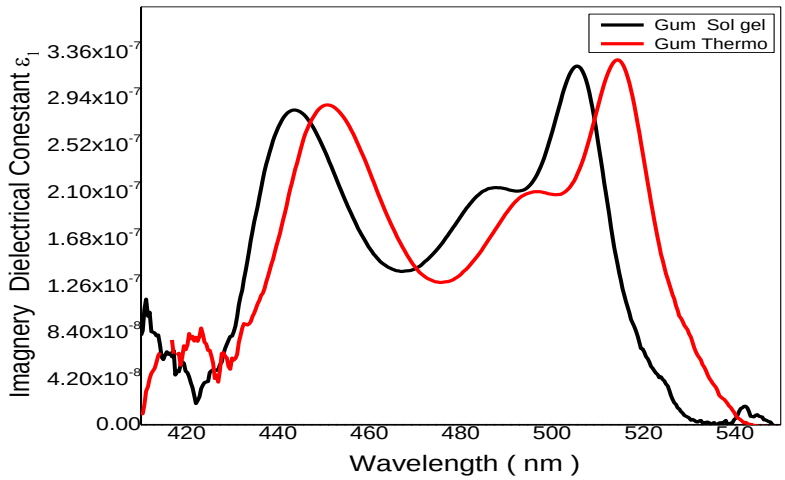

Figure (4.29) relation between imagery dialectical constant and wavelengths of Gum Arabic Made by (Sol Gal and chemo - thermal) Method and doped with Aluminum Oxide samples

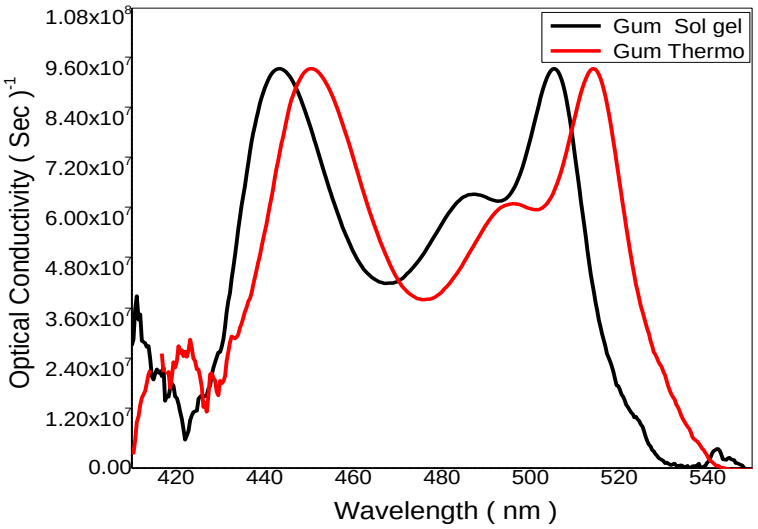

Figure (4.30) Relation between optical conductivity and wavelengths of Gum Arabic Made by (Sol Gel and chemo - thermal) Method and doped with Aluminum Oxide samples

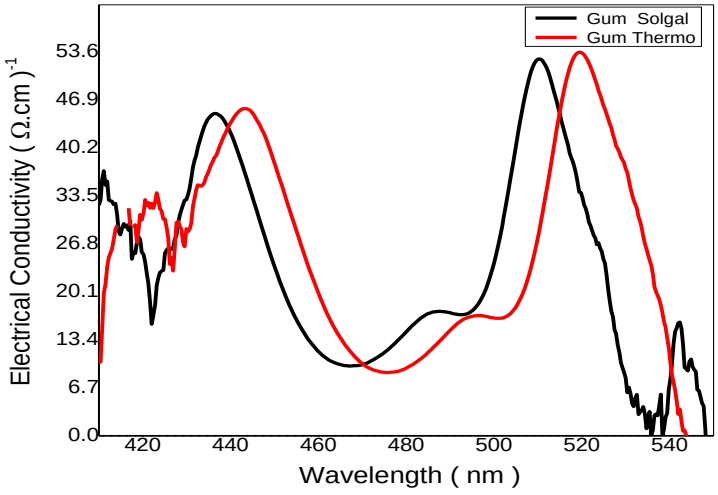

Figure (4.31) relation between Electrical conductivity and wavelengths of Gum Arabic Made by (Sol Gal and chemo - thermo) Method and doped with Aluminum Oxide samples

4.4.1 Optical Discussion of Gum Arabic Made by (Sol Gal and chemo - thermal) Method and doped with Aluminum Oxide samples

In figure (4.21) Shows the relation between absorbance and wavelengths for Gum Arabic Made by (Sol Gal and chemo - thermal) Method and doped with Aluminum Oxide samples at range (410 to 555) nm for all samples, for sol gel sample the maximal absorption at wavelengths 465 nm corresponding photon energy 2.667 eV, and for chemo thermal sample the maximal absorption at wavelengths 576 nm corresponding photon energy 2.605 eV. The transmission we found the behavior of curves is the same for Gum Arabic Made by (Sol Gal and chemo - thermal) Method and doped with Aluminum Oxide samples that showing in fig (4.22). In fig (4.22) shows the relation between transmission and wavelengths for all samples we showing that the transmission was in ranged between (410 to 553) nm, and the minimal value of transmission be zero at (450 to 510) nm for all samples .The reflection with Gum Arabic Made by (Sol Gal and chemo - thermal) Method and doped with Aluminum Oxide samples is showing in fig (4.23). In fig (4.23) shows that the reflection for the samples, maximal value in two area the first one in ranged (436and442) nm the second (510and520) nm in this two point the samples become mirrors. The absorption coefficient (α) of Gum Arabic Made by (Sol Gal and chemo - thermal) method and doped with Aluminum Oxide samples were found from the following relation $\alpha = \frac{2.303xA}{t}$where (A) is the absorbance and (t) is the optical length in the samples. In fig (4.22) shows the plot of (α) with wavelength (λ) of Gum Arabic Made by (Sol Gal and chemo-thermal) method doped with Aluminum Oxide samples , which obtained that the value of α = 4.25 cm^{-1} for Gum Arabic Made by (Sol Gel) Method and doped with Aluminum Oxide sample in the visible region(465 nm) but for Gum Arabic Made by (chemo - thermal) Method and doped with Aluminum Oxide sample equal 4.36 cm^{-1} at the (476 nm) wavelength , this absorption coefficient value means that the transition

must corresponding to indirect electronic transition, and the properties of this state are important since they are responsible for electrical conduction. Extinction coefficient (K) was calculated using the relation= $\frac{\alpha\lambda}{4\pi}$. The variation of the extinction coefficient (K) values as a function of (λ) are shown in fig (4.25) for (Gum Arabic Made by (Sol Gal and chemo - thermal) Method and doped with Aluminum Oxide samples and it is observed that the spectrum shape of (K) as the same shape of (α). The extinction coefficient (K) for Gum Arabic Made by (Sol Gal and chemo - thermal) Method and doped with Aluminum Oxide samples in fig (4.25) obtained the value of (K) for the Gum Arabic Made by (Sol Gal) Method and doped with Aluminum Oxide at the (465 nm) wavelength was depend on the samples treatment method equal $1.578x10^{-7}$, where the value of (K) at 476 nm for Gum Arabic Made by (chemo - thermal) method and doped with Aluminum Oxide sample equal $1.65x10^{-7}$ .The effects of method that treatment for the sample on the Extinction coefficient (k) is the mean of wavelength shift .The optical energy gap (E_g) has been calculated by the relation $(\alpha h\upsilon)^2 = C(h\upsilon - E_g)$ where (C) is constant. By plotting $(\alpha h\upsilon)^2$vs photon energy (hυ) as shown in fig.(4.24) for the (Gum Arabic Made by (Sol Gel and chemo - thermal) Method and doped with Aluminum Oxide samples . And by extrapolating the straight thin portion of the curve to intercept the energy axis, the value of the energy gap has been calculated .In fig (4.26) the energy band gap (E_g) value of Gum Arabic Made by (Sol Gel) Method and doped with Aluminum Oxide equal (2.397) eV but for Gum Arabic Made by (chemo - thermal) Method and doped with Aluminum Oxide equal (2.349) eV. The value of (E_g) was decreased from (2.397) eV to (2.349) eV. The decreasing of (E_g) related to the method that treatment of samples, this reason obtained the band gap shifts. 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 $n = \left[\left(\frac{(1+R)}{(1-R)}\right)^2 - (1 + k^2)\right]^{\frac{1}{2}} + \frac{(1+R)}{(1-R)}$

Where (R) is the reflectivity. The variation of (n) vs (λ) for Gum Arabic Made by (Sol Gal) Method and doped with Aluminum Oxide samples is shown in fig. (4.27), the maximum value of (n) is (2.172) for all samples at tow wavelength for the Gum Sol Gel method in 435 nm and 510 nm, and for the second method Gum – chemo- Thermal the same value at 442 nm and 520 nm. Fig (4.28) shows the variation of the real dielectric constant (ε1) with wavelength of Gum Arabic Made by (Sol Gal) Method and doped with Aluminum Oxide samples form, which calculated from the relation $\varepsilon_1 = n^2 - k^2$ where the real the dielectric (ε_1) is the normal dielectric constant. From fig (4.28) the variation of (ε_1) is follow the ``````````````refractive index, where at two area the first at two wavelength for the Gum Sol Gel method in 435 nm and 510 nm, and for the second method Gum - chemo -Thermal the same value at 442 nm and 520 nm, where the absorption of the samples at these wavelength is small, but the polarization was increase. The maximum value of (ε1) equal to (4.671) at 435 nm and 510 nm wavelength for the Gum Sol Gel method, and same value at for 442 nm and 520 nm for Gum chemo -Thermal method. The imaginary dielectric constant (ε_2) vs (λ) was shown in fig (4.29) this value calculated from the relation $\varepsilon_2 = 2nK$ (ε_2) represent the absorption associated with free carriers. The maximum values of (ε_2) are different according to the treatment operation , so the maximum value of (ε1) equal to (4.671) at 435 nm and 510 nm wavelength for the Gum Sol Gel method, and same value at for 442 nm and 520 nm for Gum chemo -Thermal method but (ε_2) for this sample equal (2.834×10^{-7}) at 435 nm and equal (3.229×10^{-7}) at 510 nm for the Gum Sol Gel method , and (2.89×10^{-7}) at 442 nm and (3.302×10^{-7}) for Gum chemo- Thermal method. The optical conductivity is a measure of frequency response of material when irradiated with light which is determined using the following relation, $\delta_{opt} = \frac{\alpha nc}{4\pi}$ where (c) is the light velocity. The electrical conductivity can be estimated using the following relation $\delta_{ele} = \frac{2\lambda\delta_{opt}}{\alpha}$. The high magnitude of optical

conductivity equal (9.63x108 Sec^{-1}) at 435 nm and equal (9.61x10^{8} Sec^{-1}) at 510 nm for the Gum Sol Gel method, and (9.58x10^{8} Sec^{-1}) at 442 nm and (9.55x10^{8} Sec^{-1}) for Gum chemo- Thermal method, confirms the presence of very high photo-response of the Gum Arabic Made by (Sol Gal) Method and doped with Aluminum Oxide samples. The increased of optical conductivity at high photo-generation is due to the high absorbance of all samples prepared may be due to electron excitation by photon energy as it is shown in Figs (4.30) and (4.31) .

4.5 I-V curve Results of Gum Arabic Made by (Sol Gal and chemo - thermal) Method and doped with Aluminum Oxide samples

After synthesis Gum Arabic Made by (Sol Gal and chemo - thermal) Method and doped with Aluminum Oxide samples. Then fabrication of the device was through spin casting of Gum Arabic Made by (Sol Gal and chemo - thermal) Method and doped with Aluminum Oxide samples and MEH-PPV and this category of device exhibits current and voltage turn on below

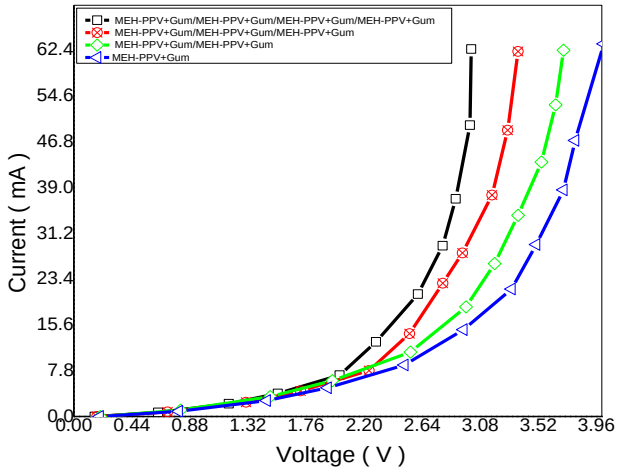

Figure (4.32) I-V characteristics of Gum Arabic Made by Sol Gel Method, And doped with Aluminum Oxide samples

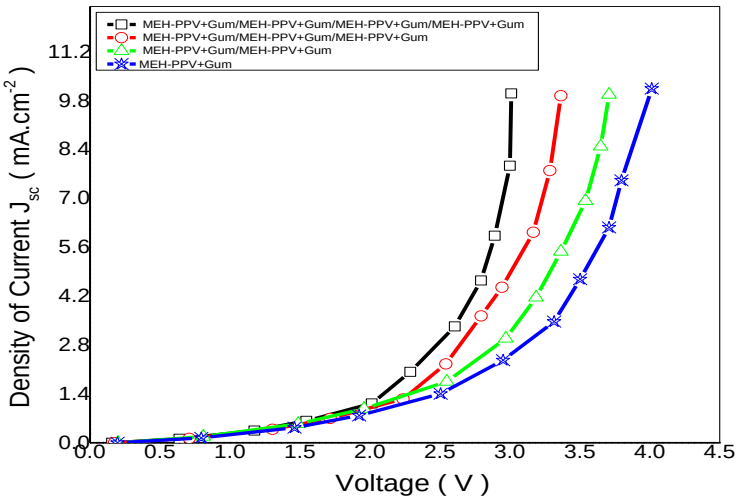

Figure (4.33) Density current characteristics of Gum Arabic Made by Sol Gel Method, and doped with Aluminum Oxide samples

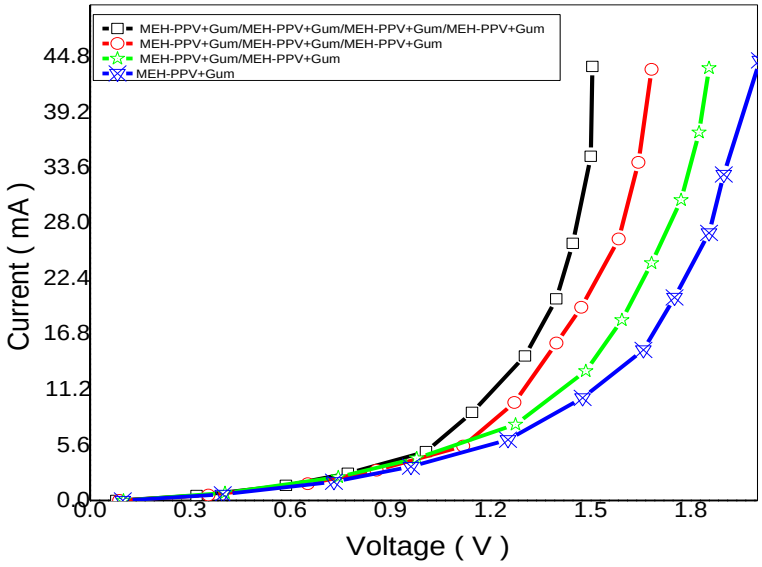

Figure (4.34) I-V characteristics of Gum Arabic Made by chemo-thermal Method, and doped with Aluminum Oxide samples

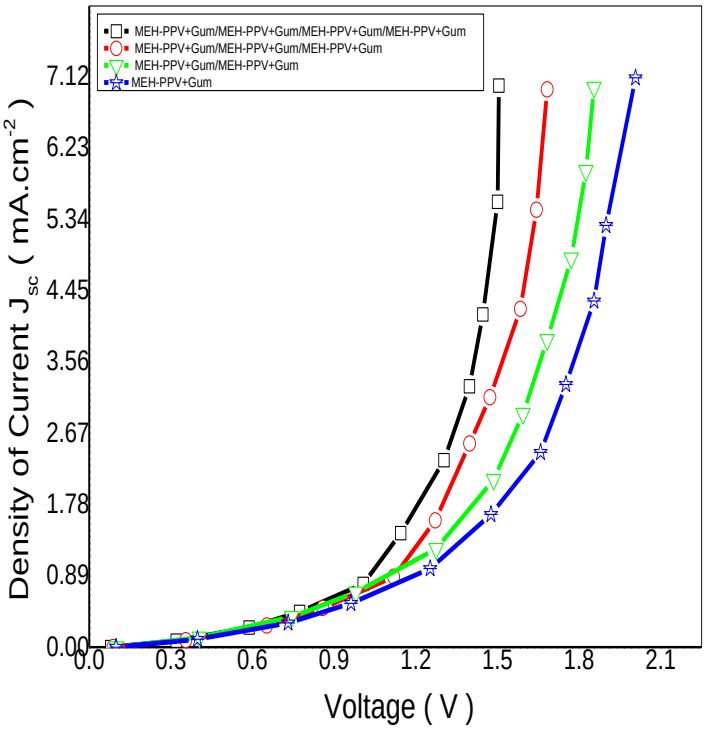

Figure (4.35) Density current characteristics of Gum Arabic Made by chemo-thermal Method, and doped with Aluminum Oxide samples

Table (4.13) the charge injection and a turn on voltage of Gum Arabic Made by (Sol Gel and chemo-thermal) Method and doped with Aluminum Oxide samples

No	Samples	charge injection voltage (V)		turn on voltage (V)	
		I-V	J_{sc} ($mA.cm^{-2}$)	I-V	J_{sc} ($mA.cm^{-2}$)
1	Sol Gel 1	3.01082	10.14804	0.15786	0.14031
2	Sol Gel 2	3.36538	10.00868	0.17540	0.11275
3	Sol Gel 3	3.70913	9.97490	0.19644	0.12528
4	Sol Gel 4	4.01442	9.94111	0.19995	0.17539
5	Chemo thermo 1	1.50541	7.10362	0.07893	0.09822
6	Chemo thermo 2	1.68269	7.00608	0.08770	0.07893
7	Chemo thermo 3	1.85457	6.98243	0.09822	0.08770
8	Chemo thermo 4	2.00721	6.95878	0.09998	0.12277

4.5.1 I-V characteristics multi-layers Discussion of Gum Arabic Made by (Sol Gel and chemo-thermal) Method and doped with Aluminum Oxide samples

The I-V characteristics of Gum Arabic synthesis by Sol Gal Method, and doped with Aluminum Oxide samples in fig (4.32) related to diode , a threshold of charge injection of around 4.01442 V and density current 9.97490 $mA.cm^{-2}$ for Fourth layer (MEH-PPV – Gum Arabic doped with Aluminum Oxide) and 3.70913V and density current 9.94111$mA.cm^{-2}$ for Tribal layers (MEH-PPV – Gum Arabic

doped with Aluminum Oxide) , 3.36538V and density current 10.00868 $mA.cm^{-2}$ for double layer (MEH-PPV – Gum Arabic doped with Aluminum Oxide) and 3.01082V and density current 10.14804$mA.cm^{-2}$ for single layers (MEH-PPV – Gum Arabic doped with Aluminum Oxide)and a high turn on voltage making very high power consumption. Later, flexible Gum Arabic synthesis by Sol Gel Method, and doped with Aluminum Oxide samples by spin coating a thin layer of poly aniline onto a sheet of poly ethylene tere phthalate, Poly (2-methoxy, 5-(2-ethylhexoxy)-1, 4- phenylene -vinylene (MEH- PPV) used ITO glass as cathode. The robust and highly twistable device had shown a turn on voltage at 0.19644V f and density current 0.17539 $mA.cm^{-2}$ or Fourth layer (MEH-PPV – Gum Arabic doped with Aluminum Oxide) and0.19995 V and density current 0.12528 $mA.cm^{-2}$ for Tribal layers (MEH-PPV – Gum Arabic doped with Aluminum Oxide), at 0.17540V and density current 0.11275 $mA.cm^{-2}$ for double layer (MEH-PPV – Gum Arabic doped with Aluminum Oxide) and 0.15786V and density current 0.14031 $mA.cm^{-2}$ single layers (MEH-PPV – Gum Arabic doped with Aluminum Oxide) as shown from Fig (4.32) to fig (4.35) .All this results keeping in table (4.12). For all above results we show the relation between the number of layers on the samples and (Charge Injection Voltage and Turn On Voltage) and current density, it's clear that the Charge Injection Voltage and Turn On Voltage increases with layers of sample increases, but for density of current decreases according to increases the thickness of layers that means increases the distance that electron pass through it.

And the I-V characteristics of Gum Arabic synthesis by chemo-thermal Method, and doped with Aluminum Oxide samples in fig (4.34) related to diode , a threshold of charge injection of around 2.00721 V and density current 6.98243 $mA.cm^{-2}$ for Fourth layer (MEH-PPV – Gum Arabic doped with Aluminum Oxide) and 1.85457 V and density current 6.95878 $mA.cm^{-2}$ for Tribal layers (MEH-PPV – Gum Arabic doped with Aluminum Oxide) , 1.68269 V and density

current 7.00608 mA.cm^{-2} for double layer (MEH-PPV – Gum Arabic doped with Aluminum Oxide) and 1.50541 V and density current 7.10362 mA.cm^{-2} for single layers (MEH-PPV – Gum Arabic doped with Aluminum Oxide) and a high turn on voltage making very high power consumption. Later, flexible Gum Arabic synthesis by Sol Gel Method, and doped with Aluminum Oxide samples by spin coating a thin layer of poly aniline onto a sheet of poly ethylene terephthalate, Poly (2-methoxy, 5-(2-ethylhexoxy)-1, 4- phenylene -vinylene (MEH- PPV) used ITO glass as cathode . The robust and highly twistable device had shown a turn on voltage at 0.09822 V f and density current 0.12277 mA.cm^{-2} or Fourth layer (MEH-PPV – Gum Arabic doped with Aluminum Oxide) and 0.099980 V and density current 0.08770 mA.cm^{-2} for Tribal layers (MEH-PPV – Gum Arabic doped with Aluminum Oxide), at 0.08770 V and density current 0.0783 mA.cm^{-2} for double layer (MEH-PPV – Gum Arabic doped with Aluminum Oxide) and 0.07893 V and density current 0.09822 mA.cm^{-2} single layers (MEH-PPV – Gum Arabic doped with Aluminum Oxide) as shown from Fig (4.34) to fig (4.35) .All this results keeping in table (4.12). For all above results we show the relation between the number of layers on the samples and (Charge Injection Voltage and Turn On Voltage) and current density, it's clear that the Charge Injection Voltage and Turn On Voltage increases with layers of sample increases, but for density of current decreases according to increases the thickness of layers that means increases the distance that electron pass through it. When to compare all results obtained by the chemo-thermal and sol gel fond that the value of sol gel greater than chemo-thermal due to enthalpy of formation.

4.6 Discussion

From XRD results, we observed the preparation effects on crystal structure. Molar crystallites with (Hexagonal- Primitive) crystal structure for Gum Arabic Made by (sol Gel) method samples and (Cubic – Primitive) for the Gum Arabic Made by (chemo-thermal) method samples .As general the first method (sol gel) had crystal parameter greater than second method (chemo-thermal). When the number of layers increases the grain size and density also increases for both methods, but the d-space was decreased in chemo-thermal while in sol gel method was increased, the variation in d-space due to enthalpy of formation in chemo-thermal method. In FTIR different preparation methods of samples (sol Gel, chemo thermal) led to the different vibration positioned of bonds in the molecule. The value of photon energy for sol gel method is greater than the value of photon energy in chemo-thermo method, this difference due to red shift appear in the maximum absorbance of samples. The optical energy gap (E_g) value in chemo- thermal sample was less than the value Sol Gel sample. The shift in energy gap (E_g) as showed according to the treatment method. This matches the results obtained from XRD device.

Both methods used gave the same refractive index in two different wavelengths (436nm and 442nm for sol gel and 510nm and 520nm for chemo-thermal method) with red shift in chemo-thermal method. In the two regions the samples behave as mirror. An optical conductivity for Sol Gel sample equal ($9.63x10^8$ Sec^{-1}) at 435 nm and ($9.61x10^8$ Sec^{-1}) at 510 nm, and for chemo -Thermal were ($9.58x10^8$ Sec^{-1}) at 442 nm and ($9.55x10^8$ Sec^{-1}) at 520 nm with red shift in chemo-thermal method, the change of optical conductivity at high photo - generation due to the high absorbance of all samples prepared according to electron excitation by photon energy. The energy gap of the materials prepared in this study was within the energy band gap range of semiconductor materials, which matches the previous studies mentioned in chapter two, so it can be used as a diode multilayer.

From I-V characteristic results of diode multilayer the relation between the number of layers and (Charge Injection Voltage and Turn on Voltage), voltage increases with number of layers increases, while the density of current decreases in two cases.

The variation in all properties (crystal structure -vibration positioned of bonds in the molecule and optical) due to enthalpy of formation based on this reasons the rest properties well change.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATION

5.1 Conclusions

In this research the Gum Arabic sample doped by aluminum oxide prepared by two methods (sol gel and chemo-thermal). Eight samples synthesis thin film on ITO glass which was cleaned by ethanol and distilled water, then were washed ITO glass to prepare the mixture to deposited on ITO a glass manner by using Spin Coating, the coating on glass was performed at room temperature, with suitable speed rate for 60 s and another layer was deposited from MEH-PPV polymer on Gum Arabic that synthesis layer (single layer, double layer, triple layer and quadrille layer) for each method. All samples characterized by XRD, the crystallites with (Hexagonal- Primitive) crystal structure for Gum Arabic Made by (sol Gel) method samples and Cubic – Primitive for the Gum Arabic Made by (chemo-thermal) method samples. And the XRD charts of all samples varied.

The FTIR spectra of Gum Arabic Made by two methods was achieved ,we observed The differences in vibration positioned of bonds in the molecule for two methods while the optical properties of Gum Arabic Made by (two methods) using by UV-VS mini 1240 spectrophotometer investigated for all samples. We found the energy gap and conductivity for sol gel samples greater than other methods. The I-V characteristic results of diode multilayer the relation between the number of layers and (Charge Injection Voltage and Turn on Voltage), voltage increases as the number of layers increases, while the density of current decreases in two cases. The materials were prepared in this study included energy band gap range of semiconductor materials that confirm with previous studies mention in chapter two, so it can be used as diode multilayer. The variation in all properties (crystal structure -vibration positioned of bonds in the molecule and optical) due to enthalpy of formation based on this reasons the rest properties will change.

5.2 Recommendation

- The study was recommended to apply this material in solar cell or other semiconductor devices such as transistor.
- Studying the surface morphology of this material by other techniques like (SEM OR TEM).
- Studying the optical properties of the materials that were used by choosing different types of Gum Arabic.
- Studying the optical, structure and magnetic properties of the material with different concentration for one type of Gum Arabic.
- Studying the optical, structure and magnetic properties of Gum Arabic doped by different oxide.
- Use this diode for convenient application.

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(FTIR and XRD) Spectroscopy for Thin Film Multilayers Gum Arabic Doping with Aluminum Oxide by Sol Gal method

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Abstract*: Syntheses Gum Arabic Made by (Sol Gal) Method and doping with Aluminum Oxide, and used XRD to study the crystal structure, and (FTIR) spectroscopy to measure the vibrational bonds. XRD get that molar crystallites with (Hexagonal- Primitive) crystal structure, and miller indices provided [at* **25.873** *(3 0 0), at* **30.656** *(0 1 1), at* **35.688** *(4 0 1) and at 48.604 (0 3 1)]* **.***Fourier transform Infrared (FTIR) spectroscopy is a versatile technique for the characterization of materials belonging to the Thin Film Gum Arabic Doping with Aluminum Oxide by Sol Gal method multilayers. Most important features of this method are non-destructive, real-time measurement and relatively easy to use. By FTIR measure the vibrational of following bonds in the molecule (water O-H stretch, O–H stretch vibration of alcohol group, 1°, 2° amines, amides (N–H stretch) alkenes (–C=C– stretch) ,(C–C stretch (in–ring)) and (C–N stretch) stretching for aliphatic amines)*

Keywords : **Gum, Arabic Doping, Aluminum**

Introduction

The main gum Arabic producing regions of the Sudan, which covers most of Kordofan and Darfur state and Part of White Nile stat [1]. Gum Arabic is a natural polymer, play an important role in our daily life. 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 foodstuffs and an adhesive material due to its high viscosity and also used as an additive to make stable suspension mixture for medical surprise, lithography, textiles, paint, inks, and cosmetic[2]. Gum Arabic is most important commercial poly- saccharine and it is probably the oldest food hydrocolloid in current use. Gum Arabic is high molecular weight polymeric compounds, composed mainly 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}[3].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%}, GA lactose {32- 50%}, rhamnose {n- 16%}, glue carbonic acid {3-50%} and protein 1. 8- 16%} with an optical rotation of {28° to 32°}[4]. Gum Arabic, also known as gum acacia, char goo, is a natural gum made of hardened sap taken from two species of the acacia tree; Acacia Senegal and Acacia seyal. The gum is harvested commercially from wild trees throughout the Sahel from Senegal and Sudan to Somalia, although it has been historically cultivated in Arabia and West Asia. Gum Arabic is a complex mixture of polysaccharides and glycoprotein's that is used primarily in the food industry as a stabilizer. It is perfectly edible and has E number E414. Gum Arabic is a key ingredient in traditional lithography and is used in printing, paint production, glue, cosmetics and various industrial applications, including viscosity control in inks, although cheaper materials compete with it for many of these roles. Chemical properties effect on surface tension in liquids .Gum Arabic reduces the surface tension of liquids, which leads to increased fizzing in carbonated beverages this can be exploited in what is known as a Diet Coke and Mantes [5].There are many studies, which are done in Gum Arabic on different domain concerning new research in addition to identifying new application of Gum Arabic. One of this study is Gum Arabic based solar cells with Rhodamin 6G were fabricated on indium tin oxide by a spin coater position. Microstructure and cell performance of the solar cells with ITO/ Rhodamin 6G/ Gum Arabic structures were investigated. Photovoltaic devices based on the Rhodamin 6G/Gum Arabic hetro junction structures provided photovoltaic properties under illumination [5].The other study was made Gum Arabic (Talha) as Nano-material doping by Iodine were prepared in different Concentration . Optical Properties of this material measured by using the UV-Spectroscopy min 1240, and study the effaced of Iodine different concentration on the optical parameters. The study reached to absorbance increases upon increasing the concentration, while the transmission decreases, and the value of Energy band gap (Eg) was decreased from (4.420) eV to (4.323) eV as increasing the concentration [6].The last one was used Gum Arabic doped by Cu O based Dye Sensitized Solar Cells (DSSC) with different type of dyes (Coumarin 500, Ecrchrom Black, Rhodamine B, DDTTc and Nile blue) were fabricated on ITO glass. Photovoltaic devices based on the Gum Arabic and dyes hetrojunction structures provided photovoltaic properties under illumination. The DSSC were produced and characterized. The analysis shows that the efficiency of the solar cell increases when the upper layer is that are more transparent [7]. The aim of this work is to syntheses Gum Arabic Made by (Sol Gal and chemo - thermos) Method and doping with Aluminum Oxide , and used XRD to study the crystal structure of all samples characterized , and used (FTIR) Fourier Transform Infrared spectroscopy is a technique used to measure the vibrational frequencies of bonds in the molecule are carried out.

Experimental

In this work, gum Arabic prepared by two methods (sol gel), .The precursor used in the synthesis gum Arabic (GA) and Aluminum Oxide (Al_2O_3). For the sol-gel process used Gum Arabic and Aluminum nitrate monohydrate, (5g) Hashab Gum Arabic dissolved in 50 ml of distillation water then 1ml ammonia added to solution .The solution was stirred for 60 min at 80°C. Moreover (2g) aluminum nitrate monohydrate Al $(NO_3)_3.9H_2O$ was dissolving in (110 ml) Ethanol C_2H_5OH in the glass beaker. Then dropped 1ml Dimethyl 2- methyl the solution was stirred for 60 min at 80°C. After that, the two solutions are mixed and put at room temperature for 24 hours, and we obtained the Sol ready to be used to prepare as layers by spinner (spin coating).. The Arabic Gum doping Aluminum Oxide was made on ITO glass. The ITO glasses were firstly cleaned by ethanol and distilled water.

Then, were washed ITO glass by deionized water .Then used the that prepper mixture to deposited on ITO a glass manner Spin Coating, the coating on glass was performed at room temperature, with suitable speed rate for 60 s, for 0.02 A and 1.9V for 60 s and another layer was deposited from MEH-PPV polymer on Gum Arabic that synthase layer . Every layer from Gum Arabic coated with MEH-PPV. Four samples were prepared with Gum Arabic doping by Aluminum Oxide (Al_2O_3)(single layer sample ,bilayer sample ,triple layered and quadruple layers sample as showing in fig (1) , the thicknesses of the thin layer were about (47.7 nm for single layer, 54.4 nm for bilayer , 61.2 nm for triple layered and 75.3 nm for quadruple layers) respectively by XRD results . After syntheses four thin film Gum Arabic by (Sol Gal) Method and doping with Aluminum Oxide and MEH-PPV samples , used XRD to study the crystal structure , and used Fourier Transform Infrared spectroscopy(FTIR) to measure the vibrational of bonds as showing
in the results blow .

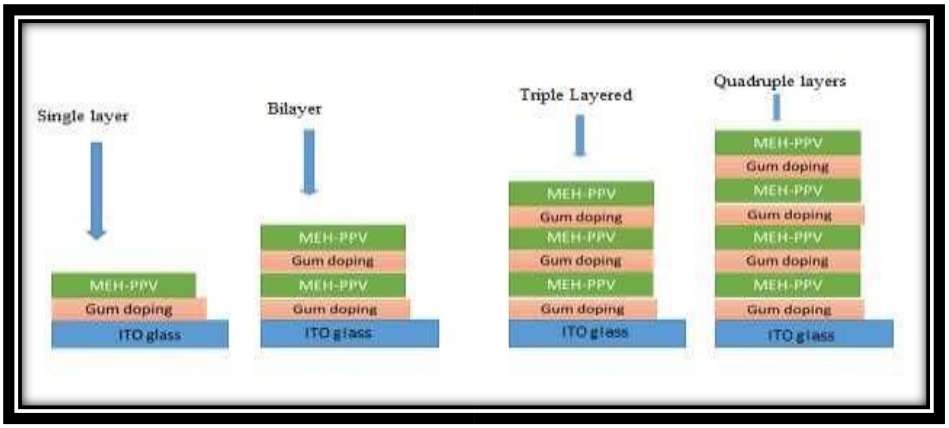

Fig (1) schematic structure of four thin film samples syntheses by Gum Arabic (Sol Gal) Method and doping with Aluminum Oxide sample and MEH-PPV

Results

After prepared four thin film multilayers of Gum Arabic by (Sol Gal) Method and doping with Aluminum Oxide and MEH-PPV samples, used XRD to study the crystal structure , and used Fourier Transform Infrared spectroscopy(FTIR) to measure the vibrational of bonds as showing in the results blow

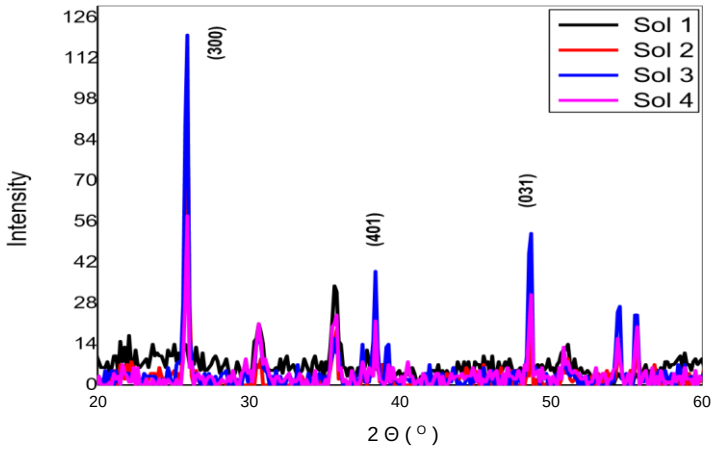

Fig (2) XRD spectrum of all sample that made from Gum Arabic doping by Aluminum Oxide sol gal method

Table (1) Calculate Lattice Constants from Peak Locations and Miller Indices of four thin film samples syntheses by Gum Arabic (Sol Gal) Method and doping with Aluminum Oxide sample and MEH-PPV

sample	d (A^0)	FWHM	Xs (nm)	δ ($mg.cm^{-3}$)
Single layer	3.4246	0.198	47.7	2.3145
Bilayer	3.4185	0.180	54.4	3.7849
Triple layered	3.3655	0.732	61.2	4.1522
Quadruple layers	3.3251	0.732	75.3	5.3423

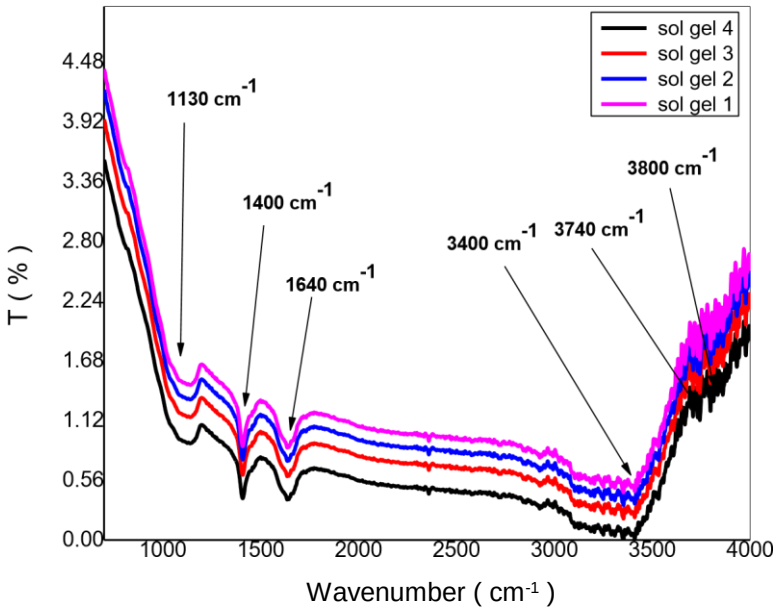

Fig (3) FTIR spectrum of Gum Arabic Made by sol Gel and doping By Aluminum Oxide Table (2) Table of Characteristic FTIR of Gum Arabic Made by sol Gel and doping By Aluminum Oxide

no	wavenumber	bond	Funcation groupe
1	1130	C–N stretch	aliphatic amines
2	1400	C–C stretch (in–ring)	aromatics
3	1640	–C=C– stretch	alkenes
4	3400	N–H stretch	1°, 2° amines, amides
5	3740	O-H strech	Alcohoal
6	3800	O-H strech	Water

Discussion

The crystal structure of all samples characterized at room temperature using a Philips PW1700 X-ray diffract meter (operated at 40 kV and current of 30 mA) and samples were scanned between 5^O and 25^O at a scanning speed of 0.06 ^{o}C/s using Cu Kα radiation with λ = 1.5418Å. The representative XRD charts of Gum Arabic Made by (sol Gel) methods and doping By Aluminum Oxide samples as show in fig (2). Miller indices provided in the fig (1) and all peaks determine transformation of Gum Arabic Made by (sol Gel) method and doping By Aluminum Oxide. Molar crystallites with (Hexagonal- Primitive) crystal structure. Table (1) shows

the XRD parameters of Gum Arabic Made by (sol Gel) method samples at various crystalline orientations. When we describe the relation between the number of samples layers and density, we showing that increase the density by increasing the number of samples layers, and other increases the crystals size as calculated from table (1) for Gum Arabic Made by (sol Gel) method samples . Moreover, for the representative XRD charts of all Gum Arabic Made by (sol Gel) method samples. The miller indices provided in the figure (2) [at 25.873 (3 0 0), at 30.656 (0 1 1), at 35.688 (4 0 1) and at 48.604 (0 3 1)] for Gum Arabic Made by (sol Gel) method samples. Table (1) shows the XRD parameters of Gum Arabic Made by (sol gel) method samples at various crystalline orientations. The treatment method of samples; it was observed that sample treatment is confirmed the reason for the crystal structure shifts, it is clear that the Charge crystal structure with layers samples. The relation between the crystal structure number of samples layers increases density and crystals size by layers sample increases, but d- spacing of sample decreases as showing in table (1). Fourier Transform Infrared spectroscopy is a technique used to measure the vibrational frequencies of bonds in the molecule. The FTIR spectra of Gum Arabic Made by sol Gel and doping By Aluminum Oxide samples is shown in Fig (3). The strong intensity peak at 3800 cm^{-1} assigned to water O-H stretch, at 3740 cm^{-1} assigned to O–H stretch vibration of alcohol group, the band at 3400 cm^{-1} assigned to 1°, 2° amines, amides (N–H stretch) vibration. Peak at 1640 cm^{-1} assigned to alkenes (–C=C– stretch) while the very intense peak positioned at 1400 cm^{-1} revealed the presence of (C–C stretch (in–ring)) stretching for aromatics. In addition, while the very intense peak positioned at 1130 cm^{-1} revealed the presence of (C–N stretch) stretching for aliphatic amines. All this results as showing in table (2).

Conclusion

Syntheses 4 thin film multilayers of Gum Arabic by (Sol Gal) Method and doping with Aluminum Oxide and MEH-PPV samples, and study the crystal structure and vibrational frequencies of bonds in the molecule. The relation between the crystal structure number of samples layers increases density and crystals size by layers sample increases, but d- spacing of sample decreases.

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Optical Parapets of Gum Arabic Syntheses by (Sol Gal and chemo - thermos) Method and doping with Aluminum Oxide samples

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Abstract: *Syntheses Gum Arabic Made by (Sol Gal and chemo - thermos) Method and doping with Aluminum Oxide, and used UV-VS mini 1240 spectrophotometer to study the optical parapets. The absorbance in range(410 to 555) nm for all samples ,the maximal absorbance of sol gel at 465 nm corresponding photon energy 2.667 eV, and for chemo thermos sample at 576 nm corresponding photon energy 2.605 eV. The value of absorption coefficient (α) equal 4.25 cm^{-1} for (Sol Gal) Method sample in the visible region(465 nm) , but for (chemo - thermos) Method sample equal 4.36 cm^{-1} at the (476 nm) wavelength. The energy band gap (Eg) value of (Sol Gal) Method sample equal (2.397) eV but for (chemo - thermos) Method sample equal (2.349) eV.*

Keywords: *Gum Arabic, Sol Gel, Chemo Thermos, Optical property, Absorption Coefficient and Optical Energy Band Gap.*

Introduction

The main gum Arabic producing regions of the Sudan, which covers most of Kordofan and Darfur state and Part of White Nile stat [1]. Gum Arabic is a natural polymer, play an important role in our daily life. 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 foodstuffs and an adhesive material due to its high viscosity and also used as an additive to make stable suspension mixture for medical surprise, lithography, textiles, paint, inks, and cosmetic[2]. Gum Arabic is most important commercial poly- saccharine and it is probably the oldest food hydrocolloid in current use. Gum Arabic is high molecular weight polymeric compounds, composed mainly 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}[3].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%}, GA lactose {32- 50%}, rhamnose {n- 16%}, glue carbonic acid {3- 50%} and protein 1. 8- 16%} with an optical rotation of {28° to 32°}[4]. There are many studies, which are done in Gum Arabic on different domain concerning new research in addition to identifying new application of Gum Arabic. One of this study is Gum Arabic based solar cells with Rhodamin 6G were fabricated on indium tin oxide by a spin coater position. Microstructure and cell performance of the solar cells with ITO/ Rhodamin 6G/ Gum Arabic structures were investigated. Photovoltaic devices based on the Rhodamin 6G/Gum Arabic hetro junction structures provided photovoltaic properties under illumination [5].The other study was made Gum Arabic (Talha) as Nano-material doping by Iodine were prepared in different Concentration . Optical Properties of this material measured by using the UV- Spectroscopy min 1240, and study the effaced of Iodine different concentration on the optical parameters. The study reached to absorbance increases upon increasing the concentration, while the transmission decreases, and the value of Energy band gap (Eg) was decreased from (4.420) eV to (4.323) eV as increasing the concentration [6].The last one was used Gum Arabic doped by Cu O based Dye Sensitized Solar Cells (DSSC) with different type of dyes (Coumarin 500, Ecrchrom Black, Rhodamine B, DDTTc and Nile blue) were fabricated on ITO glass. Photovoltaic devices based on the Gum Arabic and dyes hetrojunction structures provided photovoltaic properties under illumination. The DSSC were produced and characterized. The analysis shows that the efficiency of the solar cell increases when the upper layer is that are more transparent [7].

The aim of this work is to syntheses Gum Arabic Made by (Sol Gal and chemo - thermos) Method and doping with Aluminum Oxide , and used UV-VS mini 1240 spectrophotometer to study the optical parapets (absorbance, transmission, reflection, absorption coefficient, extinction coefficient and optical energy band gap) are carried out.

Experimental

In this work, gum Arabic prepared by two methods (sol gel and chemo thermos), .The precursor used in the synthesis gum Arabic (GA) and Aluminum Oxide (Al_2O_3). For the sol-gel process used Gum Arabic and Aluminum nitrate monohydrate, (5g) Hashab Gum Arabic dissolved in 50 ml of distillation water then 1ml ammonia added to solution .The solution was stirred for 60 min at 80°C. Moreover (2g) aluminum nitrate monohydrate Al $(NO_3)_3.9H_2O$ was dissolving in (110 ml) Ethanol C_2H_5OH in the glass beaker. Then dropped 1ml Dimethyl 2- methyl the solution was stirred for 60 min at 80°C. After that, the two solutions are mixed

and put at room temperature for 24 hours, and we obtained the Sol ready to be used to prepare as layers by spinner (spin coating).In the second method Chemo thermos has been used to prepare Gum Arabic and Aluminum nitrate monohydrate. 17 ml acid added 34 ml ethanol (C_2H_5OH) slowly and the solution was stirred for 5 min , then added (5g) Hashab Gum Arabic , the solution was stirred for 60 min at 70°C. In addition (2g) Aluminum Nitrate monohydrate Al $(NO_3)_3.9H_2$ O dissolved in 110 ml Ethanol C_2H_5OH, and then 2 ml 2 Dimethyl methyl dropped, the solution was stirred for 60 min at 100°C. After that, two solutions were mixed in ice bath with stirred for 60 min. The mixture have been leaved in lab's temperature about one day. After syntheses Gum Arabic by (Sol Gal and chemo - thermos) Method and doping with Aluminum Oxide samples used UV-VS mini 1240 spectrophotometer to study the optical parapets (absorbance, transmission, reflection, absorption coefficient, extinction coefficient and optical energy band gap) as showing in the results blow , the curves we found the behavior of Gum Arabic Made by (Sol Gal and chemo - thermos) Method and doping with Aluminum Oxide samples studied using UV-VS min 1240 spectrophotometer

Results and Discussion

After prepared gum Arabic by two methods (sol gel and chemo thermos), used UV-VS min 1240 spectrophotometer to study the Optical properties (absorbance, transmission, reflection, absorption coefficient, extinction coefficient and optical energy band gap) as showing in the results blow.

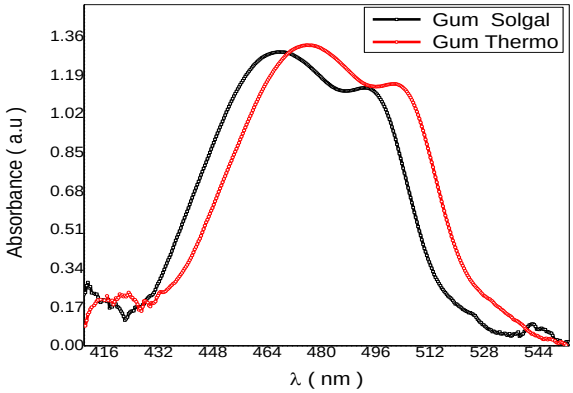

Fig (1) the relation between absorbance and wavelengths of Gum Arabic Made by (Sol Gal and chemo - thermos) Method and doping with Aluminum Oxide samples

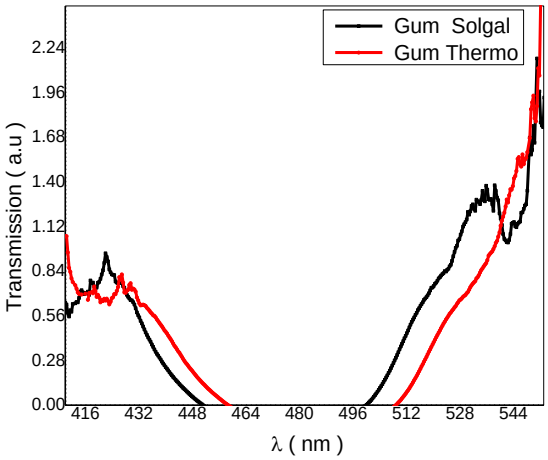

Fig (2) the relation between transmission and wavelengths of Gum Arabic Made by (Sol Gal and chemo - thermos) Method and doping with Aluminum Oxide samples

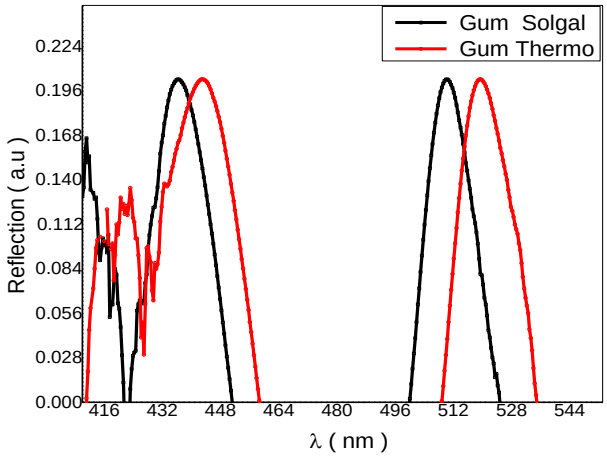

Fig (3) the relation between reflection and wavelengths of Gum Arabic Made by (Sol Gal and chemo - thermos) Method and doping with Aluminum Oxide samples

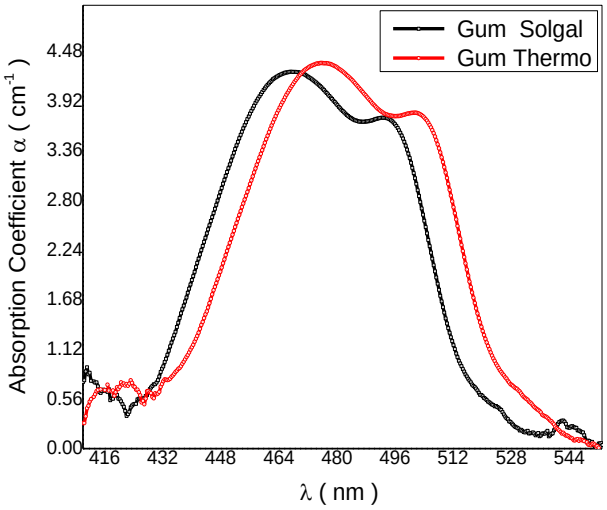

Fig (4) the relation between absorption coefficient and wavelengths of Gum Arabic Made by (Sol Gal and chemo - thermos) Method and doping with Aluminum Oxide samples

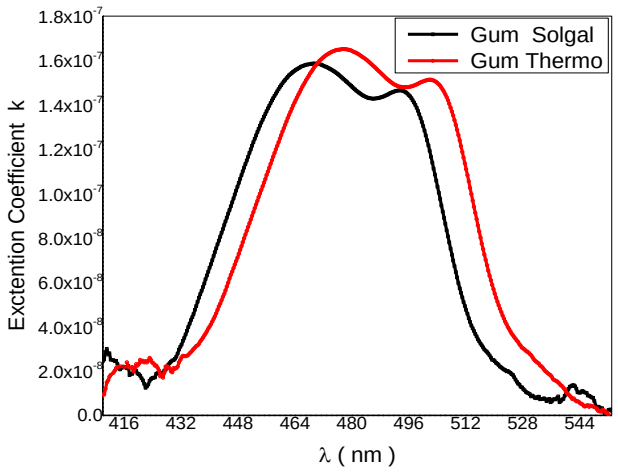

Fig (5) the relation between extinction coefficient and wavelengths of Gum Arabic Made by (Sol Gal and chemo - thermos) Method and doping with Aluminum Oxide samples

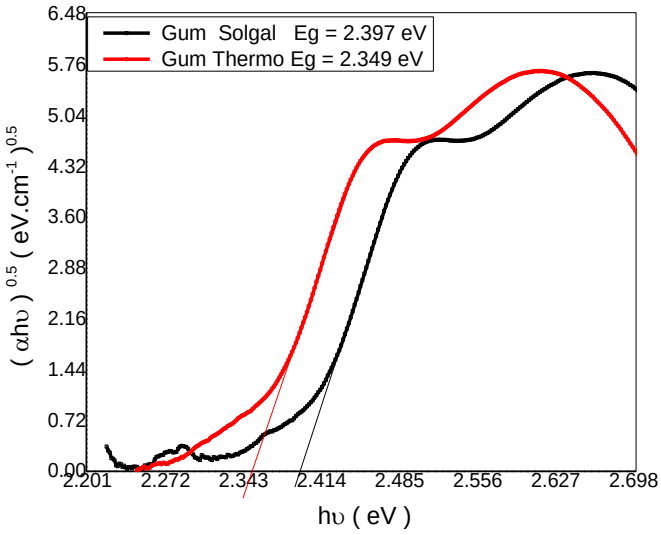

Fig (6) optical energy band gap of Gum Arabic Made by (Sol Gal and chemo - thermos) Method and doping with Aluminum Oxide samples

Discussion

For figure (1)Shows the relation between absorbance and wavelengths for Gum Arabic Made by (Sol Gal and chemo - thermos) Method and doping with Aluminum Oxide samples at range(410 to 555) nm for all samples , for sol gel sample the maximal absorption at wavelengths 465 nm corresponding photon energy 2.667 eV, and for chemo thermos sample the maximal absorption at wavelengths 576 nm corresponding photon energy 2.605 eV .The absorption coefficient (α) of Gum Arabic Made by (Sol Gal and chemo - thermos) Method and doping with Aluminum Oxide samples were found from the following relation $\alpha = \frac{2.303xA}{t}$ where (A) is the absorbance and (t) is the optical length in the samples. In fig (2) showing the relation between transmission and wavelengths of Gum Arabic Made by (Sol Gal and chemo - thermos) Method and doping with Aluminum Oxide samples**,** and in fig (3) showing the relation between reflection and wavelengths of Gum Arabic Made by (Sol Gal and chemo - thermos) Method and doping with Aluminum Oxide samples**.** In fig (4) shows the plot of (α) with wavelength (λ) of Gum Arabic

Made by (Sol Gal and chemo - thermos) Method and doping with Aluminum Oxide samples , which obtained that the value of α = 4.25 cm^{-1} for Gum Arabic Made by (Sol Gal) Method and doping with Aluminum Oxide sample in the visible region(465 nm) but for Gum Arabic Made by (chemo - thermos) Method and doping with Aluminum Oxide sample equal 4.36 cm^{-1} at the (476 nm) wavelength , this absorption coefficient value means that the transition must corresponding to indirect electronic transition, and the properties of this state are important since they are responsible for electrical conduction. Extinction coefficient (K) was calculated using the relation $= \frac{\alpha\lambda}{4\pi}$. The variation of the extinction coefficient (K) values as a function of (λ) are shown in fig (5) for (Gum Arabic Made by (Sol Gal and chemo - thermos) Method and doping with Aluminum Oxide samples and it is observed that the spectrum shape of (K) as the same shape of (α). The extinction coefficient (K) for Gum Arabic Made by (Sol Gal and chemo - thermos) Method and doping with Aluminum Oxide samples in fig (5) obtained the value of (K) for the Gum Arabic Made by (Sol Gal) Method and doping with Aluminum Oxide at the (465 nm) wavelength was depend on the samples treatment method equal $1.578x10^{-7}$, where the value of (K) at 476 nm for Gum Arabic Made by (chemo - thermos) Method and doping with Aluminum Oxide sample equal $1.65x10^{-7}$ .The effects of method that treatment for the sample on the Extinction coefficient (k) is the mean of wavelength shift . The optical energy gap (Eg) has been calculated by the relation $(\alpha h\upsilon)^2 = C(h\upsilon - Eg)$ where (C) is constant. By plotting $(\alpha h\upsilon)^2$ vs photon energy (hυ) as shown in fig.(6) for the (Gum Arabic Made by (Sol Gal and chemo - thermos) Method and doping with Aluminum Oxide samples . And by extrapolating the straight thin portion of the curve to intercept the energy axis, the value of the energy gap has been calculated .In fig (4) the energy band gap (Eg)value of Gum Arabic Made by (Sol Gal) Method and doping with Aluminum Oxide equal (2.397) eV but for Gum Arabic Made by (chemo - thermos) Method and doping with Aluminum Oxide equal (2.349) eV .The value of(Eg) was decreased from (2.397) eV to (2.349) eV . The decreasing of (Eg) related to the method that treatment of samples; it was observed that chemo thermos annealing the samples, this reason confirmed the reason for the band gap shifts.

Conclusion

Syntheses Gum Arabic by (Sol Gal and chemo - thermos) Method and doping with Aluminum Oxide samples, and study the optical parapets. The energy band gap of all samples was decreased from (2.397) eV to (2.349) eV related to the method that treatment of samples. Due to energy band gap value, the sample s can be used in the following application optoelectronic devices such as solar cell, light emitting diodes, and electrochemical sensors.

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