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Electrical Properties of Different Gum Arabic Thin Film by Optical Methods

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Abstract*: Syntheses Gum Arabic thin film made by mechanical method. The maximum value of refractive index (n) is (1.588) for all Gum Arabic (Hashaba, Neem and Talha) samples at wavelengths ranged (310 to 325) nm.The normal dielectric constant of all samples at (238 and 288) nm range where the absorption of the samples at these wavelengths is small, the maximum value of rai1 dielectric constant (ε1) equal to (19.22) at wavelength 295 nm for the Hashaba Gum Arabic samples, but for the Neem Gum Arabic samples equal 7.01 at 288 nm wavelength and for the Talha Gum Arabic samples equal 6.14 at the same wavelength (288nm).The high magnitude of optical conductivity (1.679x10^{15} sec^{-1}) at wavelengths range (303 to 315) nm for all samples confirms the very high photo-response of the 12 samples prepared by Gum Arabic.The maximum value of electrical conductivity for all samples equal 24.3 (Ω.cm)$^{-1}$ at wavelengths range (304 to 340) nm.*

Keywords*: Gum Arabic, thin film, normal dielectric constant, optical conductivity, electrical conductivity.*

I. Introduction

The main gum Arabic producing regions of the Sudan, which covers most of Kordofan and Darfur state and part of White Nile state [HIS,2015]. Gum Arabic is a natural polymer, play an important role in our daily life. It is one of the major exported goods from Sudan and more than 67% of world product is from Sudan. Gum Arabic has many uses in food stuffs and an adhesive material due to its high viscosity and also used as an additive to make stable suspension mixture for medical surprise, lithography, textiles, paint, inks, and cosmetic[Ropert. L, (1980)]. 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^{+} } [Al-Assaf,2009]. Chemically, A Senegal gum is an Arabian galactoy protein composed of arabinose {17-34%}, GA lactose {32- 50%}, rhamnose {3- 16%}, glue carbonic acid {3- 50%} and protein {1.8- 16%} with an optical rotation of {28° to 32°} [Anderson,1963]. 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.

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 [Abdalsakhi,2016].There are many studies, which are done in Gum Arabic on different domain concerning new research in addition to identifying new applications of Gum Arabic. One of these studies 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 Indium Tin Oxide (ITO)/ Rhodamin 6G/ Gum Arabic structures were investigated. Photovoltaic devices based on the Rhodamin 6G/Gum Arabic hetrojunction structures provided photovoltaic properties under illumination [Abdalsakhi,2016].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 effected 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 [H.Mustafa,2020, Fatima,2021]. The last one was used Gum Arabic doped by CuO based Dye Sensitized Solar Cells (DSSC) with different type of dyes (Coumarin 500, Ecrchrom Black, Rhodamine B, 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 [Alobid,2019]. The aim of this work is to syntheses three type of gum Arabic (Hashaba, Talha and Neem) as thin film made by mechanical method in different thicknesses (174.6, 56.0, 37.07 and 14.4) nm, and then we calculated electrical properties from the absorbance results.

II. Materials and Methods

In this work, three types of gum Arabic (Hashaba, Talha and Neem) were prepared thin film made by mechanical method in different thicknesses. The precursor used in the synthesis gum Arabic (GA) (5g) of Gum dissolved in 50 ml of distillation water and stirred for 10 min at room temperature. After that, the gum Arabic solution was ready to be used to prepare as layers by mechanical method in different thicknesses. The Arabic Gum solution was made on glass substrate. The glasses substrate was firstly cleaned by ethanol and distilled water. Then, washed substrate glass by deionized water. Then the Arabic Gum was deposited on substrate glass manner mechanical method, the coating on glass was performed at room temperature, with suitable at different thicknesses (174.6, 56.0, 37.07 and 14.4) nm. Four groups thin film Gum Arabic samples was syntheses, used UV 1240 min spectrophotometer to study the electrical properties by optical method. Firstly the absorbance was measured by UV-VIS spectrometer and then other properties like refractive index (n), real dielectric constant (ε_1), and Imaginary dielectric constant (ε_2), optical and electrical conductivity were calculated through below relations:

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

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

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

Real dielectric constant (ε_1) [Emtithal,2019**]**

$$\varepsilon_1 = n^2 - k^2 \quad (2)$$

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

$$\varepsilon_2 = 2nK \quad (3)$$

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

$$\delta_{opt} = \frac{\alpha n c}{4\pi} \quad (4)$$

$$\delta_{ele} = \frac{2\lambda\delta_{opt}}{\alpha} \quad (5)$$

Where (c) is light velocity

III. Results and discussions

After prepared three groups of Gum Arabic thin films samples at different thicknesses, the optical absorbance reading by UV-spectrophotometer as show in fig(1), then the electrical properties was calculated as monitoring below.

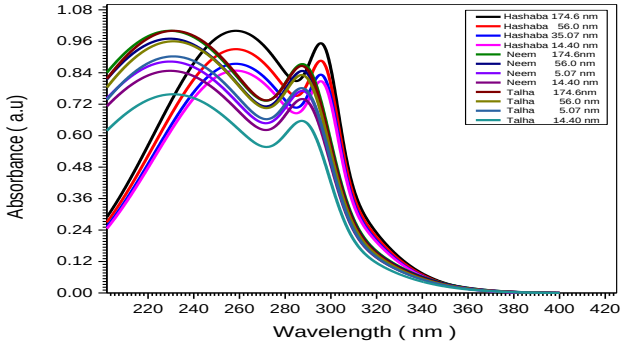

Fig (1) the relation between absorbance and wavelengths of three types of Gum Arabic at different thicknesses

In fig (1) show the absorbance curve of three types of Gum Arabic at different thicknesses. That measurement by UV 1240 min spectrophotometer in wavelengths range (190-420) nm.

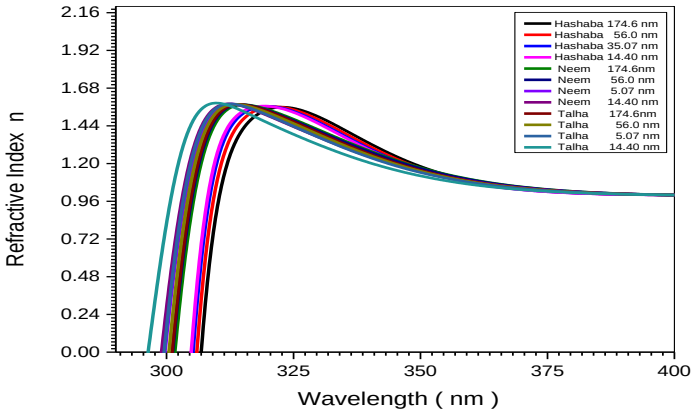

Fig (2) the relation between refractive index and wavelengths of Gum Arabic at different thicknesses

The refractive index (n) is the relative between speeds of light in vacuum to its speed in material which does not absorb this light. The value of n was calculated from the equation (1). The variation of (n) vs (λ) for 12 samples was treatment by Gum Arabic (Hashaba, Neem and Talha) at different thicknesses samples is shown in fig (2), which shows that the maximum value of (n) is (1.588) for all types of Gum Arabic at wavelengths ranged (310 to 325) nm, the point was agreement with red shift by increase for the samples thickness. Also we can notice that the value of (n) begin to decrease before 310 nm and after 325 nm on the spectrum.

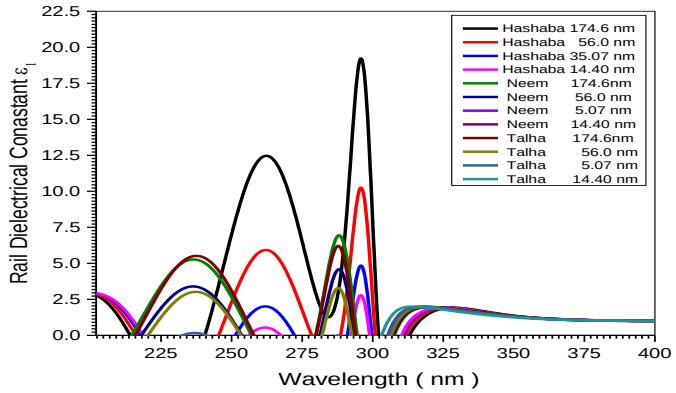

Fig (3) the relation between real dialectical constant and wavelengths of Gum Arabic at different thicknesses

Fig (3) shows the variation of the real dielectric constant (ε_1) with wavelength of three types of Gum Arabic at different thicknesses samples, which calculated from the relation(2). From fig (3) the variation of (ε_1) is follow the refractive index, where at wavelengths ranged (262 to 295) nm for all samples of Hashaba Gum Arabic, and (238 and 288) nm for (Neem and Talha) Gum Arabic samples, where the absorption of the samples at these wavelength is small, but the polarization was increase. The maximum value of (ε_1) recorded at maximal samples thickness174.6nm for three types of Gum Arabic but at different wavelength. (ε_1) equal to (19.22) at wavelength 295 nm for the Hashaba Gum Arabic, but for the Neem Gum Arabic equal 7.01, while for the Talha Gum Arabic equal 6.14,which were measure at the same wavelength (288nm) for both Neam & Talha. The effect of treatment samples on the (ε_1) were increase when the thickness increase.

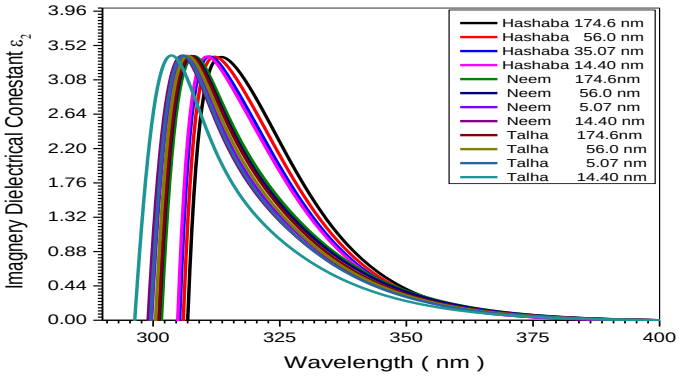

Fig (4) the relation between imagnery dialectical constant and wavelengths of Gum Arabic) at different thicknesses

The imaginary dielectric constant (ε_2) vs (λ) was shown in fig (4) this value calculated from the relation (3), (ε_2) represent the absorption associated with free carriers. As shown in fig (4) for the Gum Arabic at different thicknesses samples, the shape of (ε_2) is not the same as (ε_1), this means that the refractive index was dominated in these behavior. The maximum values of (ε_2) are different according to the treatment operation, so the maximum value of (ε_2) equal to (3.408) at wavelengths ranged (303 to 315) nm for all Gum Arabic types at different thicknesses samples, the point was agreement with blue shift by increase for the samples thickness. Also we can show that the value of (ε_2) begin to decrease before 303 nm and after 315nm on the spectrum, these behavior may be related to the different absorption mechanism for free carriers.

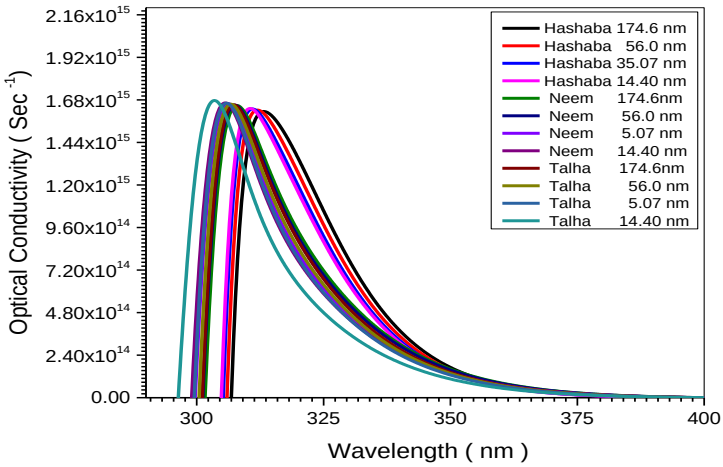

Fig (5) the relation between optical conductivity and wavelengths of Gum Arabic at different thicknesses.

The optical conductivity is a measure of frequency response of material when irradiated with light, which is determined by using the relation (4) .The high magnitude of optical conductivity ($1.679x10^{15}$ sec^{-1}) at wavelengths range (303 to 315) nm for all Gum Arabic samples confirms the presence of very high photo-response of the 12 samples prepared by Gum Arabic. The increased of optical conductivity at high photo ginneries is due to the high absorbance of Gum Arabic samples, and may be due to electron excitation by photon energy.

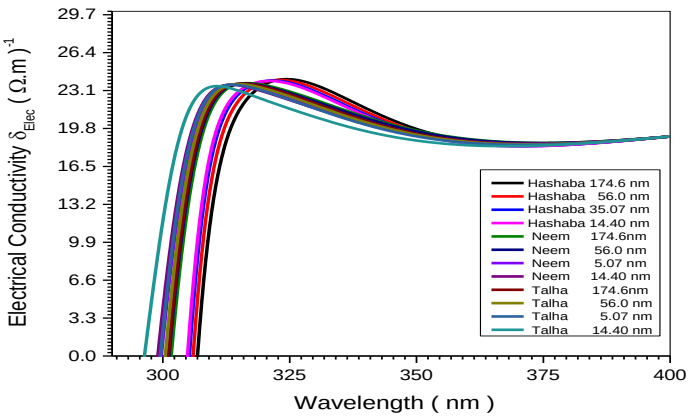

Fig. (6) The relation between electrical conductivity and wavelengths of Gum Arabic at different thicknesses.

The electrical conductivity is the measure of a materials ability to allow the transport of an electrical charge, which is determined by using the relation (5). The relation between electrical conductivity and wavelengths of Gum Arabic at different thicknesses shows in Fig. (6) The effect of Gum Arabic thin films at different thicknesses was blue shift on electrical conductivity by decreeing thin film thickness , the maximal value of electrical conductivity for all samples equal 24.3 $(\Omega.cm)^{-1}$ at wavelengths range (304 to 340) nm. According to this results of electrical conductivity, the Gum Arabic thin films can be classified as weak semiconductor materials.

IV. Conclusion

Syntheses 12 samples of three groups thin films Gum Arabic (Hashaba, Talha and Neem) samples at different thicknesses (174.6, 56.0, 37.07 and 14.4) nm. The Electrical properties were calculated by optical method. The maximum value of refractive index (n) equal (1.588) for all samples. Electrical conductivity of all samples equal 24.3 $(\Omega.cm)^{-1}$ at wavelengths range (304 to 340) nm with blue shift by increase for the samples thicknesses.

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