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Optical Properties of Different Gum Arabic Thin Film

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Abstract*: Twelve samples of Gum Arabic thin film were synthesized by mechanical method. UV- spectrophotometer was used to determine some optical properties. The maximal absorbance value equal (0.995 a.u) at wavelengths (257 and 295) nm for Hashaba, but for Neem equal (0.876 a.u) at (230 and 287) nm and for Talha equal (1.0029 a.u) at (230 and 287) nm and the value of absorbance increase by thickness of each sample increase. The absorption coefficient (α) of the three groups samples of Gum Arabic (Hashaba, Neem and Talha*) maximal value equal ($1.6x10^8$) for all types at different wavelengths (258)nm for Hashaba, (229.7) nm for Neem and 230.46nm for Talha , *this means that the transition must corresponding to a indirect electronic transition.The value of the optical energy gap (Eg) of all samples were increased from (3.925 eV) to (4.049 eV),and this due to decreased in thickness of samples.*

Keywords: *Gum Arabic, UV spectrophotometer, absorption coefficient and optical energy gap.*

I. Introduction

Gum Arabic is an exudate 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 [Williams & Phillips, 2000].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, lithography, cosmetic and pharmaceutical industry. In the food industry, GA is primarily used in confectionery, bakery, dairy, and beverage and as a microencapsulating agent. It is mostly used in food industry [Whlker, 1984], but other sectors such as textile, pottery, lithography, cosmetics and pharmaceutical industries also make use of it. Several researchers are also studying the applications 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 nanomedicine fields, due to its biocompatibility for in vivo applications, as well as its stabilization of nanostructures [S.M. Lindsay, (2010)], and it 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 [(Suresh, 2011)]. Nanotechnology has a various definitions of the fields of nanoscience and nanotechnology has 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 [GAO, 2014]. 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, material properties differ significantly from those of larger scales. The properties of matter at nanoscale 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 [Bharat,(2015)]. Finally, when the size drops below 100 nm, dramatic changes in properties can occur. The unique physical and chemical properties of nanomaterials can be exploited for commercial applications and for novel performance that benefits society. In this study prepared thin film by mechanical method from three types of gum Arabic (Hashaba, Talha and Neem) at different thickness (174.6, 56.0, 37.07 and 14.4) nm, and UV- spectrophotometer was used to determine some optical properties

II. MATERIALS AND METHODS

In this work, three types of gum Arabic (Hashaba, Talha and Neem) were prepared thin film by mechanical method at different thickness. The precursor used in the synthesis gum Arabic (GA) (5g) Gum Arabic dissolved in 50 ml of distillation water and stirred for 10 min at room temperature. After that, the gum Arabic solution we obtained ready to be used to prepare as layers by mechanical method in different thickness. The Arabic Gum solution was made on glass substrate. The glasses substrate was firstly cleaned by ethanol and distilled water, then was washed substrate glass by deionizer water. Then used the Arabic Gum to deposited on substrate glass manner mechanical method, the coating on glass was performed at room temperature, with suitable in different thickness (174.6, 56.0, 37.07 and 14.4) nm. Four samples were prepared with different type of Gum Arabic sample. After syntheses four groups thin film Gum Arabic samples, UV 1240 min spectrophotometer was used to study the optical properties like absorbance, transmission, reflection, absorption coefficient , energy band gap and extinction coefficient, which calculated from the fallowing relations:

Absorption coefficient (α)[Aldesogi, 2016]

$$\alpha = \frac{2.303 \times A}{\tau} \qquad (1)$$

Where:

α ≡ Absorption coefficient

A ≡ the absorbance

τ ≡ thickness of layer

Eg energy gap [Greene LE,2005]

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

Where:

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

υ ≡ frequuence =60Hz

C ≡ speed of light =3x10^{8}m/s

Extinction coefficient (K) [Waleed,2018]

$$k = \frac{\alpha\lambda}{4\pi} \qquad (3)$$

Where:

λ ≡ wavelength

III. Results and discussions

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

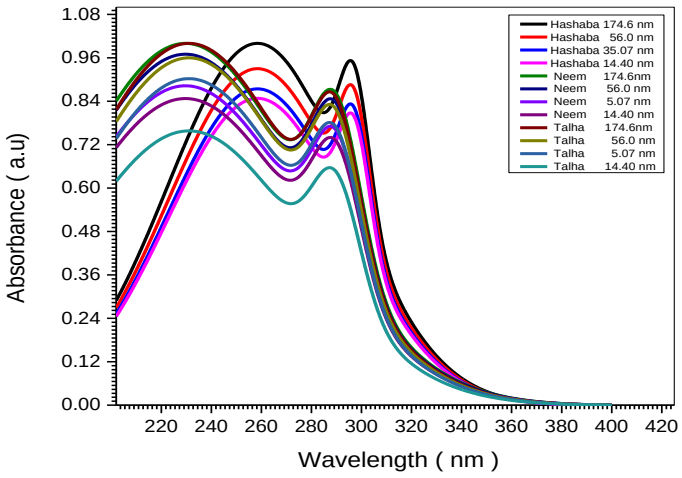

Fig (1) the relation between absorbance and wavelengths of three types of Gum Arabic (Hashaba, Neem and Talha) at different thicknesses

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

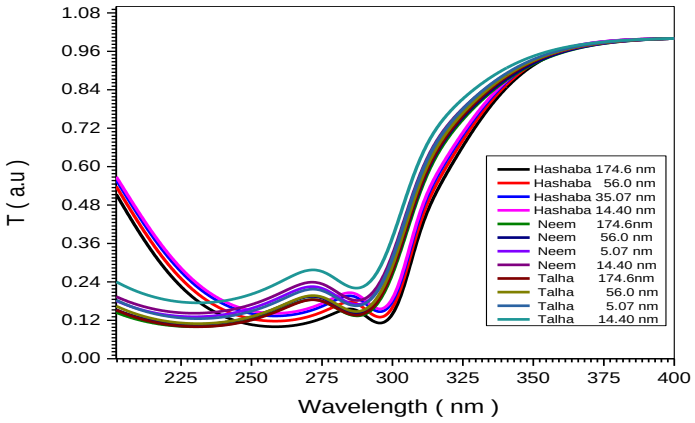

Fig (2) the relation between transmission and wavelengths of three types of Gum Arabic (Hashaba, Neem and Talha) at different thicknesses

Figur (2) shows the transmission of three Gum Arabic samples at different thicknesses. The fig (2) reveals the minimal transmission value for Neem and Talha at same wavelengths (230 and 287) nm,while for the Hashaba sample it found at wavelengths (257 and 295) nm,and all the value recorded at the same thickness. From the same figure we can notice that the increase in the transmission depends on the decrease of the thicknesses of the samples.

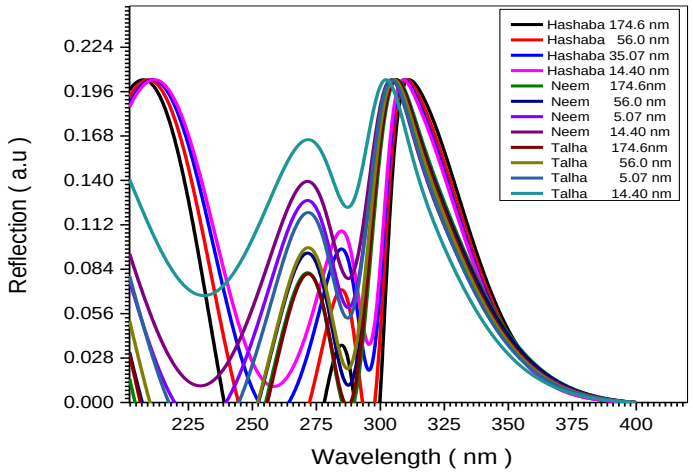

Fig (3) the relation between reflection and wavelengths of three types of Gum Arabic (Hashaba, Neem and Talha) at different thicknesses

The reflection of three samples Gum Arabic at different types and thicknesses shows in fig (3), the maximal reflection value for all samples in the maxial thickneess and it is equal (174.6nm), but at the different wavelengthes. In the Hashaba type the range of wavelengths for maximal reflection value at (305 to 313) nm. While for the range of wavelengths is (300 to 307) nm for Neem and Talha. That means the samples become mirror at the maximal reflection value.

The absorption coefficient (α) of the three groups of the Gum Arabic (Hashaba, Neem and Talha) at different thicknesses were found from the relation (1).

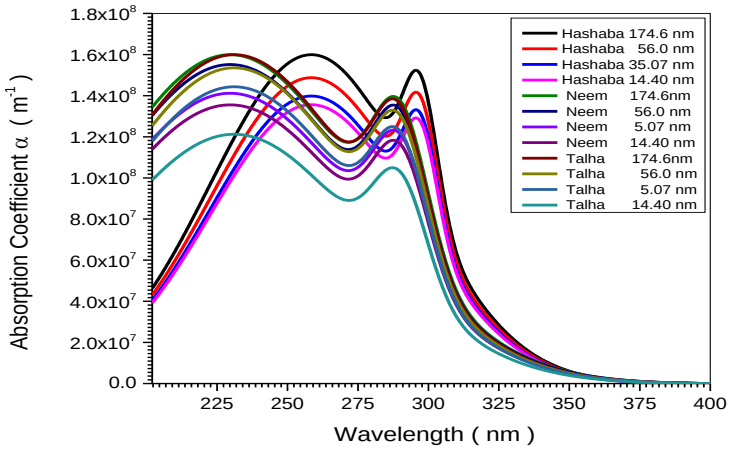

Fig (4) the relation between absorption coefficient and wavelengths of Gum Arabic (Hashaba, Neem and Talha) at different thicknesses

Fig(4) shows the plot of (α) with wavelength (λ) of all samlples of Gum Arabic at different thicknesses, which obtained the maximal value of α ($1.6x10^8$) for all types of the Gum Arabic at thicknesse174.6nm but at different wavelengths, (258)nm for Hashaba, (229.7) nm for Neem and 230.46nm for Talha.While the absorption coefficient (α) equal ($1.36x10^8$) for (Hashaba &Neem) at 14.4nm thickness but at different wavelengthes: 258.6nm for Hashaba and 229.7 nm for Neem, and it equle $1.22x10^8$ for Talha (thicknesses 14.4nm) at wavelength (230.46)nm.

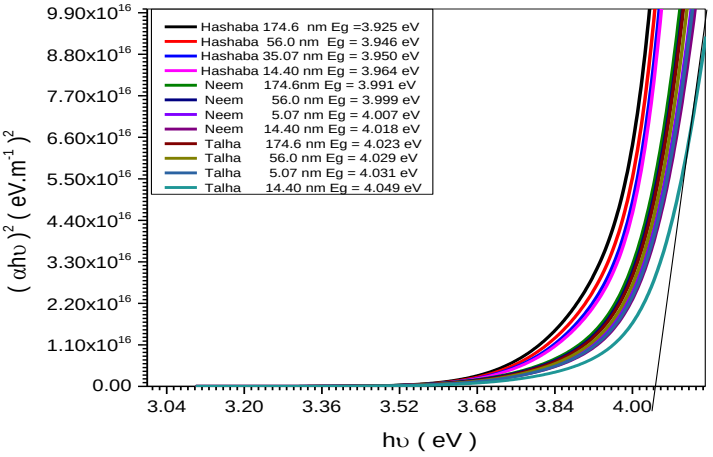

Fig (5) optical energy band gap of three types of Gum Arabic (Hashaba, Neem and Talha) at different thicknesses

The optical energy gap (Eg) has been calculated from the relation (2) . By plotting $(\alpha h\upsilon)^2$ vs photon energy (hυ) as shown in fig.(5), at the maxmal thickness 174.6 nm the energy gap equal (3.925) eV for Hashaba , (3.991) eV for the Neem and equal 4.023 eV for the Talha, but at the minimumm thickness (14.4nm) the energe gab egual (3.964) eV for Hashaba Gum Arabic sample , but Neem sample recorded 4.018 eV and Talha recieves 4.049 eV . The value of (Eg) increased from (3.925) eV to (4.049) eV. The

increasing of (Eg) related to decrease of the thicknesses of samples [H.mustafa,2020]. It was observed that the different thicknesses of Gum Arabic (Hashaba, Neem and Talha) samples confirmed the reason for the bad gap shifts. This fact can classefied the thin film gam Arabic to isollater materials.

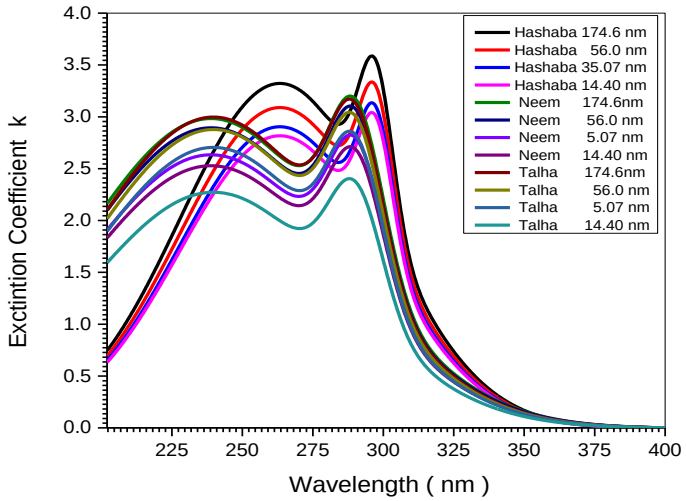

Fig (6) the relation between extinction coefficient and wavelengths of Gum Arabic (Hashaba, Neem and Talha) at different thicknesses

Extinction coefficient (K) has been calculated by using the releation (3).The variation of the (K) values as a function of (λ) are shown in fig. (6) for Gum Arabic sampleses at different thicknesses, and it is observed that the spectrum shape of (K) as the same shape of (α). The Extinction coefficient (K) for three types of Gum Arabic (Hashaba, Neem and Talha) at different thicknesses obtains deffrent value of (K) at the same wavelength, four samples of Hashaba recieves values of K at wavelength 295 nm, the Extinction coefficient equal (3.589) for thickness sample (174.6nm), while (K) equal 3.025 at thickness sample(14.4nm). Neem and Talha Gum Arabic records Extinction coefficient (K) values at same wavelength (287nm), (K) is equal (3.206 & 2.870) for Neem Gum Arabic, and (2.809 & 2.389) for Talha Gum Arabic, at the same samples thicknesses (174.6 & 56)nm. Also fig (6) shows the effects of different thicknesses of Gum Arabic (Hashaba, Neem and Talha) increasing to increasing Extinction coefficient (k) value.

IV. Conclusion

The synthesis ofn12 samples of three groups thin films Gum Arabic (Hashaba, Talha and Neem) at different thickness (174.6, 56.0, 37.07 and 14.4) nm has been conducted to measure the optical properties. The absorbance of all samples at UV region and the value of absorbance increase by samples thickness increase. The value of energy band Gap (Eg) of Hashaba Gum Arabic increased from 3.925 eV to 3.964 eV, for the Neem Gum Arabic also increased from 3.991 eV to 4.018 eV, while for Talha Guam Arabic is increased from 4.023 eV to 4.049 eV. In all samples the value of (Eg) was increased from (3.925) eV to (4.049) eV, the increasing related to decreased the of the samples' thickness.

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