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Write – Read all-Optical System Based on Diffraction Ring Patterns in Aloe, Cresson and Taramira Vegetable Oils.

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Abstract

Multiple diffraction ring patterns appeared in Aloe , Cresson and Taramira oils under irradiation with cw blue (473 nm) laser light beam . No ring patterns appeared in these oils using the green cw (532 nm) and red cw (635nm) laser light beams . As a result of irradiation of these oils with the blue beam together with the green or with red beam or with both green and red beams together, blue and green , blue and red , and blue , green and red rings appeared respectively at very low input powers of the green and red beams . The number of rings produced by the green and red lights are totally controlled by the blue beam input power and not by their input powers . By this technique .we have established a write (by the blue beam) – Read (by the green and red beams) all optical system in these three oils .

Keywords: Vegetable oils, Diffraction rings, Write – read all optical system, nonlinear optics.

Introduction: Materials with third-order optical nonlinearities have been investigated extensively for their applications in high density optical data storage, optical signal processing, optical computing ,optical phase conjugation ,high-speed all optical switches, optical bistability, optical limiting devices and other nonlinear optical (NLO)devices [1-5]. Self – induced nonlinear index changes in different media are due generally to dispersive and absorptive effects respectively[6].These two branches are classified according to relation between incident laser beam frequency , ω , and the nearest transition in the medium . First , when ω is far removed from any resonance absorption line of the medium , then the nonlinear index of refraction , n_2 , can arise from one of the following mechanisms [6] : (1) molecular – orientation Kerr effect , (2) molecular redistribution or liberation , (3) third – order nonlinear electronic polarizability , (4) electrostriction , and (5) thermal changes[7] . Second when ω is in the vicinity or at resonance with any absorption line , part of the light beam will be absorbed , the amount of absorption is dependent on how near is ω to the absorption line . In this case heat will result in the medium locally . When a laser light beam propagate in a third order nonlinear media with intensity dependent refractive index , n, like ($n = n_o + \Delta n$) where n_o is the background refractive index of the medium and Δn is the total change in the refractive index, $\Delta n = n_2 I$ and I is light intensity , and high absorption coefficient it can be accompanied with a variety of phenomena .Self – focusing , self – defocusing , self – phase modulation , spatial ring formation are among these phenomena can occur [8] . The spatial ring formation is understood to be due to spatial self – phase modulation arising from the laser – induced refractive index change . These rings can be used, to calculate both total change in refractive index , Δn , and the nonlinear refractive index, n_2. This method i.e., ring pattern ,have been used as back as 1965 by Gorden et al ., [9] and by Callen et al.,[10] for the same purpose , and still in use by many researcher's[11,12].When absorption coefficient of a certain medium at a certain laser light frequency is low , no rings pattern appear as a result of low power been absorbed by the medium . In this case less heat is produced and less change in the refractive index occur even at the peak of the Gaussian extent of the laser beam at the axis of propagation through the medium. Diffraction rings have been generated in so many materials for various goals [13 – 17]. No attempt to study the nonlinear dynamics in vegetable oils generally and diffraction ring patterns specifically except two attempts one in (2012) by Zamiri et al, in palm oil, [18]and other by the present authors recently[19] in two types of vegetable oils viz paprika oil and pepper oil . This article present new results on ring patterns generation in three vegetable oils viz Aloe ,Cresson and Taramira using 473 nm laser beam and enhancing ring patterns generation in these Aloe and Cresson oils with the use of 532 nm and 635 nm laser beams although Aloe and Cresson oils show small absorption coefficients at these wavelength ,i.e. ,it is not possible to produce rings even for high input intensities in these two oils .

Experimental

a) Samples an UV-visible spectroscopic studies : The Aloe oil ,Cresson oil and Taramira oil were used in the set experiments are available in the local market . Their chemical structures are not available since each one of them is made of number of chemical components [20]. All oils are nonpolar . A UV-visible spectroscopy have been used to determine the optical properties of these three samples using absorption spectrum in the range of (300 – 900) nm using a 6800 UV- visible spectrophotometer (Jenway – England) . Figure (1) shows the absorption spectrum of the three samples by drawing the absorbance (A) against wavelength in the spectral range (300 – 900) nm . The absorbance (A) of all samples oils were used to determine the optical absorption coefficient (α) using the formula [21] :

$$\alpha = 2.303\,\frac{A}{d} \;\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

d is the sample thickness . Table (1) shows calculated absorption coefficients , in the three laser beams wavelengths used in the experiments viz ., 473nm , 532nm and 635 nm using equation (1) and d= 1 mm .

Table (1): Absorption coefficients of Aloe oil, Cresson oil and Taramira oil.

Sample oils	Absorption coefficient , α , cm^{-1}		
	λ = 473 nm	λ = 532 nm	λ = 635 nm
Aloe	10.755	3.062	1.75
Cresson	45.00	2.855	1.451
Taramira	48.270	7.922	3.316

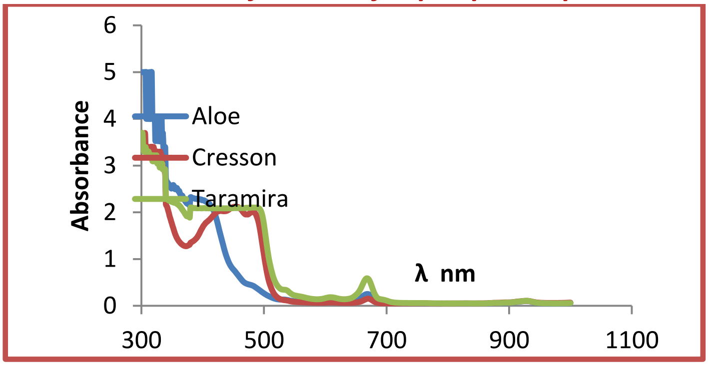


Fig. (1) : Spectral absorbance (A) in the spectral range (300 – 900) nm of (-) Aloe oil , Cresson oil and (-)Taramira oil (-) .

b) Experimental set – up : Experimental set – up used in the set of experiments is shown in fig.(2) comprised an Aloe oil , Cresson oil and Taramira oil , each in a glass cell 1mm thick . Three conventional solid state lasers operating on the lowest order transverse (TEM_{oo}) mode giving Gaussian spatial distributions with wavelength 473 nm , 532 nm and 635 nm (types SDL 473 – 66 T , SDL 532 – 100 T and SDL – 050 T respectively) , blue , green and red lights respectively . Three positive lenses of 300 mm focal lengths were used for the three laser beams . A digital camera type (Sony DSC -T99 - 8700 -82-25 mm) was used to record the diffraction ring patterns , a multi – wavelength power meter (type SDL -PM - 002). was used to measure the input power for each laser wave length . A 30x30 cm semitransparent screen was used to measure the diffraction ring patterns .

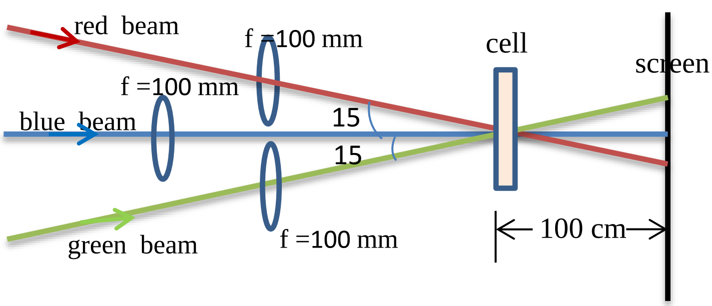


Fig (3) : Experimental set up

Each two laser beams (blue and green , blue – red) were mode matched at the entrance of each sample cell in the two beam experiments . Also in the three beams experiments the three beams were mode matched at each sample cells . The angle between each two beams was , 15° as shown in fig.(2) .Distance between the lens of the blue beam and each sample cell was 63 cm while the distance between the red and green beams lenses was 44 cm .The beam spot size of each of the three beams at the samples cells were calculated using the following formula [22].

$$\omega = \omega_{\circ} [1 + (\frac{z}{z_{\circ}})^2]^{1l2} \text{ ....(2)}$$

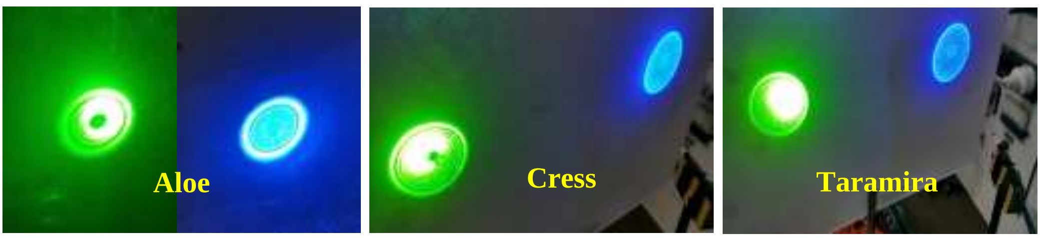
where $\omega_{\circ}$ is the spot size of each beam at the focus of each lens and $Z_{\circ} = \pi \omega_{\circ}{}^2 n/\lambda$, z is the distance along each direction of the three laser beams , n is the refractive index of air and λ is the laser beams wavelengths . $\omega_{\circ}$ can be calculated using the formula [23] : .

$$\omega_{\circ} = 1.22 \, f \lambda / \omega' \text{ ....(3)}$$

f is the focal length of each lens and ω' is the beam radius as it leaves each laser output mirror For $\omega' = 1.5$ mm for the three laser beams , f = 30 cm and λ = 473 nm , 532 nm and 635 nm respectively $(\omega_{\circ})_{473}$ = 115.412 µm , $(\omega_{\circ})_{532}$ = 129.32 µm and $(\omega_{\circ})_{635}$ = 154.440 µm using equation (3) . For n = 1 , $(\omega)_{473}$ = 0.0445 cm , , $(\omega)_{532}$ = 0.0267 cm and $(\omega)_{635}$ = 0.0239cm .

Results : According to the calculation carried out it appears that the blue beam spot size at each sample cell almost twice that of the green and red beams . By comparison of the three absorption coefficients of the three samples viz , Aloe , Cresson and Taramira it can be seen that the three oils can not produce rings pattern is the green and red lights .This was proved in separate experiments while the blue beam produces rings pattern in the three samples . For input power of the blue beam of 53.3 mW , in the three samples , hence intensity of , I_{473}= 169 $\frac{W}{cm^2}$ ($I = \frac{2P}{\pi \omega^2}$, P is the power input) , the number of rings produced in Taramira is large than Aloe's , in accordance with their absorption coefficients . At the same input blue power of 53.3 mW and as low as 2.32 mW (2.07 $\frac{W}{cm^2}$) of the green , rings in both wavelengths appeared i.e blue and green rings although it was not possible to enhance rings patterns with 100 mW input power of the green laser beam in Cresson oil .

In Taramira oil , 8.5 mW (7.57 $\frac{W}{cm^2}$) of green input laser beam was used to produce green rings in the present of the blue beam while it was not possible to produce rings using 100 mW input of the green beam alone in the same oil . 2.32 mW (2.07 $\frac{W}{cm^2}$) of input power in the present of the blue beam (53.3 mW) input was enough to produce green rings together with the blue rings , in Aloe oil . For the input power of 53,3 mW of the blue line in the three oils and the presence of the same input power of the red light of 2.14 mW (2.39 $\frac{W}{cm^2}$) blue and red rings patterns appeared .In a separate experiment three rings patterns appeared when the three blue , green and red beams passess through each sample at a time. Figs (4- 6) samples results in the rings pattern in the blue – green lights as in figs.(4) , the blue – red lights figs.(5),and the three green , red and blue rings patterns at the same time in figs.(6)



Fig(4): Rings appeared in Aloe oil , Cresson oil and Taramira oil using blue and green lights at the same time

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Fig (5): Rings appeared in Aloe oil, Cresson oil and Taramira oil using blue and red lights at the same time.

Fig.(6) : Blue , green and red rings pattern in Tararmira

We found that the number of the blue rings in the three oils is totally controlled by the blue beam only i.e ., no effect is noticed by varying the green or the red beams power in the three samples , while the green and red rings can be controlled by the blue beam only i.e variation of green beam and red beam does not affect the number of their rings . It seems that the thermal lens initiated by the blue pump beam acts as a source for the green and red rings pattern , this is why even at very low green or red beams input power , green or red , or both rings patterns appear in the three oils . We believe that the initiation of blue rings or "Writing" of them are readable " Reading "by the green beam or red beam or both beams at the same time . According to the obtained results submilliwats input power of both green and red beams can read the blue rings so that we can consider of multi reading of any pump beam that enhances a concave lens by many reading beams that have low absorption coefficients to the medium under consideration .

Conclusion: Thermal effects appeared to be responsible for the initiation of concave lens effect in three oils viz., Aloe, Cresson and Taramira . This effect has led to the diffraction ring patterns in these oils using blue laser beam which act as a pump beam. Green and red rings patterns are stimulated by the use of green and red beams in these oils although these oils have low absorption coefficients ,in these wavelengths .We termed such effect as a Write – Read all optical system which is seen for the first time to our believe.

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نظام كتابة – قراءة بصري يستند الى نماذج حلقات الحيود في زيوت الصبار والرشاد والجرجير

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الخلاصة : ظهرت نماذج حلقات حيود في كل من زيوت الصبار والرشاد والجرجير باستعمال حزمة ليزر مستمرة ومرئية زرقاء (473 nm) ولم تظهر نماذج حلقات الحيود باستعمال حزمتي ضوء مستمرتان ومرئيتان خضراء (532 nm)وحمراء (625 nm) في الزيوت الثلاثة بسبب صغر معامل الامتصاص لها عند هذين الطولين الموجيين .عند تشعيع هذه المواد الثلاثة بالضوء الازرق والضوء الاخضر معا و بالأزرق والاحمر معا وبالأزرق والاخضر والاحمر في ان واحد ظهرت حلقات زرقاء وخضراء وزرقاء وحمراء وزرقاء وخضراء وحمراء بذات الوقت بقدرات دخل واطئة جدا بالحزمتين الخضراء والحمراء . كما وان عدد حلقات حيود الحزمتين الخضراء والحمراء لا تتأثر الا بقدرة دخل الضوء الازرق . نعتقد اننا بهذه التقنية انشأنا نظام كاتب بالضوء الازرق وقارئين بالضوئيين الاخضر والاحمر في الزيوت الثلاثة .

الكلمات المفتاحية : الزيوت النباتية ، حلقات الحيود ، نظام بصري ، كاتب – قارئ، البصريات اللاخطية