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Gamma Ray Effect on the Properties of Coumarin C47 Laser Dye

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Abstract:

The research is concerned about studying the absorption spectrum of the solution coumarin dye C47. The chloroform solvent was used with C47 dye in three different concentrations 10^{-4}, 10^{-5} and 10^{-6} M. The laser dye solution was prepared by dissolving the required amount of dye in chloroform alcohol, while studying absorption spectrum before and after irradiation with gamma ray by cobalt-60 source ^{60}Co at exposure time, which are 0, 4, 6 and 18 hours with different absorbed doses 0, 136, 204 and 612 Gy.

The results show that red shift in the absorption spectrum was increased by increasing the concentration of laser dye solutions , while the increase of gamma dose led to increase the red shift after irradiation, as the exposure period and irradiation dose increased from gamma ray at ^{60}Co source. Furthermore, the decrease in the concentrations of laser dye solutions shifts the absorption spectrum peak towards the short wavelength blue shift.

Keywords: Absorption, Chloroform, Concentration, Spectrum, Source.

Introduction:

Laser dyes organic compounds conjugated double bounds. The first attempt to define the dye of the researcher Witt 1876 and was determined 206 dyes until 1980 (1).

The dyes range from a wide spectral range between 250-1100 nm. Organic compounds have been widely used in solutions, the fields of research, medicine and separation of isotopes and especially uranium isotopes (1, 2).

Organic dyes and organic compounds dissolve in organic solvents to give optical spectra wide stretching from the UV area to the infrared region. coumarin dyes bicyclic compounds have great practical importance and benefit in the blue-green region of the spectrum (3). Coumarin dye emission range is between 400 - 500 nm (4) coumarin molecule is non-fluorescent, and displays intense fluorescence properties upon substitution of functional groups at different positions (5).

The dyes used in specific lasers contain rather large organic molecules. The majority of this type of bicyclic compounds is that the coumarin derivatives are of great practical interest in the blue-green region of the spectrum. The dye lasers used in the region blue - green are much important in practical applications, especially in the field of under water and isotopes separation (6).

Laser dyes are organically unsaturated materials with a rather complex structure and high molecular weight, because they contain a series of carbon atoms that are bonded to single and double bonds in a sequential manner.

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Most dye lasers contain an extended system of molecules which have a strong absorption band in and around the visible region of the electromagnetic spectrum characterizing the particular dye (7).

C47 is used in the current research belongs to coumarin class, an unsaturated hydrocarbon compound classified by at least one double or triangular bonds containing σ bonds, as well as π bonds affecting spectral properties (8).

Gamma photons have about 10,000 times as much energy as photons in the visible range of electromagnetic spectrum. Gammas photons are electrically neutral and do not steadily lose energy as they penetrate matter. Instead, they can travel some distance before interacting with an atom. How far a given photon will penetrate is governed statistically by a probability of interaction per unit distance traveled, which depends on both the specific medium traversed and on the gamma photon energy (9, 10).

The dyes possess an important property that is tuning its frequency (11). It is possible to change the wavelength to an approximate range of 60 nm, also by changing the dye type; it becomes possible to obtain laser oscillation within a wide range of wavelengths in the near infrared NIR to the near ultraviolet NUV region (12, 13).

Materials and Methods:

Laser dye of C47 was used in this study, the scientific name coumarin 7-hydroxy- 4 - methyl the molecular weight 231, 30 gm /mole. Laser dye solutions were prepared by dissolving the required amount of dyes in chloroform which is an organic solvent known as tricolor methane, with its molecular formula CHC_{l3} and its molecular weight 119.30 gm / mole.

The weight of the dye W can be calculated by using the following equation:

W = Mw. V. C / 1000

Where W is the weight of the dye material that needed to obtain the desired concentration in g., C is concentration needed to be prepared and measured by mole / liter, M is molecular weight of dye used and measured by g per Mole, and V is the size of the necessary solvent added to the material and measured by cm^3. A high concentration of 10^{-4} M of C47 dye solution was prepared then diluted to 10^{-4}, 10^{-5} and 10^{-6} M. Absorption spectra were measured by UV-visible spectrophotometer before irradiation by gamma ray source ^{60}Co. Source of gamma-ray irradiation ^{60}Co cell activates model 900 manufactured by Bhabha Atomic research center / Bombay/ India. The dose rate of the used radioactive source ^{60}Co is estimated to 34 Gy/h.The calculation of the dose rate by dosimeter is a measure of the amount of radiation that workers are exposed to in nuclear research centers.

Secondly, the samples of different concentrations 10^{-4}, 10^{-5} and 10^{-6} M were exposed to different doses of gamma ray ^{60}Co 0,136,204 and 612 Gy along with time exposure 0, 4, 6 and 18 hours, after the explosion to different doses, measurements of absorption have to follow up the changes in its structural and characteristics; that may occur in samples.

Results and Discussion:

The UV–visible technique was used for measuring the UV–visible spectrum at a range of 300–500 nm for C47 laser dye after the absorption of spectra measurements which led to dose exposure of 0,136,204 and 612 Gy from gamma ray ^{60}Co at different doses.

As shown in Fig.1 A, B and C, absorption spectra of dye solutions C47 at molar concentration of 10^{-4}, 10^{-5}, and 10^{-6} M increased in the values of absorbance A with an increase of concentrations and increase dose. The maximum absorbance A was 0.02875 for the C47 dye solutions at 10^{-4} M and dose 612 Gy.

Figure 2 shows an increase in the values of the C47 wavelength with an increase in gamma irradiation time from 0 to 18 hours. The C47 wavelength maximum was 397 nm at 18h. In the current study, and according to the results obtained from Fig.1, we gained a linear equation relationship between the wavelengths of C47 387, 390, 394 and 397 nm and the time of gamma irradiation from 0, 4, 6, and 18 hours:

W_{max}= 0.9889 T+392.58 … 1.

Where:

Wmax is the C47 wavelength maximum in nm.

T is the irradiation time in h.

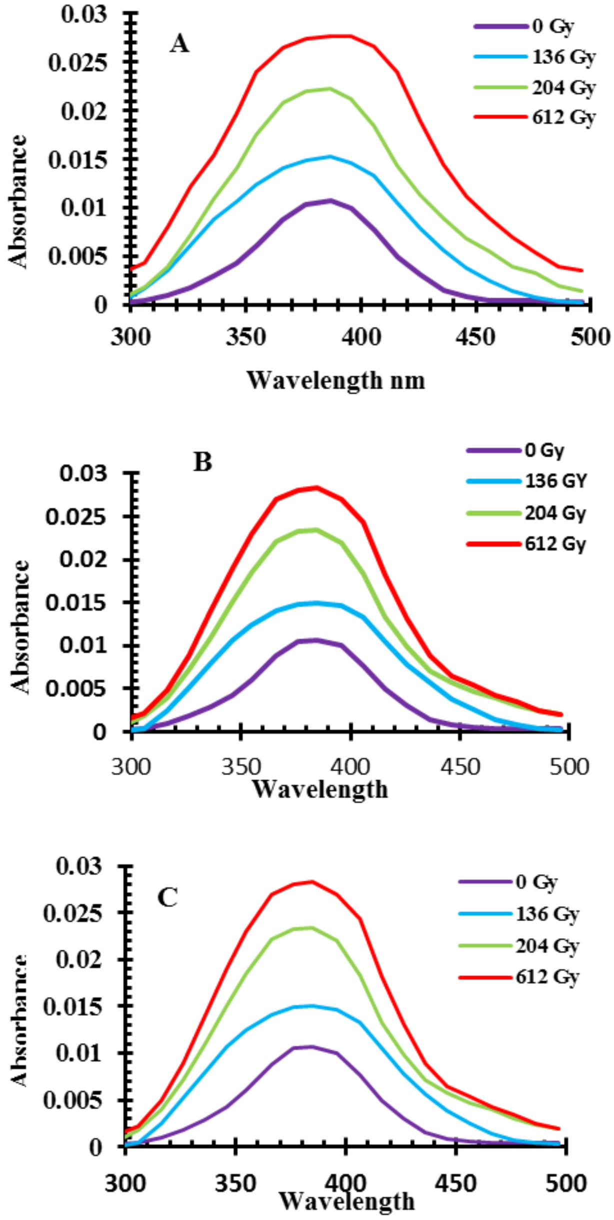

Figure.1 A, B and C: The C47 absorption spectra at different concentrations 10^{-4}, 10^{-5}, 10^{-6}M at different doses 0,136,204 and 612 Gy.

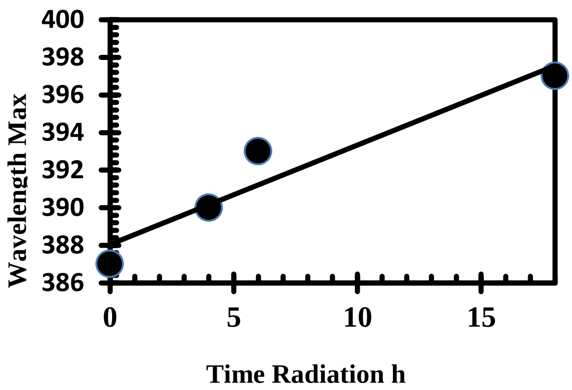

Figure.2: The C47 wavelength maximum at different concentrations of 10^{-4}, $10^{-5}$and 10^{-6}M at different doses 0, 136, 204 and 612 Gy with time radiation h.

By applying the equation 1, the exposure time can be set at a maximum wavelength compensation of C47.

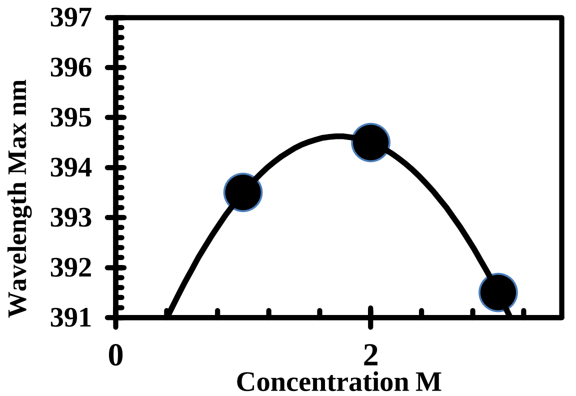

Figure.3: The C47 wavelength maximum at different concentrations of 10^{-4}, 10^{-5}, and 10^{-6}M at different doses 0, 136, 204, and 612 Gy.

Figure 3 shows the results obtained from Fig. 1 a mathematical relationship was found between the maximum wavelength of C47 392, 396, and 397 nm and different concentrations of 10^{-4}, 10^{-5}, and 10^{-6}M at different doses 0,136,204, and 612 Gy:

$W_{max} = -2C^2+7C+388.5$ …. 2.

Where:

Wmax is the C47 wavelength maximum nm.

C is the molar concentration M.

By applying the equation 2, the molar concentration can be determined by compensating the maximum wavelength of C47.

This indicates that the increase in the dose of radiation exposure to laser dyes leads to an increase in wavelengths, and this agrees with the previous studies (14, 15).

Conclusion:

Increased concentration leads to increase the C47 absorption spectra and this is actually consistent with the law of per Lambert for all solutions. While irradiation showed by the gamma ray source ^{60}Co did not change the chemical composition of the pigment studied with all concentrations. Furthermore, red shifts in the C47 absorption spectra, shifts the absorption spectrum peak towards the long wavelength that increases in gamma dose. Therefore, these results are strongly suggested that one can be used with irradiation by gamma rays to get newly dyes, which are useful in several applications.

Conflicts of Interest: None.

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تأثير أشعة كاما على خصائص صبغة الكومارين الليزرية C47

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الخلاصة :

البحث يهتم بدراسة طيف الامتصاصية لمحلول صبغة الكومارين C47 . حيث تم أستخدام مذيب الكلوروفورم مع صبغة C47 وبثلاث تراكيز مختلفة 10^{-4} و10^{-5}و$10^{-6}M$ وتم تحضير محاليل الصبغات عن طريق إذابة القدرالمطلوب من الصبغة في كحول الكلوروفورم ودراسة طيف الامتصاصيه قبل وبعد التشعيع بأشعة كاما من مصدر الكوبلت ^{60}CO وبفترات زمنية من 0,4,6,18 hour وبجرع أمتصاصية مختلفة من 0, 136, 204,612 Gy.

أظهرت النتائج أن أزاحة حمراء في طيف الامتصاص زادت بزيادة تركيز محاليل الصبغة الليزرية ، بينما أدت الزيادة في جرعة كاما إلى زيادة في أزاحة حمراء بعد التشعيع عندما زادت فترة التعرض وجرعة الإشعاع من أشعة كاما من مصدر الكوبلت ^{60}CO. علاوة على ذلك ، فإن الانخفاض في تراكيز محاليل الصبغة الليزرية ينقل ذروة الامتصاص إلى الطول الموجي القصير ازاحة زرقاء.

الكلمات المفتاحية: أمتصاصية، كلورفورم، تركيز، طيف، مصدر.