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ISSN –1817 –2695

The Effect of Gamma radiation on polyvinyl chloride And CN-85

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Received 24-9-2012,Accepted 4-12-2012

Abstract

Gamma rays effect has been worked out on polyvinyl chloride and CN-85, this effect has been found out and compared together, by using optical density technique, this work for this polyvinyl chloride, has been done for the first time.

Polyvinyl chloride used in this work shows more response and more linearity than CN-85, in response to gamma photonswithin the dose range between 679mGy and 13582mGy.

1. Introduction

Polymeric plastic materials are being increasingly used in a wide variety of application where they are routinely exposed to different kinds of nuclear radiations, these Solid State Plastic Nuclear Detectors (SSPND)have found a large field of applications in various domains of science, such as alpha particles measurements [1-4],neutron flux measurement [5],nuclear physics [6],geochemistry [7-9] or geochronology [10-13].

Solid detectors present many advantages, such as a significant low cost as well as simplicity in exploration, ability to use in various geometries and sizes, an integrating nature, which allows events to accumulate over a long interval of time as well as a differential sensitivity to charged particles such as alpha particles, protons, or fission fragments, making them very popular among scholars. Solid nuclear detectors, by their diverse nature can be used to detect almost all types of heavy charged particles. For this reason, these detectors can be used successfully among others in mapping the distribution of nuclear contamination.

Their simplicity, ruggedness, existence of threshold for registration and different energy loss for different particles make solid plastic nuclear detectors particularly suitable when it comes to the search for different particles, this can be done successfully for integrated counting.

The exposure of polymers to nuclear radiation may cause degradation in some stages, which can be used as a sign for dose received by the detector. Polyvinyl chloride

(PVC) is one of these materials; it was a subject of many investigations [14-16].

Irradiated PVC as insulation has many benefits [17]. It is going to withstand much higher temperatures than regular PVC insulation, the one which exposed to radiation, may cause the insulation to become more far superior to ordinary one in temperature, abrasion and cut-through resistance.

This effect was due to cross-linking; this can be accomplished chemically or by irradiation. Irradiation is the preferred method of cross-linking PVC as it does not use high temperatures or pressure and can be done on small conductor sizes. During the process of irradiating PVC, the material is exposed to a controlled beam of electron radiation. All of these signs can be used for nuclear radiation detection.

It is very important to check the effect of different nuclear radiation on PVC and its structure by using spectrometry. We have investigated a commercially available polymer and found that it could be used as an solid state nuclear plastic detectors. This commercials polymer material has been cheeked to be polyvinyl chloride by chemical analysis and IR spectroscopy with chemical formula [-CH_2 CHCl-]$_n$.

2. Experimental Procedure

Samples of PVC and CN-85 have been cut in a form of 1x3 cm and the irradiated spot has been marked. This spot should be used to pass UV through it, to see the effect of radiation for different doses on optical density passing the spot. Gamma source used in this work was CS^{137}. This source is present in education college, Basrah University. It was supplied by the Radiochemical LTd. J.L. Shepherd and Associates, California) .Gamma photons from CS^{137} source were normally incident on samples of polyvinyl chloride and Kodak CN-85 cellulose nitrate film, the last detector has been manufactured by Kodak Pathe - France. Spectro SC from Labomed, Inc. USA has been used as spectrophotometer to measure absorption spectrum for the samples used in this work.

3. Results and discussion

This work was done for the first time on this commercial PVCfilms, where these films are exposed normally to gamma rays and for different doses, spectrum for these detectors were measured, as shown in fig.1.

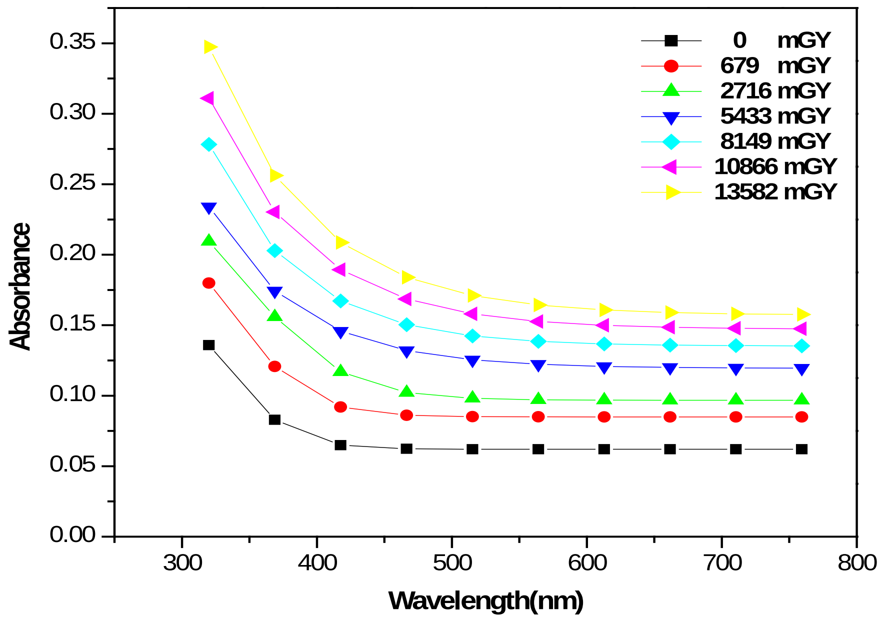

Figure 1Absorbance as a function of Wavelength for PVC

The UV-visible spectroscopy was used to investigate the effect of different doses on the absorption spectroscopy. These samples were exposed to a range of doses between 0 mGy to 13582 mGy, The irradiated samples responded to the doses exposed by an increase in the absorbance with dose, and the maximum absorbance was at wavelength 320 nm. For a single dose there is decrease in absorbance with increasing in the wavelength.

At maximum absorbance, best fit has been done as shown in Fig.2. For different doses, this figure shows the response mostly linear, increasing with constant slope, as doses increased.

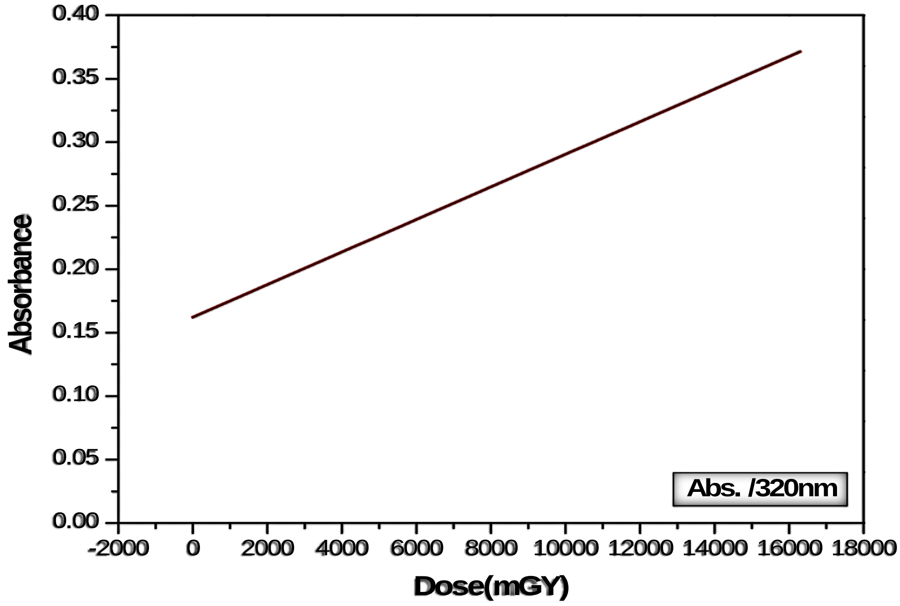

Figure 2 Absorbance best fit as a function of Doses for PVC

Difference in absorbance between a zero dose and different given doses, has been shown in figure (3a – 3f), where the peak shown in absorbance differences curve at 320 -350 nm at low doses.

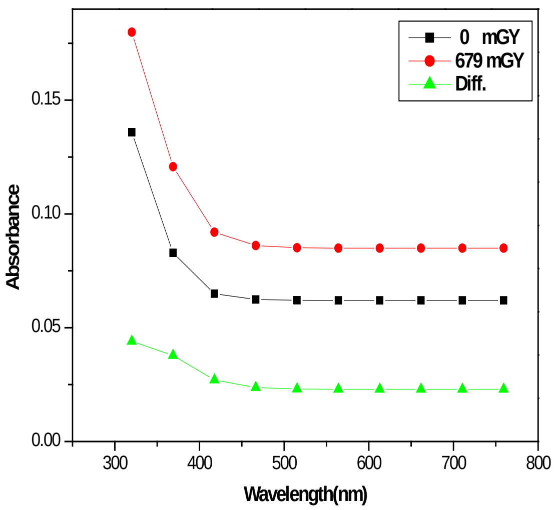

Figure 3a Absorbance difference as a function of Wavelength for PVC

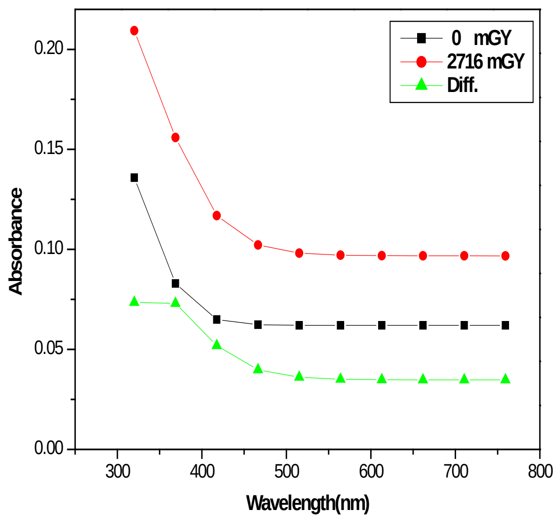

Figure 3b Absorbance difference as a function of Wavelength for PVC

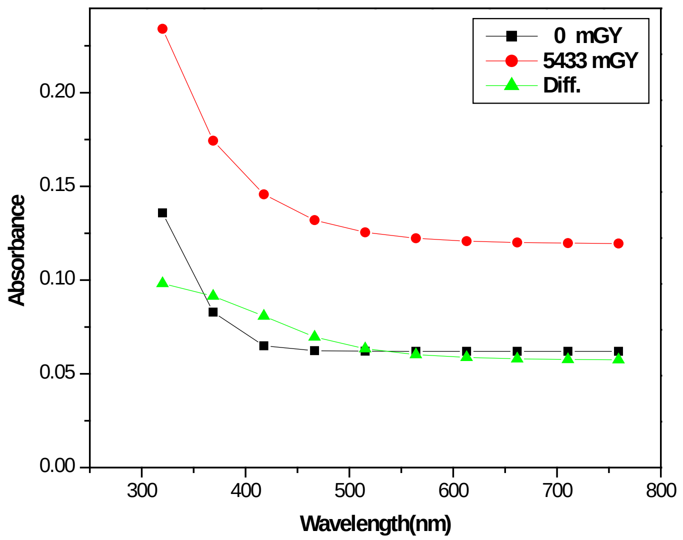

Figure 3c Absorbance difference as a function of Wavelength for PVC

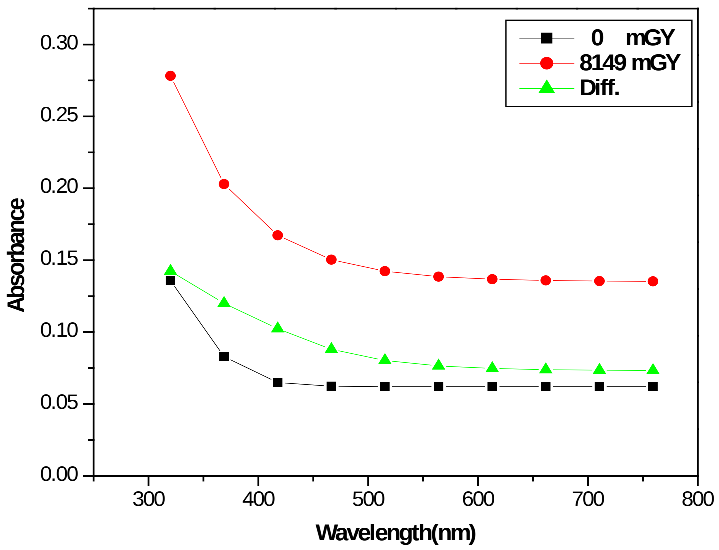

Figure 3dAbsorbance difference as a function of Wavelength for PVC

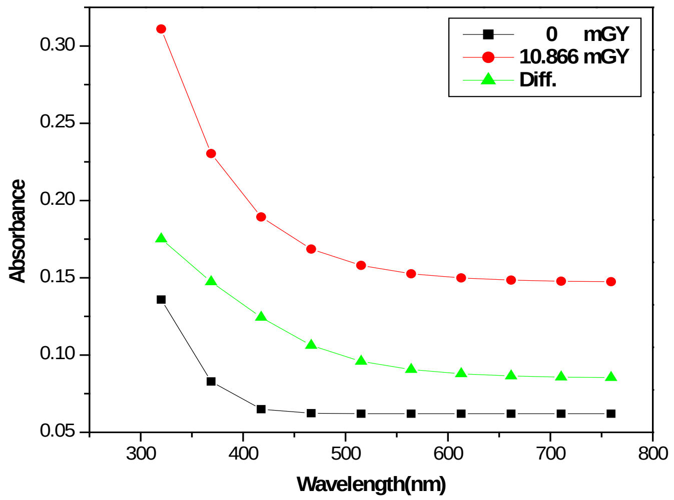

Figure 3eAbsorbance difference as a function of Wavelength for PVC

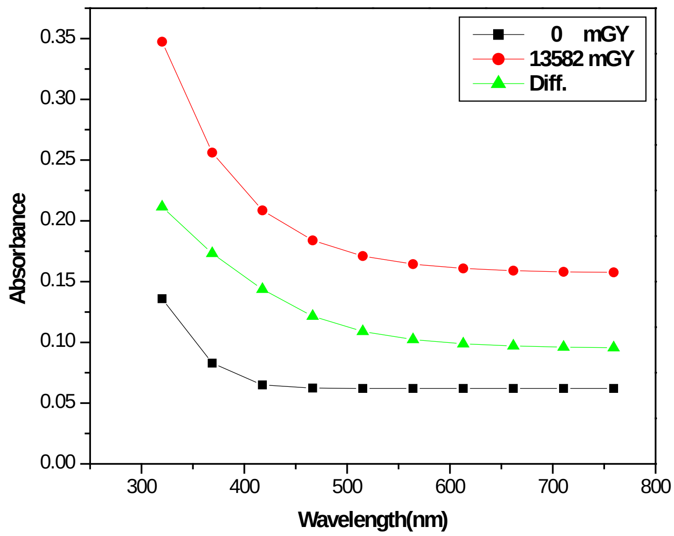

Figure 3fAbsorbance difference as a function of Wavelength for PVC

The amount of absorbance for difference absorbance curve starts to increase from low level to higher level with increasing doses, as shown in fig.4. This curve starts to cross over at 5433 mGy, and completely cross at 8149 mGy.

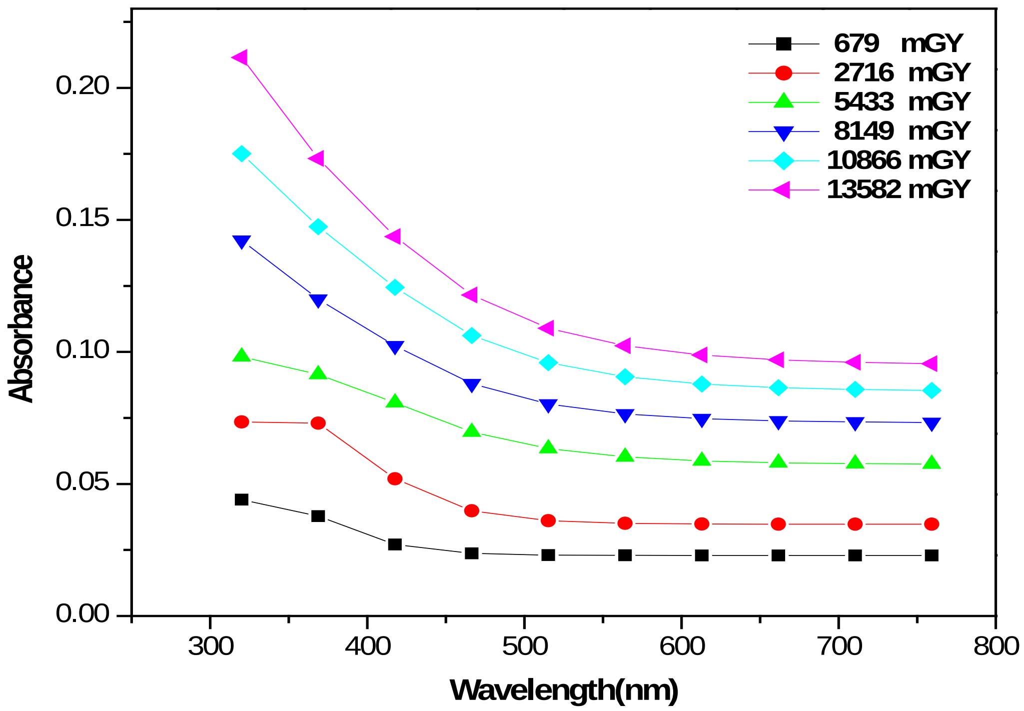

Figure 4Absorbance difference as a function of Wavelength for PVC

Absorbance differences curve at different doses is given at fig. (5), where this curve shows increasing response with dose, this response was mostly linear.

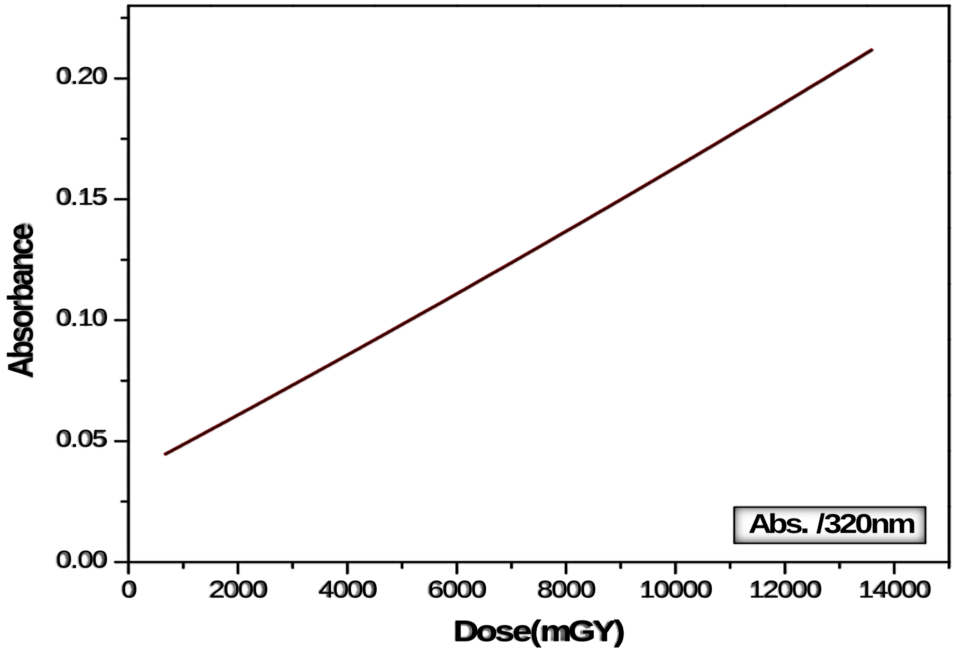

Figure 5Absorbance difference best fit as a function of Doses for PVC

In case of CN-85, samples were exposed to gamma rays. Absorbance was measured for these samples after exposing them for different doses, between 0 mGy to 13582 mGy, this measurement was done in a wavelength range between 320 – 800 nm, as shown in fig.6.

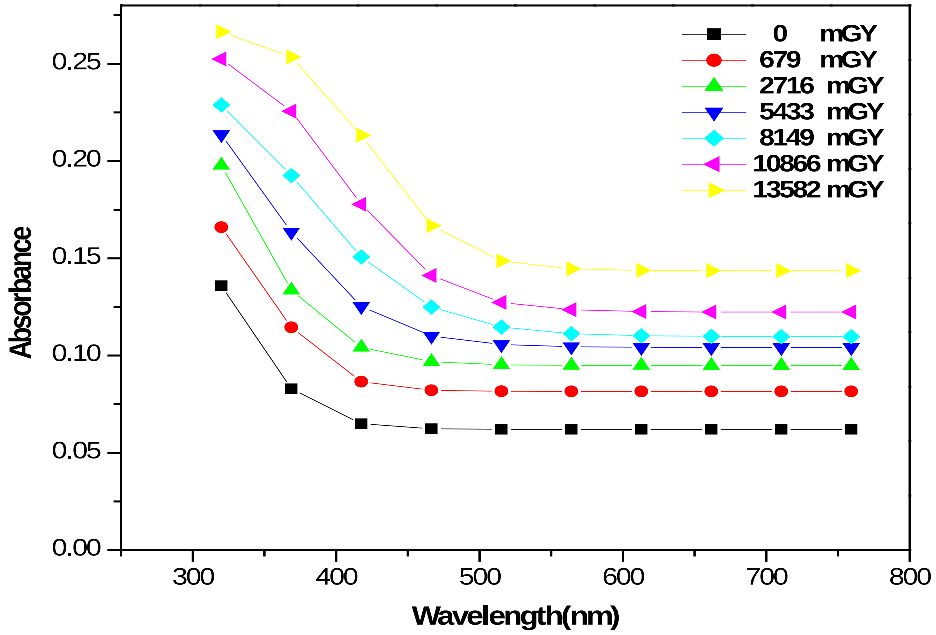

Figure 6Absorbance as a function of Wavelength for CN-85

At maximum absorbance, different doses have been compared, where their function gave little away from linearity compared to PVC, as shown in fig.7.

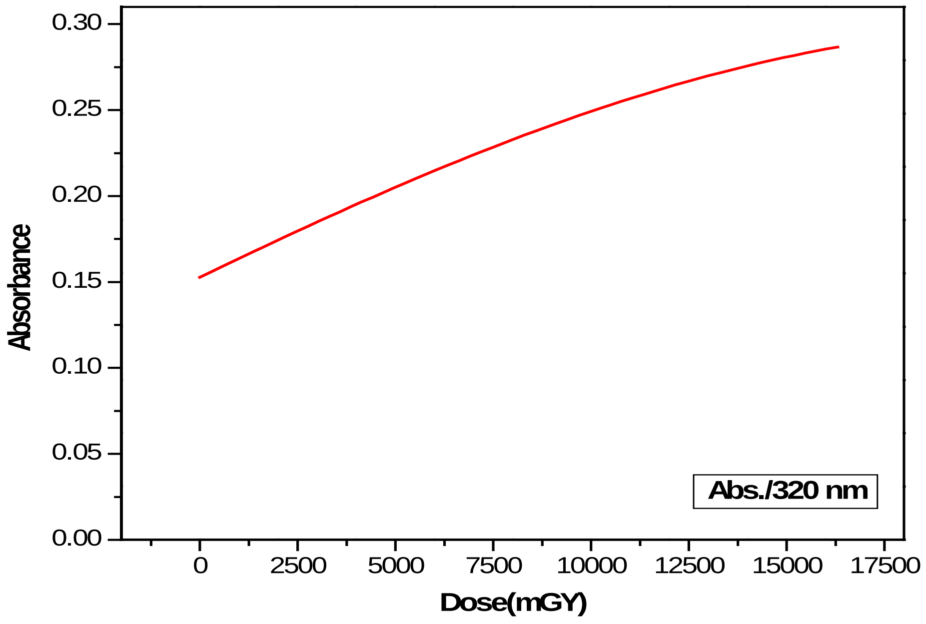

Figure 7Absorbance best fit as a function of Doses for CN-85

Differences in absorbance between zero and different doses have been worked out, to get differences absorbance curve as shown in figures (8a–8f), where the absorbance differences curve starts to cross 0 doses at 5433 mGy.

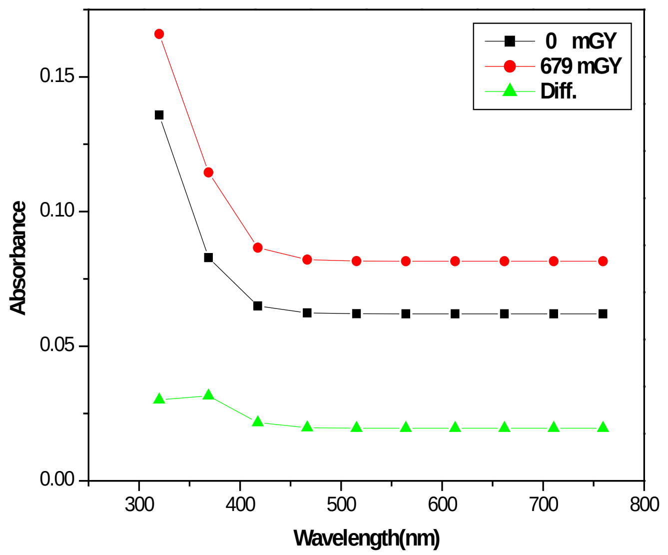

Figure 8aAbsorbance difference as a function of Wavelength for CN-85

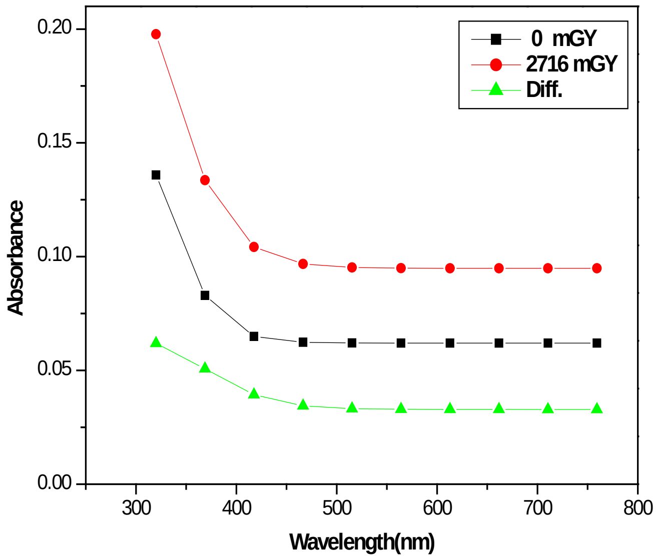

Figure 8bAbsorbance difference as a function of Wavelength for CN-85

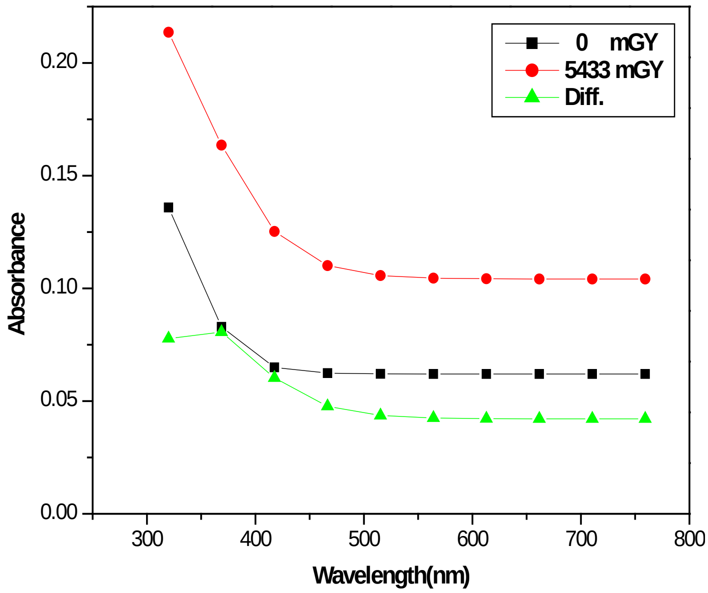

Figure 8cAbsorbance difference as a function of Wavelength for CN-85

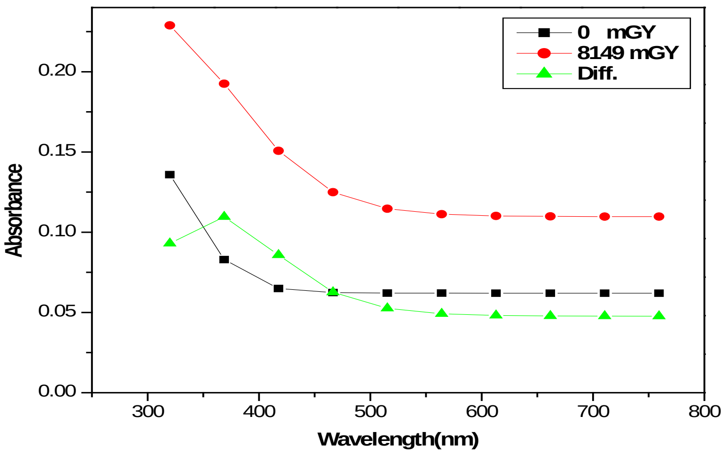

Figure 8dAbsorbance difference as a function of Wavelength for CN-85

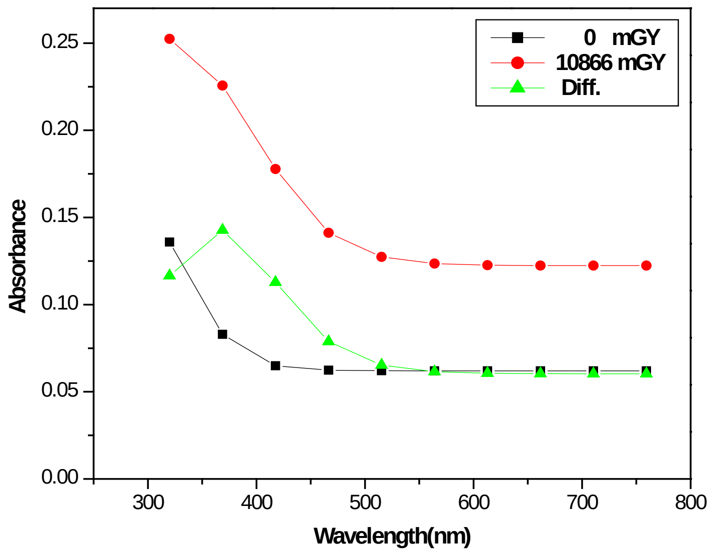

Figure 8eAbsorbance difference as a function of Wavelength for CN-85

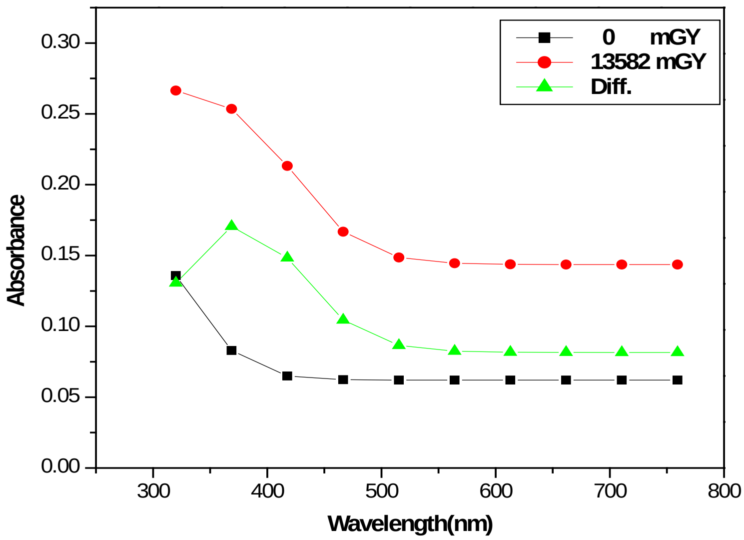

Figure 8fAbsorbance difference as a function of Wavelength for CN-85

Absorbance differences for different doses used in this work were shown in fig.9 which shows clear decreasing in absorbance with wavelength compared to PVC samples.

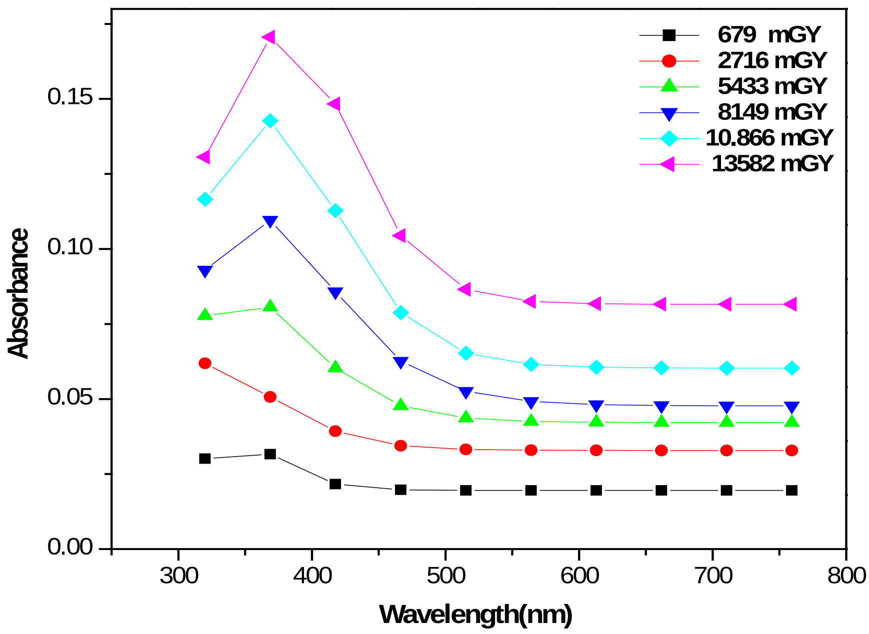

Figure 9 Absorbance difference as a function of Wavelength for CN-85

The response curve was a little away from linear, for different doses between 679 mGy to 13582 mGy.

Polyvinyl chloride shows more response to gamma radiation than cellulose nitrate CN-85, that was for different doses at ranged between 0.679 mGy to 13582mGy.

This response was more linear in polyvinyl chloride, than in CN-85. This will encourage researcher to work with Polyvinyl chloride rather than CN-85 within present dose range, under present condition, this work was done for the first time on this commercial Polyvinyl chloride.

The UV-visible absorption spectra for the deference between irradiated and non-irradiated in case of CN, shown a spectrum with a maximum absorption is around 370 nm. As shown in figure 9, and the Response curve for these absorbance difference curves, which represent the pure effect of the dose was shown in figure 10,

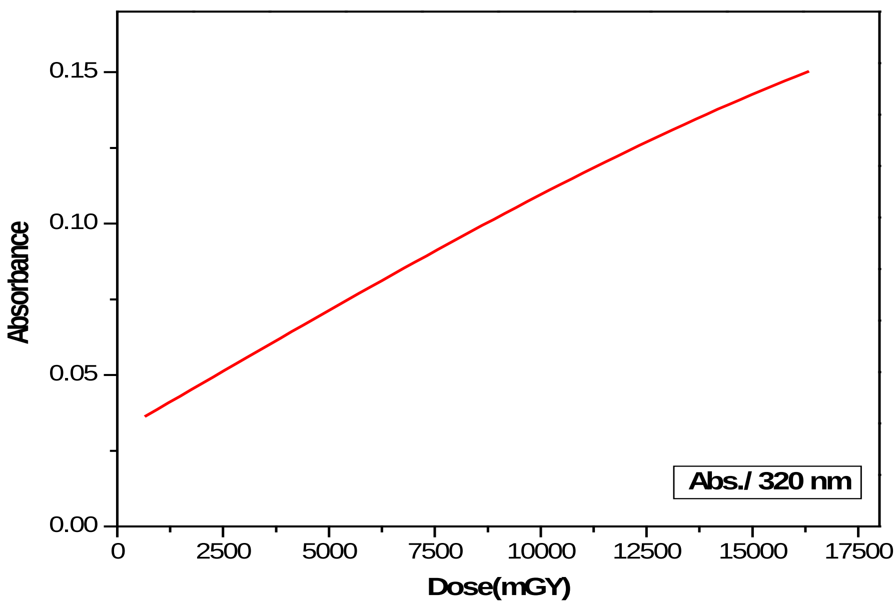

Figure 10Absorbance difference best fit as a function of Doses for CN-85

it was mostly linear in polyvinyl chloride in the dose range used in this work, rather than in CN-85, also more higher in value than respective curve in CN-85, by about 33.45%, it is fixed at all doses range used in this work. The linearity of response, with higher value in response curves suggest that polyvinyl chloride can be used as dosimeters.

The irradiated PVC films are darkening and lose transparency. The darkening is proportional to the radiation dose [18] and is explained by the formation of double bonds along the chain in a process known as the zipper effect [19].

Our results of infrared spectroscopic analysis of the films have shown a decrease in the intensity of the bands attributed to the C-H methylene stretching, an evidence of the loss of methylene protons which agrees with the formation of double bonds, as shown in following mechanism.

~~~ CH = CH — CHCl — CH_2 — CHCl ~~→ ~~ CH = CH — CH — CH —CHCl ~~

⁝ ?

→ ~~CH = CH— CH = CH—CHCl ~~+ HCl Cl----- H

Our results from infrared spectroscopy analysis, as shown in figure (11) and (12),

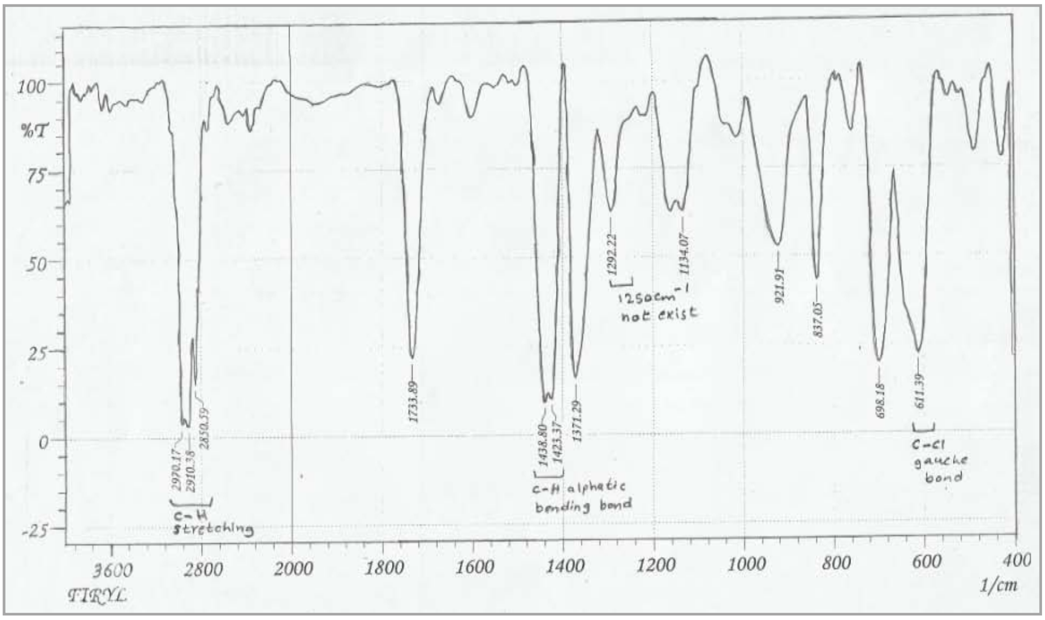

Figure 11 Infrared spectroscopy for commercials PVC, before Irradiation.

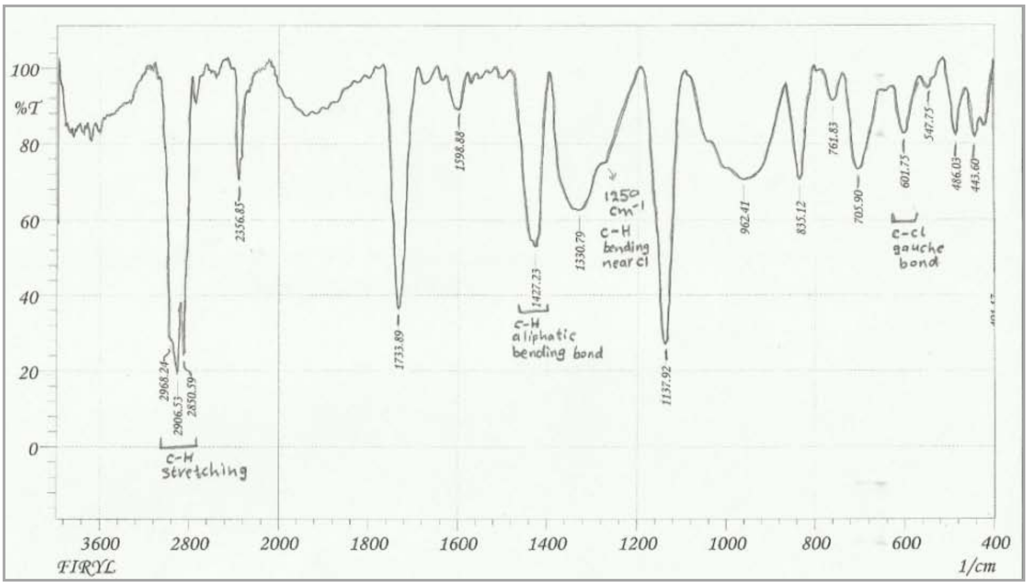

Figure 12 Infrared spectroscopy for commercials PVC, after Irradiation.

shows a decrease in the intensity of the band attributed to C-H bond 2910cm^{-1}, which agrees with the formation of double bonds. Infrared spectroscopy after gamma irradiation shows a new peak as shown in figure (12) for double bond, at 2356.85 cm^{-1}.

Acknowledgements

The authors wish to express their sincere thanks to Dr. Riyadh Ch. Abu. Hail, University of Basrah, college of education, department of physics, for his support in this work.

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تأثير أشعة كاما على بولي فينيل كلورايد ونترات السليلوز

حسين علي حسين　　　علي حسين محمد الهاشمي　　　فريال يونس نزال

الخلاصة :

تم قياس تأثير أشعة كاما على (بولي فينيل كلورا يد PVC ، نترات السليلوز CN-85) تمت دراسة هذا التأثير ومقارنته باستخدام تقنية الكثافة الضوئية . قد تم استخدام هذا العمل لـ (بولي فينيل كلورا يد) لأول مرة .

اظهر بولي فينيل كلورا يد المستخدم في هذا العمل ، أكثر استجابة وكان أكثر خطيا من نترات السليلوز، نتيجة التأثير فوتونات كاما المستخدمة في مدى الجرعات (679mGY-13582mGY) .