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Determination the Effect of Gamma Radiation on (CR-39, CN-85) Detectors by Using of Penetration of (He-Ne) Laser Beam

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Abstract: The penetration of (He-Ne) laser beam on the Nuclear Track Detectors (NTDs) types CR-39 and CN-85 was measured after the gamma radiation effects with doses (0, 42.3, 84.6, 126.9, 169.2, 211.5, 253.8 Gy) and (0, 12.7, 25.4, 38.1, 50.8, 63.4, 76.1, 88.8 Gy) or CR-39 and CN-85 detectors, respectively. The penetration of (He-Ne) laser beam was also measured after the stress effect at the range (50, 55, 65, 100, 102, 106 N) for both detectors. The penetration coefficient of (He-Ne) laser beam $\ln(P_0/P_{av})$ was calculated when P_0 is the penetration of laser beam through detectors without gamma radiation and stress effects and P_{av} is average the penetration of laser beam through detectors with the gamma radiation and stress effects. The value of $\ln(P_0/P_{av})$ was increase with increase of gamma radiation dos until to 220 and 75 Gy for CR-39 and CN-85 detectors, respectively. While the value of $\ln(P_0/P_{av})$ was increase with increase of stress effect until to 1.6×10^6 N/m^2 and 12×10^6 N/m^2 for CR-39 and CN-85 detectors, respectively. This study shows there is a possibility to use the penetration of (He-Ne) laser beam to measure the effect of gamma radiation and stress on anther (NTDs).

Key words: Nuclear track detectors, CR-39, CN-85, gamma radiation, (He-Ne) laser beam, stress, strain effect

INTRODUCTION

Nuclear Track Detectors (NTDs) used to measurements the effect of particulate radiation, including alpha particles (Mohammad and Azawe, 2013) and thermal neutrons (Kumar *et al*., 2009, 2010) protons (Sinenian *et al*., 2011) in addition to the ionic particles (Kumar *et al*., 1982).

It has been used to measure the radiation pollution of alpha rays in the environmental fields through routine radiological survey or in cases of radiation accidents accompanied by alpha emitters (Al-Saad and Abbas, 2001).

NTDs used also, to measurement of non-particulate radiation, including gamma radiation (Malek and Chong, 2002) UV radiation (Wong and Hoberg, 1982; Chun, 2007) laser (Zaki *et al*., 2013) and microwave radiation (Al-Jobouri *et al*., 2012). It was proved through these studies that the radiation effect of non-particulate radiation changed in the physical specifications of the NTDs. These change include optical absorbance through UV-visible spectroscopy (Al-Jobouri *et al*., 2015), relative transmittance of infrared radiation through -FTIR spectroscopy (Raouf, 2013). Moreover, NTDs types CR-39 and Lexan detectors were calibrated as low-LET radiation dosimeters (Sinha *et al*., 1998; Tavera *et al*., 2005). The effect of non-ionizing radiation (IR, UV and laser) on NTDs was studied by Prasher *et al*. (2009) for determining the effect of IR irradiation on some polymers and studies the modifications owing to irradiation by analyzing the X-Ray Diffraction (XRD) and UV-visible spectra (Rafique *et al*., 2010).

The mechanical specification as stress and strain of CR-39 studies by Ali (2006) which showing the change in the value of stress produce the inversing in strain value. Mandal and Nagahanumaiah (2014) found that the relationship between the height/depth of the CR-39 detector was increased by increasing the stress.

Laser beam was used with NTDs in many studies (Zaki *et al*., 2013) by measuring the radiation effect of the laser beam. Where the effect of gamma radiation on NTDs was measuring by UV-visible, FTIR spectroscopy, thermal diffusion analyzing (Al-Jobouri *et al*., 2018; Neamah, 2017) calculated the radiation effect of gamma rays by measuring the permeability of the laser beam. In this study the effect of gamma radiation and stress on CR-39 and CN-85 detectors was measuring by using the penetration of (He-Ne) laser beam .

MATERIALS AND METHODS

Two types of nuclear track detectors NTDs were used in this study. The first one was CR-39 detector with thickness 1200 μm (10×5 cm) and density 1.32 g/cm^3, supplied by TASTRAK type (Track Analysis System Ltd.), UK and having a chemical formula $C_{12}H_{18}O_7$.

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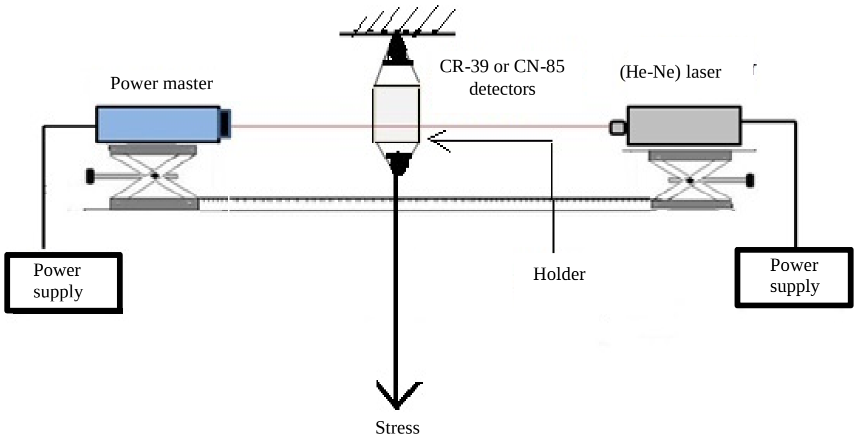

Fig. 1: Schematic of (He-Ne) laser beam penetration with following apparatus, power meter, (He-Ne) laser beam, CR-39 or CN-85 detectors, jack (holder), power supply

The second type of NTDs was the CN-85 detectors with thickness 200 μm density 1.42 g/cm^3, manufactured by the Eastman Kodak Company, Rochester, New York and having a chemical formula $C_6H_8O_9N_2$.

Gamma radiation effect: CR-39 and CN-85 gamma irradiation detectors exposed to gamma radiation from cobalt-60 source with dose rate 0.45 Gy/min.. The distance between the gamma source and NDTs detectors was 15 cm. The range of gamma radiation dose were (0, 42.3, 84.6, 126.9, 169.2, 211.5, 253.8 Gy) and (0, 12.7, 25.4, 38.1, 50.8, 63.4, 76.1, 88.8 Gy) for CR-39 and CN-85 detectors, respectively.

Mechanical stress effect: CR-39 and CN-85 detectors exposed by mechanical stress with range values (50, 55, 65, 100, 102, 106 N).

Figure 1 shown the arrangement setup of (He-Ne) laser beam with apparatus included (He-Ne) Laser beam source, power meter, CR-39 or CN-85 detectors, power supply, jack (holder).

The (He-Ne) laser penetration technique used to measuring the average of penetration rate P_{av} at gamma radiation or stress effect comparing with laser Penetration-P_0 without above effect. The power of penetration (He-Ne) laser beam was 15 mW and wavelength 632 nm. The specification of laser power meter was model (RF-1501 Shimadzu, Ltd.,) this power meter used to measuring the penetration rate-P at a distance of 13 cm from the detector.

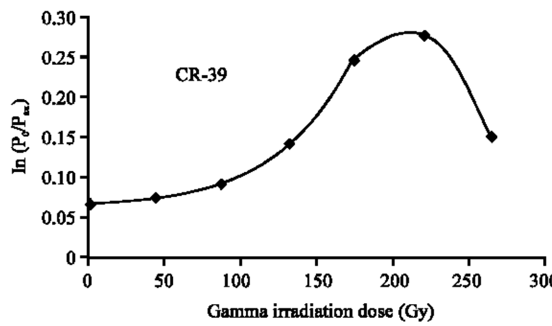

Fig. 2: The relationship between the effect of gamma irradiation on CR-39 detector with (He-Ne) laser penetration factor $\ln(P_0/P_{av})$

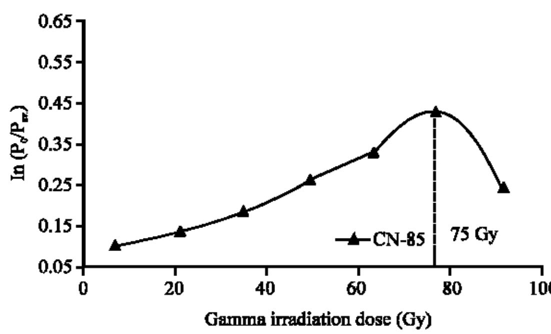

Fig. 3: The relationship between the effect of gamma irradiation on CN-85 detector with (He-Ne) laser penetration factor $\ln(P_0/P_{av})$

RESULTS AND DISCUSSION

Gamma irradiation: Figure 2 shown the effect of gamma radiation on CR-39 detector with laser penetration factor $\ln(P_0/P_{av})$ which shown the increase in $\ln(P_0/P_{av})$ with increase in gamma irradiation until to 220 Gy which represent of maximum response and dropping after this dose.

Figure 3 shown the effect of gamma radiation on CN-85 detector on laser penetration factor $\ln(P_0/P_{av})$ which appear the increase in $\ln(P_0/P_{av})$ with increase in

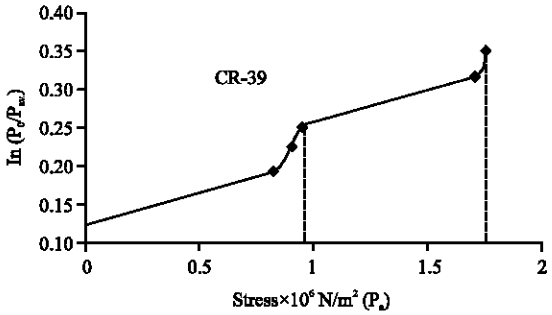

Fig. 4: The relationship between the stress effect on CR-39 with (He-Ne) laser penetration factor $\ln(P_0/P_{av})$

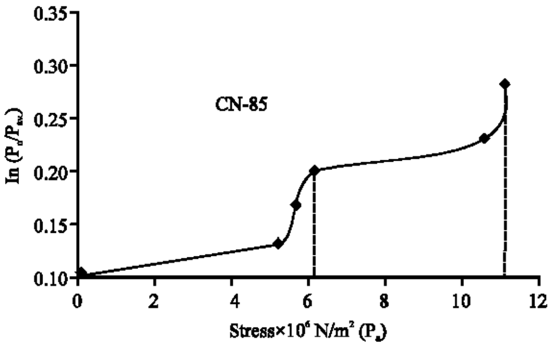

Fig. 5: The relationship between the stress effect on CN-85 with (He-Ne) laser penetration factor $\ln(P_0/P_{av})$

Table 1: The maximum response of (He-Ne) the penetration factor $\ln(P_0/P_{av})$ for gamma radiation and stress effect to CR-39 and CN-85 detectors

Detector	Thickness (μm)	Stress $\times 10^6$ -----(N/m^2)------		Maximum response of gamma irradiation (Gy)
CR-39	1200	0.9	1.6	220
CN-85	200	6.0	10.5	75

gamma irradiation for two cases until to 75 Gy which represent of maximum response and dropping after this dose.

Mechanical stress: Figure 4 show the mechanical stress on CR-39 detector with (He-Ne) laser penetration factor $\ln(P_0/P_{av})$ which appear the increase in $\ln(P_0/P_{av})$ with increase of mechanical stress. The maximum stress measured at the stress value 1.6×10^6 N/m^2 equivalent to laser penetration factor $\ln(P_0/P_{av})$ at the value 0.32.

Figure 5 shown the mechanical stress on CN-85 detector with (He-Ne) laser penetration factor $\ln(P_0/P_{av})$ which appear the increase in $\ln(P_0/P_{av})$ with increase of mechanical stress .The maximum stress measured at the stress value 12×10^6 N/m^2 equivalent to laser penetration factor $\ln(P_0/P_{av})$ at the value 0.3.

This change shows in Table 1 that there is a possibility to use the laser beam to measure the effect of stress and the radiation effect of the nuclear track detectors (CR-39, CN-85) and the possibility of identifying the physical specifications of the special types for another nuclear track detectors by using these techniques.

CONCLUSION

This study showed that there is a possibility of using a penetration of (He-Ne) laser beam technique to determination the mechanical stress and gamma radiation effects on nuclear track detectors-NTDs type (CR-39, CN-85). This technique can be considered as one of the methods that reflect the specification of physical properties of another transmitted materials.

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