Reconstruction the illumination pattern of the optical microscope to improve visibility and number of tracks on the CR-39 detector

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Abstract. In this study, the usual light source (Tungsten) used in the optical microscopy with intensity (924 W/mm²) was changed to another light source (LED) of intensity 1049 W/mm². Eight pieces of the CR-39 (SSND) track detector with dimensions (1 cm × 1 cm) and thickness (500 μm) were irradiated with the Am-241 source, has radioactivity 12 μCi, for different irradiation times (30:30:270 sec) and direct contact with track detectors. After etched-and drying the track detectors, they were read under the optical microscope (Pro-Way) before and after the source of light changed. The number of tracks in using the intensity of the Fluorescence and LED cases of lighting through the optical microscope was calculated using software via digital camera (HDEC-50B) through the calculator screen. The results showed an increase in the visibility of the track boundary with a significantly higher number of visible tracks.

Keywords: CR-39, LED light, illumination microscope pattern, thermal neutron.

1. Introduction

CR-39 detector is one of the best detectors for the detection of neutrons and charged particles such as protons, alpha particles, fission fragments, and heavy ions [1, 2]. In this research, the CR-39 solid state detector with a thickness of 500 μm was used. Where, it was cut into squares of equal dimensions 1 cm × 1 cm. These detectors were exposed to the Americium radioactive source Am-241 with an activity of 12 micro curies. Exposure time was 30, 60, 90, 120, 150, 180, 210, 240 and 270 second. The detectors were placed directly in contact with the source at a 90-degree angle. After four hours of the chemical etching process, the track influences were read using a digital camera (HDEC-50B) software connected to the optical microscope. Before and after changed the light of the microscope by a LED source to the purpose of counting the numbers of heavy alpha particles, the intensity of the track at different times of irradiation. There are several previous studies in this field, given by Ho et al. (2002) [3] which they employed variable light in optical microscopy system to evaluate the etching rate in CR-39 and LR-115 detectors. While Vazquez-Lopez et al. (2001) [4] studied the surface roughness and the function of different samples of CR-39 detector. Also, Al-Jobouri et al. (2016) [5] studied image analysis of CR-39 and CN-85 detector irradiation by thermal neutron.
2. Materials and methods

2.1 Effect of radiation on polymers

The effect of radiation on polymers can either lead to decay that specifically leads to broken chemical bonds between atoms in the main polymer chains, resulting in the annealing loss of polymer or structural strength and reduction in the weight of molecules [6] or the molecules overlap in polymers that are defined as an interaction that can tie the polymer chains together with cross-links.

This can lead to complex overlapping structures that increase polymer strength, rigidity and molecular weight. Some physical changes in polymers caused by radiation can cause color change or absorption change or lead in overlapping yield [7].

2.2 Ionization radiation

Ionizing radiation is capable of striking electrons outside their orbits around atoms, which destabilizes the electron/proton balance and gives the atom a positive charge. Molecules and electrically charged atoms are called ions. Ionizing radiation includes radiation that comes from natural and man-made radioactive materials. There are several types of ionizing radiation: alpha radiation, beta radiation, photon radiation (gamma, X-ray) and neutron ray radiation. These were collectively called Ionizing Radiation because of their ability to strip one or more electrons away from the atoms in any material passing by [8,9].

2.3 Thermal neutron source

Neutron sources vary in intensity and in the energy of neutrons emitted. They can be classified into three groups of nuclear fission reactors, radioisotopes, and particle accelerators. It is clear that nuclear reactors are not portable and not suitable for good nuclear logging sources. Radioisotopes are the most commonly used neutron source in well logging applications. The relatively limited particle accelerators (though growing) have experienced us in good logging. Neutron sources (n, α) contain a radioisotope counterpart of α emission, with low mass nuclei as a target. Compared to other isotopes, where Beryllium $^9Be_4$ is the most important target, because it contains the highest productivity of neutron.

The long half-life (~433 years) of $^{241}Am - 9Be$ would provide approximately a constant level of neutron flux from the source over the lifetime of the equipment (~20 years). Active neutrons are formed after interaction between the alpha particle and the material nucleus Target as the following equation:

$$^4He_2 + ^9Be_4 \rightarrow ^{12}C_6 + n + E$$

(1)

Alpha particles were emitted from Americium $^{241}Am$, affect the target of $^9Be_4$ and produce neutron on a wide range of energies with an average energy around 4.2 MeV and a maximum around of 10 MeV [10,11,12].

2.4 Characteristic of alpha particle tracks in polymers

Etch pits growth along alpha-particle tracks in CR-39 detectors. The etched track is initially grown in a conical-like structure. The walls of the track bend because the track etching rate is increased with the low particle range. When etching reaches the end of the particle range, it is said that the track is "etched out". All the further expansion of the track now proceeds as a result of bulk etching-the track is said to be "over-etched". Continued over-etching expands the track but gradually destroys the conical structure [13].
Light Emitting Diode (LED)

The basic principle of operating behind light emitting diodes LED is that it stimulates the conduct by negative carriers (n-type) and some by (p-type). When charged carriers are recombined from different types, the released energy may emit light [14]. LED lamps are the latest and newest addition to the list of energy efficient light sources. LEDs lamps emit visible light in a very narrow spectral band, which can produce "white light". This is achieved either a by using a red-blue-green array or a phosphor-coated blue LED lamp, in addition to its light decay, which is less than 10,000 hours of testing. Although it is still in its infancy, LED lighting techniques are fast and give hope for the future [15].

3. Results and Discussion

The first step in this research was to modify the light source of an optical microscope LED light instead of the tungsten light. The Relationship of output analysis relation between track number and light levels measured by Lux meter before and after light system change (lightness) in the optical microscope is shown in figure 1. In the second step, the track number was compared with a different irradiation time when the CR-39 was detected under Am-241 radiation, the linear relationship between the irradiation time and the number of tracks can be obtained from figure 2 & 3. The behavior of this relationship is as a linear relationship reflected the increasing numbering of the track with irradiation time with a different intensity of light as tabulated in table 1. In the third step, the MATLAB program was designed to identify image quality with four no reference scales such as the average Gradient (AG), the measurement of Enhancement by Entropy (EMEE), and the (NIQWT) were calculated to be recommended. Where a good correlation coefficient was obtained for these scales. The best correlated coefficient was 0.6431 was for (NIQWT) scale. The statically results illustrate photography when using a much better-LED light-than Tungsten light in optical microscopy. Therefore, these processes have increased the numbering of detected (discovered) nuclear track as shown in Figure 4.

4. Conclusions

For this study show there are possible to changing light optical microscope from tungsten source by light emitting diode source to increase number of track discovered of Alpha particle. The radiation track for the thermal neutrons in different time was determined before and after the value of maximum and minimum track. Finally comparison results with image processing by using four no reference scales, illustrated results conclusion the LED light increase the number of nuclear tracks. At these processes led to augment visibility and numbering of nuclear tracks discovered. It is clear from the results that the correction coefficient was high because it corresponds to the manual counting using the source of the light emitting diode instead of the tungsten light of the nuclear tracks of alpha particles on the CR-39 irradiated detector with the Am-241 thermal neutron source to increase the clarity and thus the accuracy of the number of nuclear tracks of alpha particles discovered.
Figure (1) Optical microscope and Lux meter instrument.

Figure (2) Show the relation between maximum number of tracks and time irradiation time with Tungsten light in optical microscope.
**Figure (3)** The relation between manually maximum number of tracks and time irradiation time with LED light in optical microscope.

**Figure (4)** Normalize quality NIQWT scale and number of tracks as function of normalizes power for group Tungsten images in MATLAB program.
Figure (5) Normalize quality NIQWT scale and Number of tracks as function of normalizes power for group LED images in MAT LAB program.

Table (1) Illustrates manually number of nuclear tracks before and after changing light optical microscope by LED light with different intensity of light and different irradiation time (30:30:270).

| Detector | Irradiation time (sec) | Intensity of tungsten light (Lux) | Number of nuclear tracks (before) | Intensity of LED light (Lux) | Number of nuclear tracks (after) |
|----------|------------------------|----------------------------------|----------------------------------|-----------------------------|---------------------------------|
| CR-39    | 3                      | 44                             | 931                             | 34                         | 46                             |
| CR-39    | 6                      | 39                             | 443                             | 33                         | 55                             |
| CR-39    | 9                      | 55                             | 455                             | 43                         | 65                             |
| CR-39    | 12                     | 63                             | 536                             | 63                         | 536                             |
| CR-39    | 15                     | 63                             | 536                             | 63                         | 536                             |
| CR-39    | 18                     | 72                             | 63                               | 72                         | 63                              |
| CR-39    | 21                     | 72                             | 63                               | 72                         | 63                              |
| CR-39    | 24                     | 72                             | 63                               | 72                         | 63                              |
| CR-39    | 27                     | 72                             | 63                               | 72                         | 63                              |

Table (2) Measurements of correlation coefficients for (AED, EMEE, NIQW) scales in MATLAB program by using Tungsten and LED source.

| Images | Correlation coefficient (NT, AED) | Correlation coefficient (NT, EMEE) | Correlation coefficient (NT, NIQE) |
|--------|-----------------------------------|-----------------------------------|-----------------------------------|
| Group T | 0.5377                            | 0.3621                            | -                                 |
| Group L | 0.6196                            | 0.4649                            | 0.6431                            |

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