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Fabrication of alpha irradiation technique and study the impact of low alpha particles density on the lymphoblast cells of Leukemia blood samples

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Abstract

Fabrication of alpha irradiation technique has been fabricated using CR-39 nuclear track detector, medical injection pin, and micro capillarity tubes. Optimum alpha irradiation parameters (time of irradiation and alpha energy) were used to study the impacts of the low density of accumulated alpha particles on the percentages of lymphoblast cells (Blast cells) for 20 leukemia blood samples. The results show that the fabricated cell irradiation collimator is given significant results to irradiate whole blood samples. Low alpha particle density corresponded with the short time of irradiation at the fixed alpha energy (E=4.5 MeV). The results of the blast cell irradiation approved that the accumulated alpha particles affected the percentage of blast cells depending on the time of irradiation. 20 sec of irradiation is sufficient to reduce low blast cells percentage (≤30 %) to half, and 40 sec is enough to reduce blast cell percentage to half for the cases that have more than 30 % to 60 % of blast cells. Percentage of blast cells reduced regarded to the accumulated density of alpha particles in a power relationship.

Introduction

Alpha particles are the heavy and ionizing particles, which have short range tissue (μm) and high linear energy transfer (LET), and they produce about 4K to 9K pairs of ion/μm ([1]). The range of alpha particles in tissues is around 40 to **90** μm; the LET is 50- to 500-fold greater than that of β particles ([2]). In most cases, one to three α particle tracks through the cell nucleus are sufficient to sterilize the cell, and this means that alpha density has a high impact on the living cells ([3], [4]). Alpha particles are dangerous only when they are inhaled, ingested or absorbed through a wound ([5], [6]). When they do interact with biological material they are very damaging because of their relatively large mass and double charge ([7]). So it is necessary to calibrate it regarded to the time of exposure during the measurements and using of it in treating the cells ([8], [9], [10])

Risks of accumulation alpha particles are high and make heavy damage regarding to its energy and time of irradiation. Biological effects of alpha particles have been employed in radiotherapy and radio oncology ([11]). Several alpha irradiation collimators have been fabricated to irradiation in the topics of biophysics and medical physics ([12], [9], [4], [13], [14]). Many alpha irradiation techniques have been fabricated in previous studies, however, and regarded to some of the benchmark researches ([9], [4], [15], [16]), the dimensions of the fabricated irradiation techniques were not suitable to irradiate an identified area of blood cells. Impacts of alpha particles deposition on Leukemia blood samples have been investigated for long time and high energies to destroying blast cells ([15]), whenever its impacts were more on the normal cells, and that was not satisfying for radiotherapy principles. So, the diameter of the irradiation technique and the time of irradiation were two main factors that made the previous techniques not acceptable to irradiation of blood cells (low density). An alpha irradiation collimator have been designed and fabricated by the researchers of Ismail and M.S. [17] to irradiate organic materials and living cells fabricated using polycarbonate materials type CR-39 nuclear track detector (CR-39NTDs), whenever their fabrication was not accepted to irradiation living cells. Ismail [15] calibrated an alpha irradiation collimator to study impacts of alpha particles on blood components, whenever it was not significant well due to scattering of the alpha particles to the large area of the samples, and high time of irradiation.

The main point of this research is to identify a satisfying alpha particle density to destroy blast cells into leukemia blood samples. The diameter of cell irradiation collimator (area of exposure) and the time of irradiation are the matter in radio oncology and radiation therapy. So, this study aimed to use a suitable cell irradiation technique by alpha-particle using Allyl Diglycol Carbonate (ADC) regarded to time of irradiation.

Section snippets

Materials and equipment

Allyl Diglycol Carbonate (ADC) detector and chemical solution

Trade name of this type of detector is CR-39 nuclear track detector. Engrafted and coded of 30 pieces (The detectors were cut into the pieces and each piece was encoded with a specific number by laser engraving on the surface of each detector, as shown in Fig. 1) of it used to register incident alpha particles within the irradiation process. This type of detector made in Italia, and it has calibrated through optimum etching condition...

Results and discussion

The densities of accumulated alpha particles on each piece of Allyl Diglycol Carbonate (ADC) detectors were changed regarded to the time of irradiation (Fig. 6), and this was in agreement with the benchmark references ([5], [9]). The response of the both irradiation collimators (Micro capillarity tube and a medical needle) were in coordinated, so the type of material was not affected on the track density. Capillarity tube was more stable (suitable) and has same effects of medical needle...

Conclusions

A cell irradiation technique of alpha particles fabricated using capillary tube, and it usable to deposit significant alpha particles on the surface of Leukemia blood samples that consisted of blast cells. Response of blast cells to the incident alpha particles was high and it has depended on the time of irradiation. Most of the blast cell approaches to its half values at 60 s of irradiation. Sufficient alpha particles that have 4.5 MeV can destroy blast cells at very short time (30 s)....

CRediT authorship contribution statement

Asaad H. Ismail: Conception and design of study, Analysis and/or interpretation of data, Writing – original draft, Writing – review & editing. **Runas Y. Sola:** Conception and design of study, Acquisition of data, Writing – original draft....

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper....

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