Volume 10, Issue 3 (2022) pp. 202-207 DOI: 10.22034/ijabbr.2022.552391.1395

Original Article

Production of X-Rays Using Charged Particles

Mohammad Reza Rezaie[1]* | Saeedeh Khezripour[2]

[1]Department of Nuclear Engineering, Faculty of Modern Sciences and Technologies, Graduate University of Advanced Technology, Kerman, Iran
[2]Department of Molecular and Atomic Physics, Faculty of Modern Science and Technology, Graduate University of Advanced Technology, Kerman, Iran

*Corresponding Author E-mail: mr.rezaie.r@gmail.com

Received: 20 April 2022, Revised: 30 May 2022, Accepted: 25 June 2022

Abstract

Introduction: The charged particles emit electromagnet radiation due to the ionization and excitation of atoms while stopping in the environment. The energy spectrum and irradiation intensity depend on the type and the content of ingredients in the target and their thickness. Materials: The spectrum of the produced X-rays has been examined by placing layers made of metals and other materials as well as changing their thickness in front of the inlet window of the CsI(Tl) scintillation detector. The CsI(Tl) scintillation detector channels have been calibrated using the ^{60}Co and are represented in terms of energy versuce MeV.
Results: Results revealed that iron with a thickness of 0.2 mm is the best candidate for producing X-rays. Besides, aluminum and paper are capable of producing X-rays with uniform distribution in the ranges of 0.383-2.357 MeV and 0.383-0.560 MeV, respectively.
Conclusion: Results show that the maximum X-ray radiation intensity with the energy of 383 keV is produced due to the stoppage of alpha particles in the iron sheet with a thickness of 0.2 mm. Plastic, aluminum, paper, copper, and lead with X-ray radiation (383 keV) with thicknesses of 0.1-0.4 mm are available, respectively.

Keywords: X-ray, Electromagnetic radiation, Scintillation detector.

1. Introduction

Different atomic and nuclear methods have been used so far to produce X-rays [1-3]. Stopping high-energy electrons in different ingredients is one of the most effective atomic methods, among others, widely investigated and optimized by different researchers [4,5]. Besides, the X-rays have been produced by the Triboelectric effect [6]. In this method, the X-ray can be produced by rubbing two insulating materials with different electronegative properties and moving them at a proper distance from a metal [7,8]. The rubbed insulating plates produce the electric load, and the electric discharge occurs at a proper distance from a metal; then, the X-rays can be produced as electrons are stopped at the target [9]. The X-ray production gain depends on the pressure of both gas and the chamber. It is well-known that the production gain increases by decreasing the pressure. Besides, X-rays can be produced by stopping radioactive beams [10-12]. In 2017, Radwan Durak used the nuclear radiation of ^{241}Am source in the Pr, Nd, Sm, Eu, Gd, and Tb for producing X-rays [13]. The utilization of radioactive sources is one of the most efficient methods for producing X-rays. Nuclear radiations which reach the liquid and solid samples at different energies are stopped on the desired target, and the X-ray emission is created. The X-ray spectrum depends on material type, source type, and source energy. The present study aims to study and introduce novel methods by reviewing the previous methods for producing X-rays due to the different nuclear interactions between the radioactive beams and different materials (with different contents).

2. Materials and Methods

According to Figure 1, some layers with different thicknesses made of aluminum and copper are placed between a ^{241}Am source and the CsI(Tl) scintillation detector. We investigated the number of photons received in every energy channel corresponding to the emitted beams due to the stoppage of alpha particles and secondary electrons in the layers with different thicknesses for different types of materials in the CsI(Tl) scintillation detector. The intensity and spectrum of the ray were examined by changing the source energy, source type, target dimensions, target-source distance, and target element. Also, the test conditions were optimized.

The variations of counts of channels sensitive to the emitted photons due to the stoppage of alpha particles and secondary electrons in different layers of aluminum and copper are represented in Table 1.

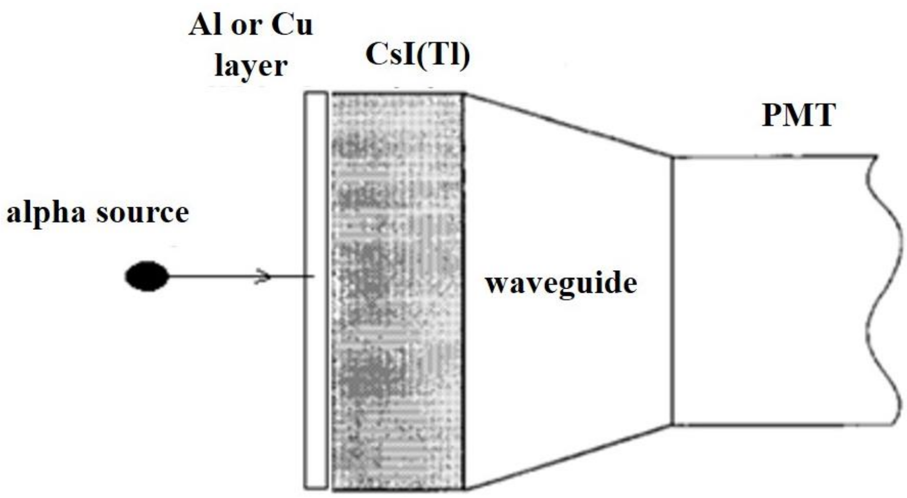

Figure 1. A view of the X-ray scintillation detector produced due to the stoppage of charged particles in the material

Table 1. Maximum X-ray produced due to the radiation of Am source alpha-ray in terms of the of layers number of paper, lead, iron, copper, and aluminum (thickness of all layers is 0.1 mm)

plastic			Paper			Lead			Iron			Copper			Aluminium		
Energy(kev)	Number of sheet	Counts	Energy(kev)	Number of sheet	Counts	Energy(kev)	Number of sheet	Counts	Energy(kev)	Number of sheet	Counts	Energy(kev)	Number of sheet	Counts	Energy(kev)	Number of sheet	Counts
383	1	67	352	4	29	383	3	20	383	2	86	383	4	27	360	5	63
391	2	34	356	5	22	580	6	6	457	2	60	572	2	18	383	4	51
457	2	32	360	2	48	795	3	10	516	2	23	637	4	25	418	7	33
461	2	12	364	1	29	825	8	13	520	4	18	649	4	16	484	6	45
468	5	19	357	2	42	1320	1	16	524	3	30	748	3	18	508	3	32
484	2	37	383	4	78	1334	2	9	528	5	42	829	2	19	524	4	27
536	3	19	391	2	53	1364	6	12	560	4	32	1229	2	15	528	5	25
552	1	15	410	2	13	1600	6	14	564	4	24	1320	1	13	536	5	47
560	1	35	457	2	27	1679	8	9	572	2	20	1344	4	11	564	7	24
564	4	19	461	2	23	1759	6	11	580	5	36	1679	1	10	572	3	38
572	1	39	465	3	38	2266	8	11	637	5	25	1759	3	16	580	5	25
637	3	23	484	2	28	2321	8	9	736	2	14	2218	3	11	612	5	17
715	3	16	488	1	31				907	3	14				637	9	35
1334	1	18	508	2	43				1049	2	20				825	2	27
1364	2	13	512	4	16				1201	3	13				990	3	14
1373	3	11	524	4	25				1224	3	11				1013	5	24
			528	1	23				1320	4	10				1031	5	18
			536	3	31										1053	8	18
			540	4	22										2358	8	147
			552	1	24												
			560	2	26												

3. Results

The maximum pure counting in the sensitive channels is shown in Figure 2. Besides, the scintillation detector channels have been calibrated using ^{60}Co and are represented in terms of energy in Figure 3. It can be seen from Table 1 that the X-rays are available with energies 0.383-2.357 MeV with a thickness in the range of 0.1-0.8 mm. The source activity is 5 mCi, and it was reported that the average number of photons received within 1160 s was 38215. Therefore, these channels are those showing the maximum intensity of emitted photons due to the stoppage of alpha particles and deaccelerated electrons in the medium.

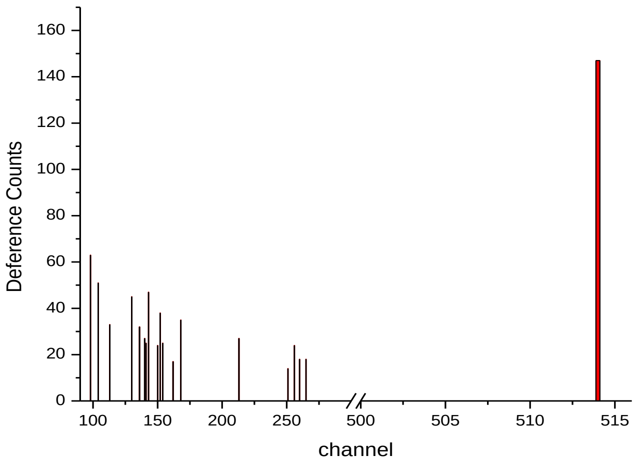

Figure 2. Maximum pure counts observed in the sensitive channels

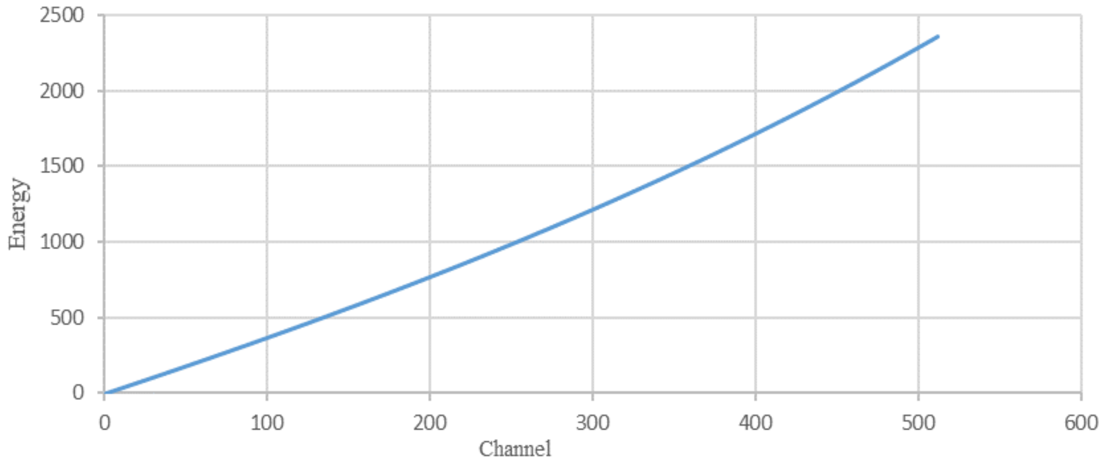

Figure 3. Calibration of scintillation detector by ^{60}Co

Results show that the maximum X-ray radiation intensity with the energy of 383 keV is produced due to the stoppage of alpha particles in the iron sheet with a thickness of 0.2 mm. Plastic, aluminum, paper, copper, and lead with X-ray radiation (383 keV) with thicknesses of 0.1-0.4 mm are respectively in the next rankings.

4. Discussion and Conclusion

X-rays are produced due to the collision of alpha beams to the aluminum and copper and their stoppage in the target. The X-ray spectrums produced in different CsI(Tl) scintillation detector channels were investigated. In the present research, alpha beams (5.48 Mev) produced by 241 Am source were emitted to the targets made of plastic, paper, lead, iron, copper, and aluminum with different thicknesses. Firstly, the sensitive channels were detected, and then the most desired thicknesses for observing X-ray spectrums were introduced by analyzing channels with different thicknesses. Results revealed that iron with a thickness of 0.2 mm was the best candidate for producing X-rays. Besides, aluminum and paper were capable of producing X-rays with uniform distribution in the ranges of 0.383-2.357 MeV and 0.383-0.560 MeV, respectively.

Declarations

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. The authors declare that there is no conflict.

Authors' contributions

Mohammad Reza Rezaie designed and simulated this study and Saeedeh Khezripour analyzed the data. Mohammad Reza Rezaie proceeded to the data quality control and the manuscript drafting. Saeedeh Khezripour revised the final version.

Consent for publications

All authors agree to have read the manuscript and authorize the publication of the final version of the manuscript

Conflict of interest

None of the authors have any conflict of interest to declare.

Availability of data and material:

Data are available on request from the authors.

Funding/Support

This paper is output of the Research Project number 7/ص/98/1416-98/7/6 in Graduate University of Advanced Technology, Kerman, Iran

Ethics approval and consent to participate

Because of the simulation of this study, no Ethics approval and consent to participate the form was required.

Orcid

Mohammadreza Rezaie: https://www.orcid.org/0000-0002-2183-7729
Saeedeh Khezripour: https://www.orcid.org/0000-0002-0935-0977

Refrences

1. Ohura M, Ozawa K, Chang J, Yamamoto Y, Morita S, Ishii K. (1987). X-ray production by channeled ions. *Nucl. Instrum. Methods Phys. Res. A: Accel. Spectrom. Detect. Assoc. Equip.*, 262: 137. [Crossref], [Google Scholar], [Publisher]
2. Ledingham K W D, Abuazoum S S, McCanny T, Melone J J, Spohr K, Schramm U, Kraft S D, Wagner A, Jochmann A. (2011). Comparison of hard X-ray production from various targets in air using a short pulse kHz laser with photon production from a high power multifilament laser beam from the same targets in air. *arXiv preprint arXiv:1106.4152*. [Crossref], [Google Scholar], [Publisher]
3. Hessenbruch A. (2002). A brief history of x-rays. *Endeavour*, 26: 137-141. [Crossref], [Google Scholar], [Publisher]
4. Geuther J A, Danon Y. (2005). High-energy x-ray production with pyroelectric crystals. *Journal of applied physics*, 97: 104916. [Crossref], [Google Scholar], [Publisher]
5. Mayles P, Nahum A E, Rosenwald J C, (2007). Handbook of radiotherapy physics: theory and practice: CRC Press. [Google Scholar], [Publisher]
6. Hird J, Camara C, Putterman S. (2011). A triboelectric x-ray source. *Applied Physics Letters*, 98: 133501. [Crossref], [Google Scholar], [Publisher]
7. Putterman S J, Hird J, Camara C. (2015). Triboelectric X-ray source, ed: Google Patents. [Google Scholar], [Publisher]
8. Kneip S. (2011). Applied physics: A stroke of X-ray. *Nature*, 473: 455. [Crossref], [Google Scholar], [Publisher]
9. Van Cleve E, Lucas B, Gamlieli Z, Wong E., Kamkar D, Jimenez G, Cortes Jr P, Mehta N, Harper J, Cuadra D, Hennessey M, Fong J, Valentine M, Fox D, Camara C, (2014). Triboelectric generation of x-rays: Pre-dictions and Results. *Proc. ESA Annual Meeting on Electrostatics*, 1. [Google Scholar], [PDF]
10. Wheeler D C, Bingham E, Winer M, Conrad J M, Robinson S P. (2018). Observation of relativistic corrections to Moseley's law at high atomic number. *arXiv preprint arXiv:1809.10480*. [Crossref], [Google Scholar], [Publisher]
11. Bissinger G, Joyce J, Ludwig E, McEver W, Shafroth S. (1970). Study of the Production of K X Rays in Ca, Ti, and Ni by 2-28-MeV Protons, *Phys. Rev. A.*, 1: 841. [Google Scholar], [Publisher]
12. Kumar S, Singh U, Oswal M, Singh G, Singh N, Mehta D, Nandi T, Lapicki G. (2017). L shell x ray production in high-Z elements using 4–6 MeV/u fluorine ions. *Nucl. Instrum. Methods Phys. Res. B: Beam Interact. Mater. At.*, 395: 39-51. [Crossref], [Google Scholar], [Publisher]
13. Durak R, Akman F, Karabulut A, (2017). Photon-Induced L-Shell X-Ray Production Cross Sections for

Lanthanides at 59.54 keV. *Materials Science Forum*, 890: 223-226. [Crossref], [Google Scholar], [Publisher]

How to cite this article:
Mohammadreza Rezaie*, Saeedeh Khezripour. Production of X-Rays Using Charged Particles. *International Journal of Advanced Biological and Biomedical Research*, 2022, 10(3), 202-207. Link: http://www.ijabbr.com/article_252905.html