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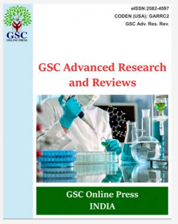

(REVIEW ARTICLE)

Fundamental characteristics and application of radiation

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Abstract

Radiation is the emission or transmission of energy as waves or particles through space or through a material medium which is able to penetrate various materials and is often categorized as either ionizing or non-ionizing depending on the energy of the radiated particles. Radiation processing can be defined as exposure of materials with high energy radiation to change their physical, chemical, or biological characteristics, to increase their usefulness, and safety purpose, or to reduce their harmful impact on the environment. Ionizing radiation is produced by radioactive decay, nuclear fission, and fusion, by extremely hot objects, and by particle accelerators. The radiation coming from the sun is due to the nuclear fusion; therefore, we are living in a natural radioactive world. Radioactive substances are common sources of ionized radiation that emit α, β, or γ radiation, consisting of helium nuclei, electrons or positrons, and photons, respectively. Alpha rays are the weakest form of radiation and can be stopped by paper. Beta rays are able to pass through paper but not through aluminum. Gamma rays are the strongest radiation. They are able to pass through paper and aluminum, but not through a thick block of lead or concrete. Alpha and beta radiation are the high energy subatomic particles where gamma radiation is a form of high energy electromagnetic waves. This review presents the fundamental introduction of radiation, the three types of radiation, and their applications.

Keywords: Radiation; Alpha radiation; Beta radiation; Gamma radiation

1. Introduction

Radiation is often considered as either ionizing or non-ionizing depending on the energy of the radiated particles. Ionizing radiation emits more than 10 eV to ionize atoms and molecules and break the chemical bonds. This is an important distinction due to the large difference in harmfulness to living organisms. Ionizing radiation is radioactive materials that emit α, β, or γ radiation, consisting of helium nuclei, electrons or positrons, and photons, respectively. Other sources include X-rays from medical radiography examinations of mesons, positrons, neutrons and other particles that constitute the secondary cosmic rays that are produced after primary cosmic rays interact with Earth's atmosphere [1].

Radiation is mainly defined as the emission or transmission of energy in the form of waves or particles through space or material medium. Electromagnetic Radiation consists with radio waves, microwaves, infrared, visible light, ultraviolet, x-rays, and gamma radiation (γ), Particle Radiation are found as the form of alpha radiation (α), beta radiation (β), proton radiation and neutron radiation, Acoustic Radiation can be exemplified as ultrasound, sound, and seismic waves and Gravitational Radiation is the radiation that takes the form of gravitational waves, or ripples in the curvature of space time [2].

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Radiation is the phenomenon of waves radiating which means traveling outward in all direction from a source. This leads to a system of measurements and physical units that are applicable to all types of radiation. Because such radiation expands as it passes through space, and as its energy is conserved (in vacuum), the intensity of all types of radiation from a point source follows an inverse-square law in relation to the distance from its source. Like any ideal law, the inverse-square law approximates measured radiation intensity to the extent that the source approximates a geometric point [3].

Radiation with sufficiently high energy can ionize atoms by knocking the electrons off atoms, creating ions. Ionization occurs when an electron is stripped or knocked out from an electron shell of the atom, leaving the atom with a net positive charge. Because living cells and, more importantly, the DNA in those cells can be damaged by this ionization, exposure to ionizing radiation is considered to increase the risk of cancer. Thus "ionizing radiation" is artificially separated from particle radiation and electromagnetic radiation, simply due to its great potential for biological damage. While an individual cell is made of trillions of atoms, only a small fraction of those will be ionized at low to moderate radiation powers. The probability of ionizing radiation causing cancer is dependent upon the absorbed dose of the radiation, and is a function of the damaging tendency of the type of radiation (equivalent dose) and the sensitivity of the irradiated organism or tissue (effective dose) [4].

If the source of the ionizing radiation is a radioactive material or a nuclear process such as fission or fusion, there is particle radiation to consider. Particle radiation is subatomic particle accelerated to relativistic speeds by nuclear reactions. Because of their momenta they are quite capable of knocking out electrons and ionizing materials, but since most have an electrical charge, they don't have the penetrating power of ionizing radiation. The exception is neutron particles; see below. There are several different kinds of these particles, but the majority is alpha particles, beta particles, neutrons, and protons. Roughly speaking, photons and particles with energies above about 10 electron volts (eV) are ionizing (some authorities use 33 eV, the ionization energy for water). Particle radiation from radioactive material or cosmic rays almost invariably carries enough energy to be ionizing [5].

Most ionizing radiation originates from radioactive materials and space (cosmic rays), and as such is naturally present in the environment, since most rocks and soil have small concentrations of radioactive materials. Since this radiation is invisible and not directly detectable by human senses, instruments such as Geiger counters are usually required to detect its presence. In some cases, it may lead to secondary emission of visible light upon its interaction with matter, as in the case of Cherenkov radiation and radio-luminescence [6].

In this review article we tried to give a general view and idea of three basic radiation processes, Alpha, Beta and Gamma radiations and their applications. Some of the major and recent scientific experiments are discussed to give an opinion and view for the wings of future and further studies.

2. Alpha Radiation

Alpha particles, also knowing as alpha rays or alpha radiation, consisting of two protons and two neutrons bound together into a particle identical to a helium-4nucleus. They are generally created in the course of alpha decay, but may also be produced in other ways. It was named after the first letter in the Greek alphabet, α. As they are identical to helium nuclei, they are also denoted as He2+ or 42He2+ indicating a helium ion with a +2 charge. The alpha particle becomes a normal helium atom 42He by getting electrons from the external source. The net spin of alpha particle is zero. By following the mechanism of their production in standard alpha radioactive decay, alpha particles automatically charged with a kinetic energy of about 5 MeV, and a velocity in the vicinity of 4% in comparison with the speed of light. Although they are a highly ionizing form of particle radiation, have low penetration depth.

However, long range alpha particles from ternary fission are considered three times as energetic, and penetrate three times as far. The helium nuclei forming 10–12% of cosmic rays are usually much higher energy than those produced by nuclear decay processes, and thus may have highly penetration and able to traverse the human body and also many meters of dense solid shielding, depending on their energy. To a lesser extent, this is also applicable to the very high-energy helium nuclei produced by particle accelerators [7].

2.1. History of Alpha Radiation Invention

In 1899, physicists Ernest Rutherford and Paul Villard separated radiation into three types: eventually named alpha, beta, and gamma by Rutherford, based on penetration of objects and deflection by a magnetic field. Alpha rays were defined by Rutherford as those having the lowest penetration of ordinary objects.

Because alpha particles occur naturally, but can have energy high enough to participate in a nuclear reaction, study of them led to much early knowledge of nuclear physics. Rutherford used alpha particles emitted by radium bromide to infer that J. J. Thomson's Plum pudding model of the atom was fundamentally flawed. In Rutherford's gold foil experiment conducted by his students Hans Geiger and Ernest Marsden, a narrow beam of alpha particles was established, passing through very thin (a few hundred atoms thick) gold foil. The alpha particles were detected by a zinc sulfide screen, which emits a flash of light upon an alpha particle collision. Rutherford hypothesized that, assuming the "plum pudding" model of the atom was correct, the positively charged alpha particles would be only slightly deflected, if at all, by the dispersed positive charge predicted [8].

Prior to this discovery, it was not known that alpha particles were themselves atomic nuclei, nor was the existence of protons or neutrons known. After this discovery, J.J. Thomson's "plum pudding" model was abandoned, and Rutherford's experiment led to the Bohr model and later the modern wave-mechanical model of the atom. In 1917, Rutherford latterly realized that the emission of alpha particles was directed nuclear transmutation of one element to another. Transmutation of elements from one to another had been understood since 1901 as a result of natural radioactive decay, but when Rutherford projected alpha particles from alpha decay into air, he discovered this produced a new type of radiation which proved to be hydrogen nuclei (Rutherford named these protons). Further investigation disclosed that the protons could come from the nitrogen component of air, and the reaction was deduced to be a transmutation of nitrogen into oxygen in the reaction which was the first discovered nuclear reaction [8-9].

$14N + \alpha \rightarrow 17O + p$

2.2. Scientific Research on Detection of Alpha Radiation Dosage

There are several detection methods that were evaluated and invented by many scientists and researchers.

Gulab Chand Yadav, Shishu Pal Singh, Vivek Singh briefly described their research in the article named with “Detection of high energetic alpha particle radiation through metal clad planar waveguide based sensor”. They simulated and studied the dispersion characteristic, electromagnetic field distribution and performance parameter of a metal clad planer waveguide sensor for detection of high energetic alpha particle radiation. The modal equation and other necessary formulae of proposed waveguide are derived by using the boundary matching technique. They proposed four layer metal clad optical waveguide consisting with a thin silver film sandwiched between BK7 glass substrate and SiO2 dielectric waveguide film. In a planar optical waveguide the light is propagated through total internal reflection (TIR). The dispersion characteristics of waveguide were observed to have their usual shape in presence of alpha particle radiation. There was a decreased in the cutoff film thickness of waveguide with increase of the dose of alpha particle radiation. Sensitivity was observed by the Transverse Electric (TE) mode analysis of proposed waveguide based sensor and overall performance were found 153.33 degree/RIU, 5.75 and 1916.67 RIU-1, respectively. This analysis also enlightened the obtained detection accuracy and overall performance of proposed waveguide for TE mode analysis which were sufficiently large comparison to the Transverse Magnetic (TM) mode analysis [10].

R. Souri, A. Negarestani, M. Mahani expressed their investigation in a scientific journal titled with “A new approach for direct imaging of Alpha radiation by using Micro Pattern Gas Detectors in SQS mode”. In this study, the design, simulation and construction of three micro pattern gas-detectors, THGEM, with different geometric dimensions are presented. Moreover, their ability of operation in SQS mode to determine the incident rays position without using any conventional imaging system is investigated. In the presence of UV absorbing gas mixtures, the proportional mode of the gas detector operation is followed by SQS mode as soon as the visible light column appears at the ray entrance location. In the method employed, each THGEM hole as an image pixel independent of other holes can operate in SQS mode with emerging a light column. As a consequence, it can be used for alpha beam imaging since the brightness of each hole at a certain voltage is proportional to the number of primary electrons entering the hole [11].

M. Daraee, Azim Araghi, M. Sadeghi, A. Hashemizadeh worked on a paper called “Investigation of thermal treatment on improving the performance behavior of Si PIN alpha radiation detectors”. The silicon-based PIN-type photodiode was designed and fabricated employing conventional bipolar planar technology using different annealing process to reduce the leakage current and detector energy resolution. In this process, the specified effects of the Annealing and gas flow rate on the detector electrical properties such as capacitance-voltage (C–V) of MOS capacitors and current voltage (I–V) of diodes and alpha spectral measurement were observed. Silicon PIN radiation detectors were made of four similar fabrication process with different post thermal annealing at constant temperature and different hydrogen gas flow (10 sccm–60 sccm). The detector with 15 sccm hydrogen gas flow showed the lower leakage current due to the lower remained interface traps density at the Si/SiO2 interface. Si PIN diodes were fabricated by considering all the important aspects [12].

R. M. Sahani, Chandni Kumari, Arun Pandya and Ambesh Dixit studied the detection of alpha rays in their research article, titled with “Detector using Low Temperature Hydrothermally Grown ZnO:Ga Nano-rod Scintillator”. An efficient detection of alpha radiation on highly textured and vertically aligned along Gallium-doped Zinc Oxide (ZnO:Ga) nanorods on a glass substrate was observed. The average diameter of the glass rods were approximately 150±10nm. Photoluminescence measurement showed near band emission 393nm, with the band-gap value ~3.22eV which was measured by UV-Vis spectroscopy. They developed ZnO:Ga nano-rod scintillator coupling with a commercially available photomultiplier tube and 1K Multichannel Analyzer to fabricate an alpha radiation detector. The performance of the alpha radiation detector was evaluated using various alpha radiation sources. The detector for different alpha sources against the background spectrum recorded a large pulse height spectrum. The highly sensitive nature to alpha radiation was calculated by detection efficiency and Minimum Detectable Activity (MDA). The response of a single scintillator for numerous exposures and inter-batch response variations showed repeatability and reproducibility of the detector’s performance. The response was repeatable within ±1% whereas reproducibility varied from ±20% for extremely low activity alpha sources to ±5% for high activity alpha sources. The performance of ZnO:Ga nano-rod scintillator grown on glass substrate was a proof that it could be a promising material system for the detection of alpha radiation [13].

2.3. Applications of Alpha Radiation

Alpha particles are large, powerful subatomic particles that are very destructive to human cells although they tend to lose their energy quickly, which limits their ability to penetrate into materials. There are many ways in which science successfully uses alpha radiation in a beneficial way.

- Cancer Treatment: Alpha radiation is used to treat various forms of cancer. This process, called unsealed source radiotherapy which involves inserting tiny amounts of radium-226 into cancerous masses. The alpha particles destroy cancer cells but lack the penetrating ability to damage the surrounding healthy cells. Radium-226 has mostly been replaced by Safer, more effective radiation sources, such as cobalt-60. Xofigo, the brand name of Radium-223, is still used to treat bone cancer [7].
- Static Eliminator: Alpha radiation from polonium-210 has great use to eliminate static electricity in industrial applications. The positive charge of the alpha particles attracts free electrons, thus reducing the potential for local static electricity. For instance, this process is common in paper mills [14].
- Smoke Detector: Alpha radiation can be useful as some smoke detectors. The alpha particles from americium-241 bombard in air molecules which sets electrons free. These electrons can create an electrical current. Smoke particles are successful in disrupting this current [7, 14].
- Spacecraft Power and Pacemaker Battery: Radioisotope thermoelectric generators have great use at power a wide array of satellites and spacecraft, including Pioneer 10 and 11 and Voyager 1 and 2. These devices function like a long life span battery. Plutonium-238 is incredibly used as the fuel source, producing alpha radiation resulting in heat, which is later converted into electricity. Plutonium-238 has half-life of 88 years; this source of power could provide a long lifespan for pacemakers. However, due to their toxicity, difficulties with patients in traveling, and problems with disposal, they are no longer used [14].
- Remote Sensing Stations: The Unites States Air Force uses alpha radiation to power the remote sensing stations in Alaska. Strontium-90 is typically used as the fuel source. These alpha-powered systems enable unmanned operations for long periods of time without the need for servicing but there are local opposition to the use of radiation is prompting the air force to replace many of these devices with alternative power sources, such as diesel-solar hybrid generators. The U.S. Coast Guard uses alpha radiation to power some of their oceanic buoys. Many oil industries also use alpha radiation to power some of their offshore equipment. [15].
- Heating Devices: Unlike radioisotope thermoelectric generators that convert heat to electricity, radioisotope thermal generators make direct use of the heat generated by alpha decay [15].

3. Beta Radiation

A beta particle (β) is either an electron or a positron that is ejected from the nucleus in the process of nuclear decay. The β-particle is typically an electron formed by the decay of a neutron (yielding both an electron and proton). A beta particle an also be a positron (a positively charged electron), but the lifetime of the positron (which is essentially an anti-electron) is very short. Beta particles have very low mass. Emission of a beta particle results in the transformation of the beta-emitting parent atom into a daughter, the atomic number of which is one greater; the atomic mass remains unchanged (because a neutron and proton have nearly identical mass). For example, 90Sr decays via beta particle emission to 90Y, which has an atomic number one greater but the same atomic mass. Beta particles emitted by radioisotopes exhibit a range of energies that extends from near zero to a maximum, which is characteristic of that radioisotope. These maximum energies extend from several kilo electron volts (keV) to several mega electron volts (MeV) [16].

Beta radiation is a particulate radiation consisting of high-speed electrons, which are rapidly attenuated by biological tissues (2 MeV beta particles have a range of only 1cm in water). This makes it very useful for superficial radiation treatments where deep tissue penetration is undesirable. It has a long history as a treatment modality in ophthalmology. It is a convenient and practical method of applying radiation and has the advantage of minimal tissue penetration. There has been a recent resurgence in the use of beta radiation in other areas in medicine, such as the prevention of resteosis after coronary artery stenting. Beta radiation has been shown in vitro and in vivo to inhibit proliferation of human Tenon's fibroblasts, which enter a period of growth arrest but do not die. Effects on the cell cycle controller p53 have been shown to be important in this process. In ophthalmology, beta radiation has been used widely for the treatment of pterygium and is under evaluation for treatment of age-related macular degeneration and for controlling wound healing after glaucoma drainage surgery. Beta radiation from radium, radon, and radium D-E has been used in the treatment of certain external ocular conditions for about 40 years because of the relatively superficial effects and accurate localization of the radiation. More recently, radioactive strontium (Sr90)-yttrium (Y90) applicators have become available as a source of beta particles or electrons for ocular use. Strontium-90 (90Sr), an unstable fission product of uranium-235 (235U), has been found to be a clinically useful source of beta radiation as it has a long half-life (28.7 years) and emits only high-energy beta particles as it decays. Ruthenium-106 (106Ru) primarily emits beta radiation but also emits a small but significant gamma component. 106Ru has been primarily used in the treatment of choroidal melanoma [17-19].

3.1. Beta Decay

Nuclear β decay has played a crucial role in the development of the weak interaction theory. Thetheoreticalframeworkwasfirmlyestablishedandtestedinthe1960sand1970sandhasbeen integratedintothewiderframeworkofthestandardelectroweakmodel.Themainmotivationsof accurate experiments carried out in nuclear β decay, with ever-increasing statistical precision, are to perform stringent tests of discrete symmetries and to determine fundamental quantities, such as the effective vector coupling, in processes involving light quarks. The status of β-decay experiments for precision tests of the SM has recently been reviewed. The sensitivity of correlation measurements from charged-current processes to test super symmetric extensions of the SM has also been analyzed recently [20].

3.2. Applications of Beta Radiation

The general uses for beta radiation are the same as for any other type of radiation such as x-ray. The effects of irradiation are destructive, and there must be a differential sensitivity between the pathological cells to be destroyed and the normal cells of the adjacent tissue. The relative sensitivity of cells to radiation has been determined previously by Desjardins and others in the following order of decreasing sensitivity: lymphoid cells, polymorpho-nuclear cells, eosinophils, epithelium (conjunctiva, cornea, lens, and ciliary), endothelium (vessels, cornea), connective tissue including the cells of the corneal stroma, muscle, bone, and nerve which includes the neural elements of the retina. In this latter role, beta radiation may be particularly appropriate for use in developing countries to improve the results of trabeculectomy while potentially avoiding some of the side effects of other antimetabolites. Penetration depends on the energy of particles released in the decay process of a particular source. Of emitters used in ophthalmology, the 90Sr source has the most marked attenuation in biological tissues, making it particularly suitable for use in ocular surface treatment. The half thickness of 90Sr is 1.5mm, that is, the radiation dose rate is attenuated by 50% after 1.5mm penetration through water-the corresponding distance for 160Ru is 2.4mm. Intracoronary beta-irradiation is a breakthrough treatment for in-stent restenosis after balloon angioplasty, with encouragingly low rates of target lesion restenosis and need for target vessel revascularization. This benefits, however, is diminished by problems with the edge effect and late stent occlusion. The solution to these problems will lie, most probably, in minimizing the geographic miss rate by careful attention to balloon and source train placement, the availability of longer source trains, and continuing combined antiplatelet therapy for longer periods of time. Beta radiation using the Beta Cath (Novoste) 30 mm system reduces the incidence of repeat target lesion revascularization by 40% after successful percutaneous intervention for ISR and is now widely used for the treatment of this disorder. ISR is occasionally diffuse and pullback radiation (tandem exposure) may be needed to cover the entire lesion. Cutting balloon (CB) angioplasty is a novel technique that combines the features of conventional balloon angioplasty with multiple microtome-sharp atherotomes (microsurgical blades). CB angioplasty may be more effective than other percutaneous techniques for the treatment of ISR [17, 18, 21-22].

In randomized, placebo-controlled trials, intracoronary radiation therapy (IRT) has shown significant improvement in angiographic and clinical outcomes in both native coronary arteries and saphaneous vein grafts. There is limited availability of long-term data regarding intracoronary beta-radiation treatment and considerable concern that intracoronary brachy therapy may only result in delaying the problem of in-stentrestenosis. The long-term clinical outcomes of patients treated with beta-radiation for in-stent restenosis [23].

3.3. Effects of Beta Decay

The fundamental biological effect of ionizing radiation is the process of ionization, where the absorption of energy by an atom or molecule results in the ejection of one or more of its orbiting electrons, resulting in unstable and highly reactive compounds. From its earliest clinical use, it has been clear that radiation influences tissue healing. In the eye, radiation has been shown to inhibit corneal wound healing, with prominent effects on fibroblast proliferation. Radiation therapy has also been utilized as a means of preventing proliferative vitreo-retinopathy (PVR). Additionally, collagen deposition and bleb thickness tended to be reduced. Concerns that focal beta radiation treatment may actually induce rather than inhibit postoperative inflammation have not been borne out, however, either in animal models or in clinical practice [17, 24-25].

4. Gamma Radiation

The gamma radiations are transmitted from the radioactive nuclide as photons, not particles; that implies that they haven't a mass or charge. The radionuclides are decayed in the form of gamma radiations, the process not accompanied by any change in the atomic number or the atomic mass. Being radiation, the gamma rays have no mass so have high penetration power more the beta particles. Due to the absence of the charge, the gamma radiations have no destructive effect. Technetium-99m is an example of a radionuclide which decayed in form of gamma radiation [26]. Gamma ray energies range from 104 to 107 eV. They are often emitted as a part of a nuclear reaction, when an atomic nucleus is left in an excited state, or during an isomeric transition. Gamma rays also can be emitted following alpha-particle decay, beta-particle decay, or orbital electron capture, if the daughter nuclide is left in an excited state[27].

Gamma radiation passes through living materials easily. Also referred to as "photons" they travel at the speed of light. Gamma rays have sufficient energy to ionize matter. Isotopes of elements that are emitters are radionuclides important in fission products from nuclear testing, nuclear power plant disasters or waste [28].

4.1. Radioactive Decay

Radionuclide decay processes often leave the product nuclide in an excited energy state. The product nuclide in such an excited state either falls directly to the ground state or descends in steps to lower energy states through the dissipation of energy as gamma radiation. A nuclide in an excited energy state is referred to as a nuclear isomer, and the transition (or decay) from a higher to a lower energy state is referred to as isomeric transition. Gamma rays are emitted in discrete energies corresponding to the energy state transitions a nuclide may undergo when in an excited state. The energy, $E\gamma$, of a gamma ray may be described as the difference in energy states of the nuclear isomers:

$$E\gamma = h\nu = E1 - E2$$

Where, $h\nu$ is the energy of the electromagnetic radiation, and E1 and E2are the energy levels of the nuclear isomers [29].

4.2. Units of measurement of Gamma Radiation

The giga becquerel (GBq), gray (Gy), and roentgen (R), the three units, are used to measure radiation. The GBq measures the number of gamma rays emitted from a source of radiation and is a unit of radioactivity that is defined as 1.37 x 10-12 atomic decays each second.A second measurement of radiation is the Gy. The absorbed dose of 1 Gy means the absorption of 1 joule of radiation energy per kg of tissue. The third, the roentgen is nearly the same as the Gy, and is used as a unit of measurement for exposure to gamma and x-rays [28].

4.3. Origin of the gamma rays

The gamma rays come from the nuclei during the nuclear reactions; it is mono-energetics for a given characteristic reaction. Natural gamma radiation sources can be easily divided into three groups according to their origin. The first group includes potassium (40K) with a half-life of 1.3 × 109 years, uranium-238 (238U) with a half-life of 4.4 × 109 years, uranium-235 (238U) with a half-life of 7.1 × 108 years and thorium (232Th) with a half-life of 1.4 × 1010 years.

The second group includes radioactive isotopes from the first group. Those have half-lives ranging from small fractions of a second to 104 to 105 years. The third group will include it isotopes created by external causes, such as the interaction of cosmic rays with the earth and its atmosphere [30].

4.4. Applications of Gamma Radiation

Apart from the use of nuclear energy for the supply of electricity, the applications of radioactivity are numerous in many areas. It is important to note that gamma radiation exposure has a great effect on the optical, electrical and physical properties of materials.

- Gamma irradiation is a well-proven technique for polymerization of conjugated polymers as well to enhance the electrical conductivity of their polymer composites [31].
- The primary application of gamma radiation is for medical devices, ranging from sterile dressings, tubes, catheters, syringes, infusions assemblies and implants; and single- use disposable technologies, such as bags for holding products or devices for making aseptic connections [32].
- Gamma radiation is using for food irradiation which is very effective in decontaminating foods, in particular in reducing and inhibiting pathogen and spoilage bacteria in raw materials and highly perishable foods [33].
- Radiotherapy is used to treat a wide variety of dermatology conditions, including non-melanoma skin cancers, lymphomas, and inflammatory skin conditions [34].
- In study of Astrophysics, Gamma-Ray Bursts (GRBs) are extra-galactic and extremely energetic transient emissions of gamma rays, which are thought to be associated with the death of massive stars or the merger of compact objects in binary systems. Their huge luminosities involve the presence of a newborn stellar-mass black hole emitting a relativistic collimated outflow, which accelerates particles and produces non-thermal emissions from the radio domain to the highest energies [35].

Gamma-ray, the electromagnetic radiation of the shortest wavelength and highest energy, has colossal application in different fields of science which is ceaselessly assuming a significant part in humankind.

5. Conclusion

Radiation existed long before the evolution of life on the earth and isan inevitable part of the environment. Radiation interacts with matter to produce excitation and ionization of an atom or molecule; consequently, physical and biological effects are produced. Compare to the traditional process, the advantage of the radiation process is the absence of any chemical residues. It can be used at all temperatures and can be limited to the surface only. The use of radiation in medicine, industry, agriculture, energy, and other scientific and technological fields has brought tremendous benefits to society as well as the benefits in medicine for diagnosis and treatment in terms of human lives saved are enormous. Radiation is a key tool in the treatment of particular kinds of cancer. The beneficial impacts are almost similar in other fields. There is no human activity or practice that is totally devoid of associated risks. Radiation should be viewed from the perspective that the benefit from it to humankind is less destructive than from many other agents.

Compliance with ethical standards

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All authors state that there is no conflict of interest.

References

[1] Yanagida T. Ionizing radiation induced emission: scintillation and storage-type luminescence. Journal of Luminescence. 2016; 169: 544-548.

[2] Ryan JL. Ionizing radiation: the good, the bad, and the ugly. Journal of Investigative Dermatology. 2012; 132(3): 985-993.

[3] Cléro E, Vaillant L, Hamada N, Zhang W, Preston D, Laurier D, Ban N. History of radiation detriment and its calculation methodology used in ICRP Publication 103. Journal of Radiological Protection. 2019; 39(3): R19.

[4] Manjunatha HC, Seenappa L, Chandrika BM, Hanumantharayappa C. A study of photon interaction parameters in barium compounds. Annals of Nuclear Energy. 2017; 109: 310-317.

[5] Eke C, Agar O, Segebade C, Boztosun I. Attenuation properties of radiation shielding materials such as granite and marble against γ-ray energies between 80 and 1350 keV. Radiochimica Acta. 2017; 105(10): 851-863.

[6] Akman F, Khattari ZY, Kaçal MR, Sayyed MI, Afaneh F. The radiation shielding features for some silicide, boride and oxide types ceramics. Radiation Physics and Chemistry. 2019; 160: 9-14.

[7] Morlat T, Fernandes AC, Felizardo M, Kling A, Girard TA, Marques JG, Carvalho FP. Application of droplet detectors to alpha radiation detection. Radiation protection dosimetry. 2018; 180(1-4): 230-234.

[8] Peccei RD, Quinn HR. Constraints imposed by CP conservation in the presence of pseudoparticles. Physical Review D. 1977; 16(6): 1791.

[9] Spergel DN. Motion of the Earth and the detection of weakly interacting massive particles. Physical Review D. 1988; 37(6): 1353.

[10] Yadav GC, Singh SP, Singh V. Detection of high energetic alpha particle radiation through metal clad planar waveguide based sensor. Optik. 2018; 171: 715-720.

[11] Souri R, Negarestani A, Mahani M. A new approach for direct imaging of Alpha radiation by using Micro Pattern Gas Detectors in SQS mode. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment. 2018; 884: 128-135.

[12] Daraee M, Araghi A, Sadeghi M, Hashemizadeh A. Investigation of thermal treatment on improving the performance behavior of Si PIN alpha radiation detectors. Optik. 2019; 184: 364-369.

[13] Sahani RM, Kumari C, Pandya A, Dixit A. Efficient Alpha Radiation Detector using Low Temperature Hydrothermally Grown ZnO: Ga Nanorod Scintillator. Scientific reports. 2019; 9(1): 1-9.

[14] Perrett GM, Maxwell JA, Campbell JL. Combined X-ray diffraction and alpha particle X-ray spectrometer analysis of geologic materials. X-Ray Spectrometry. 2017; 46(3): 171-179.

[15] Guerra Liberal FD, O'Sullivan JM, McMahon SJ, Prise KM. Targeted alpha therapy: Current clinical applications. Cancer Biotherapy & Radiopharmaceuticals. 2020; 35(6): 404-417.

[16] Thomas A. Lewandowski, Juhi K. Chandalia, Peter A. Valberg. Ionizing Radiation; John Wiley & Sons, Inc. Published. 2015; 100: 1055-167.

[17] JF Kirwan, PH Constable, IE Murdoch, PT Khaw. Beta irradiation: New uses for an old treatment: A review,Nature Publishing Group All rights reserved. 2003; 17: 217-225.

[18] Hughes WF. Beta radiation sources, uses, and dangers in treatment of the eye. Journal of the American Medical Association. 1959; 170(17): 2096-2101.

[19] Lommatzsch PK, Werschnik C, Schuster E. Long-term follow-up of Ru-106/Rh-106 brachytherapy for posterior uveal melanoma. Graefe's archive for clinical and experimental ophthalmology. 2000; 238(2): 129-137.

[20] Severijns N, Naviliat-Cuncic O. Symmetry tests in nuclear beta decay. Annual Review of Nuclear and Particle Science. 2011; 61: 23-46.

[21] Latchem DR, Urban P, Goy JJ, De Benedetti E, Pica A, Coucke P, Eeckhout E. Beta-radiation for coronary in-stent restenosis. Catheterization and cardiovascular interventions. 2000; 51(4): 422-429.

[22] Moustapha A, Salloum J, Saikia S, Awadallah H, Ghani M, Sdringola S, Schroth G, Assali A, Smalling RW, Anderson HV, Rosales O. Combined cutting balloon angioplasty and intracoronary beta radiation for treatment of in-stent restenosis: Clinical outcomes and effect of pullback radiation for long lesions. Catheterization and cardiovascular interventions. 2002; 57(3): 325-329.

[23] Vlachojannis GJ, Fichtlscherer S, Spyridopoulos I, AUCH-SCHWELK W.O.L.F.G.A.N.G, Schopohl B, Zeiher AM, Schaechinger V. Intracoronary beta-radiation therapy for in-stent restenosis: long-term success rate and prediction of failure. Journal of interventional cardiology. 2010; 23(1): 60-65.

[24] Friedman S, Soloman H, Dueker D. The effect of beta radiation on maintaining filtering blebs after glaucoma surgery in normal rabbits. Invest Ophthalmol Vis Sci (Suppl). 1987; 28: 272.

[25] Miller MH, Rice NS. Trabeculectomy combined with beta irradiation for congenital glaucoma. British journal of ophthalmology. 1991; 75(10): 584-590.

[26] Alsharef S, Alanazi M, Alharthi F, Qandil D, Qushawy M. Review about radiopharmaceuticals: preparation, radioactivity, and applications. Int J App Pharm. 2020; 12(3): 8-15.

[27] Reilly D. The origin of gamma rays. Passive Nondestructive Assay of Nuclear Materials. 1991.

[28] Richard Stalter, Dianella G Howarth. Gamma Radiation, Gamma Radiation, Prof. Feriz Adrovic (Ed).,ISBN: 978-953-51-0316-5, USA. 2012.

[29] L'Annunziata MF. Gamma- and X-Radiation — Photons. Radioactivity. 2007; 187–215.

[30] Erramli H, El Asri J. Gamma Rays: Applications in Environmental Gamma Dosimetry and Determination Samples Gamma-Activities Induced by Neutrons. In Use of Gamma Radiation Techniques in Peaceful Applications. 2019; 109.

[31] Harun MH, Othman N, Mohamed M, Alias MS, Nor K, Umar K, Abd Rahman MF. Influence of Gamma Irradiation on The Electrical Conductivity and Dielectric Properties of Polypyrrole Conducting Polymer Composite Films. Polymer. 2019; 8: 9.

[32] Sandle T, Saghee MR. Some considerations for the implementation of disposable technology and single-use systems in biopharmaceuticals. Journal of Commercial Biotechnology. 2011; 17(4): 319-329.

[33] Mahapatra AK, Muthukumarappan K, Julson JL. Applications of ozone, bacteriocins and irradiation in food processing: a review. Critical Reviews in Food Science and Nutrition. 2005; 45(6): 447-461.

[34] Cheraghi N, Cognetta Jr A, Goldberg D. Radiation therapy for the adjunctive treatment of surgically excised keloids: a review. The Journal of clinical and aesthetic dermatology. 2017; 10(8): 12.

[35] Piron F. Gamma-ray bursts at high and very high energies. Comptes Rendus Physique. 2016; 17(6): 617-631.