RADIOPHARMACEUTICAL SCIENCES

Abstract

Nowadays all the fields of sciences such as chemistry, medicines, biology, and pharmacology exploiting the use of a radionuclide as medication or other biologically active molecule. These molecules are very potent and play a very big role in improving human life by treating many diseased conditions. The new techniques have been used in various nuclear drug procedures, the produced radiopharmaceuticals are used for both internal radiation (i.e., noninvasive scintigraphy imaging). This radioligand therapy (RLT), also known as noninvasive scintigraphy imaging. The design, synthesis, radiolabeling, biology, and preclinical assessment of the medicines, as well as their clinical use, are all taken into account during the creation of radiopharmaceuticals. Contributions could be made in the areas of targeted, pre-targeted, and non-targeted radiopharmaceuticals, ranging from small molecules through peptides, peptidomimetics, antibodies, and their derivatives, to particles for use in gamma scintigraphy, such as single photon emission tomography (SPECT), positron emission tomography (PET), and endoradiotherapy. Strong interest exists in the fields of diagnostic imaging and (radio) pharmaceutical treatment that are supported by diagnostic imaging. It is also acceptable to take allied subjects including physics, dosimetry, radio pharmacy, and hybrid imaging.

Keywords: Radiopharmaceuticals; Radiotherapy; Imaging Techniques, Diagnostic tools.

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I. INTRODUCTION

An interdisciplinary area that includes biology, physics, and chemistry is called radiopharmaceutical science. It is the science of including an appropriate radionuclide in a drug or other biologically active substance during in vivo physiological or biochemical processes. Radiopharmaceuticals are defined as those preparations in pharmaceutical Sciences which comprises of those substances which are radioactive in nature. These substances are called radioisotopes or Radiopharmaceuticals. These radiopharmaceuticals are also called Diagnostic agents because these such substances are meant for diagnosis or treatment. But the use of such substances is not easy, it needs special care. While handling or during disposing off, a special protocol or guidelines drafted by Atomic Energy Regulatory Board (AERB) of India to be followed. For that we need the highly trained staff or personnel required. Radiopharmaceuticals are generally employed as pharmaceutical aids; it means they are not having pharmacologic effect on the body during diagnosis. These Radiopharmaceuticals agents played a big role by serving the physician in diagnosis.

1. **Units of radioactivity:** The unit of Radioactivity in SI (International System) is "the unit of radioactivity is one nuclear transmutation per second and is expressed in Becquerel (Bq)". This Becquerel Unit was coined by the scientist Henri Bequerel after his name. In the earlier times, the units used for measuring radioactivity was Curie (Ci). As it was named after two renowned scientists Madame Marie Curie and Pierre Curie. These two pioneer Scientists who deliberately studied the phenomenon of radioactivity.
   - The activity of the Source of Diagnostic agents is measured in Becquerel. "One becquerel is defined as one radioactive decay per second and which is equals to 2.703×10-11 Ci. Millicurie (mc) and microcurie (mc) are also used."

     Gray (Gy) is another unit, which is defined as "the dose of radiation absorbed per unit mass of tissue. One gray is the absorption of one joule of radiation energy per kilogram of matter. The amount of radiation your cells absorb is measured in grays." In equational terms, one gray is equals to one joule per kilogram.
   - 1 mGy = 1 milligray = 0.001 Gy;
   - 1 μGy = 1 microgray = 0.000001 Gy
   - 1 nGy = 1 nanogray = 0.000000001 Gy.

   The measurements of upshots of Radioactivity on health is defined in another unit i.e., Sievert. The human body's response to moderate doses of ionising radiation is measured in Sieverts (Sv). The effects of radioactivity on live tissue at equivalent dosages depend on the radiation type (alpha, beta, gamma, etc.), the target organ, and the duration of exposure. The sievert, in contrast to the Becquerel, is a relatively big unit, therefore we commonly incorporate sub-multiples: A millisievert is equal to 0.001 Sv, even though a microsievert is proportional to 0.000001 Sv.

2. **Half-Life Period:** This half-life period is used for calculating the decay of all the Radionuclides employed as Diagnostic Aids. The half-life (T1/2) of a radionuclide is the amount of time it takes for a given quantity to decay to half its initial value. - half-life in exponential decay formulas.

For calculating half-life Period, few parameters should be known such as:

- The starting amount of the substance that will degrade (this amount can be expressed in grammes, moles, atoms, etc.).
- The amount that is still present but hasn't yet degraded after a time t, t1/2 is the half-life of the degrading quantity, is a positive number known as the mean lifetime of the degrading quantity, and is a positive number known as the decay constant of the degrading.

3. **Characteristics of Alpha- α, Beta- β and Gamma- γ Radiations:** As a main focus on radionuclides, every material is made up of Atoms. These feature a nucleus in the center, with electrons surrounding the exterior. The incredibly tiny nucleus is made up of protons and neutrons. Almost all of an atom's mass is empty space. The nucleus of some atom types is unstable and will eventually decay into a more stable atom. This radioactive decay occurs entirely on its own. There are three possible methods for an unstable nucleus to disintegrate.

Alpha particles: A positively charged particle with the same structure as the helium-4 atom's nucleus that is released spontaneously by some radioactive substances has a mass of four units, a positive charge of two, and is made up of two protons and two neutrons bonded together.

The main characteristics features of Alpha -particles:

- Two neutrons and two protons make up the alpha particle radiation, which is charged and subject to magnetic and electric forces.
- The -particle's speed varies greatly depending on the source, but is approximately 10% of the speed of light.
- The ability of the -particle to permeate materials is not particularly strong; it typically only travels a few centimetres into the air and is absorbed by paper that is just slightly thicker than the human skin.
- They may, however, ionise a lot of atoms across a relatively little range of penetration due to their speed and size.
- Because the radiation from most sources is readily absorbed by the air at distances of one metre or more, this renders them comparatively safe.

Beta-particles: When some radionuclides undergo a process known as beta-decay, electrons or positrons with high energy and fast speed (-) or both are released from the nucleus. In nuclei with too many neutrons to attain stability, beta-decay often occurs.

The main characteristics features of beta -particles

- These particles can have a single positive (positron) or negative (electron) charge and have a mass that is one-hundredth of a proton's mass. They can travel at relativistic speeds because they have a low mass and can be discharged with a lot of energy (close to the speed of light).
- Due to their low mass, they contact with matter fast and lose energy as a result, moving through air or other materials in an erratic manner.
- For a given quantity of energy deposition, beta particles normally do less harm since they are significantly less ionising than alpha particles. They generally have ranges of a few millimetres in materials and tens of centimetres in air (energy dependant).
- Depending on the source, the speed can range from 80% to 90% of the speed of light.

Particles have a 1 m air penetration limit. A few millimetres of Perspex or aluminium halt them.

- They have a far lower ionising capability than -radiation. If consumed, they are very dangerous.

4. **Gamma particles:** An electromagnetic energy (photon) packet known as a gamma ray (g) is released by the nucleus of certain radionuclides during radioactive decay. The electromagnetic spectrum's highest energetic photons are known as gamma photons.

The Main characteristics features of gamma -particles

- Electromagnetic radiation includes gamma rays (EMR). With the exception of the fact that they are released from an excited nucleus, they are identical to X-rays.
- A stream of photons, which are massless particles that move at the speed of light, may be used to model electromagnetic radiation. Each photon travels in a wave-like pattern.
- All electromagnetic radiation is made up of photons, which are energy particles with a certain quantity (or bundle) of energy in each one.
- The EMR spectrum's highest-energy photons and shortest-wavelength waves are gamma-ray photons.
- Gamma radiation requires up to 30mm of lead to be stopped, which is exceedingly difficult. Despite having a far lower ionizing capability than beta radiation, radiation is nevertheless harmful even at a distance due to its great penetrating strength.
- They have the ability to enter our bodies and damage delicate organs. If consumed or breathed, they are very deadly.

Therapeutic Applications of Radioactive substances

- Treatment for Tumors and Cancer Americium 241 is therefore utilized as antineoplastic.
- Antineoplastic usage of Californium 252.
- The anti-plastic substance cobalt 60. Gold 94 is used as an anti-platelet agent.
- The development of holmium 66 (26 h) for the detection and therapy of liver tumors.
- Cancer brachytherapy using iodine-125 (60 days) (prostate and brain).

II. CONTRAST MEDIA USED FOR RADIOGRAPHY

Osmolarity (high, low, or iso-), ionicity (ionic or nonionic), and the amount of benzene rings (monomer or dimer) can all be used to categories iodine-based contrast agents. Compared to ionic agents, nonionic contrast agents are less uncomfortable and have fewer side effects. Nonionic low or iso-osmolar preparations are almost primarily employed for intravascular injections in modern practice; consequently, high-osmolar ionic agents are not mentioned in this article. For ease of usage, we refer to both low-osmolality and iso-osmolality radiographic contrast agents in this article as "low osmolality". When compared to high-osmolar contrast agents, low-osmolar contrast agents have much lower incidence of acute responses. Low-osmolar contrast agents have an initial adverse event rate of 0.2%–0.7%, and 0.04% for severe acute responses. Many Iodinated Organic Compounds are having very wide application in radiopharmaceutical Sciences as contrast media. In Iodinated Organic Compounds, the extent up to which they are opaque is directly equals to amount of Iodine present in the compounds. These compounds are ionic and may be non-ionic. There are few salts of Acetrizoic acid, iothalamic acid are those organic salts, which are monomeric Ionic salts used as contrast media.

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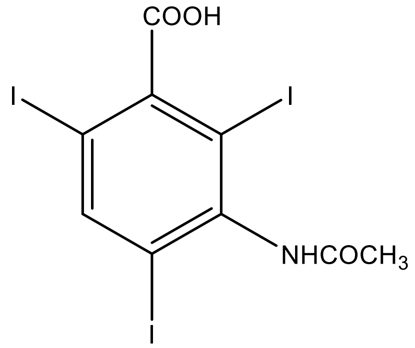
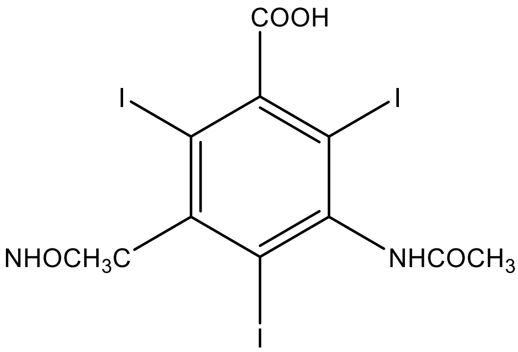
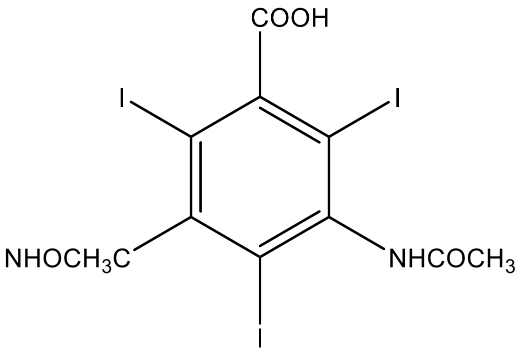


Acetrizoic Acid



Diatrizoic Acid



IothalamicAcid

Depending on their decay characteristics, certain radionuclide types are required for each of these uses. For diagnostic purposes, the radiation dosage to the patient should be as low as is reasonably possible, and the radiation should be able to almost completely bypass the body. These requirements are met by short-lived gamma emitters or by positron (beta+) emitters that release annihilation rays. These radionuclides' radiation may be effectively detected from outside the body using positron emission tomography (PET) and single-photon emission computed tomography (SPECT), respectively (PET). The administration of matching radiopharmaceuticals in accordance with the radiotracer/radio indicator concept at the microdosing level is justified since the caused radiation dose is not considerable. A thorough understanding of the pertinent nuclear processes and the accompanying nuclear data forms the cornerstone of all radionuclide applications. This information is crucial for the effective production of radionuclides as well as for ensuring the creation of chemically pure end products with clearly defined decay properties that will provide the patient with the greatest benefit and the fewest risks from radioactive and nonradioactive impurities. The most promising radionuclides for this purpose must have their excitation functions measured in order to accomplish these objectives. To do this, it is necessary to calculate the nuclear reaction cross sections, which are often given in milli-barn (mb), a non-SI unit.

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