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Radioisotopes and Their Biomedical Applications

Nida Tabassum Khan*

Department of Biotechnology, Balochistan University of Information Technology Engineering and Management Sciences, Quetta, Pakistan

Abstract

Radionuclides also termed as radioisotopes are elements that possess radioactivity. It means upon decay they emit radiations like alpha, beta or gamma particles and transformed their nuclei to a stable state. This decaying property of radioisotopes is called half-life. Thus radioisotopes could be used for numerous biomedical purposes such as cancer and tumour treatment, imaging, biochemical assays, biological labelling, sterilization, clinical diagnostics, radioactive dating etc.

Keywords: Urinalysis; Bioassay; Tracer; Carbon dating

Introduction

Radioisotopes are widely used for a number of purposes following are some major applications of radioisotope.

Biochemical analysis

Biochemical assays are used to detect the presence and absence of radioisotopes. Therefore radioactive isotopes are used to label biological molecules. Such assays estimate the concentration of different constituents of plasma, body fluids, urine, blood etc. This technique is called radioimmuno-assays. An example is iodine bioassay which uses gamma emitters' radionuclides of Iodine-125 and Iodine-131 that accrues inside thyroid. Therefore gamma detector can be used to quantify the iodine content (uptake and intake) of the person's thyroid. The amount of measured radioiodine in the thyroid is compared with the Annual Limit on Intake (ALI) [1].

Urinalysis

Radioisotopes are eliminated from the body in body fluids. By determining the active contents in urine one can analyse the uptake and intake of a specific radionuclide [1].

Tracer studies

Radioisotope is used for biological labelling of cells or entities for identification or tracing specific molecules in an organism. S 35 P 32 and I 125 are widely used radioisotopes used for labelling [2].

Carbon dating

Radioactive carbon-14 decay could be used to estimate the age of organic materials. For example carbon dating revealed that the burial cloth of Jesus Christ originated during the medieval times between A.D. 1260-1390. Similarly mummified remains found frozen in the Italian Alps were at least 5000 years old [3].

Potassium dating

Radio potassium-40 decays to stable 40Ar. Thus, by measuring relative ratio of 40K and 40Ar in rocks enable us to determine the age of rocks since its formation [4].

Clinical diagnostic

Positron Emission Tomography (PET) and PETCT make use of radionuclides emitting positron particle that is injected in to the target cell or tissue. Radionuclide decay release positron particles which interact with the nearby negatively charged particle resulting in the emission of gamma rays which is detected by a PET or gamma camera to give an exact image of the target [5].

Radionuclide Therapy (RNT)

This therapy makes use of radioisotopes that emits radiations upon their decay. These emitted radiations are used to target specific cancerous cells, tumours etc. to control their abnormal growth or completely eradicate it. For example cobalt-60 is use as a source of gamma radiation for radionuclide therapy, gamma knife radiosurgery and brachytherapy. Similarly targeted alpha therapy uses alpha-emitting radionuclide such as Bi-213, Lead-212, and Boron-10 to for treating pancreatic, ovarian and melanoma cancers [6].

Sterilizing

Sterilization of surgical instruments such as syringes, gloves, clothing and instruments using gamma mitting radionuclides including Cobalt-60, Cs-137 etc. [7].

Radiopharmaceuticals

Incorporation of radioisotopes to biologically active substances is introduced into body in order to observe the functioning of an organ functioning or a metabolic path way etc. For example Yttrium-90 and Iodine-131 is used as radiopharmaceuticals for the treatment of non-Hodgkin's lymphoma and hyperthyroidism respectively (Table 1) [8].

Conclusion

Radioisotopes are used for numerous medical purposes which marks it potential in the field of medical science.

***Corresponding author:** Nida Tabassum Khan, Department of Biotechnology, Balochistan University of Information Technology Engineering and Management Sciences, Quetta, Pakistan, Tel: 03368164903; E-mail: nidatabassumkhan@yahoo.com

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Isotope	Half-life	Medical uses
Ac-225	10.0d	Cancer treatment
Ac-227	21.8y	Cancer treatment
Am-241	432y	Detection of osteoporosis
As-72	26.0h	PET/ SPECT
As-74	17.8d	In biomedical
At-211	7.21h	Cancer treatment
Au-198	2.69d	Cancer treatment
B-11	Stable	Tumor treatment
Be-7	53.2d	Used in berylliosis (chronic lung disease) studies
Bi-212	1.10h	Cancer treatment, cellular dosimetry studies
Bi-213	45.6m	Cancer treatment
Br-75	98m	SPECT/ PET
Br-77	57h	Monoclonal antibody labeling
C-11	20.3m	Radiotracer in PET scans
C-14	5730y	Radiolabeling for tumors detection
Cd-109	462d	Cancer detection, pediatric imaging
Ce-139	138d	Calibration of germanium gamma detectors
Ce-141	32.5d	diagnosis of gastrointestinal tract, myocardial blood flow measurement
Cf-252	2.64y	Cancer treatment.
Co-55	17.5h	Planar and SPECT /PET imaging
Co-57	272d	In radiotracer, source for X-ray fluorescence spectroscopy
Co-60	5.27y	Teletherapy, disinfectant, radiotherapy
Cr-51	27.7d	Radiolabeling and dosimetry
Cs-130	29.2m	Myocardial localizing agent
Cs-131	9.69d	Intracavity implants for radiotherapy
Cs-137	30.2y	Blood irradiators, PET imaging, and tumor treatment
Cu-61	3.35h	Planar imaging, SPECT or PET
		Positron emitting radionuclide
Cu-62	4.7m	Tracer, PET/SPETC imaging
Cu-64	12.7h	Cancer treatment
Cu-67	61.9h	Cancer treatment/diagnostics, radio immunotherapy, SPECT or PET
Dy-165	2.33h	Radiation synovectomy, rheumatoid arthritis treatment
Eu-152	13.4y	Medical uses
Eu-155	4.73y	Osteoporosis detection
F-18	110m	Radiotracer, imaging
Fe-55	2.73y	Heat source
Fe-59	44.5d	Medical use
Ga-64	2.63m	Treatment of pulmonary diseases ending in fibrosis of lungs. detection of Hodgkin's/non-Hodgkins lymphoma
Ga-67	78.3h	osteomyelitis detection
Ga-68	68.1m	Imaging, detection, treatment of pancreatic cancer
Gd-153	242d	Photon source, detection, imaging
Ge-68	271d	Imaging
H-3	12.3y	Radiolabeling, imaging
I-122	3.6m	Neurology studies
I-123	13.1h	Imaging, cancer treatment
I-124	4.17d	Tracer, imaging
I-125	59.9d	Detection of osteoporosis, imaging, tracer, brain cancer treatment, radiolabeling, interstitial radiation therapy
I-131	8.04d	Tumor treatment, antibody labeling, radio immunotherapy, cellular dosimetry, SPECT imaging, treatment of prostate cancer
I-132	2.28h	Mapping of areas
In-111	2.81d	Detection of transplant rejection, imaging, labeling, treatment of tumors
In-115m	4.49h	Radiolabelling
Ir-191m	6s	Cardiovascular angiography
Ir-192	73.8d	treatment of cancers
Kr-81m	13.3s	Lung imaging
Lu-177	6.68d	Heart disease treatment), cancer therapy
Mn-51	46.2m	Myocardial localizing agent
Mn-52	5.59d	PET scanning
Mo-99	65.9h	Organ imaging
N-13	9.97m	PET imaging, myocardial perfusion
Nb-95	35d	Myocardial tracer, PET imaging
O-15	122s	PET imaging / SPECT imaging
Os-191	15.4d	Cardiovascular angiography
Os-194	6.00y	Cancer treatment
P-32	14.3d	Cancer treatment, imaging, radiolabeling
P-33	25d	Labeling
Pb-203	2.16d	Planar imaging, SPECT or PET, cellular dosimetry
Pb-212	10.6h	Radioactive labelling, cellular dosimetry
Pd-103	17d	Prostate cancer treatment
Pd-109	13.4h	Potential radio therapeutic agent
Pu-238	2.3y	Pacemaker
Ra-223	11.4d	Cancer treatment
Ra-226	1.60e3y	Target isotope to make Ac-227, Th-228, Th-229
Rb-82	1.27m	Myocardial imaging agent, PET imaging, blood flow tracers
Re-186	3.9d	-
Re-188	17h	Cancer treatment
Rh-105	35.4h	Potential therapeutic applications, radiolabeling
Ru-97	2.89d	Monoclonal antibodies labelling, imaging
Ru-103	39d	Radiolabeling, imaging
S-35	87.2d	Radiolabeling, cellular dosimetry
Sc-46	84d	Imaging
Sc-47	3.34d	Treatment of cancer/diagnostics
		Radio immunotherapy
Se-72	8.4d	Brain imaging, immunotherapy
Se-75	120d	Radiotracer
Si-28	Stable	Radiation therapy of cancer
Sm-145	340d	Brain cancer treatment
Sm-153	2.00d	Cancer treatment/diagnostics
Sn-117m	13.6d	Pain relief
Sr-85	65.0d	Detection and imaging
Sr-89	50d	Cancer treatment, cellular dosimetry
Sr-90	29.1y	Immunotherapy
Ta-178	9.3m	Imaging
Ta-179	1.8y	Source of X-ray
Ta-182	115d	Urinary cancer treatment
Tb-149	4.13h	Cancer treatment
Tc-96	4.3d	Animal studies
Tc-99m	6.01h	nuclear imaging
Th-228	720d	Cancer treatment
Th-229	7300y	cancer treatment
Tl-201	73.1h	Imaging, cellular dosimetry
Tm-170	129d	Treatment of cancers
Tm-171	1.9y	Medical uses
W-188	69.4d	Treatment of tumors
Xe-127	36.4d	Neuroimaging
		Lung studies
Xe-133	5.25d	Lesion detection
Y-88	107d	Cancer tumor therapy
Y-90	64h	cellular dosimetry, treating rheumatoid arthritis and cancers
Y-91	58.5d	Tumor treatment, dosimetry
Yb-169	32d	Clinical diagnostics

Zn-62	9.22h	Study of neurology
Zn-65	244d	Medical uses
Zr-95	64.0d	Medical uses

Table 1: Lists of radionuclides and their biomedical applications [9-48].

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