

Radioisotopes and Their Biomedical Applications

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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 emitting 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 its potential in the field of medical science.

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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		
		Detection of osteoporosis, imaging, tracer, brain cancer treatment, radiolabeling, interstitial radiation therapy		
I-125	59.9d			
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].**References**

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