Strontium-90

Strontium-90 (^{90}Sr) is a radioactive isotope of strontium produced by nuclear fission, with a half-life of 28.8 years. It undergoes β^- decay into yttrium-90, with a decay energy of 0.546 MeV.[1] Strontium-90 has applications in medicine and industry and is an isotope of concern in fallout from nuclear weapons and nuclear accidents.[2]

Strontium-90, ^{90}Sr	
General	
Symbol	^{90}Sr
Names	strontium-90, Sr-90
Protons	38
Neutrons	52
Nuclide data	
Natural abundance	syn
Half-life	28.79 years
Decay products	^{90}Y
Decay modes	
Decay mode	**Decay energy (MeV)**
Beta decay	0.546
Isotopes of strontium	
Complete table of nuclides	

Contents

Radioactivity

Naturally occurring strontium is nonradioactive and nontoxic at levels normally found in the environment, but ^{90}Sr is a radiation hazard.[3] ^{90}Sr undergoes β^- decay with a half-life of 28.79 years and a decay energy of 0.546 MeV distributed to an electron, an antineutrino, and the yttrium isotope ^{90}Y, which in turn undergoes β^- decay with a half-life of 64 hours and a decay energy of 2.28 MeV distributed to an electron, an antineutrino, and ^{90}Zr (zirconium), which is stable.[4] Note that $^{90}Sr/Y$ is almost a pure beta particle source; the gamma photon emission from the decay of ^{90}Y is so infrequent that it can normally be ignored.

^{90}Sr has a specific activity of 5.21 TBq/g.[5]

Fission product

^{90}Sr is a product of nuclear fission. It is present in significant amount in spent nuclear fuel and in radioactive waste from nuclear reactors and in nuclear fallout from nuclear tests. For thermal neutron fission as in today's nuclear power plants, the fission product yield from U-235 is 5.7%, from U-233 6.6%, but from Pu-239 only 2.0%.[6]

Medium-lived fission products

Prop: Unit:	$t_{1/2}$ (a)	Yield (%)	Q * (keV)	βγ *
^{155}Eu	4.76	0.0803	252	βγ
^{85}Kr	10.76	0.2180	687	βγ
^{113m}Cd	14.1	0.0008	316	β
^{90}Sr	28.9	4.505	2826	β
^{137}Cs	30.23	6.337	1176	βγ
^{121m}Sn	43.9	0.00005	390	βγ
	88.8	0.5314	77	β

Nuclear waste

^{151}Sm

Strontium-90 is classified as high-level waste. The half life is long, around 30 years. It can take hundreds of years to decay to negligible levels. Exposure from contaminated water and food may increase the risk of leukemia and bone cancer.[7]

Remediation

Algae has shown selectivity for strontium in studies, where most plants used in bioremediation have not shown selectivity between calcium and strontium, often becoming saturated with calcium, which is greater in quanitity and also present in nuclear waste.[7]

Researchers have looked at the bioaccumulation of strontium by *Scenedesmus spinosus* (algae) in simulated wastewater. The study claims a highly selective biosorption capacity for strontium of S. spinosus, suggesting that it may be appropriate for use of nuclear wastewater.[8]

A study of the pond alga *Closterium moniliferum* using non-radioactive strontium found that varying the ratio of barium to strontium in water improved strontium selectivity.[7]

Biological effects

Biological activity

Strontium-90 is a "bone seeker" that exhibits biochemical behavior similar to calcium, the next lighter group 2 element.[3][9] After entering the organism, most often by ingestion with contaminated food or water, about 70–80% of the dose gets excreted.[2] Virtually all remaining strontium-90 is deposited in bones and bone marrow, with the remaining 1% remaining in blood and soft tissues.[2] Its presence in bones can cause bone cancer, cancer of nearby tissues, and leukemia.[10] Exposure to ^{90}Sr can be tested by a bioassay, most commonly by urinalysis.[3]

The biological half-life of strontium-90 in humans has variously been reported as from 14 to 600 days,[11][12] 1000 days,[13] 18 years,[14] 30 years[15] and, at an upper limit, 49 years.[16] The wide-ranging published biological half life figures are explained by strontium's complex metabolism within the body. However, by averaging all excretion paths, the overall biological half life is estimated to be about 18 years.[17]

The elimination rate of strontium-90 is strongly affected by age and sex, due to differences in bone metabolism.[18]

Together with the caesium isotopes ^{134}Cs, ^{137}Cs, and iodine isotope ^{131}I, it was among the most important isotopes regarding health impacts after the Chernobyl disaster. As strontium has an affinity to the calcium-sensing receptor of parathyroid cells that is similar to that of calcium, the increased risk of liquidators of the Chernobyl power plant to suffer from primary hyperparathyroidism could be explained by binding of strontium-90.[19]

Uses

Radioisotope thermoelectric generators (RTGs)

The radioactive decay of strontium-90 generates a significant amount of heat, 0.536 W/g in the form of pure strontium metal or approximately 0.256 W/g as strontium titanate[20] and is cheaper than the alternative ^{238}Pu. It is used as a heat source in many Russian/Soviet radioisotope thermoelectric generators, usually in the form of strontium titanate.[21] It was also used in the US "Sentinel" series of RTGs.[22]

Industrial applications

^{90}Sr finds use in industry as a radioactive source for thickness gauges.[2]

Medical applications

^{90}Sr finds extensive use in medicine as a radioactive source for superficial radiotherapy of some cancers. Controlled amounts of ^{90}Sr and ^{89}Sr can be used in treatment of bone cancer, and to treat coronary restenosis via vascular brachytherapy. It is also used as a radioactive tracer in medicine and agriculture.[2]

Aerospace applications

^{90}Sr is used as a blade inspection method in some helicopters with hollow blade spars to indicate if a crack has formed.[23]

^{90}Sr contamination in the environment

Strontium-90 is not quite as likely as caesium-137 to be released as a part of a nuclear reactor accident because it is much less volatile, but is probably the most dangerous component of the radioactive fallout from a nuclear weapon.[24]

A study of hundreds of thousands of deciduous teeth, collected by Dr. Louise Reiss and her colleagues as part of the Baby Tooth Survey, found a large increase in ^{90}Sr levels through the 1950s and early 1960s. The study's final results showed that children born in St. Louis, Missouri, in 1963 had levels of ^{90}Sr in their deciduous teeth that was 50 times higher than that found in children born in 1950, before the advent of large-scale atomic testing. Reviewers of the study predicted that the fallout would cause increased incidence of disease in those who absorbed strontium-90 into their bones.[25] However, no follow up studies of the subjects have been performed, so the claim is untested.

An article with the study's initial findings was circulated to U.S. President John F. Kennedy in 1961, and helped convince him to sign the Partial Nuclear Test Ban Treaty with the United Kingdom and Soviet Union, ending the above-ground nuclear weapons testing that placed the greatest amounts of nuclear fallout into the atmosphere.[26]

The Chernobyl disaster released roughly 10 PBq, or about 5% of the core inventory, of strontium-90 into the environment.[27] The Fukushima Daiichi disaster released 0.1 to 1 PBq of strontium-90 in the form of contaminated cooling water into the Pacific Ocean.[28]

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External links

- NLM Hazardous Substances Databank – Strontium, Radioactive (http://toxnet.nlm.nih.gov/cgi-bin/sis/search/r?dbs+hsdb:@term+@na+@rel+strontium,+radioactive)