Polonium-210

$t_{½}$: 1–2 months (whole body)
4.6 months (radioactive isotope)
Vd: ?
Fb: 0.74–0.90
b/p: 5–17
CAS: 7440-08-6
MW: 208.98 (Po)

Occurrence and Usage. Polonium-210 (^{210}Po) is the primary naturally-occurring isotope for the metallic element polonium out of the 33 known to exist, all of which are radioactive and most of which have very short half-lives. It is found in trace amounts in uranium ore, but can also be produced from aged radium salts or by bombardment of bismuth or lead in a particle accelerator. ^{210}Po has been used commercially, primarily in Russia, in antistatic devices for cleaning delicate surfaces, as an industrial measurement tool (based on the penetration depth of its emitted alpha particles), a heat source for space satellites or planetary exploration vehicles and a component of thermonuclear trigger devices. he specific activity of the isotope is approximately 4500 µCi/µg (166 MBq/µg). The average daily adult dietary intake of ^{210}Po from environmental sources has been estimated at 4 pCi/day (160 MBq/day).

Blood Concentrations. Over 90% of the ^{210}Po present in blood is found in the erythrocytes (Thomas, 1964). Blood ^{210}Po concentrations in a group of middle-aged men averaged 0.8 pCi/L (30 mBq/L) in the nonsmokers and 1.7 pCi/L (63 mBq/L) in the smokers (Little and McGandy, 1966). These levels averaged 1.3 pCi/L (range, 0.6–3.1) (48; 22–115 mBq/L) in 12 nonsmoking Saudi men and 1.8 pCi/L (range 0.9–4.6) (67; 33–170 mBq/L) in 18 smokers (Shabana et al., 2000).

Metabolism and Excretion. Background levels of ^{210}Po arise in the human body largely as a result of its natural presence in the environment. This can occur due to oral consumption of foods or beverages, inhalation of atmospheric particulate matter, smoking of tobacco or other plant products and also from the natural decay of ^{222}Rn in inhaled environmental radon gas. Five days after oral ingestion, approximately 0.9% of a ^{210}Po dose is present in blood, 0.2% in bone, 2.8% in the liver and 0.8% in the kidneys, while 0.3% has been excreted in urine and 90% in feces (Harrison et al., 2007). Background lung, liver and kidney ^{210}Po concentrations averaged 3.2, 15 and 15 pCi/kg (118, 555 and 555 mBq/kg), respectively, in 5 nonsmokers and 8.6, 20 and 21 pCi/kg (318, 740 and 777 mBq/kg) in 4 smokers (Hill, 1965).

The range of urinary ^{210}Po concentrations in most healthy persons living in developed countries is 0.1–0.4 pCi/day (5–15 mBq/day); concentrations in excess of 0.8 pCi/day (30 mBq/day) are consistent with excessive exposure to the isotope, whether from natural or manmade sources (Ham, 2009; Sisti et al., 2009). The 24 hour urinary ^{210}Po levels of 10 Brazilian uranium mine workers (smokers and nonsmokers) averaged 0.3 pCi/L (10 mBq/L), versus 0.2 pCi/L (7.5 mBq/L) for 10 adult control subjects (smokers and nonsmokers) (Santos et al., 1994). Forty-three London hospital staff attending a fatally-poisoned patient provided urine specimens that contained a median ^{210}Po level of 0.3 pCi/day (10 mBq/day), with an interquartile range of 0.1–1.2 pCi/day (3–46 mBq/day) (de Waroux et al., 2011).

Toxicity. As an alpha particle emitter, ^{210}Po must be inside the body to exert its toxic effects. The body distribution of the isotope is quantitatively different for oral versus inhalation exposure, but its resultant toxicity is more a function of the total absorbed dose rather than the route of administration (Della Rosa and Stannard, 1964). The radiation injuries characteristic of ^{210}Po are usually seen first as nausea, vomiting and diarrhea; after several days, these may progress to bone marrow suppression and pancytopenia, severe damage to the gastrointestinal tract lining, cerebral edema and myocarditis. A single oral lethal dose for an adult male has been estimated to range from 6–30 µg of ^{210}Po (27–135 mCi or 1000–5000 MBq) (Harrison et al., 2007; Jefferson et al., 2009).

Of 726 UK residents potentially exposed to ^{210}Po during a London poisoning episode in 2006, 92 had urine ^{210}Po concentrations within a range of 0.8–2.7 pCi/day (30–100 mBq/day), 41 were within a range of 2.7–27 pCi/day (100–1000 mBq/day) and 6 had values >27 pCi/day (>1000 mBq/day); none of the individuals tested had evidence of acute radiation poisoning (Fraser et al., 2012).

In the London poisoning case mentioned above, a 43 year old man believed to have been orally-administered ^{210}Po for criminal purposes died of multiorgan failure 23 days later; the dose necessary to have produced this result was estimated at 0.2–8.5 µg (0.7–38 mCi or 27–1408 MBq) (Li et al., 2008). A Russian worker who accidentally inhaled an estimated 14 mCi (530 MBq) of ^{210}Po and died 13 days later had total postmortem lung, liver and kidney ^{210}Po content values of 0.35 (13), 0.57 (21) and 0.12 mCi (4.5 MBq) (Harrison et al., 2007).

Analysis. ^{210}Po has been quantitated in biological specimens by alpha particle spectrometry following acid digestion of organic matter and thermal deposition of the metal onto a silver disk (Ham, 2009; Sisti et al., 2009).

References

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