Technetium-99

All isotopes of technetium are radioactive. Technetium-99, chemical symbol Tc-99, is a silver-gray, radioactive metal. It occurs naturally in minute amounts in the earth's crust, but is primarily man-made. The most commonly available isotope is Tc-99m (called metastable Tc-99) and is the shorter-lived parent of Tc-99.

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The Basics

Who discovered technetium-99?

In 1925, Ida Noddack-Tacke, Walter Noddack, and Otto Berg published an article in which they reported the discovery of element 43, which they named "masurium," in samples from

uranium-rich ores. Because they were unable to concentrate masurium, the International Union of Pure and Applied Chemistry eventually rejected their discovery. Discovery of technetium in 1937 in the form of technetium-97 has been credited to Emilio Segré and Carlo Perrier at the University of California - Berkeley. Technetium-99m, one of the most common isotopes used in modern medicine, was developed by Glenn T. Seaborg and Emilio Segré.

Where does Technetium-99 come from?

Technetium-99 is produced in commercial quantities mainly as a byproduct from the operation of nuclear reactors. Most of the Tc-99 produced in a nuclear reactor originates from the fission of uranium-235. The Tc-99 produced in the reactor may become part of its airborne, liquid, or solid wastes. In addition to being produced in nuclear reactors, Tc-99 is produced in the detonation of nuclear weapons.

Medical and academic institutions use molybdenum/technetium generators as a source of Tc-99m for diagnostic tests or research. In this case, the nuclear reactor provides the radioactive parent, molybdenum-99, for the technetium generator. Molybdenum-99 has a short (66 hour) half-life, and decays to the even shorter-lived (6 hrs) Tc-99m.

What are the properties of technetium-99?

Technetium-99 is silver-gray, radioactive metal. It occurs naturally only in very small amounts. Its melting point is 3,942 °F and its boiling point is 8,811 °F. It is also a very dense material--at room temperature, a mass of technetium-99 weighs 11.5 times as much as an equal volume of water.

Technetium-99 has a radioactive half-life of 212,000 years. Technetium-99m (called metastable Tc-99) has a half-life of only about 6 hours and decays to Tc-99 primarily by gamma emission. Technetium-99 decays to form ruthenium-99, which is stable, by emitting beta and gamma radiation.

Technetium exhibits the complex chemistry of a transition metal. It dissolves in nitric acid, aqua regia, and hot concentrated sulfuric acid, but is insoluble in hydrochloric acid.

What is technetium-99 used for?

Technetium-99 has no significant industrial use. Technetium-99 is found in the radioactive wastes from defense-related government facilities, nuclear reactor and fuel cycle facilities, academic institutions, hospitals, and research establishments.

Its short-lived parent, Tc-99m, however, is the most widely used radioactive isotope for medical diagnostic studies. Technetium-99m is used for medical and research purposes, including evaluating the medical condition of the heart, kidneys, lungs, liver, spleen, and bone, among others, and also for blood flow studies.

Exposure to Technetium-99

How does technetium-99 get into the environment?

Most Tc-99 in the environment comes from a few sources:

the detonation of nuclear weapons (especially atmospheric weapons tests)
nuclear reactor airborne emissions
nuclear fuel reprocessing plant airborne emissions
facilities that treat or store radioactive waste.

Extremely small amounts of Tc-99 have entered the environment near a few radioactive waste disposal sites.

How does technetium-99 change in the environment?

Given its long half-life, 212,000 years, Tc-99 remains in the environment. Air, sea water, soils, plants, and animals contain very low concentrations of Tc-99. Organic matter in soils and sediments slows the transport of Tc-99.

In the presence of oxygen, plants readily take up technetium compounds from the soils. Some plants such as brown algae living in seawater are able to concentrate Tc-99. Technetium-99 can also transfer from seawater to animals.

How are people exposed to technetium-99?

Tiny amounts of Tc-99 are part of the environment, and are therefore found in food and water. Higher amounts may be found close to contaminated facilities such as federal weapons facilities or nuclear fuel cycle facilities. Exposure to technetium from the environment is unlikely. Most human exposure to technetium comes from the use of Tc-99m in nuclear medicine.

How does technetium-99 get into the body?

Ingestion is the primary entry route for Tc-99 into the body. This may occur by eating food or drinking water contaminated with Tc-99.

What does Technetium-99 do once it gets into the body?

Once in the human body, Tc-99 concentrates in the thyroid gland and the gastrointestinal tract. The body, however, excretes half of the ingested Tc-99 within 60 hours. It continues to excrete half of the remaining Tc-99 every 60 hours that follow. After 120 hours, only one-fourth of the ingested Tc-99 remains in the body. Nearly all of ingested technetium will be excreted from the body within a month.

Health Effects of Technetium-99

http://www.epa.gov/radiation/radionuclides/technetium.html
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How can technetium-99 affect people's health?

As with any radioactive material, there is an increased chance that cancer or other adverse health effects can result from exposure to radioactivity.

Is there a medical test to determine exposure to technetium-99?

Special tests that measure the level of radioactivity from Tc-99 or other technetium isotopes in the urine, feces, and exhaled air can determine if a person has been exposed to technetium. These tests are better done soon after exposure as the body constantly excretes Tc-99 once ingested. However, hair retains Tc-99 for long periods and can be an indicator of Tc-99 contamination. The tests require special equipment and cannot be done in a doctor's office.

Protecting People from Technetium-99

What are EPA and other government agencies doing about technetium-99?

EPA has issued a variety of regulations that limit the release of radionuclides, including Tc-99, to the environment. These regulations address the following potential sources:

airborne and liquid releases from the nuclear fuel cycle
airborne emissions from a variety of industrial and governmental facilities
allowable radioactive releases from radioactive waste disposal systems.

Most recently, EPA finalized public health and environmental radiation protection standards for the potential high level waste repository at Yucca Mountain, Nevada. Because of the large quantity of spent nuclear fuel and defense high-level waste, Tc-99 is one of the more important radionuclides considered. The standards limit the radiation exposures of individuals and concentrations in ground water from the release of Tc-99 and other radionuclides in the vicinity of Yucca Mountain.

Yucca Mountain Standards
describes EPA's role in the repository
The Department of Energy's Yucca Mountain Project
describes DOE's role in building and licensing this DOE facility

EPA has established specific Maximum Contaminant Levels (MCLs) that limit the concentration of Tc-99 and other radionuclides in drinking water from public water supplies.