HYDROISOTOP gmbh
Laboratorium zur Bestimmung von Isotopen in Umwelt und Hydrologie

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Technetium-99(m)

In 1937, technetium was the first element to be generated **artificially**. Therefore it was given its name which is derived from the Greek *technētós* („artificial"). The production was implemented by irradiating a molybdenum sample with Deuterium:

$${}_{42}Mo + {}_{1}D \rightarrow {}_{43}\mathbf{Tc} + {}_{0}n$$

The **natural** occurrence of this silver-grey metal in the Earth's crust is limited to traces in the **range of micrograms**. Accordingly, it is ranked number three in rarity compared to all other elements. It can be found in uranium ores as a spontaneous fission product of uranium. However, technetium itself decays due to its radioactivity. In this way one kilogram of pure uranium includes only 1 nanogram of technetium, approximately. Besides, technetium is created in molybdenum ores by bombardment of molybdenum with neutrons from cosmic rays and its subsequent nuclear transmutation.

The **anthropogenically** caused release of a total of several tons of technetium into the biosphere occurred by nuclear tests above ground in the past, as well as from nuclear fuel reprocessing plants and nuclear reactors at present.

Up to now, there can be differentiated **34 technetium isotopes** with mass numbers ranging from 85 to 118. Without exception, all of them are radioactive, implying that they emit radiation and transform into an atom with a different nucleus after a certain time. The **most stable** isotope is $^{98}\mathbf{Tc}$ with a half-life of 4.2 million years. Contrarily, ^{110}Tc decays most rapidly with a half-life of less than a second.

The only technetium isotope which can be produced on a large scale (worldwide around 5 tons per year) in nuclear reactors by bombardment of uranium with neutrons is $^{99}\mathbf{Tc}$. Thus it is classified as **economically most significant** technetium isotope, emitting economically viable electron radiation as a result from beta decay with a half life of 211,000 years.

Apart from their different mass numbers, technetium isotopes can be distinguished by the particular energy state of their nucleons. There are **metastable** states like ^{95m}Tc and ^{97m}Tc, whose half lives are around 2 respectively 3 months. The metastable isotope $^{99m}\mathbf{Tc}$, having a half time of only 6 hours, is the **most radioactive** among them and of high relevance for nuclear medicine.

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On account of its ability to be incorporated into biologically-active substances and to emit appropriate energy gamma rays it is suitable for **scintigraphic nuclear medical examinations**. For this radioactive tracer test, ^{99m}Tc is bound to a pharmaceutical and injected intravenously to the patient. This causes an increased concentration of the radioactive technetium isotope in the considered tissue or organ of the human organism. After that, the enhanced accumulation can be detected by the specific gamma radiation of ^{99m}Tc.

In order to **generate** the medically important technetium isotope, molybdenum is bombarded with neutrons:

$$^{98}Mo + n \rightarrow {}^{99}Mo$$

After that, the heavy molybdenum isotope decays into the viable metastable ^{99m}Tc, emitting beta particles:

$$^{99}Mo \rightarrow \mathbf{^{99m}Tc} + e^- + \nu_e$$

In plus, technetium isotopes in the form of the salts ammonium and sodium pertechnetate can be applied as corrosion inhibitors for steel. Due to the radioactivity of technetium this property can only be employed in closed systems such as boiling water reactors. Furthermore, the isotope ^{99}Tc as nuclear fallout resulting from the Chernobyl disaster can be used in ocean sediments on the large scale.