January 24, 2011

Lawson Health Research Institute Receives Funding to Develop Non-Reactor Based Isotopes

FAQ

What is an isotope?
The nucleus of an atom is composed of protons and neutrons. The number of protons in the nucleus defines what element the atom is. For example, a nucleus with 8 protons makes it the element oxygen. Molybdenum (Mo) has 42 protons and Technetium (Tc) has 43 protons. The total mass of the nucleus is the sum of the number of protons and the neutrons. The number of neutrons in the nucleus can vary without changing the element. Thus Mo-98 and Mo-99 are isotopes of Mo, both having 42 protons but one has 46 neutrons and the other 47 neutrons.

Stable isotopes of an element do not change over time. Atoms of unstable isotopes – also called radioisotopes--change into other elements over time through radioactive decay. Radioisotopes are used in many medical imaging and diagnostic procedures, with the isotope Tc-99m being used in 80 percent of tests.

What is a radionuclide?
A radionuclide is an isotope of an element that is radioactive. The radioactive nucleus emits energy in the form of light rays or particles to form a stable (non-radioactive) form.

How are medical isotopes used?
If an incoming patient is thought to have had a heart attack, a doctor will often inject the patient with a medical isotope called Tc-99m attached to a biomolecule called teboroxime (the combination is called a "radiotracer"). The patient will then typically perform a rest-and-stress treadmill test. The Tc-99m goes to the heart because the teboroxime molecule is designed to accumulate there. When the heart is imaged with a SPECT camera, the picture will tell the doctor if blood flow is adversely restricted in portions of the heart muscle.

Iodine isotopes (such as I-123 for imaging and I-131 for therapy), accumulate in the thyroid when injected into the body. The patient is imaged with a SPECT camera and the thyroid functionality is evident. Doctors can then identify what part of the thyroid gland is working properly, and areas that aren't. If you have ever known anyone who has battled thyroid cancer, they were likely diagnosed and treated successfully as a result of advancements made because of medical isotopes.

What is Technetium-99m or Tc-99m?
In Canada alone, Tc-99m is used in approximately 5,500 medical scans a day. This medical isotope or radionuclide is combined with any of a variety of biologically active molecules to perform non-invasive, real-time imaging of the human body. A typical dose of Tc-99m for a medical procedure uses 10-30 mCi. Tc-99m can be used to perform imaging of:

- The heart for myocardial perfusion studies;
- Bones for identifying cancerous lesions;
- Brain function; and
- A number of specialized tests such as immunoscintigraphy, ventriculography, spleen function, and so on.

Where are medical isotopes made?

Of the approximately 200 radioisotopes commonly available today, almost all are artificially created. The most significant quantities of radioisotopes rich in neutrons (e.g. Mo-99, I-131) come from neutron bombardment of elements in a nuclear reactor. Cyclotrons are used to produce isotopes rich in protons. Some cyclotron-produced isotopes are well-suited for radiation therapy. Others are used for nuclear imaging with single photon emission computed tomography (SPECT) or positron emission tomography (PET) technologies.

Tc-99m comes from the parent atom Molybdenum-99 or simply Mo-99. Mo-99 is produced in nuclear reactors (such as Canada's NRU reactor at Chalk River) by irradiating highly enriched "weapons-grade" uranium (U-235). The Mo-99 has a fairly long half-life (it takes on average 66 hours for half of a sample of Mo-99 to decay to Tc-99m). The Mo-99 decays into Tc-99m, which has a half-life of 6 hours. The Tc-99m is used at the hospitals all over North America to create the radiopharmaceuticals used in patients.

Using nuclear reactors to produce medical isotopes introduces a number of challenges. Aging reactors are becoming increasingly unreliable and outages---such as the year-long outage of the NRU reactor at Chalk River---contribute to ongoing shortages. The use of highly-enriched uranium as the target material is also a major security and proliferation concern; many nations, including the United States, are actively working to eliminate its use in civilian applications. Since half of the Mo-99 decays every 66 hours, much of the resulting Tc-99m ends up being wasted as it decays during shipment from far-flung reactors, to pharmaceutical companies, and finally to hospitals. Isotope-generating reactors also create other by-products besides Mo-99 that persist as long-lived nuclear waste.

What is a cyclotron?

A cyclotron is an electromagnetic device used to accelerate charged particles (ions) to sufficiently high speed (energy) so that when it impinges upon a target the atoms in the target are transformed into another element. A cyclotron differs from a linear accelerator in that the particles are accelerated in an expanding spiral rather than in a straight line.

Cyclotrons are used for many different applications in industry, medicine, and research and are one of the most popular forms of accelerators. Most cyclotrons produce beams of protons although some produce beams of alpha particles or other heavier nuclei. Around Canada and around the world, medical cyclotrons are presently used to produce medical isotopes such as Fluorine-18 or Carbon-11. Other cyclotrons are used to generate the beams of radiation for treatment of cancer. Lawson has a GE PETtrace 8, 16.5 MeV medical cyclotron on site at St. Joseph's Health Care, London which is used for a variety of clinical, commercial and research applications.

What is a target?

A target is the material which is irradiated by the beams from the cyclotron---or in the case of a nuclear reactor, the target would be irradiated by beams of neutrons from the reactor core. The target contains atoms that are to be transformed into another element after bombardment by the high-speed protons from the cyclotron. In the case of the research project "A Collaborative Program for the Production of Tc-99m Using Medical Cyclotrons", the target material is made of molybdenum (Mo) and a fraction of this is converted into technetium (Tc). For this project, the key investigations will focus on developing robust, high-yield, and easy-to-handle targets so that Tc-99m can be produced reliably and efficiently using existing medical isotope cyclotrons.

What is half-life?

The time interval over which one half of the atoms present disappear through nuclear decay.