Centre for Probe Development and Commercialization

Fact Sheet:
Medical Isotopes, Technetium and Cyclotrons

What are medical isotopes?
Medical isotopes, such as technetium-99m, are safe, short-lived radioactive particles that are produced in nuclear reactors or in particle accelerators. As the particles undergo radioactive decay, they release energy that can be detected by specialized cameras to produce three-dimensional images of bones, organs and tissues in the body.

How are medical isotopes used in health care?
Isotopes are used in molecular imaging procedures to provide a non-invasive view inside the body and aid physicians in diagnosing disease. Unlike X-rays or MRI scans, molecular imaging shows the biochemical activity of cells rather than the anatomy of the body. Where an MRI shows bones, organs and other tissues in the body, molecular imaging shows how the cells of the body are behaving. Physicians can use this information to accurately diagnose diseases such as cancer, heart disease, Alzheimer's disease and disorders of the bones, kidneys and liver. Since changes in biochemical activity of cells occur before diseases reach an advanced stage, molecular imaging can reveal abnormalities long before conventional imaging devices like X-ray or MRI can show anatomical changes.

How do isotopes show disease?
Isotopes are attached to specialized pharmaceutical molecules that are designed to seek out and bind to certain types of diseased tissue. This pharmaceutical molecule, or probe, is injected into a patient and after a period of time, the patient is scanned with a single photon emission computed tomography (SPECT) camera or a positron emission tomography camera (PET) to produce a 3D image of the area scanned. The type of camera depends on the type of probe used. In either case, the radioactive decay of the isotope emits energy that the camera can image. High concentrations of probes light up on the image and alert physicians to potential disease.

What is technetium?
Technetium is the workhorse of nuclear medicine and is used for more than 85% of all medical diagnostic imaging procedures worldwide. It is primarily made in nuclear reactors that are designed to produce medical isotopes. Only five reactors, located in Canada, Belgium, the Netherlands, France and South Africa, produce nearly all of the world's supply of Tc-99m. The isotope is made by irradiating highly enriched uranium and processing it to produce Molybdenum-99 (Mo-99). This is the parent isotope, which decays to produce Tc-99m. Since Tc-99m has a half-life of only six hours, it cannot be stored and must be produced frequently to ensure a continuous supply for medical use.

What is a cyclotron?

A cyclotron is a type of particle accelerator. It uses magnetic fields to accelerate particles in an outward spiral and directs them to a target where a collision produces a nuclear reaction. An unstable isotope is formed that releases energy by emitting particles over a period of time. One of the most common isotopes produced by a cyclotron is fluoride. Positron Emission Tomography (PET) scanners can detect the particle emissions from the fluoride and produce an accurate diagnostic image for physicians.

How can a cyclotron make technetium-99m?

A cyclotron accelerates atomic particles called protons and directs them at a target composed of Molybdenum-100. Medium- to high-energy cyclotrons can accelerate protons to a speed that provides enough energy to force the protons to react with the target. This reaction creates an unstable isotope of technetium-99m that emits energy, which can be detected by a SPECT camera. Like the technetium produced by a reactor, this isotope also has a half-life of six hours and is combined with a pharmaceutical compound that seeks out specific sites of disease in the body.

How much technetium-99m can a cyclotron produce?

There are several types of commercially available cyclotrons. The primary distinction among them is the energy applied to the beam, which accelerates the protons to produce the reaction. This difference in energy means that technetium yields will vary among cyclotrons. One of the objectives of the Non-reactor Based Isotope Supply Contribution Project (NISP) is to gather detailed data on technetium yields from commercially available cyclotrons.

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