Technetium (Tc-99m) Imaging Agents

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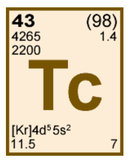
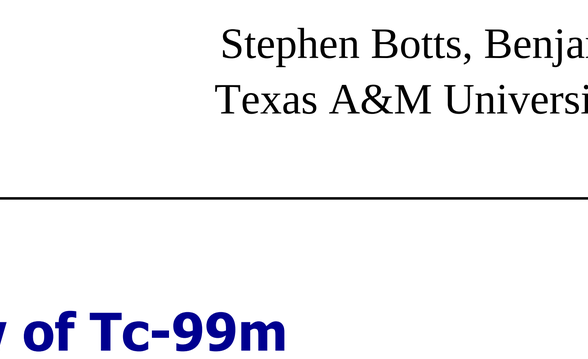
Overview of Tc-99m



Technetium-99m (Tc-99m) is a metastable nuclear isomer of technetium-99 used in many radiology diagnostic procedures. Its primary use in medical imaging is to detect the presence of biological interactions and abnormalities through the formation of target compounds within the body. Through the emission of gamma rays, Tc-99m radioisotopes within the target compounds can be detected via Single Photon Emission Computed Tomography (SPECT).

Examples:

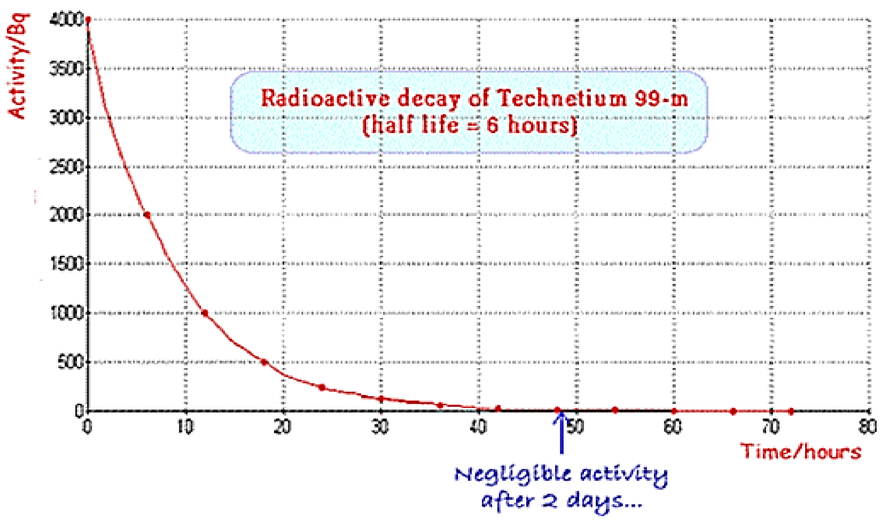
- Tc-99m HMPAO labelled WBC
- Tc-99m Pertechnetate
- Tc-99m Methyl Diphosphonate (MDP)



$$^{98}_{42}Mo + {}^{1}_{0}n \rightarrow {}^{99}_{42}Mo + \gamma$$

$$^{98}_{42}Mo \rightarrow {}^{0}_{-1}e + {}^{99m}_{43}Tc$$

Characteristics of Tc-99m



- Gamma ray energy permits easy collimation.
- Low radiation dose.
- Absent Beta emission.
- Half-life of six hours.

Tc-99m HMPAO labelled WBC: Infection scintigraphy

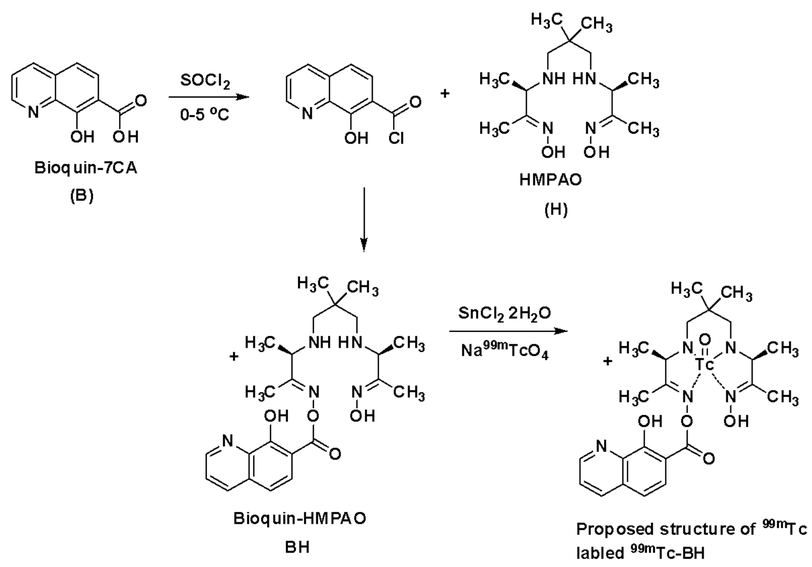


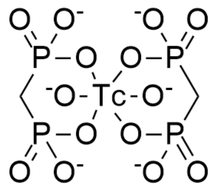
Figure 1. Synthesis of HMPAO.

Scintigraphy: Detects gamma radiation and generates an image of the area analyzed.

Applications: Infection scans of spleen, liver, kidney, bone marrow and white blood cells.

Facts: Able to cross cell membranes and the blood-brain barrier; Able to bind to mitochondria and cell nuclei.

Tc-99m Methyl Diphosphonate (Tc-99m MDP)



Used in nuclear medicine, especially for bone scans.

Accumulates on the bone by chemical adsorption and incorporation into the hydroxyapatite structure.

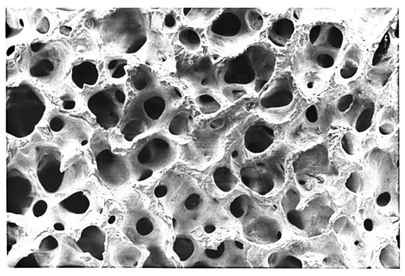


Figure 2. Hydroxyapatite structure.

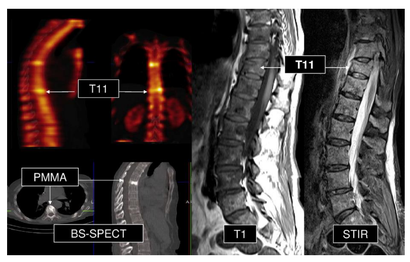
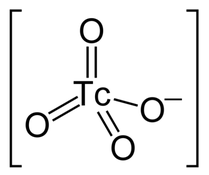


Figure 3. Acute T11 vertebral fracture appreciated by a bone scan but not by MR.

Tc-99m Pertechnetate



Used for imaging of the thyroid, colon, bladder and stomach.

Disadvantages: relatively low thyroid uptake and the high background activity at the optimum time for examination.

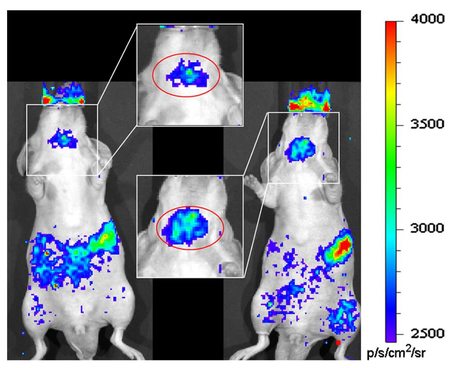


Figure 4. RLI image of the Tc-99m pertechnetate distribution in mice. The most important sources of light emission are the salivary-thyroid gland along with the stomach-intestine.

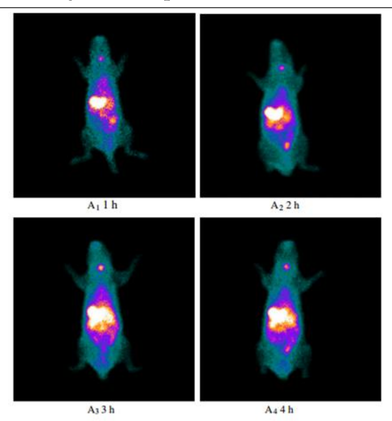


Figure 5. *In vivo* SPECT images of SD white rats having received injection of Na ^{99m}TcO4 (1.2 mCi) solution after 1, 2, 3 and 4h, respectively.

Tc-99m derivatives

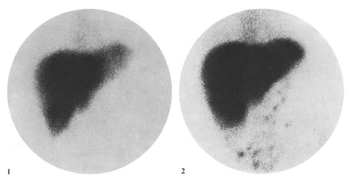


Figure 6.
Left: Splenic scintiscan with sulphur colloid. Only the liver takes up the tracer and is visualised.
Right: Heat-damaged RBC splenic scintigraphy. The appearance of many small islets of splenic tissue; the liver may also be seen because of the small amount of splenic tissue.

Figure 7. ECAM 2® - SCINTRON® Gamma Camera System.

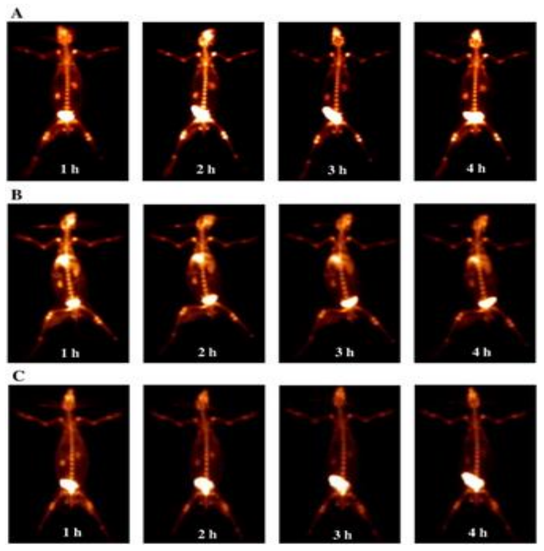


Figure 8. Static images of rabbit bone scanning after injection of ^{99m}Tc-IPrDP (A), ^{99m}Tc-ZL (B), and ^{99m}Tc-MDP (C) from 1 to 4 h.

Conclusions

- Tc-99m results in lower toxicity than other radiopharmaceuticals.
- Tc-99m is more cost effective compared to other radionuclides (Cr, I, Hg).
- Tc-99m results in reduced background allowing further tests to be carried out in a few days.

Limitations
- Radiopharmaceuticals cannot differentiate between cysts and tumors.
- Resolution of images may not be as clear as CT or MRI.

References

1. R. Herbert, W. Kulke, R. R. Shepherd. “The Use of Technetim 99m as Clinical Trancer Element.” *Postgrad. MED. J.* (1965), 41, 656
2. Lin, Jianguo, Ling Qiu, Wen Cheng, Shineng Luo, and Wanzhong Ye. "Preparation and in vivo biological investigations on a novel radioligand for bone scanning: technetium-99m-labeled zoledronic acid derivative." *Nuclear Medicine and Biology* 38.5 (2011): 619-29.
3. Jones, D. J., Tc-99m HMPAO labelled WBC. 2014.

Acknowledgements

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