DEVELOPMENT OF A RADIOCHEMISTRY LABORATORY FOR THE PRODUCTION OF ^{99m}Tc USING NEUTRON ACTIVATION

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Purpose

- Goal: To set up a comprehensive graduate radiochemistry laboratory to isolate ^{99m}Tc using the neutron activation of stable ammonium molybdenate
- Included:
  - An overview of the nuclear medicine information of ^{99m}Tc
  - Radiation dose received for specific medical diagnoses
  - Germanium detector efficiency curve that can be used for activity measurements of other medical isotopes.

What is ^{99m}Tc?

- Most widely used radioisotope in nuclear diagnostic imaging.
- Traditionally produced from fission of uranium to produce ^{99}Mo which then decays to ^{99m}Tc

^{99}Mo (t½ = 66 h) → ^{99m}Tc (t½ = 6.01 h) → ^{99}Tc (t½ = 2.1 x 105y) → ^{99}Ru (stable)

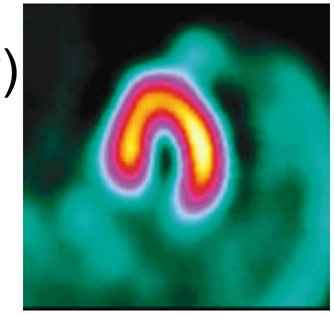
^{99m}Tc and Medical Imaging

- A small amount of ^{99m}Tc is incorporated in a carrier molecule and injected into the patient’s blood stream. Selective accumulation of the ^{99m}Tc in specifically targeted internal organs is achieved through the design of the carrier molecule.
- In 0.9% NaCl, ^{99m}Tc is a sterile, non-pyrogenic, diagnostic radiopharmaceutical suitable for intravenous injection, oral administration, and direct instillation.
- ^{99}Mo is constantly decaying to fresh ^{99m}Tc, so it is possible to elute the generator at any time.

^{99m}Tc Characteristics

- The eluate is a clear liquid with a pH of 4.5-7.5.
- ^{99m}Tc decays by isomeric transition with a physical half-life of 6.02 hours.
- ^{99m}Tc decays by gamma emission to ^{99}Tc

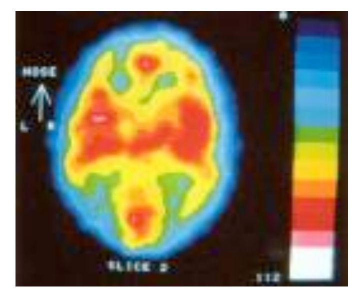
Sodium Pertechnetate ^{99m}Tc Injection is used in adults as an agent for:



- Brain Imaging (including cerebral radionuclide angiography)
- Thyroid Imaging
- Salivary Gland Imaging
- Placenta Localization
- Blood Pool Imaging (including radionuclide angiography)
- Urinary Bladder Imaging (direct isotopic cystography) for the detection of vesico-ureteral reflux.
- Nasolacrimal Drainage System Imaging

Sodium Pertechnetate ^{99m}Tc Injection is used in children as an agent for:

- Brain Imaging (including cerebral radionuclide angiography)
- Thyroid Imaging
- Blood Pool Imaging
- Urinary Bladder Imaging (direct isotopic cystography)
- For the detection of vesico-ureteral reflux.



Laboratory Calculations

The amount of ^{99}Mo (in mCi) produced from 5.0 m ammonium molybdate $(NH_4)_6Mo_7O_{24}$·4H2O) irradiated for 1 hour at 6 x 10^{12} $cm^{-1}s^{-1}$ is given by:

$$A = N\sigma\Phi(1- e^{-\lambda t})$$

where:

A = activity of 99Mo in Becquerels at the end of irradiation

N = number of 98Mo atoms

σ = thermal Neutron capture cross section for 98Mo in cm2

Φ = thermal Neutron flux in the reactor in cm2s-1

l = decay constant for 99Mo in h

λ = irradiation time in h

The total activity is calculated to be 0.91 mCi.

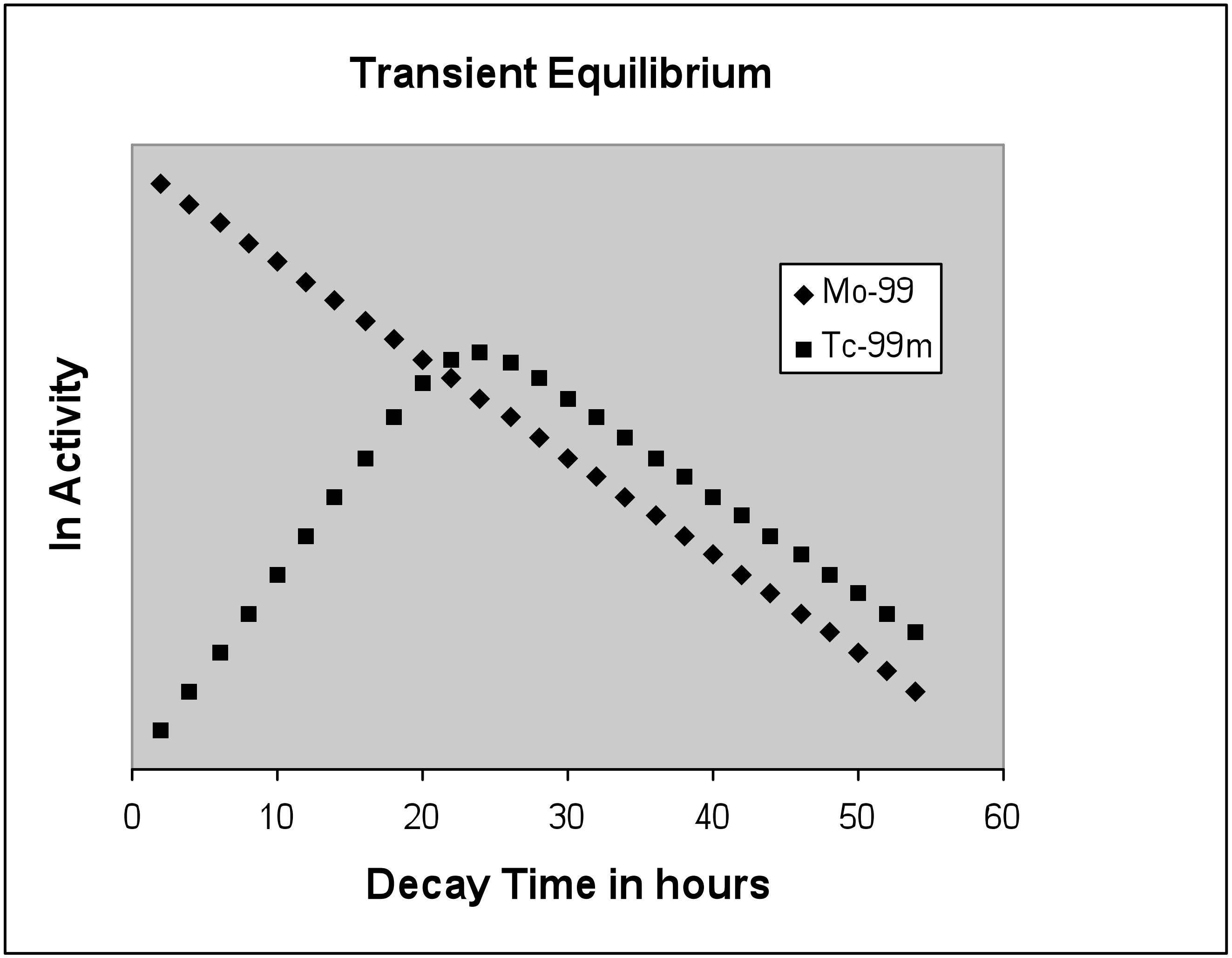
Laboratory Procedure

- Materials Used:
  - Irradiated Ammonium Molybdate solution
  - 20 mL 0.9% NaCl solvent
  - Activated Alumina
- Vacuum filtration system
- Eluate collection
- Analysis

Chromatography Column

An ammonium molybdate solution is used as a ^{99}Mo source, and is eluted with 0.9% sodium chloride. ^{99}Mo is also polar, and so it is embedded in the stationary phase, while the non-polar ^{99m}Tc acts as the mobile phase which passes through the column to be collected.

^{99}Mo and ^{99m}Tc Equilibrium Curves



Calculation of a Germanium Detector Efficiency Curve

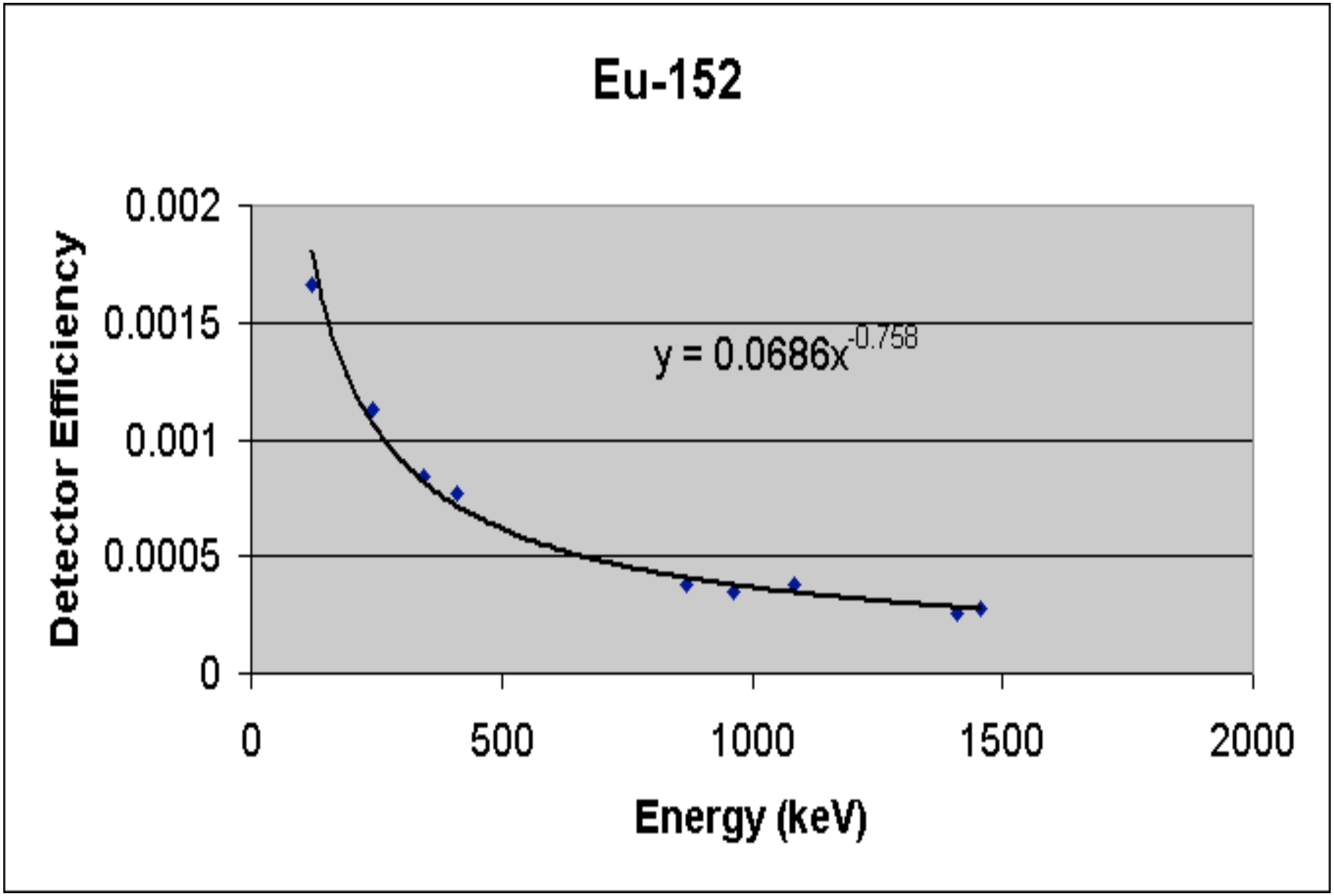
Half-life of ^{152}Eu	13.542	Y
	427353019.2	s
Decay Constant (lamda)	1.62195E-09	1/s
Activity	106.39	kBq
	106390	Bq
Certification Date	1/1/1999 0:00	
Current Date	6/10/2003 15:00	
Decay Time	1621.63	days
	140108400.00	seconds
Current Activity	84763.25443	Bq

found by A = Aoe^-((lamda)(decay time))

Efficiency Curve Data

Energy	Intensity	Counts	Gammas	Efficiency
121.8	28.67	2.88E+06	1.73E+09	0.001665
244.7	7.61	5.18E+05	4.59E+08	0.001127
344.3	26.6	1.34E+06	1.6E+09	0.000837
411.1	2.233	1.03E+05	1.35E+08	0.000767
867.4	4.2	9.68E+04	2.53E+08	0.000382
964.1	14.6	3.11E+05	8.81E+08	0.000353
1085.9	9.9	2.28E+05	5.97E+08	0.000382
1408.0	20.8	3.28E+05	1.25E+09	0.000261

Germanium Detector Efficiency Calibration



Calculation of ^{99}Mo breakthrough in terms of activity

Federally allowed limit:

0.15 microcuries of Mo per millicuries of ^{99m}Tc

The mCi of ^{99m}Tc obtained can be calculated below:

$$\frac{P(140)}{0.89(3.7\times10^{7})(t)}$$

P(140) is the number of net counts for the 99mTc peak at 140 keV

The mCi of ^{99}Mo is determined by using the number of counts per second for the ^{99}Mo peak at 181 keV, a branching ratio of 0.0599, and the constant 3.7 x 10^4 disintegrations per second/mCi.

Results

- The required 20 mL can be eluted through the column in less than five minutes when vacuum filtrated
- No peak was found at 181 KeV
- Upper limit of the background interference was above the 99mTc peak.
- A higher activation or larger sample of ^{99}Mo is needed for a larger amount of ^{99m}Tc to be filtrated out.

Bibliography

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