Triathler in Nuclear Medicine: Measurement of disposal activities of radiopharmaceutical Y-90-Zevalin®

Radioimmunotherapy is a new method for cancer treatment. It utilizes a monoclonal antibody with a radioisotope attached. The antibody recognizes a specific antigen on the cancer cells. The method enables delivery of radioactivity more accurately to the tumour, thus reducing dose to the normal tissue.

Ibritumomab tiuxetan which is sold under the tradename Zevalin®, was the first monoclonal antibody based radiopharmaceutical approved by the FDA for cancer treatment. Zevalin® utilizes a monoclonal antibody labeled with Yttrium-90 isotope. Doses of Zevalin® may exceed over 1000 MBq. Yttrium-90 is a beta emitter with energy of 2.3 MeV and a half-life of 64.1 h.

After treatment, monitoring of leftover activity is an important safety measure for minimizing dose to personnel and the environment. The Triathler™ multilabel tester can be used to measure the activity levels with a variety of methods.

The following measurements were made with Triathler Multilabel Tester (425-004, no Internal Lead Shield) in Helsinki University Hospital, Department of Oncology, six days after a patient was treated with Y-90-Zevalin®. The purpose was to find out efficiences of the non-destructive counting methods.

Cerenkov Counting

The high energy (2.3 MeV) beta particles of Y-90 produce Cerenkov light pulses directly in water, allowing simple counting without scintillation cocktails. The Cerenkov pulses are of relatively low amplitudes and should be counted in soft beta protocols.

Mode: LSC
Key: H-3, C-14, S-35, P-33 or Cer*; window 30 - 200

* (The Cer key is available in Triathler LSC 425-034).

Samples: 20 mL and 4 mL water samples in standard (20 mL) vials and minivials. Both glass and plastic vials were included.

Efficiencies

20 mL water in standard glass vial	24%
20 mL water in standard plastic vial	28 %
4 mL water in glass minivial	31 %
4 mL water in plastic minivial	34 %

Typical backgrounds: 80 CPM for standard vials, 55 CPM for minivials.

Counting in NaI(Tl) crystal

Triathler Multilabel Tester (425-004) and Gamma Counter (425-024) are provided with a NaI(Tl) crystal, ordinarily used for gamma isotopes. Y-90 will produce pulses in the crystal, possibly via two mechanisms: 1) the high energy betas have some probability to directly go through the aluminium (Al) lining of the crystal hole and hit the crystal and 2) the betas produce bremsstrahlung in the Al-lining and becomes detected in the crystal. The resulting spectrum is broad and featureless.

Mode: Gamma
Key: Any gamma key; window 15 – 1000 (300 – 1000).

Sample: A 2 mL water sample in gamma vial (463-104).

Efficiency 10 %; Typical background 1300 CPM

In a narrower window 300 – 1000, efficiency was 5 % and background 330 CPM.

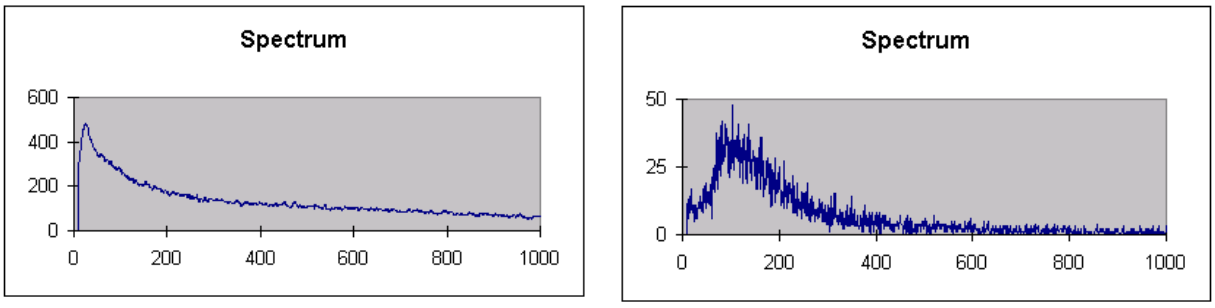

Figure: Y-90 spectrum (left) and background (right) in Triathler NaI(Tl) crystal.

Counting in Plastic Scintillator Adapter

The Plastic Scintillator Adapter (431-010) can take a microtube, e.g. Eppendorf®, containing the Y-90 sample. The betas can penetrate through the sample solution and microtube wall, hitting the plastic scintillator. Because the plastic produces true scintillations of large amplitudes, the P-32 key should be used.

Mode: LSC
Key: P-32; window 10 – 1000

Sample: A 1 mL water sample in 1.5 mL capacity microcentrifuge tube, inserted into the Plastic Scintillator Adapter.

Efficiency 45 %; Typical background: 160 CPM

Conclusion

Cerenkov counting is the most straightforward method for Y-90-Zevalin®. It is simple, yields reasonable efficiency, low background and up to 20 mL water can be counted to maximize sensitivity. Additionally, it is less sensitive to external radiation, if counting has to be performed in environment with elevated activity.

Sensitivity evaluation: Using very conservative values for a 20 mL sample, efficiency 20 % and background 100 CPM, the following estimates can be calculated for the lowest detectable activities (= signal exceeding 4.65 times background standard deviation).

1 minute counting: 11625 DPM/L = 194 Bq/L
3 minute counting: 6712 DPM/L = 112 Bq/L
10 minute counting: 3676 DPM/L = 62 Bq/L

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