RP GN002: Safe Working with Tritium (Hydrogen-3)

VERSION CONTROL	
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Risk

Tritium, also known as hydrogen-3, decays by emitting only very low-energy beta particles. These beta particles cannot penetrate the outer dead layer of the skin. There is a possibility of the generation of bremsstrahlung, but the low energy of about 6 keV, and the small quantity means that it can normally be ignored. Tritium therefore poses a negligible external radiation hazard and is generally regarded as a low toxicity radionuclide.

Tritium will however present a risk if it gains entry to the body. It can be inhaled, ingested and absorbed, even through unbroken skin, and the risk varies according to the chemical form. It has a relatively long radiological half life, and is obtainable in very high values of specific activity. Tritium gas is mainly a risk only to the lungs, although there is some transfer by the formation of tritiated water. Tritiated water is a higher risk; three to four hours after uptake, it is uniformly distributed in all body water. If ingested in the form of a tritiated organic compound, there may be an even higher risk due to potential deposition within cells, with a suspected biological half-life of several months. Tritium is a highly mobile material, and it should be assumed that elemental tritium can arise in labelled compounds kept for a long time, and there can be exchange of tritium across different components in a sample, resulting in particular in the formation of tritiated water.

Although the low energy of the beta radiation gives tritium a low radiotoxicity it does create an additional problem compared to other, more energetic, radionuclides. Most laboratory surface contamination monitors will not detect the beta radiation (see below). Because of this difficulty in monitoring there is a greater risk of surface contamination being unnoticed, and a consequential greater potential for accidental contamination and ingestion.

Special Considerations

- Use of protective shielding is unnecessary for tritium.
- Work must be done in well-ventilated laboratories; as a guide, the air-change rate should be at least 5 h-1. This can probably be achieved if necessary by running a fume cupboard.
- The tritiated material must be kept in well-sealed containers.

- Containers used for the long-term storage of tritiated material should be opened in a fume cupboard or other suitable extracted enclosure.
- If highly volatile compounds of tritium are being used, or there is a risk of the generation of tritiated water vapour or the production of elemental tritium, the URPA must be consulted before starting work.
- Storage procedures must be such as to reduce the rate of decomposition of labelled material (Details can be found from the suppliers, although a useful reference is the booklet, “Radiochemical Decomposition”, published by Amersham Biosciences).
- Tritiated material should be kept in glass containers in preference to plastic.
- Where the requirements of the experiment allow it, it is preferable to store tritiated material outside of a refrigerator or freezer.
- It tritiated material has to be stored in a refrigerator or freezer, the condensate or frost must be regularly checked to ensure that no tritiated water vapour has been released as a result of self-hydrolysis or decomposition or a poorly sealed container. Where it is continuously stored, monthly intervals should be used.
- As tritium can be absorbed through the skin, it is advisable to wear two pairs of disposable gloves when handling the material. The gloves should be changed frequently.
- Due to the difficulty of monitoring tritium contamination on the skin, the hands must be washed thoroughly each time a worker leaves the laboratory after any work with this radionuclide.

Monitoring

- Field contamination monitors for tritium are specialised, expensive and problematic to use. Contamination therefore has normally to be monitored by liquid-scintillation counting of wipe test swabs.
- Conventional personal dosimeters are not appropriate for work with tritium because of the low penetrating power of the radiation.
- The most suitable form of personal monitoring is to measure the concentration of tritium in the urine of those handling the material. The presence of tritium indicates that there has been an uptake, and the actual concentration can be used to estimate to an approximate committed effective dose. The measurement should be undertaken by an outside competent laboratory. Details of the procedure are outlined in Information Sheet IS003.
- The need for personal monitoring is reported in the relevant Proposed Scheme of Work form.

Physical Data and properties

Decay data	Timespan
Half life ($t½$)	**12.3 years**
Decay constant (λ)	**0.056 y^{-1}**
Daughter product	**Stable (He-3)**

Emissions	Max. Energy	Av. Energy	Abundance
Beta emission	18.6 keV	6 keV	**100%**
Gamma emission	**None (1)**		
Dose rate from a point source of 1 GBq at 1m distance (1)	**No significant external radiation**		

Transmission through materials	Air	Plastic	Water	Glass
Maximum range of beta	**5 mm**	**< 0.1 mm**	**6 μm**	**< 0.1 mm**

Biological Data	Elemental	HTO	Organically Bound
Annual Limit of Intake by ingestion (2)	-	1.1 BGq	**480 MBq**
Annual Limit of Intake by inhalation (2)	11 TBq	1.1 GBq	**490 MBq**
Critical organ	**Whole Body**		
Typical Contamination Monitor Readings			
Contamination must be assessed by wipes counted by liquid scintillation			

Notes:

1. This excludes any possible bremsstrahlung.
2. The Annual Limit of Intake (ALI) represents the activity which, if taken into the body, would lead to a committed effective dose equal to the occupational annual dose limit for the whole body for classified workers of 20 mSv. This value would have to be reduced if there is any other source of occupational exposure.

For advice on any of the above topics please contact the Radiation Protection Unit, radiation@ed.ac.uk.