

LIQUID SCINTILLATION USERS' FORUM

# Organically Bound Tritium (OBT) Standard

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# Contents

Introduction tritium in the environment

Measurement of OBT in environmental samples

Method of standardisation

Instability of OBT / Separation OBT and HTO

Summary

# Tritium introduction

Tritium:  $^3\text{H}$  or T

Half-life 12.33 years

Emits  $\beta^-$  particles with a maximum energy of 18.57 keV

Produced by

- a) Nuclear reactions caused by cosmic rays
- b) Nuclear bomb tests
- c) Nuclear facilities

# Tritium in the environment (I)

“Natural” tritium inventory: about 1.3 EBq (E [exa] =  $10^{18}$ )

Production by processes induced by cosmic rays: 0.07 EBq  $y^{-1}$

Total nuclear bomb tests release between 1952 and 1962: about 200 EBq (now decayed to about 30 EBq)

Total release of nuclear power stations: 0.02 EBq  $y^{-1}$

# Tritium in the environment (II)

Chemical forms of tritium: HTO (water), HT (hydrogen gas) and organically bound tritium (OBT)

Most tritium in the environment is HTO

A relatively small amount is OBT, which has a much higher accumulation factor in marine species (up to  $2 \times 10^4$ ) than HTO (1)

Severn Estuary/Bristol Channel: seawater contains  $\sim 10 \text{ Bq } ^3\text{H kg}^{-1}$ , while some fish may contain up to  $0.2 \text{ MBq } ^3\text{H kg}^{-1}$

# Measurement of OBT in environmental samples

(I) HTO is separated by distillation or freeze-drying of the sample

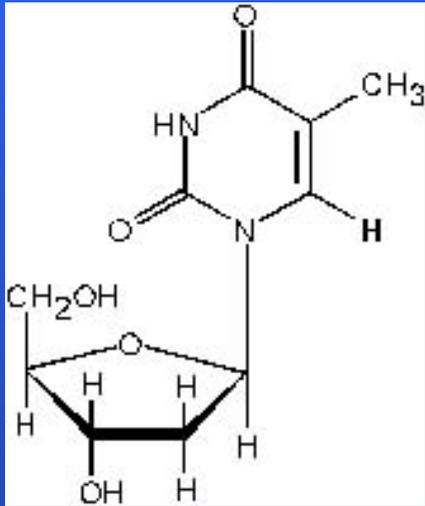
(II) Total tritium (HTO and OBT): sample combustion (Ar/O<sub>2</sub> mixture at 700 °C with CuO catalyst) resulting in HTO

Subsequently, both HTO fractions are measured by liquid scintillation counting (LSC)

OBT is taken to be the difference between (I) and (II)

An OBT standard is needed to validate the combustion procedure

# Choice of OBT standard



## [6-<sup>3</sup>H]-Thymidine

- Relevant (DNA building block)
- Difficult to combust
- Readily available in tritiated form
- Consensus within the user community (?)

# Method of Standardisation for OBT standard

HTO:HT converter  
Proportional Gas Counter

*Primary standardisation*

↓  
HTO standard

↓  
Liquid Scintillation Counter

*Secondary standardisation*

↓  
OBT standard

# The way forward

The OBT standard (e.g., thymidine) will be standardised with liquid scintillation counting

**Internal standard method** Measurement of OBT samples. Subsequently, addition of known amounts of standardised HTO to the OBT samples followed by remeasurement

It is assumed that:

- i) No additional quenching occurs due to the addition of HTO
- ii) Counting efficiency for HTO is identical to that of thymidine

# Instability of OBT (I)

OBT standards may be unstable: (self-)decomposition rates vary between <0.5% per year and 10% per month (all under recommended storage conditions).

Formation of OBT fragments or HTO

(Self-)decomposition of OBT may be caused by:

- Natural decay of tritium
- Direct interaction of the emitted particles (electrons) with molecules of OBT that surround the decaying atom
- Free (hydroxyl) radicals created by radiation
- Chemical or microbiological effects

# Instability of OBT (II)

The rate of (self-)decomposition for a specific form of OBT is related to:

- Number of tritium atoms in a molecule
- Specific activity
- Type of solution (EtOH is a common radical scavenger)
- Storage temperature

Knowledge of the purity (at the moment of use by the customer) is a necessary condition for a meaningful OBT standard

# Separation of OBT and HTO

Separation of OBT (e.g., thymidine) and HTO

- Distillation
- Liquid chromatography
- Paper chromatography
- Thin-layer chromatography

Destruction of OBT

- Combustion
- Chemically [Ag(I)/Ag(II) system or chromic acid]

# Summary

OBT shows in general a much higher accumulation factor in biota (e.g., fish) than HTO

An OBT standard is needed to validate the analytical procedure (i.e., combustion) for environmental OBT

The way forward: secondary standardisation of OBT with LSC using HTO which is standardised by a primary method

OBT standards may be instable (self-decomposition). Knowledge of the purity is a necessary condition for a useful standard