Ultra Low Level Tritium Analysis Method Using a Liquid Scintillation Counter

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1. Introduction

About 600 kg Tritium (^{3}H also written as T) has been generated in the atmosphere from 1952 to 1962 due the nuclear tests performed during the same period[1]. In 1963, ^{3}H content in the rainwater reached 10,000TU (Tritium Unit). However the Nuclear Test Ban Treaty reduced the ^{3}H content in the atmosphere greatly, to the environmental level currently. ^{3}H generated artificially (e.g. ^{3}H from nuclear facilities) will be finally distributed on a global scale[2]. However it will be first distributed in the working environment and local environment, thus it is essential to consider the radiation exposure for the foregoing reason. The dependency on nuclear power is increasing worldwide and the amount of ^{3}H to handle is increasing due to the operation of heavy water reactor and nuclear reprocessing facilities. Moreover the commercialization of fusion reactor will cause the amount of ^{3}H discharged into the atmosphere to increase.

Liquid Scintillation Counter is the most widely used to analyze ultra-low level ^{3}H by using CPM / DPM Counting Mode using external radiation source and Spectrum Plot Mode using internal radiation source. In CPM / DPM Counting Mode, multiple samples can be measured by single calibration despite its rather higher background whereas Spectrum Plot Mode requires more time and cost to analyze multiple samples despite its reliability to reduce the contribution of other radionuclides.

Thus this study was conducted with the aim to suggest a standardized analytical method for the ^{3}H in the atmosphere using a liquid scintillation counter, thereby producing more reliable measurement results.

2. Methods and Results

2.1 Liquid scintillation counter Quantulus 1220

A low level liquid scintillation system Quantulus 1220 (Wallac, Turku, Finland) was used[3]. The detector background is reduced by means of a passive shield (made of lead, cadmium and copper) and an active shield (based on mineral oil scintillate) around the vial chamber. Low activity materials are used in its construction. The system is provided with two pulse analysis circuits that are accessible to the user: a pulse shape analysis (PSA) and a pulse amplitude comparator (PAC) circuit. In order to correct for chemiluminescence, Quantulus 1220 is provided with a delayed coincidence circuit (DCOS). Delayed coincidence pulses are routed to a multi-channel analyzer (MCA), and stored as chemiluminescence spectrum. The rest of the pulses are routed to a second MCA, and stored as the tritium spectrum. The tritium window was optimized for each measurement in function of the recorded background and type of scintillation cocktail used. The range was between 10 and 190 channels[4]. Quenching was observed with the standard quenching parameter, SQP(E), which was used to compare unknown, references and background samples. In the SQP(E) technique the channel number which is the end point of spectral distribution (external standard for Quantulus is ^{152}Eu) indicates degree of quenching[5].

2.2 LSC calibration

To calibrate the liquid scintillation counter, both CPM / DPM counting mode and Spectrum plot mode. In CPM / DPM counting mode, external radiation source is used to calibrate extinction level whereas Spectrum plot mode is used to analyze the spectrum of external radiation source.

To determine the extinction level of specimens, SQP (E) values were calculated using external gamma rays and to increase the reliability and accuracy in the analysis of specimens, the correlation with the activity concentration values obtained in the optimal FM region through spectrum analysis in Spectrum plot mode was used.

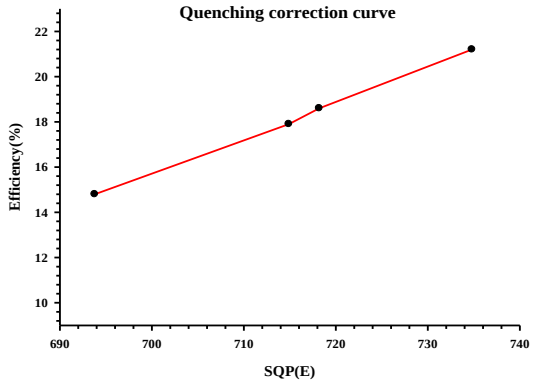

Fig. 1. Efficiency dependence of SQP(E) paramete

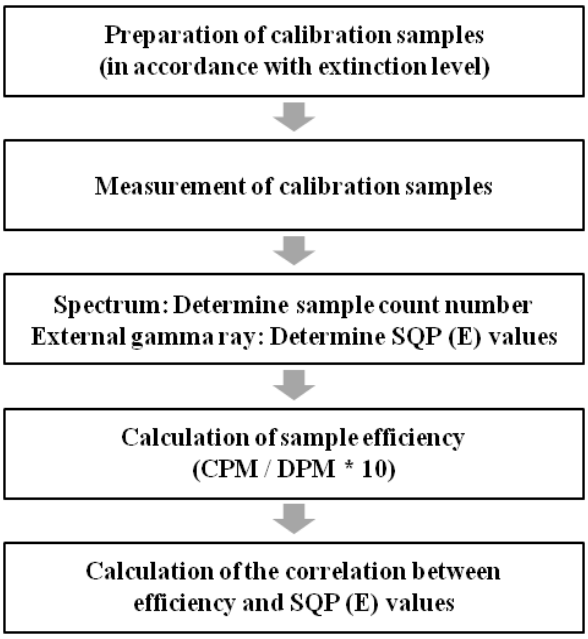

Fig. 2. Flow chart of LSC calibration.

2.3 Sample analysis

^{3}H concentration was evaluated by setting 51 ~ 150 channel as effective channel. To evaluate the state of samples, the consistency in count values was determined by setting 201 ~ 1,024 channel as reference channel. In the event of the inconsistent count in 201 ~ 1,024 channel, i.e. deviation from normal level, it was deemed there were problems during preprocessing or measurement, thus the problems were analyzed and re-evaluation was performed.

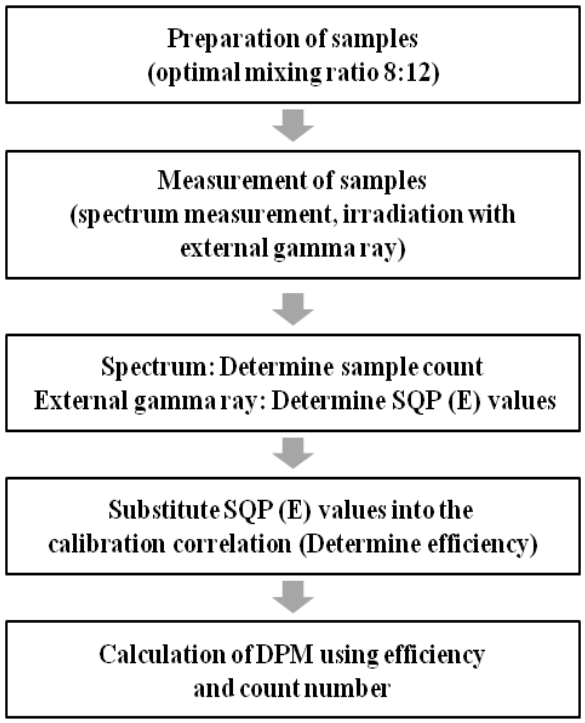

Fig. 3. Flow chart of sample analysis.

3. Conclusions

To evaluate ^{3}H concentration in the atmosphere more accurately compared to the conventional methods, the author of this paper intended to suggest more improved analytical methods and derived the elements which might occur during analysis or required improvements.

The method suggested in this study is able to reduce the uncertainty and errors which may be existent in evaluating the ^{3}H concentration of environmental sample s and thus will serve as the best solution in the technical and economic point of view.

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