Rapid Determination of ^{90}Strontium in Water Using Empore™ Strontium Disk

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Application Note
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Abstract
This application note establishes a rapid analysis method for ^{90}Strontiumin water in emergency situations. The 1.00 L water sample was acidified and filtered with Empore™ Strontium solid-phase extraction disk, and then measured 90Strontium levels on the extraction disk with a low-background α/β counter. The method is simple to operate with stable chemical recovery rates. The lower detection limit of the method is 0.019 Bq/L under typical conditions, and the whole experimental process takes about 2 hours, which is suitable for the rapid determination of ^{90}Strontiumin water in emergency situations.

Introduction
^{90}Strontium is an artificial pure β radionuclide. Its maximum β decay energy is 545.9 keV and its half-life is 28.8 years. It is one of the nuclides that need to be paid attention to in natural water. At present, many laboratories use Extraction Chromatography to analyze 90Strontiumin water samples, but this method is cumbersome to operate and has a long analysis period. It takes an average of 2-3 days for each water sample, which is not conducive to rapid determination of ^{90}Strontiumin water samples in emergency situations.

Empore™ Strontium solid-phase extraction disk is made of Strontium-specific sorbent embedded in polytetrafluoroethylene fiber web to make a thin disk with a diameter of 47mm, which can be directly put into a low-background α/β counter for measurement [1-3]. In this experiment, after the water sample passes through the Empore™ Strontium SPE disk, the 90Strontium adsorbed on the disk is directly measured with a low background α/β counter. Compared with the traditional analysis method of 90Strontiumin water, the operation of the current method is simpler with shorter detection time and stable chemical recovery rate. It is suitable for the rapid determination of 90Strontiumin water samples in emergency situations.

Experiment Setup

1.1 Reagents and instruments
^{90}Strontiumstandard solution 87.0 Bq/g; Strontium carrier solution 2.00mg-Sr/mL; Strontium SPE disk, Empore™ (SKU: 98-0405-0064-1, CDS Analytical, Oxford, PA, USA); Nitric acid, analytically pure. MPC-9604 low-background α/β counter, (ORTEC, USA).alyzed using Evolved Gas Analysis (EGA) as an initial screening step. Using the information from this step, multi-step pyrolysis was followed. Then, a reproducibility study was also performed on the P brand packaging at a setpoint of 400°C.

1.2 Experimental method
Take 1.00 L water sample, add 150 mL of 65% nitric acid solution and 1.00 mL of 2.00 mg/mL Strontium carrier solution, and stir for 10 min. In series, 50 mL of 2 mol/L nitric acid solution, the sample solution, 200 mL of 2 mol/L nitric acid solution, and 50 mL of deionized water were flowed through the Empore™ Strontium SPE disk at a speed of 80 mL/min, and the effluent was discarded. Remove the Strontium SPE disk and put it into a low background α/β counter and measure for 60 minutes.

1.3 Result Calculation method

Calculate the activity concentration of 90Strontiumin the water sample according to formula (1)

$$A = \frac{n_s - n_b}{60 \times E \times V} \quad \text{.....(1)}$$

In the formula (1), A is the activity concentration (Bq/L) of ^{90}Strontiumin the water sample; ns is the sample count rate (cpm); nb is the background count rate (cpm); V is the sample volume (L); 60 is the unit conversion factor; E is the total detection efficiency (%) of the instrument, and its measurement method is as follows.

Results and Discussion

2.1 Minimum detectable concentration

The minimum detectable concentration of this method is calculated according to formula (2),

$$MDC = \frac{4.66 \times \sqrt{\frac{n_b}{t_b}}}{60 \times E \times V} \quad \text{.....(2)}$$

In formula (2), MDC is the minimum detectable concentration (Bq/L) of the method; under typical conditions, the background measurement time tb is 60 min, the background count rate n_b is 0.65 cpm, the sample volume V is 1.00 L, and the total detection efficiency E is 42.1%. After calculation, the minimum detectable concentration of this method is 0.019 Bq/L.

2.2 Real sample analysis

After being verified for the performances, this method was used to analyze two groups of water samples as a laboratory comparison, and the measurement results are shown in Table 1.

Table 1 Sample measurement results

Sample	Total detection efficiency E (%)	Measured value of ^{90}Strontium (Bq/L)	Standard value of ^{90}Strontium (Bq/L)	Relative deviation (%)
A	42.1	27.36	24.84	4.8
B	42.1	7.42	8.29	5.5

From Table 1, the relative deviations of ^{90}Strontiummeasurement results are all less than 10%. This method can be used for the analysis of ^{90}Strontiumin in water samples in emergency situations.

Conclusion

In this application note, a rapid analysis method for ^{90}Strontiumin in water under emergency conditions was established. After 1.00 L water sample passed through the Strontium SPE disk, the 90Strontiumin on the disk was directly measured with a low background α/β counter. The method has a stable chemical recovery rate, and the product of the recovery rate and the detection efficiency of the instrument can be used as the total detection efficiency. This method realizes the rapid analysis of ^{90}Strontiumin in water under emergency conditions, and it has a good application potential.

References

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