§6. Performance Evaluation of the Analyzer Developed for Detection of Dideuterium in Pure Diprotium

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An analyzer able to detect extremely small concentrations of dideuterium in diprotium gas was developed previous year. The developed analyzer is shown in Fig.1 and consisted of two components, a gas chromatograph and an atomic absorption spectrophotometer. The gas chromatograph is distinctive in the installation of two gas line switches, which are used for removing impurities and protium molecules contained in a sample gas. Last year, performance of the developed analyzer was examined using four gas samples containing different concentrations of dideuterium in pure diprotium.

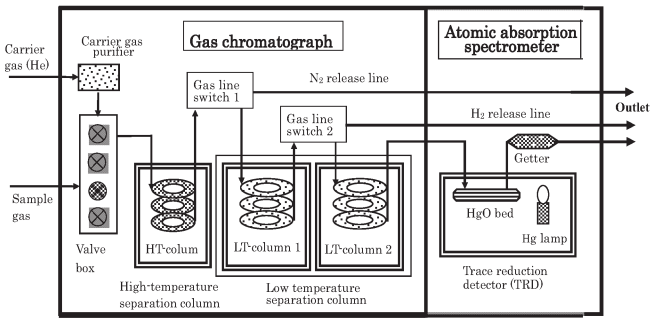

Fig. 1 Configuration of developed analyzer composed of a gas chromatograph and atomic absorption spectrophotometer.

The test gas samples were prepared in a commercially available tetra-gasbag (an aluminum-lined gasbag, 3000 cm^3 in volume) by diluting a commercially available standard gas of a known dideuterium concentration (100 cm^3/m^3) in nitrogen balance gas with diprotium gas. The purity of dideuterium used for a 100 cm^3/m^3 dideuterium standard gas was greater than 99.5%. The prepared gas samples with dideuterium concentrations of 0.25, 0.5, 1, and 5 cm^3/m^3 in almost 100% diprotium were loaded from the tetra-gasbag directly into the analyzer through its sample inlet. In the experiment, a chromatogram of pure diprotium gas was also measured and subtracted from each of the sample chromatograms so as to obtain dideuterium retention times and peak areas.

In Fig. 2, the peaks and retention times in the chromatograms obtained for individual gas samples are shown from left to right along the x-axis in the order the measurements were performed. The y-axis represents signal intensity and retention time on the left and right sides, respectively. The dideuterium concentrations of the individual samples are denoted by square symbols in the upper part of Fig. 2. Results for samples of the same concentration are indicated using solid lines, for different signal intensities and retention times.

The retention time of the peak corresponding to dideuterium is given in minutes in the chromatograms. As shown by solid circles in Fig. 2, all retention time data for the four gas samples are distributed along a horizontal line, and are virtually indistinguishable, independent of concentration and repetition time. The average retention times (and relative standard deviations) were 53.6 min (0.17%), 53.3 min (0.69%), 52.6 min (0.42%), and 52.8 min (0.17%) for gas samples with dideuterium concentrations of 0.5, 0.25, 5, and 1 cm^3/m^3, respectively.

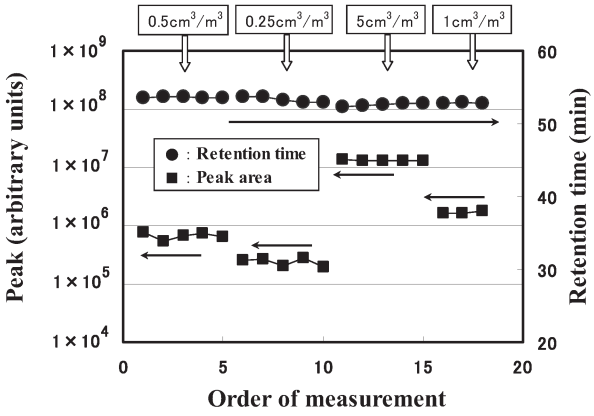

Fig.2 Retention times and peak areas of dideuterium obtained from chromatograms measured for gas samples containing four infinitesimal concentrations of dideuterium in pure diprotium.

The changes in the peak areas obtained for the four gas samples are also shown using solid squares in Fig. 2. The peak areas on average were 6.77×10^5, 2.39×10^5, 1.32×10^7, and 1.68×10^6 for dideuterium at 0.5, 0.25, 1.0, and 5.0 cm^3/m^3, respectively, with relative standard deviations of 13.1, 15.3, 1.2, and 5.8%. It seems reasonable that the standard deviation increases as concentration decreases.

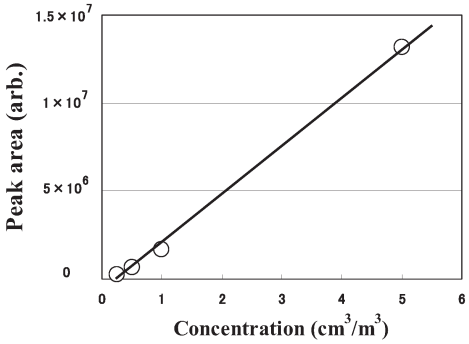

Fig.3 Linear relationship between peak area and concentration.

The average peak areas plotted in Fig. 3 confirm a linear relation between signal intensity and concentration, being concluded that the analyzer can detect a dideuterium concentration of approximately 0.25 cm^3/m^3 in pure diprotium.