Chromatographic Separation of Hydrogen Isotopes in Helium Gas Using Combination of GC & QMS

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1. Introduction

Analysis of hydrogen isotopes is of importance to comprehend the hydrogen nuclear fusion reaction step. Cryogenic gas chromatography (GC) is used in analysis hydrogen isotopes as one of the well-known methods [1-3]. However, the cryogenic analysis using a micro GC has not only disadvantage due to a long time retention [1,2], but very complex in actual application [3]. Near room temperature GC or QMS (quadruple mass spectrometer) has been applied in hydrogen isotope separation system [4,5]. By combining two independent strengths with GC and QMS, the three component gas mixture with hydrogen isotopes (H_2 and D_2) in helium was analyzed in this study. It is expected to complement the cryogenic micro GC that has a long time analysis.

2. Methods and Results

2.1 Gas Chromatography (GC) Study

Agilent 7890A GC was used to analyze the hydrogen isotopes mixture system. Packed column with Molecular Sieve 5A was successively applied to separate the helium gas from H_2, D_2 gas mixture. All experimental gases were 99.999% purities as standards which were utilized to make calibration curves for the separation condition in room temperature GC analysis. Oven temperature was about 300K and the TCD detector was used. Other GC operation conditions were listed in Table I. The whole retention time in GC operation was approximately 30min. For the QMS analysis binary gas mixtures of hydrogen isotopes that have different concentrations were used.

Table I: Condition and Specification related in GC

Condition	Specification
Sample gas	H_2 mixture gas balanced with He
Other gas	D_2 gas (all gases: 99.999%)
Carrier gas	N_2, 30 psi, 26 ml/min
Column	Packed column MS-5A, 80/100, 24ft, ID 2.0mm, 1/8 in., Temperature 300K
Detector	TCD

2.2 Modified Quadruple Mass Spectrometer Study

Modified QMS has a very high mass resolution and shows compactness features in this study. This QMS distinguishes the mass of He, H_2 and D_2 well, respectively. The sample gas is ionized by the electron impact method in a molecular chamber. Fig. 1 shows the modified QMS procedure.

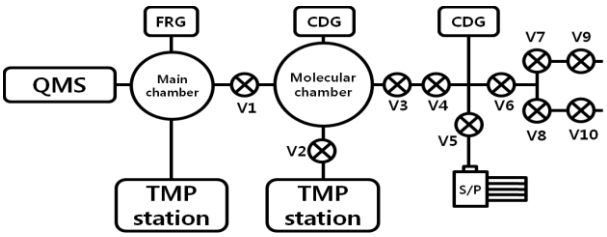

Fig. 1. Schematic drawing for the modified QMS system.

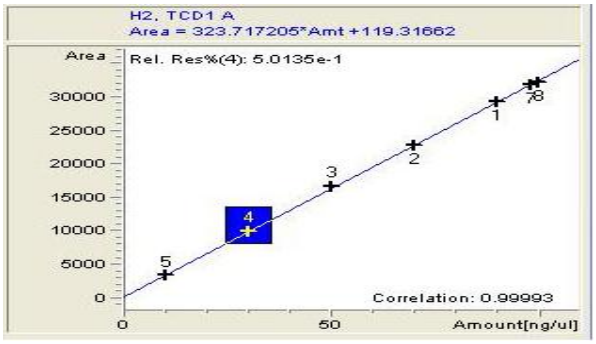

Fig. 2. GC calibration curve for H_2 gas.

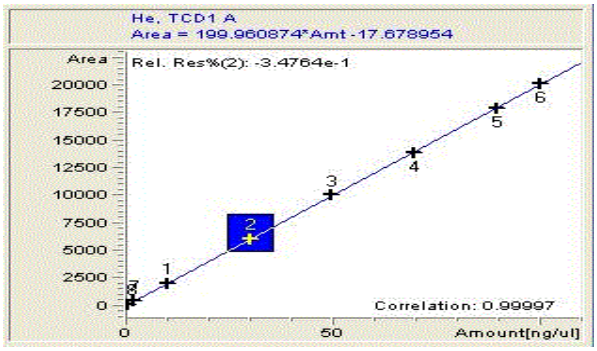

Fig. 3. GC calibration curve for He gas.

Fig. 2 and Fig. 3 show the calibration curves in GC analysis having a correlation of 0.99997 for H_2 and He, respectively. In the mixture analysis of hydrogen isotopes was not available in this GC condition.

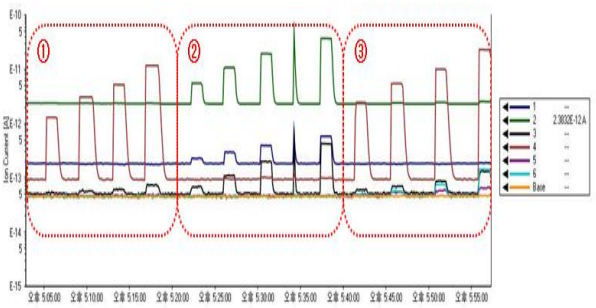

Fig. 4. QMS Mass measure (He, H_2, D_2).

Fig. 4 shows ① Mass data: a measure of He (main peak of mass 4 and additional peak of mass 3) ② Mass data: a measure of H_2 (main peak of mass 2 and additional peak of mass 1, 3) ③ Mass data: a measure of D_2 (main peak of mass 4 and additional peak of mass 3, 4, 5, 6) with QMS.

In a complex hydrogen isotope gas mixture including helium gas was interfered each other for both of GC and QMS.

3. Conclusions

Two independent strong analyzing systems, by combining GC and QMS in series, were applied to separate the complex gas mixture of hydrogen isotopes in helium gas. Each analyzing device is imperfect to separate this complex gas mixture in near room temperature analyzing condition. The possibility of near room temperature–chromatographic separation using a combination of GC and QMS will be introduced.

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