Quantitative Analysis of Beer Aroma Using Ball SAW Gas Chromatograph

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1. Introduction

On-site analysis of many kinds of volatile organic compounds (VOC) has various needs. For example, monitoring of the work environment by combining robotics and sensors and quality control by analyzing odorants in food production and distribution.

A gas chromatograph (GC) is effective for analyzing many kinds of gases, but GC is large and difficult to apply in the field. In contrast, we have developed a portable ball surface acoustic waves (SAW) GC using a ball SAW sensor [1], which uses SAWs orbiting the surface of a sphere in multiple turns [2-4].

In this study, we report the development of a palm sized ball SAW GC and the analysis of odorants of beer.

2. Palm sized Ball SAW GC with

A schematic diagram of the ball SAW GC is shown in Fig. 1. The sample gas is drawn by a pump and collected in the preconcentrator. Then, by switching the valve to rapidly increase the temperature of the pre-concentrator tube by resistive heater, the collected components are instantly heated and desorbed, and the hydrogen carrier gas flows introduced into the separation column in a backflush. Each component is separated in time by the difference in adsorption on the stationary phase coated on the inner surface of the column, and adsorbed on the sensitive film deposited on the ball SAW sensor, which is detected as SAW delay time change and amplitude change.

The palm-sized ball SAW GC fabricated in this study is shown in Fig. 2. This system is equipped with a hydrogen canister for gas supply, a pressure regulator, the preconcentrator, the column, the ball SAW sensor, the valve manifold, the ball SAW drive circuit, and a valve drive and heater circuit, and can be connected to a PC via USB for control and analysis.

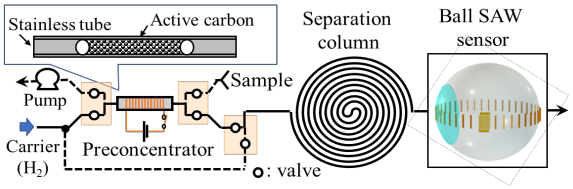

Fig. 1 Schematic diagram of a ball SAW GC with pre concentrator.

The preconcentrator was a stainless-steel pipe with an outer diameter of 1.61 mm and a wall thickness of 0.18 mm, packed with approximately 2 mg of Tenax TA as the adsorbent, and wrapped around the periphery with nichrome wire for resistive heating. The column was a metal capillary, 30 m long Ultra-Alloy®, coated with polyethylene glycol (PEG) as the stationary phase, and wound in a solenoid shape.

Fig. 2 A palm sized ball SAW gas chromatograph

3. Experiment

We used the palm-sized ball SAW GC to analyze the headspace gas of sake. The samples of sake were placed in a vial and the headspace gas was collected in the preconcentrator at 16 ml/min for 2 min. The temperature profile of the Wax column was maintained at 40 °C for 5 min and then the temperature was raised to 140 °C at 10 °C/min using a sheet heater in the column unit. Samples were prepared from different brands of Beer A, B, C.

4. Result and discussion

Figure 3 shows the chromatograms obtained

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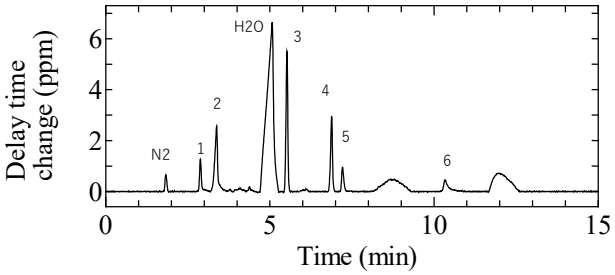

Fig. 3 Chromatograms obtained by analysis of Beer.

from the analysis of Beer A . The components of each peak were identified as 1: ethyl acetate, 2: ethanol, 3: isoamyl acetate, 4: isoamyl alcohol, 5: ethyl caproate, and 6.

Since beer is a sparkling, the concentration of aroma components in the headspace changes with time after opening the bottle. Fig. 4 shows a chromatogram of beer A measured eight times in, showing that the isoamyl acetate peak at 5.5 minutes decreased with each measurement.

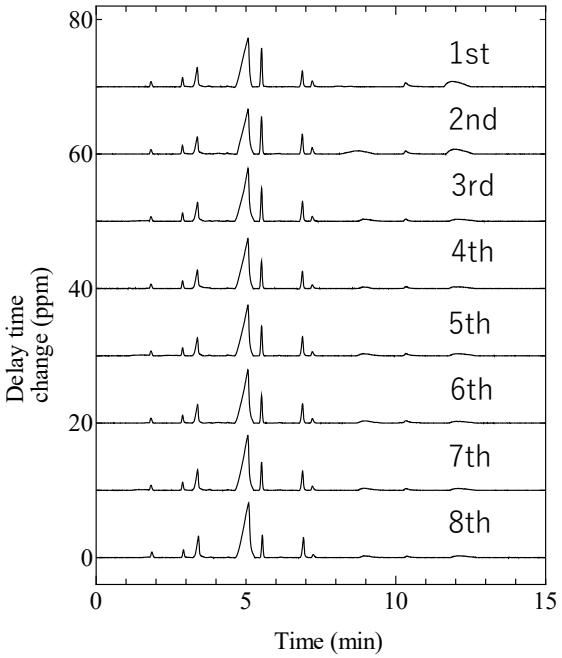

Fig. 4 Peak area of aroma components of each brand

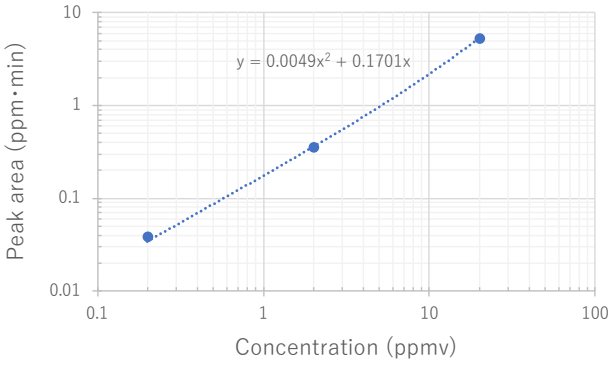

Fig. 5 Concentration dependence of peak area in isoamyl acetate

Next, to quantify the headspace concentration of isoamyl acetate, dilution system gas bags were prepared for concentrations of 20 ppmv, 2 ppmv, and 0.2 ppmv, and the concentration dependence of the peak area when collected under the same conditions is shown in Fig. 5. The variation of the concentration of isoamyl acetate in beer A, B, and C over time is shown in Fig. 6.

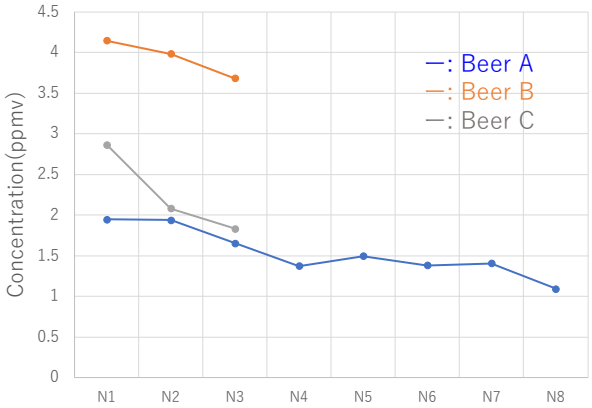

Fig. 6 Changes in concentration of isoamyl acetate in beer A, B, and C over time

Figure 5 shows the calibration curve for isoamyl acetate, and Fig. 6 shows the change over time in the concentration of isoamyl acetate in beer A, B, and C.

Concentrations of isoamyl acetate in the three beers decreased with time. The headspace concentration of isoamyl acetate in beer B exceeded 4 ppmv. The higher concentration of isoamyl acetate in the beer B was due to its longer aging time, which is indicative of the design of each beer.

5. Conclusion

A palm-sized ball SAW GC was developed and used for the concentration and quantification of headspace gases in beer. The behavior of the peak area of aroma components decreasing with time was observed. This size GC is expected to be applicable to quality control of aging in the brewing process and temporal design of aroma components, and such highly sensitive analysis is expected to be useful for the brewing industry in general.

References

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