Application Note

No. 080AT0189-E

Evaluation of Alcoholic Content of Liquors using ATR Accessory

Introduction

The alcohol content of alcoholic drink is an indication of the drinks' ethanol concentration as measured in percent ethanol per 100 mL. This concentration is determined by the manufacturing method and its processes. Alcoholic drinks can be broadly classified into distilled and fermented liquors. Distilled liquors, typical examples of which are whisky, brandy, and shochu, are produced by distilling of fermented liquors, so they generally have a higher alcohol content than the fermented liquors. On the other hand, the alcohol content of fermented liquors such as wine, beer and sake can be varied by the degree of fermentation of sugar by yeast. It also can be varied by material and maturation. Alcohol content is an extremely important numeric indicator for both manufacturers of liquors and their consumers. It can be easily measured and quantitated by using a Fourier Transform Infrared Spectrometer and an ATR accessory. This measurement method can be applied to both distilled and fermented liquors.

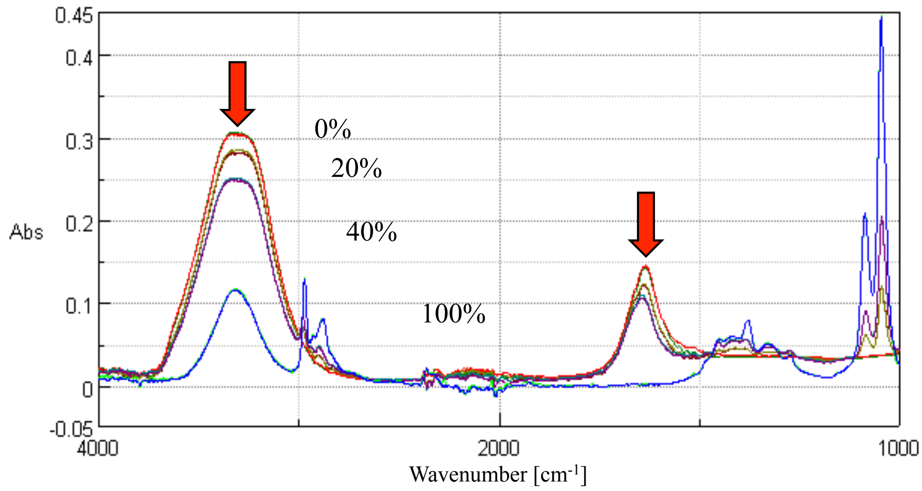

Fig. 1 Spectra of Ethanol solution

Experimental

The ATR accessory ATR PRO410-S was placed in the sample compartment of FT/IR-4100 Fourier Transform Infrared Spectrometer. A liquid sample was dropped in the ATR prism, and then measured directly. To prevent the decrease of the accuracy due to the vaporization of ethanol, accumulation of the measurement was set at 16 to 32 times, and the measurement time was shortened, so that the measurement conditions were so configured to avoid any possible errors.

An ethanol solution (prepared to concentrations 0 to 100%) and off-the-shelf liquors were used as standard samples. The alcohol contents listed on the label of the off-the-shelf liquors were assumed to be their ethanol concentrations. The calibration curves were created in the range of 3400 cm^{-1} attributed to OH stretching vibration, and 1650 cm^{-1}, HOH bending vibration. Photo 1 shows the ATR accessory with a diamond prism. Figure 1 shows the spectra of ethanol (0, 20, 40 and 100%). Each one was measured twice.

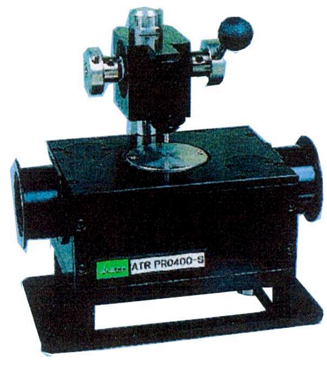

Photo 1 ATR PRO410-S

Conditions

Standard Sample:	Ethanol solution (0 ,10, 20, 30, 40, 50, 100 %)
Accumulation :	32
Resolution :	8 cm^{-1}
Apodization:	Cosine
ATR prism:	Diamond

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Calibration curve

Although it would be possible to create a calibration curve from the peak heights of 3400 cm^{-1} (OH stretching) and 1650 cm^{-1} (HOH bending), in this application data, a calibration curve was created using a multivariate analysis technique (PCR) in the specified wavenumber range. The calculation range of 3740 to 3014 cm^{-1} and 1800 to 933 cm^{-1} were used, while the first derivative data were utilized as spectral data. Fig. 2 shows the calibration model created. This calibration model indicates an extremely good value of correlation coefficient R=0.999.

Measurement Results

Table 1 shows the results of quantitation of 17 types of off-the-shelf liquors using the calibration model. For reference, the values listed on their labels are also provided. Fig. 3 shows the example of ATR spectra for a number of those liquors.

Table 1 Results of quantitative measurement

Liquors	Alcoholic content on labels	PCR calibration model
Beer A	5.0	5.1
Beer B	5.0	5.0
Low-malt beer A	5.5	5.6
Low-malt beer B	5.5	5.3
Fluit liquor	6.0	6.0
Highball	7.0	7.3
Cider	8.0	8.5
Red wine A	14.0	13.4
Red wine B	14.0	12.0
Sake A	15.0	15.8
Sake B	15.0	15.1
Spirits (Sweet potato)	10.0	10.3
Spirits	25.0	25.4
Spirits (Sugarcane)	25.0	22.4
Wisky	39.0	38.5
Brandy	39.0	38.8

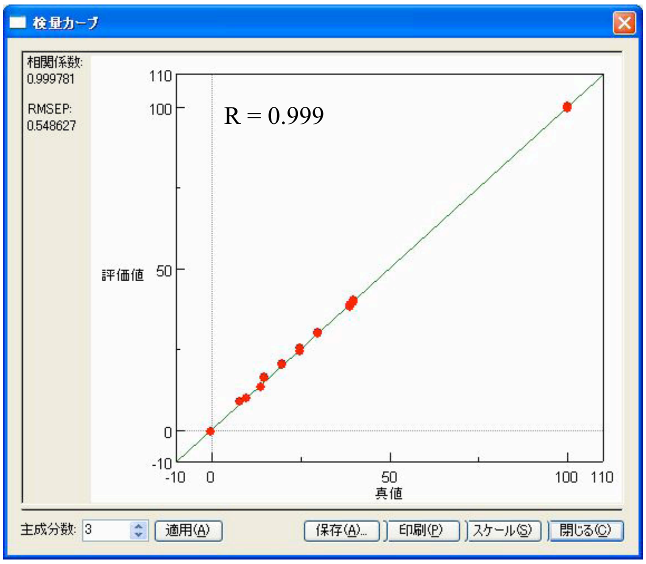

Fig. 2 PCR Calibration curve

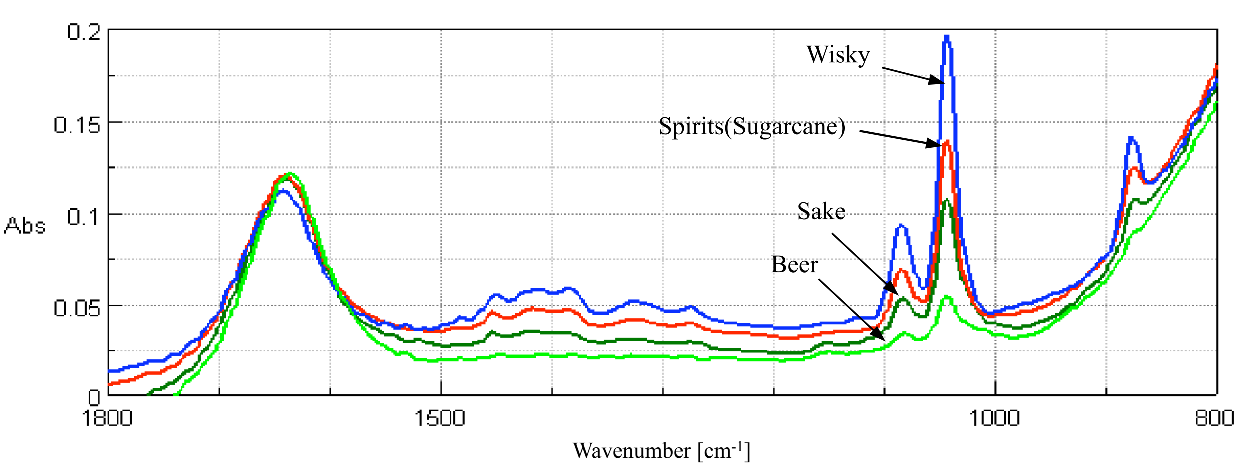

Fig. 3 ATR Spectra of Liquors