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Application News

Gas Chromatograph Nexis™ GC-2030
Fourier Transform Infrared Spectrophotometer IRXross™
Transportable Gas Analyzer CGT-7100

Comparison of Gas Analyzers for Catalyst Reaction and Gas Emission Analysis

Karen Maruyama, Yu Nagao, Atsuko Senda, Kanno Natsuko, Emiko Shimbo, Kei Usui

User Benefits

- ◆ By selecting analytical instruments according to your measurement objectives, you can optimize your gas analysis workflow.
- ◆ CGT allows for online long-term measurements, while FTIR enables short-term continuous measurements and qualitative analysis using a library.
- ◆ GC offers highly accurate quantitative analysis by choosing appropriate columns and detectors.

■ Introduction

In recent years, as part of efforts to achieve carbon neutrality, research on gas synthesis using CO_2 has been actively conducted. For energy-efficient gas synthesis, the selection of novel reaction systems using catalysts is crucial. Qualitative and quantitative analysis of gases generated in catalytic reaction systems serves as an important indicator for evaluating these systems.

In this paper, three types of instruments capable of quantitative and qualitative gas analysis were used to measure standard gases, including H_2, CO, CO_2, and CH_4, which are often the targets in catalytic reactions using CO_2. The instruments used were a gas chromatograph (GC), a Fourier transform infrared spectrophotometer (FTIR), and a transportable gas analyzer (CGT). The characteristics of each model are introduced along with the measurement results of the standard gases.

■ Feature of Each Instrument

The appearance and features of each instrument are shown in Table 1.

The GC separates the components to be measured using columns and measures the quantity of each compound with detectors. Due to the separation of components, a single measurement takes time, limiting continuous measurements. However, it offers high quantitative accuracy. Standard gases are necessary for qualitative analysis, and identification is performed based on the column elution time of each component. Carrier gas is required for measurements, and various piping connections are needed during installation.

The FTIR irradiates the sample with mid-infrared light and detects the degree of light absorption for qualitative and quantitative analysis. Since components are not separated, its quantitative accuracy is inferior to that of GC. However, qualitative analysis of gas components is possible using commercially available libraries. Additionally, its response time is about one second, allowing for short measurement times. Depending on the type and concentration of gas components, the peaks of interest may overlap with water vapor or CO_2 in the atmosphere, necessitating the purging of the optical system and sample compartment with N_2 gas or dry air.

The CGT employs a non-dispersive infrared absorption method. It can measure only CO, CO_2, CH_4, and optionally O_2, but it specializes in continuous measurement, enabling long-term real-time monitoring of emitted gases. It also has built-in preprocessing equipment such as a pump, filter, and electronic cooler, allowing direct measurement by simply introducing gas at the inlet, even if the gas contains dust or moisture.

Table 1 Appearance and feature comparison of each gas measuring instrument

	GC	FTIR	CGT
			
	Nexis™ GC-2030	IRXross™	CGT-7100
Quantitative	✓✓	✓	✓
Qualitative	✓ Requires standard gases	✓✓ Qualitative analysis using libraries	- Monitors specific components only
Standard gases for quantitative analysis	Necessary	Necessary	Not necessary *1
Zero point gas	Not necessary	Necessary *2	Not necessary *3
Responsiveness Time from installation to detection	- Depends on separation measurement time	✓✓ 1 s ~	✓ ~ 3 min *5
Automatically Retrievable Time	Possible with automated valve GC systems	~ 48 H *6	~ 8 H
Measurement Interval	- Several minutes ~ *4	✓✓ 1 s ~ *7	✓✓ 1 s ~
Advantages	High quantitative accuracy for many compounds	Good responsiveness Qualitative analysis of various gases	Built-in Preprocessing Equipment (Dust removal, Moisture removal, Gas suction)

*1 Span gas required for range calibration.
*2 Required if the absorption position of the target component overlaps with atmospheric components.
*3 N_2 gas required for range calibration.
*4 Dependent on separation measurement time.
*5 Switchable at 15/30/60s with standard flow rate.
*6 Can be set up to a maximum of 48 hours, but background measurement may be necessary depending on the gas components.
*7 In rapid scan system, measurement is possible at a speed of 1/20 second.

■ Measurement by GC

The configuration of measuring H_2, CO, CH_4, and CO_2 by GC, along with an example of detailed analysis conditions, is shown in Table 2. The Thermal Conductivity Detector (TCD) is suitable for measuring high concentration samples as it can detect all components except the carrier gas. Since measurement sensitivity varies based on the thermal conductivity difference between the carrier gas and the target components, He or H_2 is used as the carrier gas for measuring CO, CH_4, and CO_2, while N_2 or Ar is used for measuring H_2. The gas sampler MGS-2030 is used for introducing mixed gases, allowing for the stable introduction of a fixed amount of gas. A 1000 ppm or 1% mixed standard gas is connected to the MGS-2030, and the resulting chromatogram and the relative standard deviation of the area values from three consecutive measurements are shown in Fig.1 and Table 3. In GC, since peaks are separated and measured, the influence of other contained components is minimal, allowing for accurate measurements.

Table 2 GC Configuration and Analysis Conditions

Model	: Nexis GC-2030＋MGS-2030 (Loop Vol. 1 mL)	
Detector	: TCD	
	CO, CO_2, CH_4	H_2
Inj. Mode	: Split 10	Split 5
Inj. Temp.	: 100 ℃	150 ℃
Carrier Gas	: He	①N_2 ②Ar
Flow mode	: Column Flow(4 mL/min)	Column Flow(3 mL/min)
Purge Gas	: 3.0 mL/min	3.0 mL/min
Column	: MicroPacked-ST (2 m×1 mm)	SH-Msieve 5A (30 m×0.53 mm I.D., 50 µm) P/N: 221-75763-30
Oven Temp.	: 35 ℃(3 min)→15 ℃/min →150 ℃(2 min)	①35 ℃(3 min) ②35 ℃(3 min) →30 ℃/min→100 ℃
Det. Temp.	: 150 ℃	100 ℃
TCD Current	: 80 mA	①40 mA ②30 mA
Makeup Gas	: 8.0 mL/min	4.0 mL/min

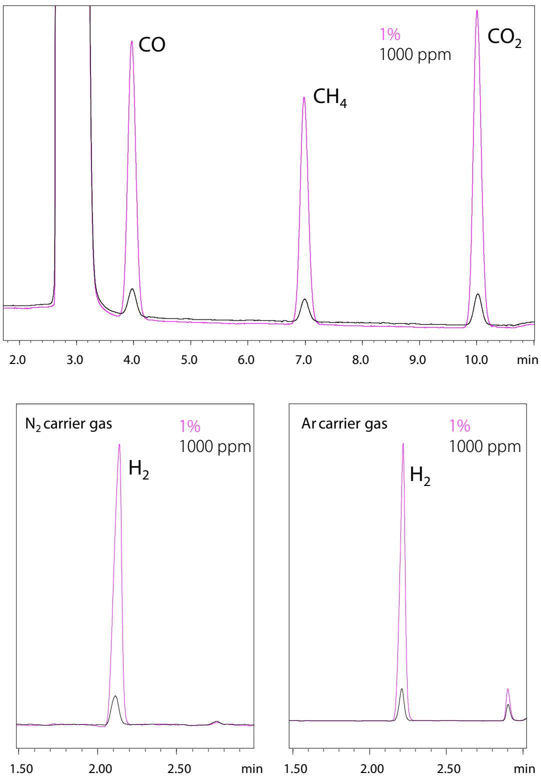

Fig. 1 GC Chromatogram - 1000 ppm, 1% in N_2
Top: CO, CO_2, CH_4, Bottom: H_2
*Carrier gas: N_2 (left), Ar (right)

Table 3 Average Area Values and Relative Standard Deviation (RSD%) for Three Consecutive Measurements

	1000 ppm	1%
H_2(Carrier gas N_2)	61619 (1.2)	600725 (0.30)
H_2(Carrier gas Ar)	59567 (0.41)	575596 (0.19)
CO	21239 (1.3)	231129 (0.060)
CH_4	18518 (1.5)	191934 (0.085)
CO_2	25292 (0.52)	262342 (0.30)

For simultaneous analysis of the target components above, or for the measurement of trace or low concentrations, the more sensitive detector BID is effective (Application News G297). Additionally, if H_2 measurement is not required, analysis using Jetanizer-FID, which can detect CO and CO_2 by converting them to CH_4 through catalytic reduction, is convenient (Application News 01-00599). Since GC can be equipped with multiple detectors in a single unit, it is possible to select and configure the optimal combination according to the concentration and composition of the sample to be measured.

■ Measurement by FTIR

Measurements were conducted using the IRXross and a gas cell with a 10 cm optical path length (during the measurement, the optical system and sample compartment were purged with N_2 gas to eliminate the effects of water vapor and CO_2 in the atmosphere). The background measurement was performed by filling the gas cell with N_2 gas. The measurement conditions are shown in Table 4.

Table 4 FTIR Analysis Conditions

Instruments	: IRXross Gas cell with a 10 cm optical path length (Window : KRS-5)
Resolution	: 1 cm^{-1}
Number of scan	: 30
Apodization function	: SqrTriangle
Detector	: DLATGS

The results of measuring the 1000 ppm mixed standard gas are shown in Fig. 2. In FTIR, the spectrum shape and peak position differ for each gas component. By matching the spectra with those stored in the library, qualitative analysis of gas components can be performed without preparing standard gases. In this measurement, peaks originating from CO, CO_2, and CH_4 were identified.

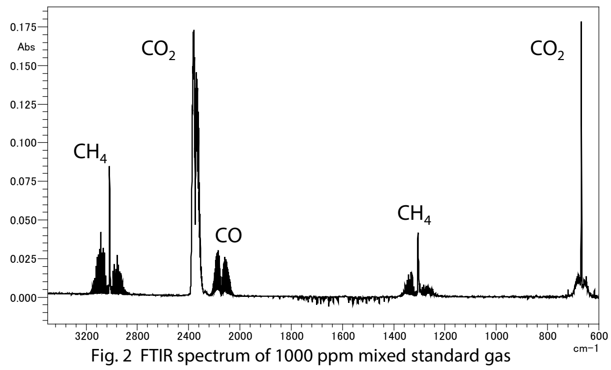

Fig. 2 FTIR spectrum of 1000 ppm mixed standard gas

Next, Fig. 3 shows the overlaid spectra of CH_4 gas at concentrations of 100 ppm and 1000 ppm. In FTIR, according to Beer–Lambert law, the peak intensity of the obtained gas component is proportional to their concentration. Since the peak intensity is also proportional to the optical path length of the gas cell, using a long-path gas cell is effective for analyzing low-concentration gas component. However, due to the insufficient sensitivity of the detector in long-path gas cells, it is necessary to use an MCT detector.

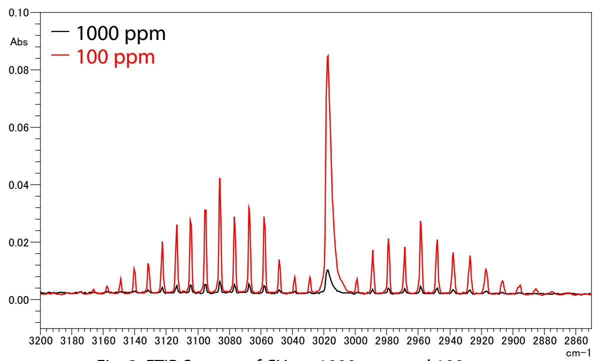

Fig. 3 FTIR Spectra of CH_4 at 1000 ppm and 100 ppm

Measurements with FTIR are very quick, taking only a few seconds to several tens of seconds, and have the advantage of better responsiveness compared to other instruments. However, since they are affected by water vapor and CO_2 present in the atmosphere, it is necessary to purge the optical system and sample compartment with gas to remove these interferences.

■ Measurement by CGT

Measurements were conducted using the transportable gas analyzer CGT-7100 (low flow type). The measurement conditions are shown in Table 5. The 100 ppm gas was measured in the 200 ppm range, and the 1000 ppm gas was measured in the 2000 ppm range.

The results of measuring the 100 ppm and 1000 ppm gases are shown in Fig. 4. After starting the gas flow, the indicated value increased over time and stabilized upon reaching the cylinder gas concentration.

The measurement performance is defined by the range used. Therefore, by selecting the appropriate range according to the application, measurements can be performed with the required performance.

Table 5 CGT Analysis Conditions

Instruments	: CGT-7100 (low flow type)
Measurement Components and Range	: CO 200/2000 ppm、 CH_4 200/2000 ppm
Sampling Flow Rate	: 100 mL/min
Other	: Sample Gas Collection with Built-in Pump

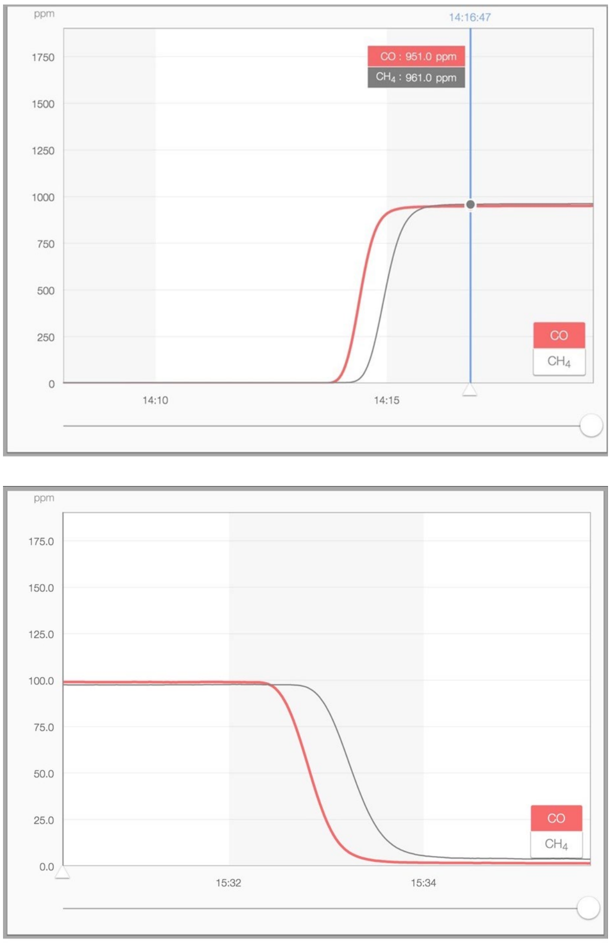

Fig. 4 Real-time Measurement with CGT-7100
1000 ppm (top) and 100 ppm (bottom)

The CGT-7100 is an all-in-one analyzer with built-in sampling, preprocessing, and optical systems for sample gas. If the gas is within the specified conditions, sample gas can be sampled without the need for external pumps or filters.

As shown in Fig. 4, the CGT-7100 allows real-time monitoring of trend data, making it useful for applications that require verification of temporal changes in emitted gases. Additionally, with pre-set background correction and calibration curves, measurements can be taken more easily compared to other devices.

Using the CGT-7100 communication set, the indicated values can be checked on a tablet device. By recording the indicated values on the main unit, data can be retrieved and graphs can be reviewed after the experiment.

■ Conclusion

The measurement results of standard gases and the features of the three types of instruments capable of quantitative and qualitative gas analysis GC, FTIR, and CGT were introduced.

GC separates the components to be measured using a column, which takes longer measurement times but allows for high-precision quantitative analysis with minimal interference from other components. Multiple detectors can be installed on a single GC, allowing for the selection of the optimal detector based on the sample.

FTIR enables quantitative and qualitative analysis within a short measurement time of a few seconds to several tens of seconds. Quantitative analysis requires the creation of a single-point calibration curve using library data that includes concentration information or a calibration curve using standard gases. Qualitative analysis can be performed by matching with commercially available libraries. By changing the optical path length of the gas cell, it is possible to perform quantitative analysis over a wide range of concentrations.

CGT is specialized for real-time monitoring of four gas components: CO, CO_2, CH_4, and O_2 (optional). It has built-in preprocessing equipment, and background correction and calibration curves are pre-set, making it easy to perform measurements.

These three types of instruments with different features support effective analysis of emitted gases.

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01-00725-EN First Edition: Sep. 2024