

Application News

Gas Analysis for CO₂ Conversion Using a GI-30 Auto Gas Injector

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User Benefits

- ◆ Enables quantitative gas analysis for CO₂-derived methanol synthesis and conversion to hydrocarbons.
- ◆ Using GC with INJ2-way branch unit allows simultaneous analysis of CO, methanol, and hydrocarbons.
- ◆ The newly introduced GI-30 automatic gas injector enables automatic and reproducible analysis of gas samples.

Introduction

The catalytic conversion of carbon dioxide (CO₂) to methanol (MeOH) and to hydrocarbons has garnered significant attention as a strategy to realize a sustainable chemical industry. Analytical targets in CO₂ conversion studies typically include carbon monoxide (CO), hydrocarbons, alcohols, and other reaction products. Selection of appropriate column and detector combinations must therefore be guided by the nature and concentrations of target analytes.

In this application news, we demonstrate simultaneous analysis on two parallel columns by using INJ2-way branch unit to permit detection of CO and hydrocarbons together with alcohols such as MeOH. We also present a simplified measurement approach employing a single-column configuration equipped with a thermal conductivity detector (TCD).

System Configuration and Analysis Conditions

Two reaction schemes using CO₂ as feedstock were envisaged: (1) MeOH synthesis and (2) conversion to hydrocarbons. The instrumentation comprised the Auto Gas Injector GI-30 and the SPI inlet, which minimizes air ingress and sample adsorption (Fig. 1).

For the MeOH synthesis application, a Jetanizer™-FID—which permits detection of CO and CO₂ that are not observable by a conventional FID—was employed. A MICROPACKED-ST packed column provides separation of CO from O₂ (ambient contamination); however, higher-boiling hydrocarbons and alcohols such as MeOH are not eluted from this column. To achieve comprehensive analysis, the injector was splitted and an SH-Q-BOND capillary column was used to resolve hydrocarbons and MeOH concurrently. The injection-port splitting is implemented using dedicated hardware ([Application News No. 01-00661-EN](#)).

For the conversion to hydrocarbons scenario, when analytes are permanent gases and C3-or-smaller hydrocarbons, quantitative analysis can be performed with a single MICROPACKED-ST column coupled to a TCD. The TCD responds to differences in thermal conductivity between carrier and analyte gases; measuring low-thermal-conductivity species such as hydrocarbons requires a carrier gas with high thermal conductivity (helium or hydrogen) (Table 1). The GC-2050 TCD uses a single filament design, resulting in rapid baseline stabilization (~10 minutes), which is advantageous for routine operation.

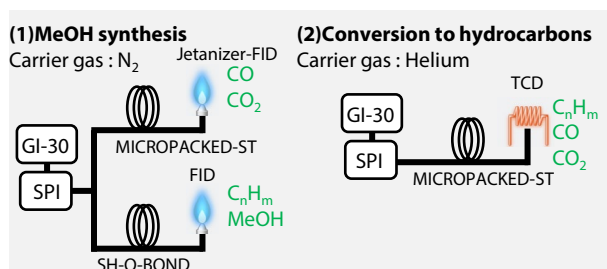


Fig. 1 System configurations

Table 1 Thermal conductivities of typical compounds (10⁻⁶ cal/s · cm · °C)

Helium	: 408	Nitrogen	: 73
Hydrogen	: 547	Ethane	: 77

Sample Preparation

Gas mixtures were prepared in vacuum sampling bottle. Liquid MeOH, *n*-C₅H₁₂, and *n*-C₆H₁₄ were introduced via microsyringe; gaseous components were introduced with gastight syringes into the vacuum sampling bottle. Subsequently, CO₂ collected in a sampling bag was connected to the vacuum sampling bottle and the total pressure adjusted to 1 atm.

Measurement Using INJ2-way branch unit (MeOH synthesis)

INJ2-way branch unit was implemented to enable concurrent quantification of CO, hydrocarbons, and MeOH. Analysis conditions are summarized in Table 2.

Despite its compact footprint (~35 cm width), the Brevis GC-2050 accommodates two conventional columns within the oven, enabling configurations such as injection-port splitting and dual injection. In this study, hydrocarbons and MeOH were analyzed on an SH-Q-BOND capillary column with an FID, while CO was quantified using a MICROPACKED-ST packed column coupled to a Jetanizer-FID.

Table 2 System configuration and analysis conditions

GC Model	: Brevis GC-2050 / GI-30 ^{*1}
Loop Volume	: 1 mL
Injection Port	: SPI
Injection Temp.	: 150 °C
Flow Control Mode	: Constant linear velocity mode (Column1 : 50 cm/s) (N ₂)
Purge Flow	: 3 mL/min
Split Ratio	: 15
Column Oven Temp. Program	: 60 °C → 10 °C/min → 240 °C (2 min)
Column1	: SH-Q-BOND (30 m × 0.32 mm I.D. × 10 μm) (P/N : 221-75764-30)
Detector1	: FID
Detector Temp.	: 250 °C
Makeup Gas	: N ₂ 24 L/min
Detector Gas	: H ₂ 32 L/min, Air 200 L/min
Column2	: MICROPACKED-ST (1 m × 1.0 mm I.D.) (P/N : M00-00002-657)
Detector2	: Jetanizer-FID
Detector Temp.	: 400 °C
Makeup Gas	: N ₂ 24 L/min
Detector Gas	: H ₂ 32 L/min, Air 250 L/min

*1 Requires an INJ2-way branch unit (P/N: 221-75231-41). The unit consists of a two-way branched adapter (a multi-column hanger and two INJ nuts).

Fig. 2 shows chromatograms obtained from a gas mixture consisting of CO, MeOH, and hydrocarbons (C1–C6) in a CO₂ matrix. The SH-Q-BOND + FID chromatogram (black) shows elution and resolution of compounds other than CO; the MICROPACKED-ST + Jetanizer-FID chromatogram (pink) demonstrates CO elution together with hydrocarbons up to C3. Calibration curves were constructed using four concentration levels for CO, hydrocarbons (C1–C5, 1–100 ppm v/v), and MeOH (6–600 ppm v/v). All analytes exhibited excellent linearity with R² ≥ 0.999 (Fig. 3).

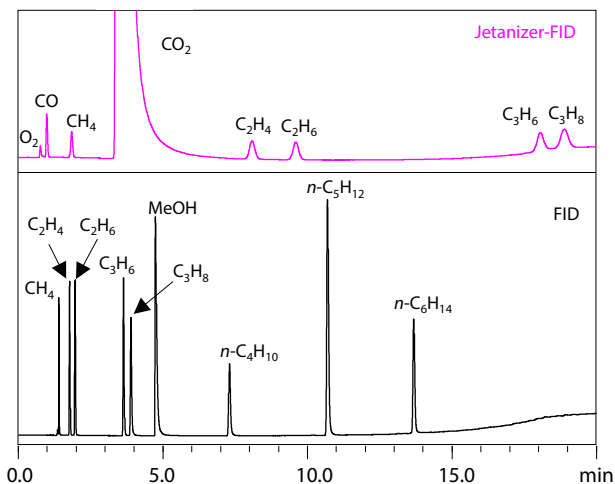


Fig. 2 Chromatograms of CO, hydrocarbons, and MeOH

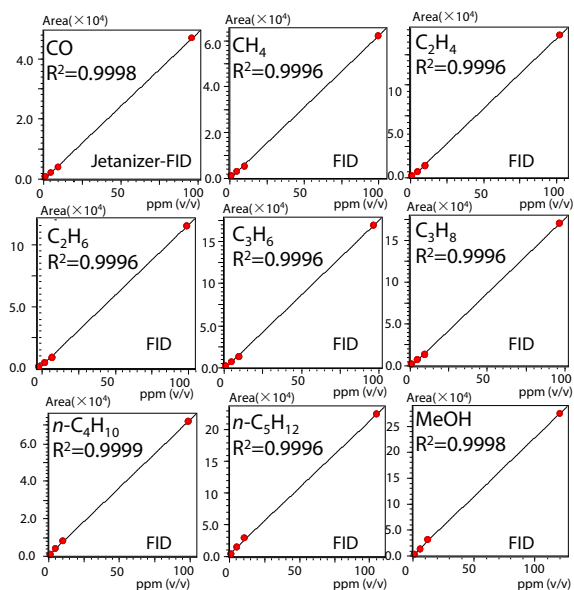


Fig. 3 Calibration curves of CO, hydrocarbons, and MeOH

TCD Analysis of CO and Hydrocarbons

TCD analysis was performed for CO and hydrocarbons (C1–C3) at 100 ppm each. Analysis conditions are in Table 3. The MICROPACKED-ST column achieved excellent separation of all analytes. S/N ratios exceeded 10 for each component, indicating adequate sensitivity for quantitative analysis (Fig. 4).

Table 3 System configuration and analysis conditions

GC Model	: Brevis GC-2050 / GI-30
Loop Volume	: 1 mL
Injection Port	: SPI
Injection Temp.	: 150 °C
Flow Control Mode	: Constant Column Flow Mode (7 mL/min) (He)
Purge Flow	: 3 mL/min
Split Ratio	: 4
Column Oven Temp. Program	: 35 °C(3.5min) → 20 °C/min → 270 °C
Column	: MICROPACKED-ST (2 m × 1.0 mm I.D.) (250 m × 0.50mm I.D., df=15µm entered to calculate flowrate)
Detector	: TCD
Detector Temp.	: 270 °C
Makeup Gas	: He 2.0 mL/min
Reference Gas	: He 50.0 mL/min

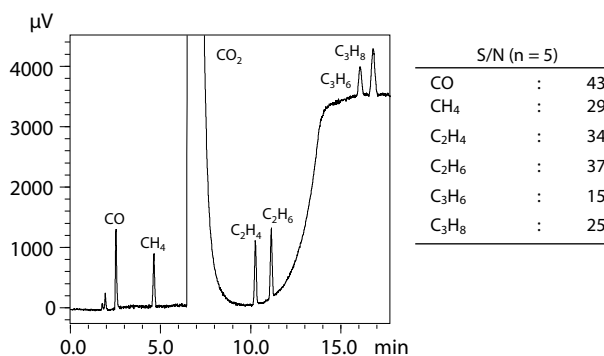


Fig. 4 Chromatogram and S/N values of CO and hydrocarbons (100ppm)

Conclusion

Using INJ2-way branch unit enables simultaneous analyses using distinct column-detector combinations within a single chromatographic cycle, permitting comprehensive quantification of reaction products from CO₂ conversion—ranging from CO and hydrocarbons to alcohols such as MeOH. For analyses restricted to hydrocarbons up to C3, a streamlined single-column TCD configuration provides sufficient separation and sensitivity. It should be noted that MeOH and hydrocarbons of carbon number ≥ C4 may adsorb or be retained on the MICROPACKED-ST column; periodic column conditioning is therefore recommended.

<Related Applications>

1. Gas Analysis Using a Brevis GC-2050 Gas Chromatograph with a GI-30 Auto Gas Injector and TCD and BID Detectors, [Application News No. 01-00858-EN](#)
2. Simultaneous Analysis of Greenhouse Gases Using Nitrogen Carrier Gas, [Application News No. 01-00661-EN](#)

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