Application Note

Energy & Chemicals

CO_2 Reduction Gas Products Analysis Using the Agilent 990 Micro GC

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Abstract

This application note describes the use of the Agilent 990 Micro GC for CO_2 for reduction gas products analysis, which can be used to assess catalyst or process control in the CO_2 reduction. Two channels were used—the Agilent CP-Molsieve 5Å and the PoraPLOT U—to analyze hydrogen (H_2), carbon monoxide (CO), methane (CH_4), ethane (C_2H_6), and ethene (C_2H_4) as CO_2 reduction products.

Introduction

Coal and oil have been the main power sources providing energy for human activities for more than a century. Owing to the excessive use of these energy sources, the concentration of carbon dioxide (CO_2) in the atmosphere has increased dramatically. The atmospheric CO_2 concentration increased from approximately 280 ppm in 1750 to approximately 385 ppm currently, and it is predicted to reach approximately 500 ppm in 2050. The increase raises the global mean temperature, thus threatening all life on the planet. The conversion of CO_2 into other useful carbon materials, forming a sustainable recycling system, is one possible route for reducing the climatic hazards of the increasing CO_2 concentration.

An ideal solution is to convert atmospheric CO_2 into small organic molecules with improved energy density, such as carbon monoxide, methane, ethane, ethene, formic acid, methanol, etc., using renewable energy. Such a strategy can not only reduce the accumulation of CO_2 in the atmosphere, but also produce fuels and useful industrial chemicals, thus relieving our dependency on conventional fossil resources. To this end, various CO_2 reduction approaches, including electrochemical, photochemical, biochemical, and thermochemical methods, have been proposed and intensively researched in the past decades.

During the CO_2 reduction process, the concentration of CO_2 reduction products should be monitored. The common gas products of CO_2 reduction are H_2, CO, CH_4, C_2H_6, and C_2H_4 in the CO_2 balance. The 990 Micro GC provides fast and accurate measurement of CO_2 reduction products, which improves the efficiency of CO_2 reduction research.

Experimental

Channel 1: A 10 m, Agilent CP-Molsieve 5Å, 5 m precolumn backflush channel, with retention time stability (RTS) option for H_2, CH_4, and CO analysis. The backflush option and RTS is used to protect the Molsieve 5Å column from moisture, CO_2, and other contaminants. This is beneficial to the long-term RT repeatability and column performance of the Molsieve 5Å column.

Channel 2: A 10 m, Agilent CP-PoraPLOT U straight channel for CH_4, CO_2, C_2H_4, and C_2H_6 analysis.

Table 1. Analytical methods for sample analysis.

Channel Type	5 m Precolumn and 10 m Agilent CP-Molsieve 5Å RTS, Backflush	10 m Agilent CP-PoraPLOT U, Straight
Carrier Gas	He	He
Injector Temperature	60 °C	50 °C
Column Temperature	60 °C	40 °C
Column Pressure	180 kPa	100 kPa
Injection Time	100 ms	20 ms

Table 2. Composition of standards gas.

Components	Concentration (ppm)
Hydrogen	98.7
Methane	99.7
Carbon Monoxide	491.9
Carbon Dioxide	Balance
Ethylene	49.6
Ethane	50.0

Figure 1 shows that H_2, CH_4, and CO are well separated within 2.5 minutes on a 10 m CP-Molsieve 5Å RTS backflush channel. Figure 2 shows that CH_4, CO_2, C_2H_4, and C_2H_6 are well separated within 2 minutes on a 10 m CP-PoraPLOT U straight channel. Due to the high concentration of CO_2 as balance gas in the standard gas, to ensure good separation of CO_2 and light components on the precolumn, and to ensure that CO_2 is backflushed completely, the 10 m CP-Molsieve 5Å RTS backflush channel uses a 5 m precolumn to backflush the CO_2 balance gas. The column temperature is selected as 60 °C.

Table 3 shows the repeatability results of the 10 sample runs. For all components, the RT RSD% are less than 1%, and the area RSD% are less than 3% with the 10 m CP-Molsieve 5Å channel.

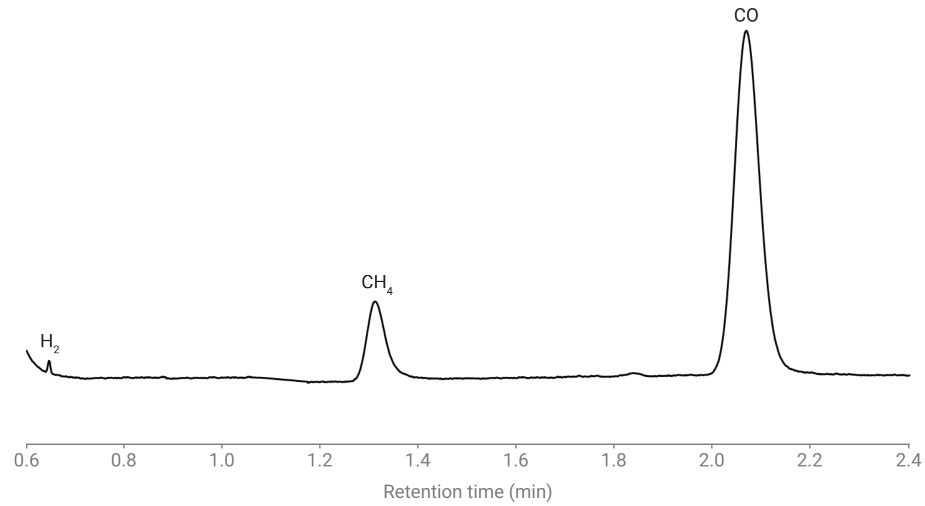

Figure 1. Chromatogram of H_2, CH_4, and CO on the 10 m Agilent CP-Molsieve 5Å channel.

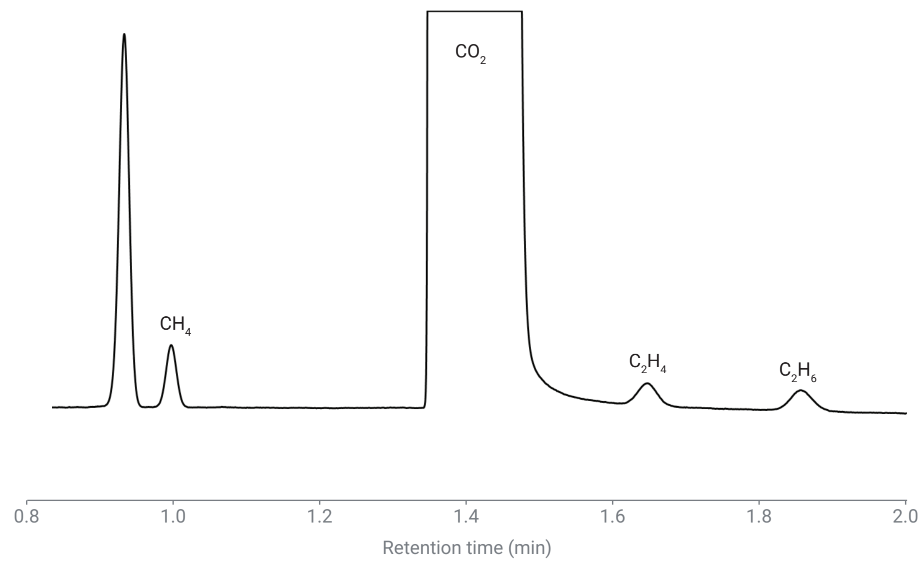

Figure 2. Chromatogram of CH_4, CO_2, C_2H_4, and C_2H_6 on the 10 m Agilent CP-PoraPLOT U channel.

Table 3. RT and area repeatability of 10 runs of standards gas.

Compounds	RT (min)	RT RSD%	Area (mV × s)	Area RSD%
Hydrogen	0.643	0.07	0.003	2.33
Methane	0.988	0.00	0.084	2.10
Carbon Monoxide	1.845	0.87	0.970	0.71
Carbon Dioxide	1.342	0.04	1120.3	0.23
Ethylene	1.628	0.03	0.053	1.78
Ethane	1.834	0.04	0.062	2.33

Conclusion

This study demonstrates the applicability of the 990 Micro GC for CO_2 reduction gas products analysis, which can be used for performance evaluation of the catalyst or process control in the CO_2 reduction. The quantitation precision was evaluated by 10 consecutive analyses of calibration standard gas with RT repeatability less than 1% and area repeatability less than 3%, demonstrating excellent instrument performance for reliable qualification and quantitation of CO_2 reduction gas products.

References

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2. van Loon, R. C1 – C3 Hydrocarbon Analysis Using the Agilent 490 Micro GC – Separation Characteristics for PoraPLOT U and PoraPLOT Q Column Channels. *Agilent Technologies application note*, publication number 5990-9165EN, **2011**.

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