Application News

Transportable Gas Analyzer CGT-7100

Evaluation of Carbon Deposition by Different Catalytic Processes in Dry Reforming of Methane (DRM) Reaction

- Using CGT-7100 to Study the Conversion of Greenhouse Gases into Valuable Chemicals -

Minako Tanaka[1], Yuya Kurata[1], Kazuyoshi Nakajima[1], Ayaka Motomura[2], and Yasushi Sekine [2]
1: Shimadzu Corporation, 2: Waseda University

User Benefits

- Non-dispersive infrared absorption (ratio photometry) offers excellent measurement stability.
- Measurements are simplified by an all-in-one transportable analyzer with sample preparation (built-in sampling pump, filter, dehumidifier, etc.).
- Save recorded data on USB flash drives for easy editing on a PC or sharing with other departments.

■ Introduction

Dry reforming of methane (DRM) (Fig. 1) is a process that uses the greenhouse gases CH_4 and CO_2 to produce syngas, a raw material used in various chemical products. DRM uses a catalyst at high temperatures in a heated catalytic reaction to convert greenhouse gases into useful chemicals and is attracting interest for its potential role in stopping global warming. However, the need for high temperatures, catalyst deterioration induced by carbon deposition, and blockage of the reaction vessel pose challenges for the practical implementation of DRM. Applying an electric field to the DRM catalyst (Fig. 2) is being studied to lower the reaction temperature and reduce carbon deposition. Catalysis in an electric field involves applying a weak direct current to the catalyst bed, which can result in much lower reaction temperatures. This article describes using the CGT-7100 to quantify the carbon deposits generated by side reactions to evaluate the impact of different catalytic processes on catalyst longevity.

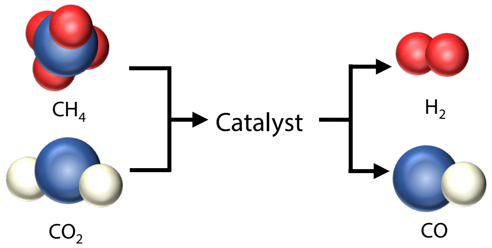

Fig. 1 Dry Reforming of Methane Reaction

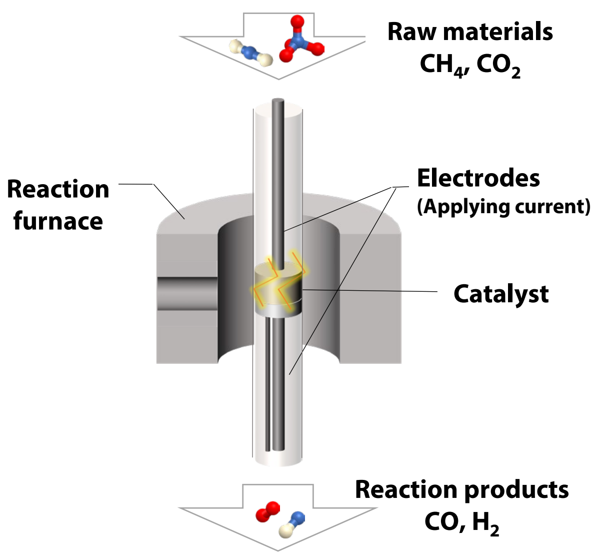

Fig. 2 Catalytic Reaction in an Electric Field: Catalyst Activity Test Setup

■ Principle of Measurement

The CGT-7100 uses non-dispersive infrared absorption (NDIR). Heteroatomic gases such as carbon dioxide have unique infrared absorption spectra. The concentration of individual heteroatomic gases in a sample gas can be determined by passing infrared light through the sample and using a detector to measure the amount of infrared light transmitted in absorption bands specific to each gas species. The CGT-7100 can measure up to three gases, including two gases from among CO_2, CO, and CH_4 (measured by NDIR) and oxygen when an optional O_2 meter (zirconia limiting current type) is installed. The CGT-7100 monitors the concentration of each gas over time across a wide concentration range from ppm to vol % levels.

■ Experimental Method

Carbon deposition was compared between the conventional heated catalytic reaction and the catalytic reaction in an electric field by performing catalyst activity testing under the conditions shown in Table 1. The reaction in an electric field was performed by placing electrodes at the top and bottom ends of the catalyst and passing a current through the catalyst bed, as shown in Fig. 2. Upon ending the reaction, carbon deposited on the surface of the catalyst was quantified by passing 10 % O_2 gas over the catalyst at 100 mL/min, raising the temperature of the catalyst bed from ambient to 850 ° C, and using the CGT-7100 to measure the CO_2 concentration in the outlet gas under the conditions shown in Table 2 according to the process flow shown in Fig. 3.

Table 1 Catalyst Activity Test Conditions

	Heated catalytic reaction	Catalytic reaction in electric field
Temp. [°C]	400	200
Current [mA]	—	10

Table 2 Measurement Conditions

Analyzer:	CGT-7100
Measured Component:	CO_2
Measurement Range:	0 to 2 vol %
Sample Gas Flowrate:	100 mL/min

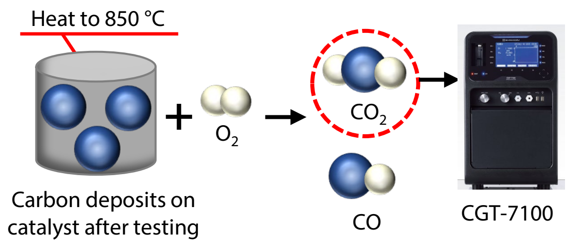

Fig. 4 Analytical Process Flow

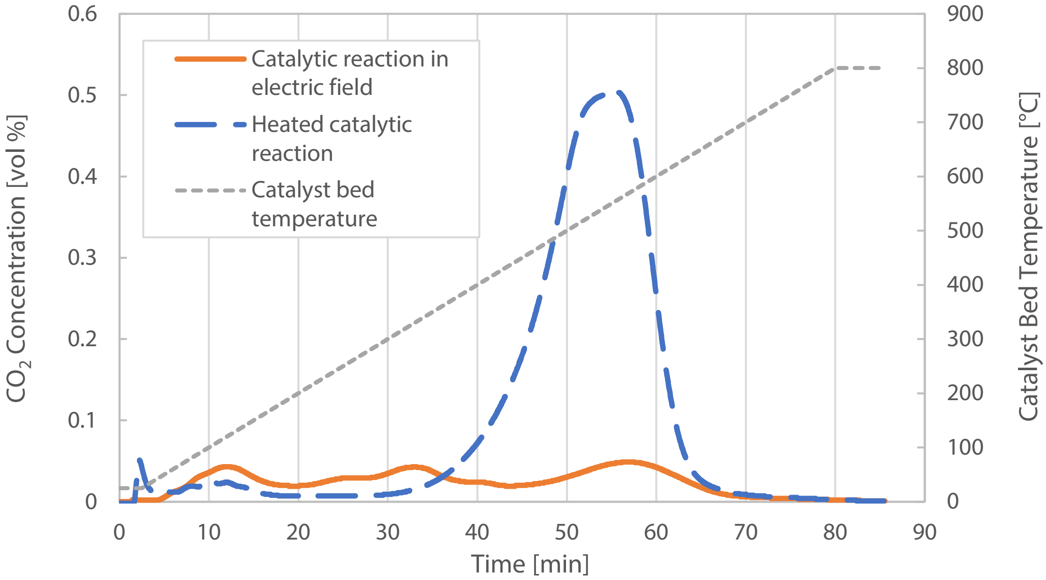

Fig. 4 Carbon Deposition Caused by Each Catalytic Process (Carbon Bed Temperature and CO_2 Generation)

Table 3 Amounts of Carbon Deposition [mg]

Catalytic reaction in electric field:	3.48
Heated catalytic reaction:	14.07

■ Results

The measurements obtained during testing are shown in Fig. 4, and the amounts of carbon deposition calculated based on CO_2 concentration measurements are shown in Table 3. The results show the catalytic reaction in an electric field caused approximately one-fifth the amount of carbon deposition compared to the conventional heated catalytic reaction. The carbon deposited by the catalytic reaction in an electric field was also predominantly highly reactive carbon species that burned at lower temperatures of up to around 600 °C. The above results show that the new catalytic process that passes an electric current across the catalyst bed allows the DRM reaction to take place at lower temperatures and substantially reduces the amount of carbon deposition compared to the conventional catalytic reaction performed at high catalyst temperatures.

■ Conclusion

This article describes using the CGT-7100 transportable gas analyzer in a research application related to technology that converts greenhouse gases into useful chemicals. Performing a DRM reaction in an electric field lowered the reaction temperature and reduced the amount of carbon deposition, demonstrating that an electric field-assisted catalytic reaction can improve catalyst longevity and resolve reaction vessel blockages.

The gas species measured by the CGT-7100 (CO_2, CO, CH_4, and O_2) and the ease of analysis and data handling offered by the CGT-7100 make it suitable for a wide range of testing and research applications. As well as the conversion of greenhouse gases into useful chemicals described in this article, the Shimadzu CGT-7100 transportable gas analyzer can be used in testing and research applications related to absorption and capture, separation, and reduction of greenhouse gas emissions.

Fig. 5 Shimadzu CGT-7100 Transportable Gas Analyzer

■ Related Links

For more information about the CGT-7100, please see the product website below.

https://www.an.shimadzu.co.jp/enviro/gas/cgt7100/index.htm

Please visit the website below for information about the NOA-7100 transportable NO_X-O_2 analyzer.

https://www.an.shimadzu.co.jp/enviro/gas/noa7100/support.htm

[References]
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2) Ogo S, Yabe T, and Sekine Y. Catalysts for methane, carbon dioxide, and hydrogen. Chemistry & Education. Vol. 66, No. 2, pp. 68-71 (2018)

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