Using the Agilent 490 Micro GC for the Monitoring of a Circulating Fluidized Bed Biomass Gasifier

Application Note

Micro Gas Chromatography, Reaction/Production Monitoring, Renewable Energy

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Abstract

Biomass has been recognized as a potential renewable and sustainable energy source. The Delft University of Technology researches the gasification of woody and agricultural biomass in a Circulating Fluidized Bed Reactor. The Agilent 490 Micro GC is used to characterize the product gas using a COX column for the permanent gases and a CP-Sil 5CB for the BTX compounds.

Introduction

There is a growing interest in sustainable heat and power generation using biomass. A possible way to use the biomass is through thermal conversion processes; combustion and gasification are the most well-known examples. The Process and Energy Department of the Delft University of Technology researched the gasification of woody and agricultural biomass in a Circulating Fluidized Bed. The product gas consists roughly of 5–15% Carbon monoxide, 10–15% Hydrogen, 3–5% Methane, 10–20% Carbon dioxide, 5–10% Nitrogen, and 40–70% Water, also (poly)aromatic compounds, minor inorganic species, and particles are present in the gas.

This product gas can be subsequently upgraded to Syngas (a mixture of Hydrogen, Carbon monoxide, Carbon dioxide and eventually water vapor). After applying the water-gas shift reaction ($CO + H_2O \rightarrow CO_2 + H_2$), Syngas could be used as a hydrogen-rich fuel gas for Fuel Cells. Other applications of Syngas are Fisher Tropsch processes (Gas to Liquid fuels), platform chemicals (like furfural), or the combustion in a gas turbine to generate heat and power. For the characterization of the product gas, the Agilent 490 Micro GC was used.

Experimental

Fluidization media and woody or agricultural biomass are fed into the Circulating Fluidized Bed Reactor, where the biomass is gasified at around 850 °C. The sample is taken from the product gas stream using a heated probe. Particles present in the sample are removed by the dust filter. Water vapor is stripped from the sample using two condensers. Figure 1 gives an overview of the sampling and sample conditioning setup. An external gas pump provides a continuous sample gas flow to the Agilent Micro GC. Every 3 min, the Micro GC starts an analytical run and analyses the gas sample on both column channels.

The Agilent 490 Micro GC used for the analysis of the product gas is equipped with a 1 m COX column channel for permanent gas analysis and a 4 m CP-Sil 5 CB column channel for the analysis of Benzene, Toluene and the Xylenes. The Micro GC conditions for both channels are displayed in Table 1.

Table 1. Agilent 490 Micro GC Instrument Conditions

	1 m COX	4 m CP-Sil 5 CB
Column temperature	100 °C	100 °C
Carrier gas	Argon, 200 kPa	Argon, 150 kPa
Injector temperature	110 °C	110 °C
Injection time	20 ms	40 ms
Detector sensitivity	Auto	High
Sample line temperature	110 °C	
Sampling mode	Continuous flow	
Sampling time	10 s	

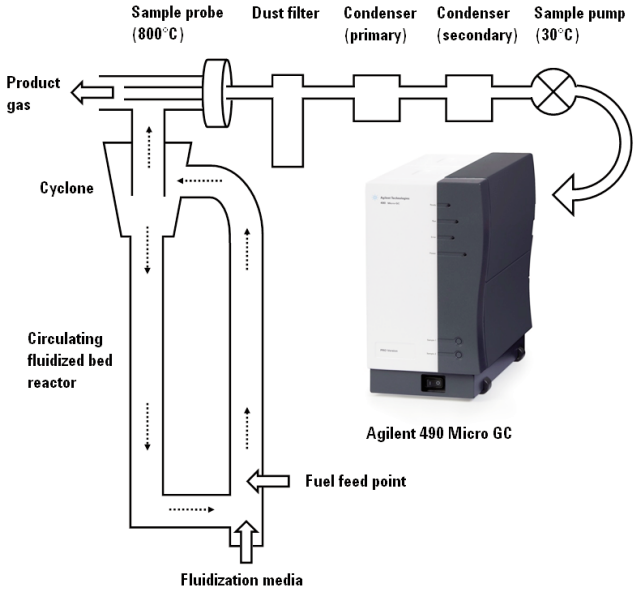

Figure 1. Reactor, sampling and sample conditioning setup.

Results and Discussion

The COX column shows an excellent separation for the permanent gases, as shown in Figure 2.

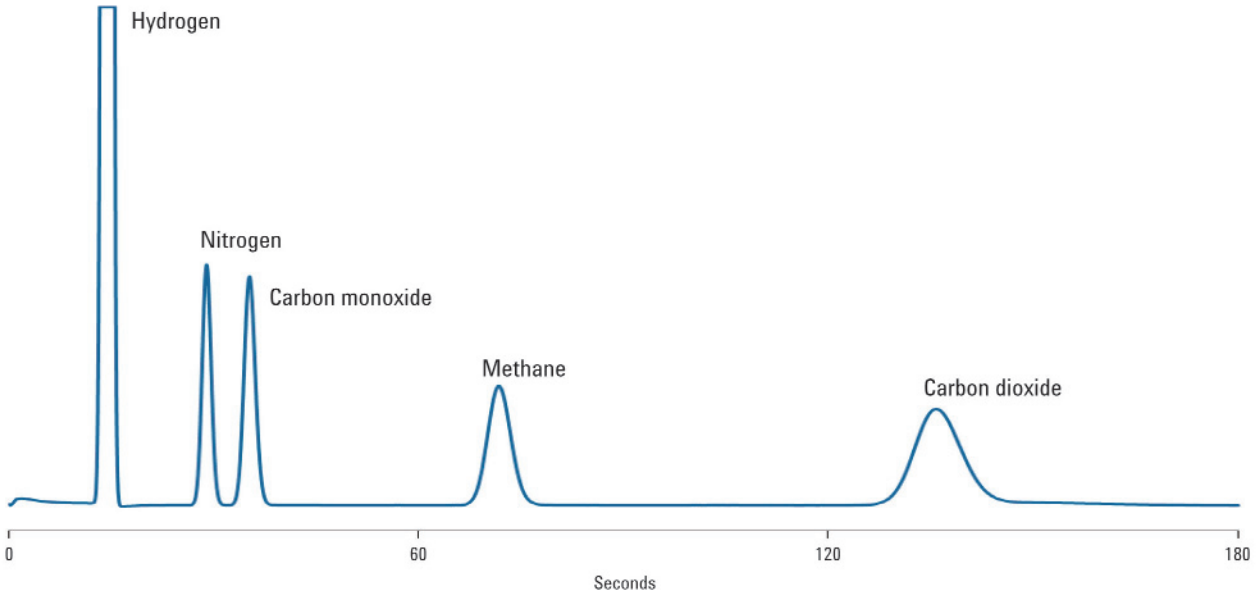

Figure 2. Permanent gases on the COX column.

Although the COX column does not separate oxygen and nitrogen, it is very suitable for the analysis of permanent gases including carbon dioxide. In the case of gasification, the product gas sample does not contain oxygen. When the sample contains both oxygen and nitrogen, and these gases need to be quantified separately, the use of a MolSieve5A column channel instead of the COX column channel is required. The COX column can be equipped with a back flush to vent. This option makes it possible to back flush later eluting compounds to reduce analysis time and to prolong column lifetime.

For each component a multi-level calibration (4 levels) is performed. Figures 3 and 4 show an excellent calibration curve for Methane and Carbon monoxide. For a linear regression, the R-Squared for these compounds is nearly perfect.

The BTX compounds are analyzed on a CP-Sil 5 CB column channel. The chromatogram in Figure 5 shows that all compounds are eluted in less than 90 sec. On the CP-Sil 5 CB column type it is not possible to separate meta- and para-Xylene. These compounds are reported in a single result. For all BTX compounds, a 4-level calibration is performed. Figure 6 shows an example of Benzene. R-squared (linear regression) for Benzene is 0.9969.

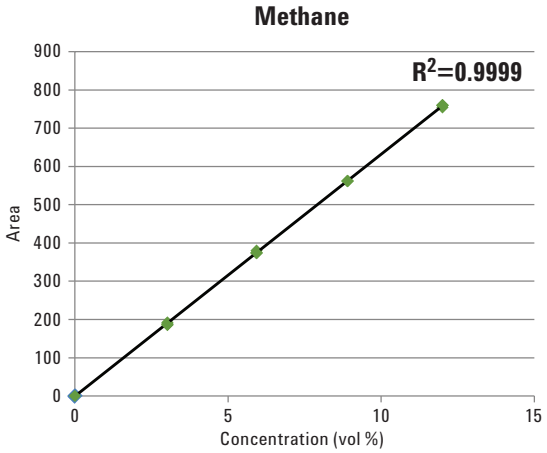

Figure 3. Calibration curve for methane.

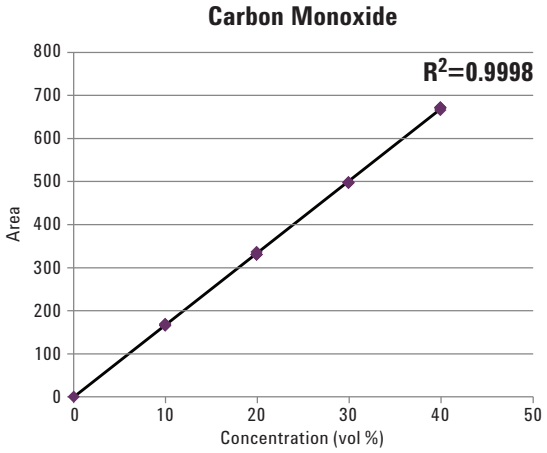

Figure 4. Calibration curve for Carbon monoxide.

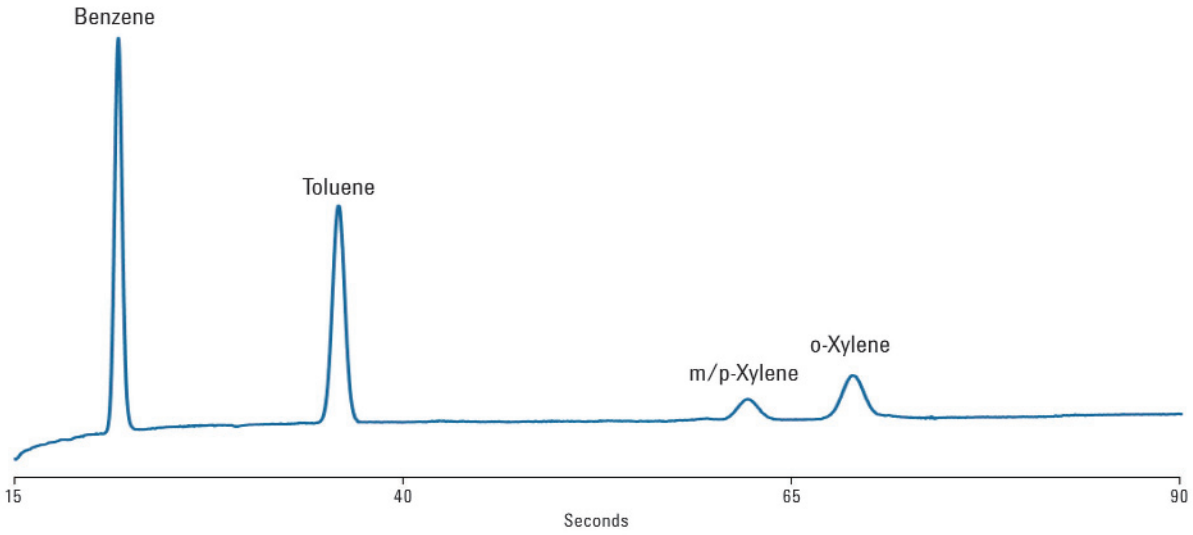

Figure 5. BTX analysis on the CP-Sil 5 CB column.

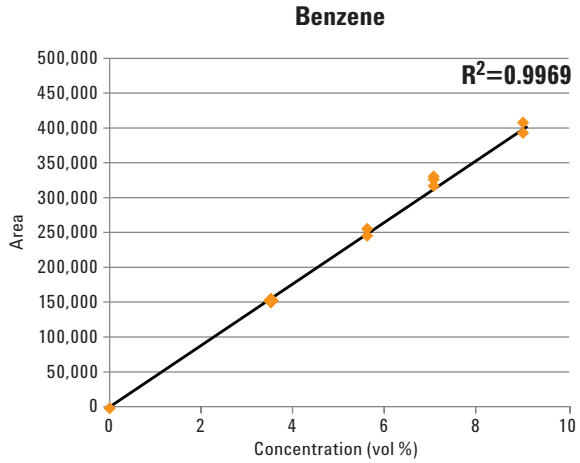

Figure 6. Calibration curve for Benzene.

Conclusion

The data presented in this application note clearly shows that the Agilent 490 Micro GC equipped with two column channels was capable of monitoring the product gas from the Circulating Fluidized Bed biomass gasifier. Within 180 sec the permanent gases were analyzed using a COX column channel. The BTX analysis was performed on a CP-Sil 5CB column channel with an analysis time of less than 90 sec.

The Agilent 490 Micro GC is considered a key apparatus for the quantification of the main product gas components in the gasification test rig at the Process & Energy Laboratory at Delft University of Technology. The main advantages of the 490 Micro GC analyzer are its reliability, short analysis times, ease of use (both hardware and software), and a certain degree of flexibility. The modular setup of the 490 Micro GC makes it possible to exchange the column modules if other gas components need to be analyzed.

The Agilent 490 Micro GC is a rugged, compact and portable lab-quality gas analysis platform. When the composition of gas mixtures is critical, count on this fifth generation micro gas chromatograph.

References

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2. Application note 5990-7054EN; Simone Darphorn-Hooijschuur and Marijn van Harmelen, Avantium Technologies; Remko van Loon and Coen Duvekot, Agilent Technologies; 'Permanent Gases on a COX Module Using an Agilent 490 Micro GC'; 2010.

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