ADVANCES IN MICRO GAS CHROMATOGRAPHY
Fast and Accurate Analysis of Extended Natural Gas Composition and Physical Properties Using a Temperature Programmable Micro GC Fusion

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Debbie Alcorn
INFICON, Inc.
2 Technology Place
East Syracuse, NY 13057, USA
INFICON Global Presence

900 employees; offices in 17 countries
Outline

• Natural Gas Analysis
• Natural Gas Composition
• Micro GC History
• Micro GC Fusion Features
• Micro GC Configuration
• Diablo EZReporter for Physical Property Calculation
• Chromatograms
• Compliance with GPA Standards
• Conclusion
Natural Gas Analysis

- Natural gas composition analysis is critical for:
  - Producers and gatherers
  - Gas distribution companies
  - Gas utility companies
  - Gas engine and appliance manufacturers
  - Independent testing laboratories
- Due to variations in natural gas composition, it is important to measure **physical properties**, especially for custody transfer situations.
- Software automatically calculates physical properties such as:
  - **Heating Value (BTU/cu. ft)**: The amount of heat released during the combustion of a specified amount of a substance.
  - **Relative Density/Specific Gravity**: The ratio of the density of a substance to the density of water.
## Natural Gas Composition

<table>
<thead>
<tr>
<th>Component</th>
<th>Gross Heating Value (BTU/Cu. Ft)</th>
<th>Wellhead %</th>
<th>Pipeline %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>0</td>
<td>&lt;10</td>
<td>&lt; 2</td>
</tr>
<tr>
<td>Carbon Dioxide</td>
<td>0</td>
<td>&lt;10</td>
<td>&lt; 1-2</td>
</tr>
<tr>
<td>Methane</td>
<td>1010</td>
<td>70-90</td>
<td>93-96</td>
</tr>
<tr>
<td>Ethane</td>
<td>1770</td>
<td>&lt;10</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>Propane</td>
<td>2516</td>
<td>&lt;10</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td>Isobutane</td>
<td>3252</td>
<td>&lt;2</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td>n-Butane</td>
<td>3262</td>
<td>&lt;2</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td>Isopentane</td>
<td>4001</td>
<td>&lt;2</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td>n-Pentane</td>
<td>4009</td>
<td>&lt;2</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td>Hexanes Plus</td>
<td>5129</td>
<td>&lt;2</td>
<td>&lt; 0.2</td>
</tr>
</tbody>
</table>
Micro GC History

- 3000 Micro GC (µGC) has over ten years of proven excellent analytical performance
- Micro GC Fusion® expands the capability of the 3000 Micro GC
3000 Micro GC

- Microelectromechanical systems (MEMS) based GC
- Isothermally heated capillary columns
- Micro Thermal conductivity detector (µTCD)
- Analysis can be conducted directly on-site or in a lab
The Next Generation – Micro GC Fusion

- Micro GC Fusion builds on proven 3000 Micro GC technology
  - Utilizes the same MEMS injectors and TCD
  - Modular design

- Traditional Micro GC technology is limited due to:
  - Isothermal column temperature, leading to potential carryover issues
  - Ambient temperature effects
  - Software and operating system compatibility

- Micro GC Fusion addresses these issues using new technology
Micro GC Fusion Features

- Micro GC Fusion hardware features include:
  - Temperature programmable columns for fast temperature ramping
  - Additional heated zones to minimize ambient temperature effects
  - Optional integrated sample conditioner
  - Lightweight chassis
Micro GC Fusion Features

• Micro GC utilizes a modular architecture
• Each module is its own GC:
  • MEMs based injector
  • Resistively heated fused silica capillary columns
  • MEMs based $\mu$TCD
Micro GC Fusion Features

- Micro GC Fusion utilizes a new User Interface (UI)
  - Front panel display
  - Direct Ethernet connection to a computer
  - Direct Ethernet connection to a LAN hub for remote access
  - Wi-Fi enabled
  - License free
  - On board solid state drive for data storage
  - Works with any platform (ex. Windows, Apple, Android)
An optional integrated sample conditioner can be configured.

The sample conditioner allows for:

- Reduction of sample pressures of up to 1000 psi down to approximately 5-10 psi
- Filtering of particulates
- Heated sample at 100°C

A quick connect replaces the standard 1/16 in. inlet.
Benefits of Temperature Programming

• Temperature ramping based on resistive column heating allows for:
  • Faster runs
  • Rapid column cleaning
  • Sharper peaks
  • Expanded application range (ex. extended natural gas analysis)
• Ramping profile is independently optimized for each module
• Cooldown time is optimized to achieve short cycle times
Isothermal vs. Temperature Programming

- Isothermal runs result in broad, late eluting peaks
- Fast temperature ramping improves peak shape, run time, and column cleaning
- Example – Propane
  - Isothermal ~160 seconds
  - Temperature ramping ~50 seconds
  - Increase in peak height

Column: RT-Q-Bond
Injector: Variable
Ramp: 50°C → 90°C → 240°C (2°C/s, 2.2°C/s)
Single Module Natural Gas Analysis

Column: RT-Q-Bond
Injector: Variable
Ramp: 45°C → 250°C (2.5°C/s)
Extended Natural Gas

- Often, it is desirable to analyze C$_6$ to C$_{12}$ components in order to obtain more information about the gas sample.
- A second channel using a Rxi-1ms column provides additional information for extended hydrocarbon analysis.

Column: Rxi-1ms
Ramp: 50°C $\rightarrow$ 130°C $\rightarrow$ 280°C (2°C/s, 5°C/s)
In order to analyze C12 in the gas phase, the extended natural gas calibration standard was heated.

For retention time comparison, a heated sample bag containing straight chain hydrocarbons (C6 to C12) is overlaid with the calibration standard.

**Column:** Rxi-1ms  
**Ramp:** 50°C → 130°C → 280°C (2°C/s, 5°C/s)
Diablo EZReporter for Physical Property Calculation

- Allows customized viewing of results
- Calculates physical properties such as:
  - Component and gross heating values (BTU/cu. ft)
  - Relative density (specific gravity)
  - Wobbe Index
  - And more
- Creates reports in PDF, CSV, or TXT format
Natural Gas Standards

• Method Standard GPA 2261 (Industry standard)
  • Portable Micro GC statement
  • TCD
  • Grouped hexanes plus
  • Repeatability
  • Updated in 2013

• Calculation Standards used by EZReporter:
  • ASTM 3588
  • GPA 2145
  • GPA 2172
  • ISO 6976
Micro GC Fusion Repeatability

- Percent relative standard deviation (%RSD) is used to measure instrument performance
- 10 runs were conducted using the same gas standard

<table>
<thead>
<tr>
<th>Component</th>
<th>Calibration Gas Concentration</th>
<th>Retention Time %RSD</th>
<th>Concentration/Area %RSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>1.550%</td>
<td>0.054</td>
<td>0.236</td>
</tr>
<tr>
<td>Carbon Dioxide</td>
<td>1.201%</td>
<td>0.061</td>
<td>0.177</td>
</tr>
<tr>
<td>Methane</td>
<td>88.654%</td>
<td>0.132</td>
<td>0.163</td>
</tr>
<tr>
<td>Ethane</td>
<td>3.001%</td>
<td>0.120</td>
<td>0.252</td>
</tr>
<tr>
<td>Propane</td>
<td>1.996%</td>
<td>0.067</td>
<td>0.211</td>
</tr>
<tr>
<td>Isobutane</td>
<td>1.003%</td>
<td>0.054</td>
<td>0.187</td>
</tr>
<tr>
<td>n-Butane</td>
<td>0.998%</td>
<td>0.053</td>
<td>0.178</td>
</tr>
<tr>
<td>Isopentane</td>
<td>0.299%</td>
<td>0.05</td>
<td>0.295</td>
</tr>
<tr>
<td>n-Pentane</td>
<td>0.300%</td>
<td>0.053</td>
<td>0.276</td>
</tr>
<tr>
<td>C6s</td>
<td>0.598%</td>
<td>Group range</td>
<td>0.309</td>
</tr>
<tr>
<td>C7s</td>
<td>0.332%</td>
<td>Group range</td>
<td>0.391</td>
</tr>
<tr>
<td>C8 Plus</td>
<td>0.068%</td>
<td>Group range</td>
<td>2.76</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Property</th>
<th>%RSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross Heating Value – Ideal</td>
<td>0.015</td>
</tr>
<tr>
<td>(BTU/cu. ft)</td>
<td></td>
</tr>
<tr>
<td>Gross Heating Value – Real</td>
<td>0.015</td>
</tr>
<tr>
<td>(BTU/cu. ft)</td>
<td></td>
</tr>
</tbody>
</table>
Ten Run Overlay

Column: RT-Q-Bond
Injector: Variable
Ramp: 45°C → 250°C (2.5°C/s)
Compliance with NGA Standard

- GPA 2261-13 calls out repeatability for compound concentrations
- EZReporter has the ability to compare repeatability using this standard

<table>
<thead>
<tr>
<th>Component</th>
<th>Result 1 Amount</th>
<th>Result 2 Amount</th>
<th>Repeatability</th>
<th>Lower Limit</th>
<th>Upper Limit</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>1.5487</td>
<td>1.5461</td>
<td>0.04</td>
<td>1.51</td>
<td>1.59</td>
<td>Pass</td>
</tr>
<tr>
<td>Methane</td>
<td>88.6648</td>
<td>88.66100999999999</td>
<td>0.04</td>
<td>88.62</td>
<td>88.69</td>
<td>Pass</td>
</tr>
<tr>
<td>CO2</td>
<td>1.202</td>
<td>1.1594</td>
<td>0.01</td>
<td>1.19</td>
<td>1.21</td>
<td>Pass</td>
</tr>
<tr>
<td>Etane</td>
<td>3.0012</td>
<td>2.9579</td>
<td>0.02</td>
<td>2.98</td>
<td>3.02</td>
<td>Pass</td>
</tr>
<tr>
<td>Propene</td>
<td>2.0001</td>
<td>1.9996</td>
<td>0.01</td>
<td>1.99</td>
<td>2.01</td>
<td>Pass</td>
</tr>
<tr>
<td>isoButane</td>
<td>1.0026</td>
<td>1.0017</td>
<td>0.01</td>
<td>0.99</td>
<td>1.01</td>
<td>Pass</td>
</tr>
<tr>
<td>n-Butane</td>
<td>0.9977</td>
<td>0.9974</td>
<td>0.01</td>
<td>0.99</td>
<td>1.01</td>
<td>Pass</td>
</tr>
<tr>
<td>isoPentane</td>
<td>0.2038</td>
<td>0.2079</td>
<td>0.01</td>
<td>0.29</td>
<td>0.31</td>
<td>Pass</td>
</tr>
<tr>
<td>n-Pentane</td>
<td>0.3016</td>
<td>0.3016</td>
<td>0.01</td>
<td>0.29</td>
<td>0.31</td>
<td>Pass</td>
</tr>
<tr>
<td>C6 Plus</td>
<td>0.9925</td>
<td>0.9973</td>
<td>0.01</td>
<td>0.98</td>
<td>1.01</td>
<td>Pass</td>
</tr>
</tbody>
</table>
Conclusion

- Micro GC Fusion is an ideal measurement for natural gas analysis across a variety of applications
- Micro GC Fusion complies with industry standard methods and has excellent retention time, area, and concentration repeatability
- Combined with Diablo EZReporter, Micro GC Fusion is a powerful tool that can be used in the field or in the lab
For more application information, visit:

www.INFICON.com
Questions?