Agilent Atomic Spectroscopy Solutions for Energy & Chemicals

AA, MP-AES, ICP-OES, ICP-MS.
<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1957</td>
<td>Built components for world's first AA (as Techtron)</td>
</tr>
<tr>
<td>1971</td>
<td>Applies for patent on Zeeman background correction</td>
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<tr>
<td>1985</td>
<td>SpectrAA instruments released with central instrument control</td>
</tr>
<tr>
<td>1987</td>
<td>Introduction of the first computer controlled ICP-OES, the PMS 100</td>
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<tr>
<td>1991</td>
<td>Releases first sequential ICP-OES</td>
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<tr>
<td>1994</td>
<td>Launch of the 4500 Series, the world's first benchtop ICP-MS</td>
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<tr>
<td>1997</td>
<td>Fast Sequential AA reduces analysis times by 50%</td>
</tr>
<tr>
<td>1998</td>
<td>Releases first simultaneous ICP-OES with full wavelength coverage</td>
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<tr>
<td>2000</td>
<td>Launch of 7500 Series ICP-MS</td>
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<tr>
<td>2004</td>
<td>Introduction of 200 Series AA and GTA120 GFAA with extended tube life</td>
</tr>
<tr>
<td>2006</td>
<td>Launch of the 700 Series ICP-OES - world's fastest ICP-OES</td>
</tr>
<tr>
<td>2009</td>
<td>Launch of the Agilent 7700 Series, with HMI, 3rd generation ORS, and Masshunter s/w</td>
</tr>
<tr>
<td>2011</td>
<td>Agilent redefines elemental analysis with the introduction of the Agilent 4100 MP-AES</td>
</tr>
<tr>
<td>2012</td>
<td>Agilent releases the world's first triple quad ICP-MS, the Agilent 8800 ICP-QQQ</td>
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</tbody>
</table>
And still leading the way with recent innovative releases!

**Agilent 4200 MP-AES**
Safer, more cost effective elemental analysis that is uniquely suited for a wide range of sample types and applications.

- Reduce your analysis cost
- Improve your laboratory safety
- Simplify your workflow
- Increase analytical performance

**Agilent 7900 ICP-MS**
The most robust, sensitive, and easy to use quadrupole ICP-MS ever.

- 10x better matrix tolerance – up to 25% total dissolved solids
- 10x better signal to noise performance – improved sensitivity and detection limits
- 10x wider dynamic range – up to 11 orders of concentration from ppt to 10,000s ppm
- Software so simple yet powerful it writes your methods for you
- Enhanced customer experience – better training, easier maintenance

**The new Agilent 5100 ICP-OES!**
The world’s most productive, high performance ICP-OES.

- World’s first and only non-sequential dual view instrument; Synchronous Vertical Dual View (SVDV)
- Highest throughput reduces your analysis cost
- Vertical plasma runs your toughest sample
- Dichroic Spectral Combiner (DSC) simplifies method development
The Agilent Atomic Spectroscopy Portfolio

Agilent’s 55 and 200 Series includes the world’s fastest flame AA and the world’s most sensitive furnace.

Agilent’s 4200 MP-AES runs on air for the lowest cost of ownership and improved safety.

Agilent’s 5100 ICP-OES is the world’s most productive, and only Synchronous Vertical Dual View ICP-OES.

Agilent’s 7900 is the most robust, sensitive, and easy to use quadrupole ICP-MS ever.

Agilent’s 8800 ICP-QQQ provides accurate measurement of difficult and interfered elements.
Typical applications

Biofuels and Alternative Energy
- Biodiesel QA/QC – monitor elemental contamination
  - ASTM methods include for:
    - Na+K, Ca+Mg, S and P.
- Solar
  - Impurities in wafer etching chemicals

Exploration and Production
- Oil
  - Crude – toxic pollutants and elemental fingerprinting
  - Formation water
  - Additives in lubricants and high performance oil – modify performance
  - Coolants - pollutants
- Hydraulic fracturing of shale formations
  - Drilling fluids, cuttings, produced water, fracturing fluid returns
Typical applications

Refining
- QA/QC of production streams
  - Purity of finished products
  - Catalyst contamination/degradation
- Monitoring refinery formulations
- Transportation or containment impurities

Plant waste streams
- Effluent/water
  - Ensure compliance to regulatory agencies
Typical applications

Chemical purity

- Analysis of raw and refined chemicals for contaminant level
  - Fine chemicals
  - Chemicals used in semiconductor fabrication
  - Additives for Food and Agro business

Polymers

- Elemental contamination can lead to poor yield.
  - Catalysts - PGMs
  - Storage – Fe, Cr, Ni,
  - Production process - various
Today’s Agilent: Atomic Spectroscopy

More choices

Agilent provides the best choice for every lab through:

• A full range of atomic spectroscopy instrumentation
• Optimal product offering for any budget / application
• Continued focus on reliability and performance
Regardless of your application needs and drivers, Agilent’s unique and comprehensive Atomic Spectroscopy Portfolio provides the right solution for your Energy & Chemical analysis requirements.

Stay tuned for some application examples in energy and chemical industry…
Petrochemical Applications for the Agilent 4200 MP-AES
Key benefits of the 4200 MP-AES

- **Highest performance**
  - Handles major, minor and most trace levels
  - Wider linear dynamic range
  - Lower detection limits

- **Easy operation**
  - New generation software
    - Simultaneous auto background correction
    - Plug and play torch

- **Safer laboratory operation**
  - No flammable gases
    - Unattended multi-element operation

- **Lowest cost of ownership**
  - Runs on air!
    - Eliminates on-going gas supply costs

- **Ideal flame AA alternative**
  - Plug and play torch

February 18, 2015
Organics Kit - External Gas Control Module (EGCM)

1. Prevents carbon build up on the injector when running organics

2. Reduces the background emissions from the plasma

3. A controlled flow of air is bled into the Auxiliary gas flow through the torch
Petrochemical Applications for the MP-AES

**Determination of Cr, Ni, Pb and V in ethanol fuel by Microwave Plasma-Atomic Emission Spectrometry**

Application note
Energy and fuels

Authors
George L. Kissel, Renata B. Areias, Dorena Schievano and Joaquim A. Nascimento
* Group of Applied Instrumental Analytical, Department of Chemistry, Federal University of São Carlos, São Carlos, SP, Brazil
1 Agilent Technologies São Paulo, SP, Brazil
2 Agilent Technologies São Paulo, SP, Brazil

**Analysis of wear metals and contaminants in engine oils using the 4100 MP-AES**

Application note
Energy and fuels

Authors
Phil Lowerstein and Elizabeth Reisman
Agilent Technologies
Melbourne, Australia

**Determination of silicon in diesel and biodiesel by Microwave Plasma-Atomic Emission Spectrometry**

Application note
Energy and fuels

Authors
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* Group of Applied Instrumental Analytical, Department of Chemistry, Federal University of São Carlos, São Carlos, SP, Brazil
1 Agilent Technologies São Paulo, SP, Brazil
2 Agilent Technologies São Paulo, SP, Brazil

**Direct measurement of metallic impurities in petroleum fuels using the 4100 MP-AES**

Application note
Energy and fuels

Authors
Phil Lowerstein and Elizabeth Reisman
Agilent Technologies
Melbourne, Australia

**Analysis of diesel using the 4100 MP-AES**

Application note
Energy and fuels

Authors
Phil Lowerstein and Elizabeth Reisman
Agilent Technologies
Melbourne, Australia

**Measurement of additives in lubricating oils using the Agilent 4100 MP-AES**

Application note
Energy and fuels

Authors
Phil Lowerstein and Elizabeth Reisman
Agilent Technologies
Melbourne, Australia

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**Introduction**

The performance of engine or turbine components can be compromised over time through exposure to certain trace elements that may be present in gasoline, diesel and jet fuel. It is important to monitor these elements in order to ensure the quality of the fuel and to guard against corrosion and deposition on moving parts. For example, ASTM method D6759 specifies a maximum limit of 5 ppm for the combined concentration of Ca and Mg, and 5 ppm for the combined concentration of Na and K [1]. Trace elemental analysis is used to determine the level of contamination of diesel fuel.

The Agilent 4100 Microwave Plasma-Atomic Emission Spectrometer (MP-AES) uses magnetically-coupled microwave energy to generate a stable plasma using nitrogen gas. This plasma is capable of evaporation not only aqueous solutions, but also challenging organic matrices. When compared to conventional Flame AA, the 4100 MP-AES eliminates expensive and dangerous gases such as acetylene, resulting in lower running costs, unattended operation, and improved productivity.

This application note describes the determination of trace elements in diesel using the Agilent 4100 MP-AES.
Wear Metals
Standard and Sample Preparation

Analysis based on ASTM D5185 and D4628

Wear metals and contaminants

• 1:10 dilution with kerosene

Additives

• 1:100 dilution with kerosene
### Measured Recoveries on 10 ppm Spike in Gear Oil

<table>
<thead>
<tr>
<th>Element</th>
<th>Wavelength (nm)</th>
<th>Unspiked gear oil (ppm)</th>
<th>Spiked gear oil (ppm)</th>
<th>Spike recovery (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ag</td>
<td>328.068 nm</td>
<td>0.27</td>
<td>11.01</td>
<td>105</td>
</tr>
<tr>
<td>Al</td>
<td>396.152 nm</td>
<td>0.32</td>
<td>10.31</td>
<td>98</td>
</tr>
<tr>
<td>Cd</td>
<td>228.802 nm</td>
<td>0.14</td>
<td>9.85</td>
<td>95</td>
</tr>
<tr>
<td>Cr</td>
<td>276.653 nm</td>
<td>0.25</td>
<td>9.92</td>
<td>95</td>
</tr>
<tr>
<td>Cu</td>
<td>327.395 nm</td>
<td>2.68</td>
<td>13.14</td>
<td>103</td>
</tr>
<tr>
<td>Fe</td>
<td>259.940 nm</td>
<td>10.41</td>
<td>20.09</td>
<td>95</td>
</tr>
<tr>
<td>Mn</td>
<td>259.372 nm</td>
<td>0.80</td>
<td>11.54</td>
<td>105</td>
</tr>
<tr>
<td>Mo</td>
<td>319.398 nm</td>
<td>9.02</td>
<td>19.34</td>
<td>101</td>
</tr>
<tr>
<td>Na</td>
<td>589.592 nm</td>
<td>0.46</td>
<td>10.70</td>
<td>100</td>
</tr>
<tr>
<td>Ni</td>
<td>305.081 nm</td>
<td>0.07</td>
<td>10.13</td>
<td>99</td>
</tr>
<tr>
<td>Pb</td>
<td>283.305 nm</td>
<td>0.25</td>
<td>11.36</td>
<td>109</td>
</tr>
<tr>
<td>Si</td>
<td>251.611 nm</td>
<td>2.23</td>
<td>11.60</td>
<td>92</td>
</tr>
<tr>
<td>Sn</td>
<td>303.411 nm</td>
<td>0.16</td>
<td>10.62</td>
<td>103</td>
</tr>
<tr>
<td>Ti</td>
<td>323.452 nm</td>
<td>0.01</td>
<td>10.87</td>
<td>106</td>
</tr>
<tr>
<td>V</td>
<td>310.229 nm</td>
<td>0.15</td>
<td>10.71</td>
<td>104</td>
</tr>
</tbody>
</table>

Great recoveries for all key elements
## Measured Results for Additive Elements

### Measured Results vs Certified Values

<table>
<thead>
<tr>
<th>Element</th>
<th>Measured (mg/kg)</th>
<th>Certified (mg/kg)</th>
<th>Recovery %</th>
</tr>
</thead>
<tbody>
<tr>
<td>P 213.618</td>
<td>301.5 ± 0.1</td>
<td>299.9 ± 7.2</td>
<td>101</td>
</tr>
<tr>
<td>Zn 481.053</td>
<td>314.9 ± 0.3</td>
<td>296.8 ± 6.8</td>
<td>106</td>
</tr>
<tr>
<td>Mg 285.213</td>
<td>300.6 ± 0.2</td>
<td>297.3 ± 4.1</td>
<td>101</td>
</tr>
<tr>
<td>Ca 422.673</td>
<td>279.6 ± 0.1</td>
<td>298</td>
<td>94</td>
</tr>
<tr>
<td>Ba 614.171</td>
<td>281.2 ± 0.1</td>
<td>300.1 ± 2.4</td>
<td>94</td>
</tr>
</tbody>
</table>

### Measured Recoveries on 10 ppm Spike of Gear Oil

<table>
<thead>
<tr>
<th>Element</th>
<th>Mixed Gear (ppm)</th>
<th>Spike (ppm)</th>
<th>Recovery %</th>
</tr>
</thead>
<tbody>
<tr>
<td>P 213.618</td>
<td>17.16</td>
<td>26.71</td>
<td>95</td>
</tr>
<tr>
<td>Zn 481.053</td>
<td>6.99</td>
<td>17.17</td>
<td>101</td>
</tr>
<tr>
<td>Mg 285.213</td>
<td>1.53</td>
<td>11.32</td>
<td>97</td>
</tr>
<tr>
<td>Ca 422.673</td>
<td>8.89</td>
<td>19.69</td>
<td>107</td>
</tr>
<tr>
<td>Ba 614.171</td>
<td>0.00</td>
<td>9.16</td>
<td>91</td>
</tr>
</tbody>
</table>
Organics – Long Term Stability

10 ppm S21. All lines show precision of <1% RSD
Conclusion
The Agilent 4200 MP-AES is the ideal FAAS replacement.

Improved performance
• Increased working range
• Lower detection limits
• Reduced interferences

Reduced running costs
• Runs on air with the nitrogen generator
• Reduced reagent costs

Increased safety
• No acetylene
• No nitrous oxide

Ease of use
• MP Expert
• Simple sample prep
• No burner change over
LEAD TOGETHER
YOUR JOURNEY TO INNOVATIVE SOLUTIONS STARTS HERE

Agilent leads the way in atomic spectroscopy innovation. Our comprehensive and trusted portfolio offers you the most diverse application coverage for AA, ICP-OES and ICP-MS, while our unique MP AES and ICP-QQQ technologies deliver new possibilities for your lab. Now Agilent introduces the next generation atomic spectroscopy equipment that will redefine the way you work. Choose Agilent, together we’ll take the path to success.

The Measure of Confidence

Agilent Technologies