High-speed Agilent 1100 Series diode-array detector SL for optimization of resolution, sensitivity, spectral sensitivity and linearity

Technical Note

Abstract

Standard UV detectors with a maximum of 10 Hz (10 data points per second) are not fast enough to ensure the collection of enough data points (at least 20 data points per peak) to provide reliable results for peaks with a peak width at half height as small as 0.3 s. This Technical Note describes the new Agilent 1100 Series diode-array detector SL (DAD SL), which addresses the need for fast and ultra-fast LC. Besides 80 Hz data acquisition for highest resolution in ultra-fast LC the Agilent 1100 Series DAD SL provides high precision, linearity and sensitivity. In addition, a built-in data recovery card ensures "data never lost insurance". RFID tags for cells and UV lamps ensure unambiguous data traceability. Electronic temperature control provides highest baseline stability and practical sensitivity under fluctuating temperature and humidity conditions. The new standard flow cell increases practical sensitivity with minimized dispersion and RI influence.
Introduction

The demands of high sample throughput in condensed time frames have given rise to high efficiency, fast LC. From the processing of hundreds of samples in overnight runs, to efficient and timely screening of metabolic studies, to rapid method development, and to reducing solvent disposal costs, fast chromatography has become a necessity in the chromatography lab. Using this new methodology, results can be reported in a few hours, rather than a day or even later. Complete validated results in such a short time mean that manufactured goods can be released the same day that they are produced. The end result is greater productivity for customers and greater cost efficiency. This Technical Note illustrates the accurate quantitation and spectral confirmation of impurities at trace level under ultra-fast HPLC conditions with the 1100 Series HPLC system.

To provide a simple structure for discussion, we have categorized fast LC into the following areas:

- Conventional LC means cycle times > 5 minutes
- Fast LC means cycle times < 5 minutes
- Ultra fast LC means cycle times < 2 minutes

The later results in a gradient time of 0.2 – 1.5 minutes, cycle times of 0.5 – 2.5 minutes and 50 % peak width of 0.1 – 1.0 seconds. Standard UV detectors with a maximum of 10 Hz (10 data points per second) are not fast enough to ensure the collection of enough data points (at least 20 data points per peak) to provide reliable results in ultra-fast HPLC. The Agilent 1100 Series diode-array detector SL addresses the need for fast and ultra-fast LC by offering the following new features and benefits:

- 80 Hz data acquisition of up to 8 signals
- for more ultra-fast, high-resolution quantitative LC
- 80 Hz full spectral data acquisition
- for ultra-fast peak purity analysis and spectral confirmation
- Built-in data recovery card
- for a “data never lost insurance”
- RFID tags for all flow cells and UV lamps
- for unambiguous data traceability
- Improved diode-array front-end electronics
- for minimized noise (typical < ± 6 µAU ASTM)
- LAN on board
- eliminates the need for additional LAN interface
- Built-in web-server, USB, PCM-CIA (WLAN, Bluetooth)
- for a future-proof design
- Electronic temperature control – ETC
- for maximum baseline stability and practical sensitivity under fluctuating ambient temperature and humidity conditions
- New standard flow cell
- for minimized dispersion and RI-influence
- Micromechanical slit
- for automated slit width changes during method
- Dual lamp design
- for optimal light intensity and thus maximum sensitivity

In the following examples we will describe the influence and benefits of the new features on fast and ultra-fast applications. Hints and tips are provided for setting detector parameters according to the specific needs of ultra-fast applications. Detector performance regarding fast data acquisition, noise, linearity, spectral data acquisition and peak purity data at trace levels are evaluated.

Experimental

The instrument used was an Agilent 1100 Series high-throughput (HT) LC system, equipped with an Agilent 1100 Series well-plate sampler with cooling option, an Agilent 1100 Series binary pump with optional degasser, an Agilent 1100 Series column compartment and the Agilent 1100 Series diode-array detector SL. The columns used were short ZORBAX SB C-18, packed with 1.8-µm particles. The Agilent 1100 Series high-throughput LC system is modified versus the standard system for the shortest flow connection and the standard mixer is replaced by a mixer with 80-µL (frit) volume. When the Agilent 1100 Series DAD is switched on for the first time or when selecting the default method, default values for all modules are set automatically. These default values are a good starting point for standard applications with a run time > 5 minutes. If fast (<5 minutes) and ultra-fast runs (<2 minutes) have to be performed the Agilent 1100 Series DAD parameters have to be modified to provide the best performance for high-speed applications with optimal resolution, optimum signal sensitivity, best spectral sensitivity or best spectral resolution.
Optimization of data rate for highest resolution in high-speed applications

For LC/UV analysis with cycle times around 1 minute the data rate of the detector can become a limiting factor resulting in peak broadening and reduced peak resolution. In figure 1 an example is given how significantly the data rate influences the peak performance and consequently the quality of results.

This example demonstrates that a UV detector with only 5, 10 or 20 Hz data rate is not suitable for a demanding application. At 10 and 20 Hz the peak width is increased 40 %, respectively 120 % compared to the peak width obtained for a data rate setting of 80 Hz. Peak width directly influences resolution and peak capacity (table 1). At a data rate of 80 Hz the peak width is about 0.3 s at half height. This means an increase in peak capacity of 40 % versus a data rate of 20 Hz. The resolution is improved by 30 % which results in an improvement in the column efficiency of 70 %. Compared to a data rate of 10 Hz the improvement is even more apparent. Peak capacity is increased by 120 %, resolution by 90 % and the column efficiency by 200 %. These results clearly demonstrate that data rates above 20 Hz are needed to take full advantage of fast and ultra-fast LC.

### Chromatographic conditions:
- **Column:** 30 x 4.6 mm ZORBAX SB C18, 1.8 µm
- **Instrument optimized for lowest delay volume:** 80-µL (frit volume) mixer, short flow capillaries
- **Mobile phases:** water (A) and acetonitrile (B)
- **Flow rate:** 5 mL/min
- **Gradient:** at 0 min 50 %B, at 0.3 min 100 %B, at 0.5 min 100 %B, at 0.6 min 50 %B
- **Column temp.:** 50 °C
- **Injection vol.:** 3 µL
- **Detector:** Sample wavelength 245/10 nm, reference wavelength 360/80 nm, data rate from 5 to 80 Hz, 5-µL volume detector cell with 6-mm path length, optical slit width 4 nm

### Table 1

<table>
<thead>
<tr>
<th>Data rate</th>
<th>Peak width</th>
<th>Resolution</th>
<th>Peak capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>80 Hz</td>
<td>0.300</td>
<td>2.25</td>
<td>61</td>
</tr>
<tr>
<td>40 Hz</td>
<td>0.329</td>
<td>2.05</td>
<td>56</td>
</tr>
<tr>
<td>20 Hz</td>
<td>0.416</td>
<td>1.71</td>
<td>55</td>
</tr>
<tr>
<td>10 Hz</td>
<td>0.666</td>
<td>1.17</td>
<td>28</td>
</tr>
<tr>
<td>5 Hz</td>
<td>1.236</td>
<td>0.67</td>
<td>16</td>
</tr>
</tbody>
</table>

**Figure 1**

Influence of data rate on resolution.
Setting the Agilent 1100 Series DAD SL parameters can be done either through the ChemStation software or with the handheld controller. In the ChemStation the parameters are set in the Agilent 1100 Series DAD setup screen (figure 2). The data rate is selected in the “Peak width (Response time)” field. The correlation-to-data rates in Hz units is given in table 2.

**Optimization of noise**

The analysis of trace compounds in the presence of a main compound is a common application problem for pharmaceutical samples. The goal here is to be able to simultaneously quantify a compound and its byproducts at a level of 0.05%. To achieve this goal the UV detector needs to provide a minimum linear range from 1 to 2000 mAU.

One very important parameter for the precise analysis of trace compounds is the signal to noise ratio.

**Figure 2**

Set up screen for DAD parameters.

**Table 2**

Correlation between peak widths, response time and data rate in Hz.
This ensures that the detector noise is as low as possible. Figure 3 and table 3 illustrate the influence of the data rate and optical slit on the short-term noise of the Agilent 1100 Series DAD SL.

At a data rate of 2.5 Hz the influence of the slit width on the ASTM noise was evaluated. The ASTM noise specification is 20 µAU peak-to-peak (± 10 µAU). Under the given chromatographic conditions this is fulfilled for all slit width settings. In table 3 the influence of data rate and slit width on ASTM noise is combined, showing that the lowest noise level is obtained using low data rate settings and an optical slit width of 16 nm. However, setting the data rate at 80 Hz and using a 4-nm slit would produce a noise level of 42 µAU which would still be sufficient to quantify by-products and impurities at a level of 0.05 %. Under actual ultra-fast LC gradient conditions, however, baseline noise may increase to a certain extent. In this case 8-nm or 16-nm slit and/or 40-Hz data rate can be chosen to reduce noise and achieve highly demanding quantitative limits while accepting a certain trade-off in peak resolution and spectral quality. The degree of reduced resolution and spectral accuracy depends on analytical conditions and the natural bandwidth of compound spectra.

Chromatographic conditions:
Eluent: water/ACN = 70/30
Flow rate: 1 mL/min
Column: 4.6 x 30 mm ZORBAX SB C18, 1.8 µm
Temperature: 20 °C
DAD: 254 nm, 16 nm, ref 360, 80 nm
PW: > 0.1 min (2.5 Hz, 2 s RT), standard
13-µL detector cell with 10-mm path length

Figure 3
Influence of optical slit width on noise.

<table>
<thead>
<tr>
<th>Slit Width</th>
<th>4-nm Slit Peak-to-peak Noise</th>
<th>8-nm Slit Peak-to-peak Noise</th>
<th>16-nm Slit Peak-to-peak Noise</th>
</tr>
</thead>
<tbody>
<tr>
<td>80 Hz</td>
<td>42 pAU</td>
<td>31 pAU</td>
<td>23 pAU</td>
</tr>
<tr>
<td>40 Hz</td>
<td>30 pAU</td>
<td>22 pAU</td>
<td>16 pAU</td>
</tr>
<tr>
<td>20 Hz</td>
<td>21 pAU</td>
<td>16 pAU</td>
<td>11 pAU</td>
</tr>
<tr>
<td>10 Hz</td>
<td>15 pAU</td>
<td>11 pAU</td>
<td>8.0 pAU</td>
</tr>
<tr>
<td>2.5 Hz</td>
<td>7.4 pAU</td>
<td>5.4 pAU</td>
<td>4.0 pAU</td>
</tr>
</tbody>
</table>

Table 3
Influence of optical slit width and data rate on peak-to-peak noise. 2.5-Hz data rate is not sufficient for fast LC, as shown in figure 1. In this case 80 or 40 Hz with a 16-nm slit width is the best compromise.
A practical example for the evaluation of limits of detection (LOD) at different data rates is given in figure 4. 10 pg/µL of anthracene were injected at 10, 20, 40 and 80 Hz. Using these ultra fast chromatographic parameters the LOD at 10 Hz is about 0.67 pg, which is the lowest achievable level under these conditions but the resolution is far better at 20, 40 or 80 Hz. In this case a good compromise would be to use the 40 Hz setting with less sensitivity but with better resolution and more reliable integration for improved quantitation.

**Evaluation of linearity**

Measuring high and low concentrations in one run is only possible if the detector offers a wide dynamic range. In figure 5 the linearity was tested using caffeine as a test compound. Two experiments were done, one with only the UV lamp on and the second one with both UV and Vis lamps on.

The result is that the Agilent 1100 Series DAD SL provides a “linear” dynamic range for the tested caffeine sample up to 2.5 AU with a deviation of 5% at 2.5 AU. At 2 AU the deviation is about 2%. A common specification for a UV detector is that at 2.0 AU the deviation should be in the 5% range. These experiments also demonstrate that the tungsten lamp could be switched off to maximize the linear range if the analytical wavelength is chosen in the UV range. However, there is a two-fold trade-off when switching the visible lamp off. First, the positive effect of using a reference wavelength to increase practical sensitivity by reducing baseline drift and wander is sacrificed due to increased noise in the visible range, where the reference wavelength is typically chosen. Second, qualitative analytical results for peak purity analysis, library searches and spectral confirmation are sacrificed, because spectral quality decreases when the visible lamp is switched off, especially at trace levels (compare figures 14 and 15).
Evaluation of precision for areas and retention times for ultra-fast LC

For analysis times of 24 s, total cycle time of 55 s (figure 6) and demanding gradients of 0.3 minutes the precision of retention times was determined to be between 0.7 and 0.22 % RSD. The precision for the areas was between 1.5 and 0.3 % RSD. The exact data are shown in table 4.

This precision data is typically useful for screening experiments and semi-quantitative work. Lower % RSD values, however, may be needed to comply with strict regulatory performance requirements. One way to achieve this goal is to decrease gradient speed. Figure 7 shows that when using a less demanding gradient and higher concentrations the precision for retention times is between 0.1 and 0.5 % RSD and the precision for areas is between 0.2 and 0.5 %. The more detailed results are summarized in table 5. Both tests show that even under highly demanding analytical conditions with run times below 1 minute very good precision can be achieved.

Chromatographic conditions:
Sample: Phenone test mix
Column: 4.6 x 30 mm, 3.5 µm ZORBAX SB C18
Gradient: 50-100 % ACN in 0.3 min
Flow rate: 5 mL/min
Temperature: 40 °C
Data rate: 40 Hz
Flow cell: 5 µL

Table 4
% RSD for retention times and areas for the phenone test mix with a highly demanding gradient.

<table>
<thead>
<tr>
<th>Peak</th>
<th>RSD RT (%)</th>
<th>RSD Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.70</td>
<td>1.3</td>
</tr>
<tr>
<td>2</td>
<td>0.58</td>
<td>0.7</td>
</tr>
<tr>
<td>3</td>
<td>0.43</td>
<td>0.9</td>
</tr>
<tr>
<td>4</td>
<td>0.34</td>
<td>0.3</td>
</tr>
<tr>
<td>5</td>
<td>0.32</td>
<td>0.9</td>
</tr>
<tr>
<td>6</td>
<td>0.29</td>
<td>0.9</td>
</tr>
<tr>
<td>7</td>
<td>0.26</td>
<td>1.5</td>
</tr>
<tr>
<td>8</td>
<td>0.24</td>
<td>0.7</td>
</tr>
<tr>
<td>9</td>
<td>0.22</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Table 5
% RSD for retention times and areas for the phenone test mix with a less demanding gradient and at a higher concentration.

<table>
<thead>
<tr>
<th>Peak</th>
<th>RSD RT (%)</th>
<th>RSD Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.47</td>
<td>0.47</td>
</tr>
<tr>
<td>2</td>
<td>0.44</td>
<td>0.19</td>
</tr>
<tr>
<td>3</td>
<td>0.31</td>
<td>0.30</td>
</tr>
<tr>
<td>4</td>
<td>0.27</td>
<td>0.27</td>
</tr>
<tr>
<td>5</td>
<td>0.25</td>
<td>0.48</td>
</tr>
<tr>
<td>6</td>
<td>0.23</td>
<td>0.42</td>
</tr>
<tr>
<td>7</td>
<td>0.20</td>
<td>0.33</td>
</tr>
<tr>
<td>8</td>
<td>0.17</td>
<td>0.35</td>
</tr>
<tr>
<td>9</td>
<td>0.15</td>
<td>0.27</td>
</tr>
</tbody>
</table>

Figure 6
24 second analysis of a phenone test mix.

Figure 7
48 second analysis of phenone mix.
Application example: Analysis of nimodipin as the main compound and nifedipin as the by-product

To mimic the analysis of impurities beside a main compound as is common in process control or stability analyses the structurally related compounds nifedipin and nimodipin were mixed in different ratios (figure 8). Our sample of nimodipin as the main compound and nifedipin as the trace compound was analyzed using ultra-fast chromatographic conditions with run times of 1 minute. Precision for both compounds was evaluated as well as spectral performance and peak purity.

Nifedipin was also injected in a ca. 50-fold concentration (approx. 60 µg/mL) compared to the highest concentration (1.1 µg/mL in the 1:500 mixtures) in the subsequent experiments. Nimodipin was injected in the same concentration as in the subsequent experiments (approx. 550 µg/mL) and in a 1/10th dissolution (approx. 55 µg/mL). It was discovered that

Chromatographic conditions:
Column: 4.6 x 50 mm ZORBAX SB C18 RRHT 1.8 µm
Solvents: A=water (0.1 % FA), B=ACN (0.1 % FA), Water MilliQ, ACN: Merck Grad., FA: 96 %
Flow: 4.1 mL/min
Temperature: 60 ºC
Gradient: 50 – 70 % B in 0.85 min, 70 % B for 0.15 min, 50 % B for 0.5 min, total 1.5 min
UV-Detection: UV=245 nm (10), ref. 460 nm (80), range 190 – 500 nm store all spectra, 80 Hz
Injection: 5.0 µL injections of a mixture of nifedipin and nimodipin in the following ratios: 1:500, 1:1000, 1:2000 and 1:4000
Agilent 1100 Series well-plate sampler with minimized carry over, overlapped injection, automatic delay volume reduction, 10 injections

Figure 8
Analysis of nimodipin in the presence of trace levels of nifedipin and some degradation products.

Figure 9
Chromatogram of 1:500 mixture at 245 nm using different instrument set ups with different delay volumes.
nifedipin as well as nimodipin showed a distinct degradation in the DMSO stock solution. The identity of the nifedipin peak was established by comparison to a freshly prepared solution and by LC/MS analysis. Figure 9 shows the influence of different configurations on the peak resolution. The configuration providing the lowest delay volume was chosen (figure 10). After selecting the optimum configuration the performance of the analysis was evaluated. In figure 11 the precision for retention times and areas of the main compound are shown. Both precision of retention times and areas for the main compound are very good and quantitation is reliable and robust. In figure 12 the precision of retention time for the trace compound is evaluated. The relative standard deviation for nifedipin is below 0.1 %. The precision for areas is < 5 % relative standard deviation for the 0.05 % level.

**Chromatographic conditions:**
- **Gradient:** 50–70 % B in 0.85 min
- **Column:** 4.6 x 50, ZORBAX SB C18, 1.8 µm
- **Injection:** 5 µL of 550 µg/mL nimodipin
- **Flow rate:** 4 mL/min
- **Flow cell:** 13 µL
- **Data rate:** 80 Hz
- **Slit:** 8 nm
- **Wavelength:** 245 nm

**Chromatographic conditions:**
- **Nifedipin:** Nimodipin = 1:500
- **Column:** 4.6 x 50, ZORBAX SB C18, 1.8 µm
- **Gradient:** 50-70 % B in 0.85 min
- **Injection:** 5 µL
- **Flow rate:** 4 mL/min
- **Flow cell:** 13 µL
- **Data rate:** 80 Hz
- **Slit:** 8 nm
- **Wavelength:** 245 nm
The limit of detection for the trace level impurity nifedipin is far below the 0.05 % level (figure 13). This means even under ultra-fast LC conditions the Agilent 1100 Series DAD SL allows accurate quantitation of impurities and by-products at levels less than 0.05 % of the main compound(s). Accurate 80 Hz spectra collection allows peak purity data to be obtained with high reliability using ultra fast chromatographic conditions. In figure 14 the spectra of nifedipin at a 0.1 % level and the overlay of the spectra of the nifedipin (A) and nimodipin (B) at a high concentration level are shown. Even at the 0.1 % level the identification in the low mAU range is possible. Based on the high spectral acquisition rate, peak purity of the trace compound nifedipin could be evaluated, showing that the peak is pure and no other compound is co-eluting (figure 15). To provide accurate data it is important to select the “Calculate Threshold” option. This ensures that even at trace levels calculations are based on correct threshold values.
More features and benefits of the Agilent 1100 Series DAD SL

Data recovery card – DRC
This card is situated at the back of the instrument and offers:

- All signals, spectra and metadata are buffered on a high-capacity, embedded 256 MB compact flash card.
- Prevents any data loss in case of communication breakdown between instrument and PC.
- Automatic run recovery in case of temporary communication failures.
- Manual run recovery in case of permanent communication failures after software, PC, and/or instrument re-boot.

Radio frequency identification tags
For more compliance the lamp and cell now also have identification tags:

- RFID tags records all relevant data necessary to recall instrument conditions under which a run has been executed.
- Minimizes the risk of false data interpretation, because measurement conditions are documented.
- Meta data stored on RFID tags are saved with each raw data file for unambiguous answers to (auditor) questions like:
  - “Which type of flow cell was used to generate this chromatogram – what was the path length and volume?”
  - “Did the accumulated burn-time of the lamp exceed the pre-defined limit?”

For the flow cell the following data are stored as part of the method:

- path length
- volume
- maximum pressure
- date last test passed
- product number
- serial number
- production date

For the lamp the following data are stored:

- accumulated on-time
- actual on-time
- number of ignitions
- date last test passed
- product number
- serial number
- production date

All listed parameters can be printed as part of reports.

Electronic temperature control – ETC
This new feature ensures more baseline stability for demanding environments, providing:

- compensation for changes in ambient conditions (temperature and humidity)
- reduced baseline wander for improved practical sensitivity and reproducibility under harsh environmental conditions

In figure 16 a comparison is made between the Agilent 1100 Series DAD B and the Agilent 1100 Series DAD SL regarding sensitivity versus ambient relative humidity and ambient temperature. The improved ambient rejection on the Agilent 1100 Series DAD SL ensures that drift and wander is reduced to < 30 mAU/°C versus ~100 mAU/°C for the Agilent 1100 Series DAD B version.

New 13-µL standard flow cell design
The new flow cell is based on “drilled” flow path with improved flow characteristics and in addition a ceramic ring was installed for thermal decoupling. This provides:

- reduced RI-sensitivity (figure 17)
- reduced peak dispersion
- minimized noise in high-flow, high-temperature applications

Several cells are available for the Agilent 1100 Series DAD SL covering a wide range of applications. This ensures that the Agilent 1100 Series DAD SL is compatible with conventional LC, capillary LC, nano LC as well as with preparative LC systems.

![Figure 17](image)

Influence of the cell design on refractive index behaviour.
The following cell types are available:

- **Standard:** 13 µL, 10-mm path length, 120 bar
- **Semi-Micro:** 5 µL, 6-mm path length, 120 bar
- **Micro:** 1.7 µL, 6-mm path length, 400 bar
- **Semi-Nano:** 500 nL, 10-mm path length, 50 bar
- **Nano:** 80 nL, 6-mm path length, 50 bar
- **Preparative:** 3 mm, 120 bar
- **Preparative:** 0.3 mm, 20 bar
- **Preparative:** 0.06 mm, 20 bar

For fast and ultra-fast LC applications, 3 cell types are recommended:

13-µL standard flow cell:
- for highest sensitivity
- highly demanding quantitative work, e.g. analytical method development, QA/QC
- 4.6 – 3-mm id columns

1.7-µL micro flow cell:
- For highest selectivity
- Ultra-fast semi-quantitative work, e.g. screening experiments, HT LC/MS/UV
- 2.1 – 1-mm id columns

5-µL micro flow cell:
- Best compromise for sensitivity and selectivity
- For good quantitative and qualitative results, e.g. screening, HT LC/MS/UV, early formulation studies
- 4.6 – 1-mm id columns

In Table 6 an overview is given about the influence of different cell types on resolution and sensitivity for 4.6-mm and 2.1-mm internal diameter columns. The three cell types are stainless steel cells, which can be used from pH 1 up to pH 12. The 1.7-µL cell offers the best performance if resolution is the leading requirement. This cell is also recommended if the UV and MS are serially connected and resolution should be as good as possible. For optimum sensitivity the 13-µL with a 10-mm path length is the best choice. A good compromise is the 5-µL cell with a 6-mm path length for applications where resolution and sensitivity is of equal importance.

<table>
<thead>
<tr>
<th>Flow cell</th>
<th>Sensitivity &amp; linearity</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>13 µL/10 mm</td>
<td>+++</td>
<td>+</td>
</tr>
<tr>
<td>5 µL/6 mm</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>1.7 µL/6 mm</td>
<td>+</td>
<td>+++</td>
</tr>
</tbody>
</table>

Table 6: Influence of cell types on sensitivity and resolution

Kits for optimizing the Agilent 1100 Series LC system for high throughput analysis are offered to reduce system delay volume to an appropriate level for different column dimensions and corresponding flow rates. Three kits are available:

- Fast LC modifications for Agilent 1100 Series instrument with DAD, 4.6-mm id columns (Agilent p/n 5188-5324)
- Ultra-fast LC modifications for Agilent 1100 Series instrument with DAD/MS, 2.1-mm id columns (Agilent p/n 5188-5328)
- Ultra-fast LC modifications for Agilent 1100 Series instrument with VW UV detector, 4.6-mm id columns (Agilent p/n 5188-5323)

**Conclusion**

The Agilent 1100 Series DAD SL provides more accurate results faster. A significantly higher peak capacity and better data security using the 80 Hz data acquisition enables highest resolution in ultra-fast LC.

- The examples have proven the high precision, excellent linearity and high sensitivity. This prevents compromising data quality under ultra-fast LC conditions and ensures compliance with strict regulatory performance requirements.
- The proven dual lamp design allows for spectral analysis at trace levels (DAD SL only).
- The high quality of the rugged 1100 Series HPLC, the ZORBAX RR-HT column and method stability enables robust 4 x 7 operation.

Angelika Gratzfeld-Huesgen and Michael Frank are Application Chemists, Stefan Schuette is Product Manager at Agilent Technologies, Waldbronn, Germany.

www.agilent.com/chem/1200

Published April 1, 2007
Publication Number 5989-3070EN