

Waters® 2996 Photodiode Array (PDA) Detector incorporates uniquely-integrated software and optics innovations that deliver no-compromise chromatographic and spectral sensitivity, reliability and ease of use for analytical and preparative separations. Advanced spectral analysis enhances component recognition and homogeneity assessment.

Do you face these challenges when it comes to PDA detection?

- Attaining maximum chromatographic sensitivity to detect the smallest peaks?
- Maintaining spectral sensitivity to detect smallest co-elutions?
- Maximizing linear range for your method for accurate quantitation so that smallest and largest peaks can be detected?
- Maintaining maximum uptime despite increasing workloads and shorter time-to-market schedules?
- Decreasing turnaround time for rugged method development?
- Ensuring compliance with current regulatory requirements including the FDA Electronic Records and Electronic Signatures Rule (21 CFR Part 11)?

Waters 2996 PDA detector provides:

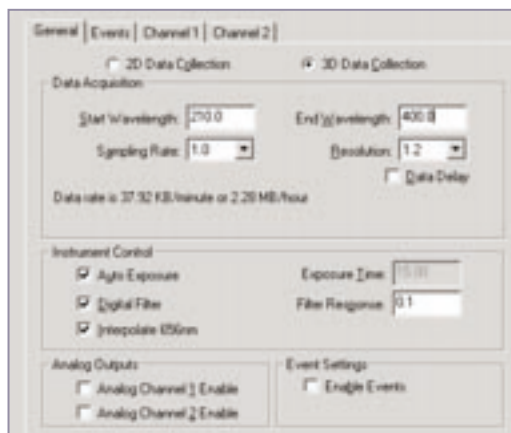
- Unprecedented trace impurity detection and quantification using maximum chromatographic sensitivity
- Definitive compound identification and co-elution detection using optimized spectral sensitivity and proprietary purity algorithm
- Superior linear range with constant optical bandpass
- Simple optics that are reliable and easy to maintain
- Uncomplicated method development tools within Millennium^{®32} software making method development and validation fast and straightforward
- Compliance-ready for the FDA Electronic Records and Electronic Signatures Rule
- Start-up diagnostics that ensure optimal detector performance prior to use



Maximum chromatographic sensitivity

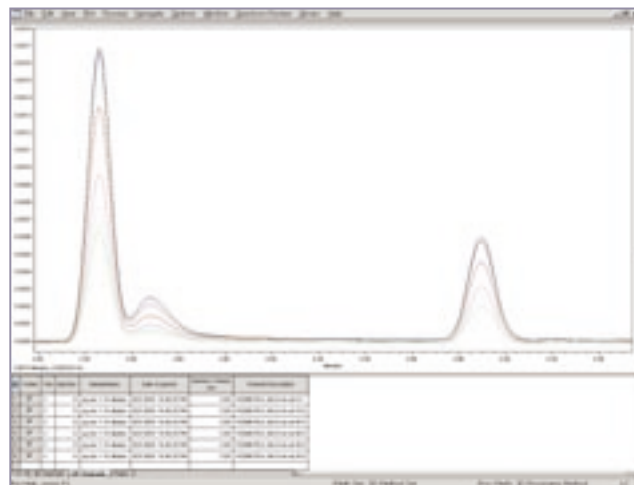
Exceptional signal-to-noise (S/N) ratios allow the 2996 detector to map low levels of compounds and determine trace impurity levels within the compound's peak. Unique Lamp Optimization Software optimizes light intensity and maintains a minimal noise level across the entire deuterium spectrum over the lifetime of the lamp. The need to compromise optical bandpass and linear range simply to reduce noise is eliminated. The mechanism is simple; as light intensity decreases, the PDA is scanned less frequently allowing for longer exposure of the diodes.

There is no need to use supplementary lamps to offset noise in visible regions where deuterium energy is generally lower. MaxPlot automatically detects UV/Vis absorbing compounds anywhere within the selected chromatographic range and plots a peak for each compound without the operator's need to know each peak's absorbance maxima.



Intuitive operator set up helps you get the right answer, faster.

For chemists looking to optimize to the highest possible S/N ratios, the 2996 detector can collect up to eight chromatograms at multiple digital bandwidths, using the simple-to-operate 2D mode.

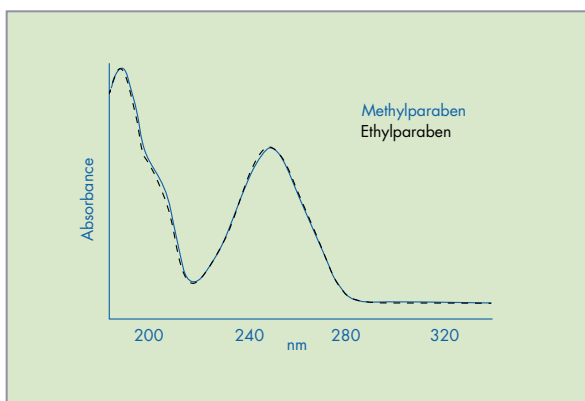


New 2D capabilities allow for multiwavelength analysis in routine lab applications.

Low stray light contributes significantly to the 2996 detector's unparalleled ability to meet high sensitivity requirements. In the TaperBeam™ flowcell, refractive index (RI) effects that contribute to noise are eliminated from the raw absorbance signal without data manipulation.

Definitive compound identification

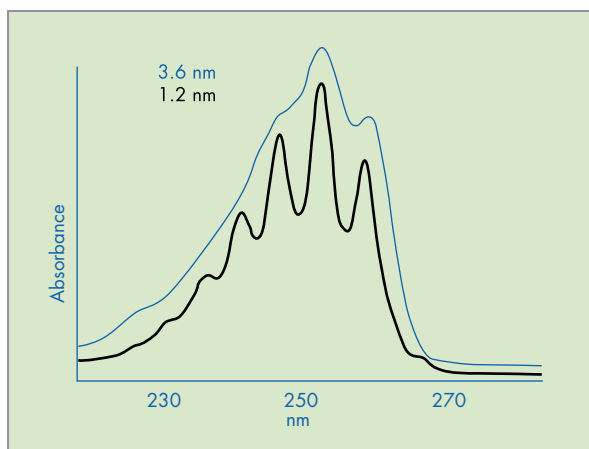
While virtually any PDA detector can distinguish between compounds possessing comparatively large spectral differences, very few can differentiate between the spectra of closely related compounds.



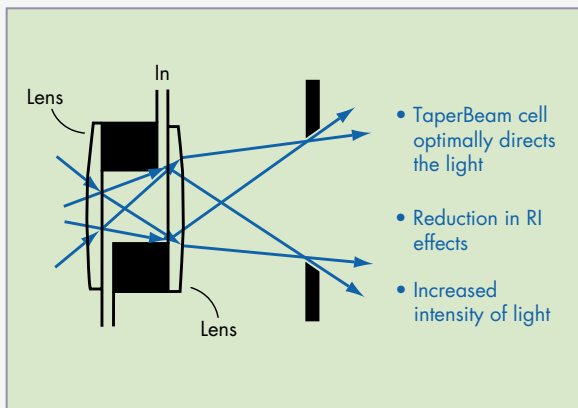
Spectral analysis of methylparaben and ethylparaben that differ by only one CH₂ group demonstrates the ability of the 2996 detector to distinguish closely related products.

Reliable co-elution detection

High optical and digital resolution is required in 3D data-collection mode for high-sensitivity library matching and co-elution detection. The key lies in using Lamp Optimization to maximize the signal. Optical bandpass is set to its minimum 1.2 nm, enabling the system to accurately detect and quantify the fine spectral structures that confirm the identity and spectral purity even with low contaminant concentration.



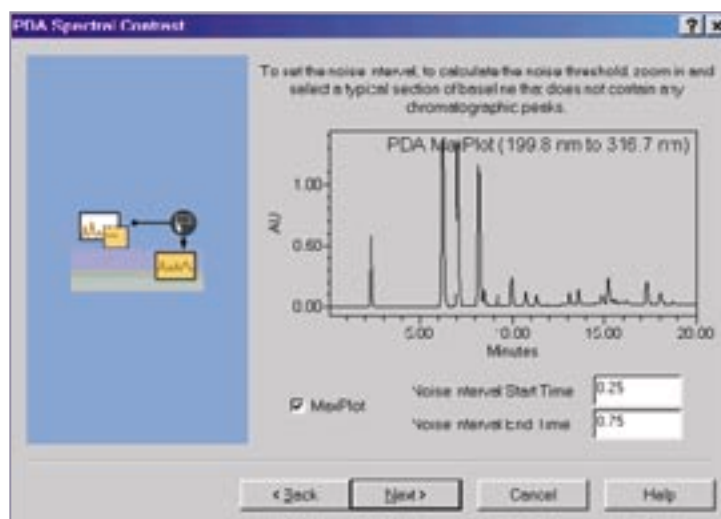
An overlay of a benzene spectrum for the 2996 PDA detector using 1.2 nm digital resolution and a benzene spectrum of a PDA detector using 3.6 nm digital resolution clearly demonstrates the importance of digital resolution when defining the spectral details of a compound.



TaperBeam optics reduces RI effects at the eluate/flowcell interface with a lens arrangement designed to maximize the light intensity reaching the diode.

Reliable co-elution detection

Millennium³² software's 3D spectral-contrast algorithm accounts for random system noise in spectral comparisons. Using MaxPlot, you simply identify the area in the chromatogram where no peaks elute; the software uses this information to eliminate random photometric noise.

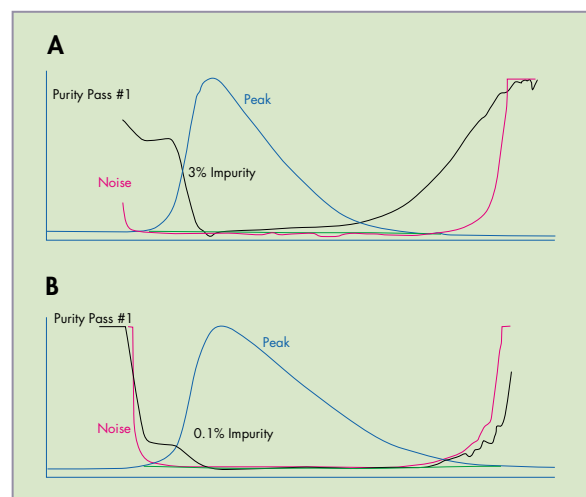


Select representative baseline sample for noise rejection.

Optimal digital and optical resolution

The resolving power of any PDA detector depends on both digital and optical resolution. In the 2996 detector, both the maximum digital resolution and the maximum fixed optical resolution are 1.2 nm. Spectra become distorted when digital resolution is increased and are less easy to discriminate.

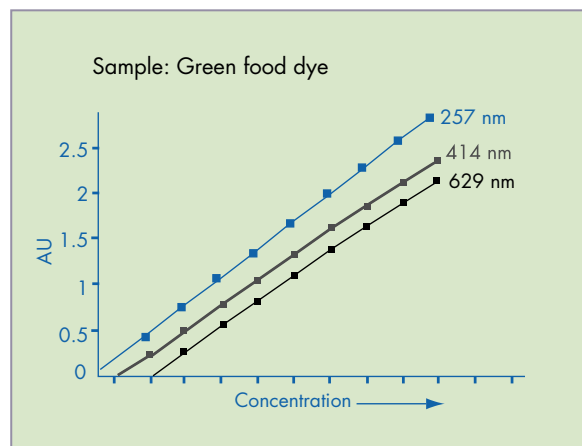
With other PDA detectors, increasing digital resolution increases S/N, reducing linear range. The 2996 detector operates continually at a fixed optical bandpass of 1.2 nm resulting in excellent S/N and linearity. Unlike other systems, any changes in the 2996 detector's digital resolution (optical bandpass never varies) is fully documented both in libraries and in chromatograms and, because of the Millennium³² relational database, can never be overwritten.



Looking at the front of the peaks, a sample of pseudoephedrine spiked with a 3% impurity (A) demonstrates a sharp distortion in the Purity Angle Plot (designated by the color of the trace), clearly verifying the presence of the co-elution. A sample with an 0.1% impurity shows a smaller, but still significant, distortion of the Purity Plot (B) in the same position.

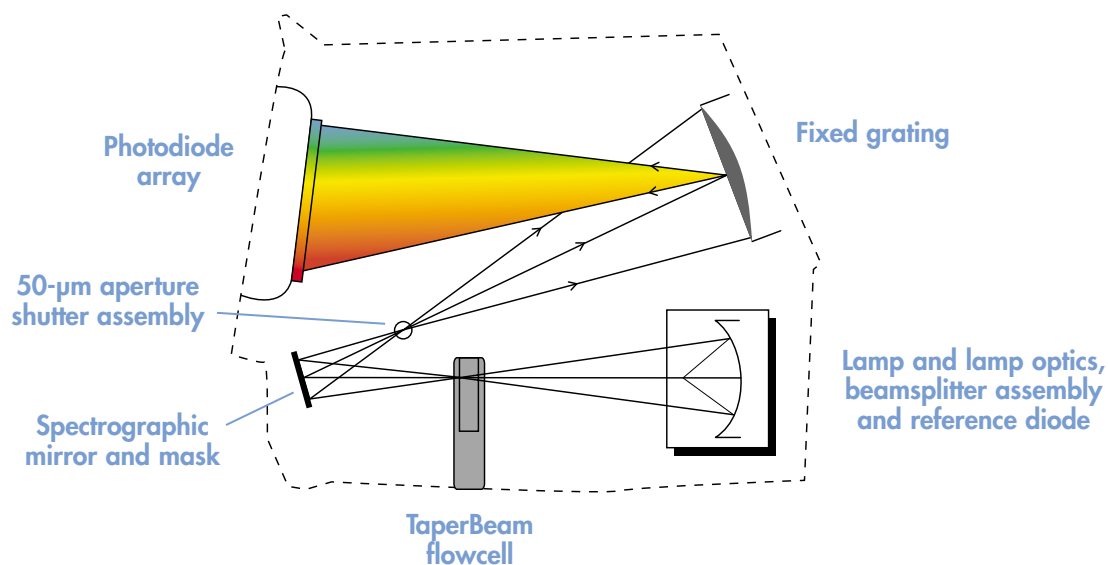
Superior linearity range defined by a fixed optical bandpass

The 2996 detector can acquire chromatographic and spectral data at wavelengths above 600 nm and up to 2.0 AU—without compromising linearity. Such conformity is crucial when comparing spectra across a broad wavelength and concentration range. Without it, disparate levels in common stability indicating methods cannot be quantified at the wavelength that offers the best S/N and minimal interference.



Plotting the detector response versus concentration clearly demonstrates the linearity and dynamic range across all wavelengths. (X-axis starting points are offset to facilitate viewing.)

The 2996 PDA Detector — simple optics, reliable and easy to maintain



Outstanding system performance and reliability

The 2996 detector has been incorporated into sophisticated systems such as the Waters FractionLynx™ UV Autopurification System. With its variable pathlength flowcell, the 2996 detector is popular as a preparative detector.



The Waters FractionLynx UV-based Autopurification System delivers exceptionally accurate and reproducible performance.

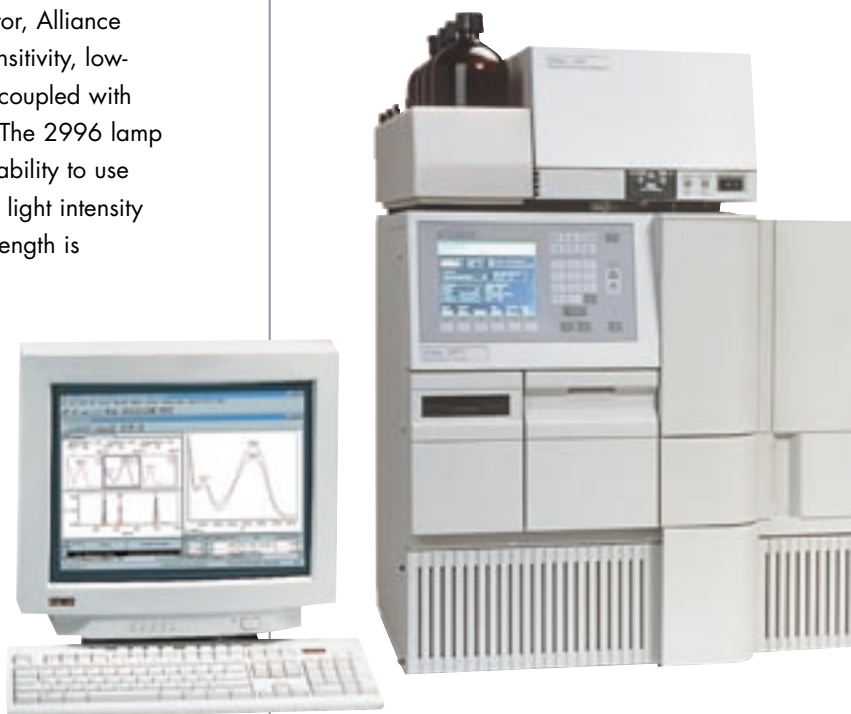
Method development and validation—fast and straightforward

Waters Millennium³² Software, Version 4.0, is the most powerful chromatography data management software available. With Millennium³² software you can acquire, store and retrieve single or multiwavelength data, complete spectra or all three.

Millennium³² software transforms data translation and presentation from a time-consuming process to a virtually effortless operation using these features:

- An intuitive graphic interface and interactive Wizards that provide easy-to-follow, step-by-step assistance
- The only integrated Oracle relational database, eliminating the need to navigate through layers of software or export data to other programs
- A variety of report options including:
 - 3D Reports (annotation including structures)
 - Extracted Spectral Reports
 - Purity Reports
 - Library Matches, Compound Confirmation Reports
 - Triple/Difference Plots
- Structural validation and compliance with the FDA's Electronic Records and Electronic Signatures Rule, 21 CFR Part 11.

Coupled with the 2996 detector, Alliance HPLC Systems support high-sensitivity, low-dispersion applications when coupled with the 2996 microbore flowcell. The 2996 lamp optimization accounts for the ability to use shorter pathlengths with lower light intensity signals, even though the pathlength is reduced by 70 percent.



Turn raw data into knowledge

With the simple click of a mouse, Millennium³² software conducts an astonishing array of complex calculations and charts the results in a variety of exceptionally-explicit graphs.

- **Demonstrate peak homogeneity**
Instantly visualize any major difference in spectra by clicking the Spectrum Index Plot that displays apex spectrum and other spectra within the peak—all corrected for noise, normalized and displayed in a color-coded overlay plot.
- **Quantify peak purity**
For a more quantitative analysis, view the Purity Angle Plot that mathematically compares the apex spectrum of a peak to the spectrum at every data point across a peak. With automatic adjustments to noise and background solvent absorbance, plus complete data plotting, any spectral differences and potential impurities become virtually impossible to miss.
- **Confirm peak identity**
The Library Match function automatically identifies each peak in a sample by mathematically comparing unknown peaks to reference spectra stored in the library. Once initiated, the match function automatically searches for the closest spectral match and reports findings with a value indicating the degree to which the spectra match. Numerous libraries containing any number of compounds can be created, stored, searched and shared among networked workstations.
- **Document wavelength monitoring choices**
PDA Software automatically selects and stores maximum absorbencies for each peak. Documentation of λ -max will justify wavelength selection to auditors.
- **Construct a multi-wavelength chromatogram**
PDA Software automatically selects and stores maximum absorbencies for each peak that are then used by the software to construct a multi-wavelength chromatogram. The result is a meticulous composite chromatogram of all compounds detected.

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