SHIMADZU
Excellence in Science

Liquid Chromatograph

P-Series

High Performance All Round HPLC System

P-Series

Proven Performance with Productivity

Environment

Chemicals

Food

Pharma

Proven

Industry proven capabilities with compliance and ease of use

Performance

Superb system performance ensures exceptional reliability and flexibility

Productivity

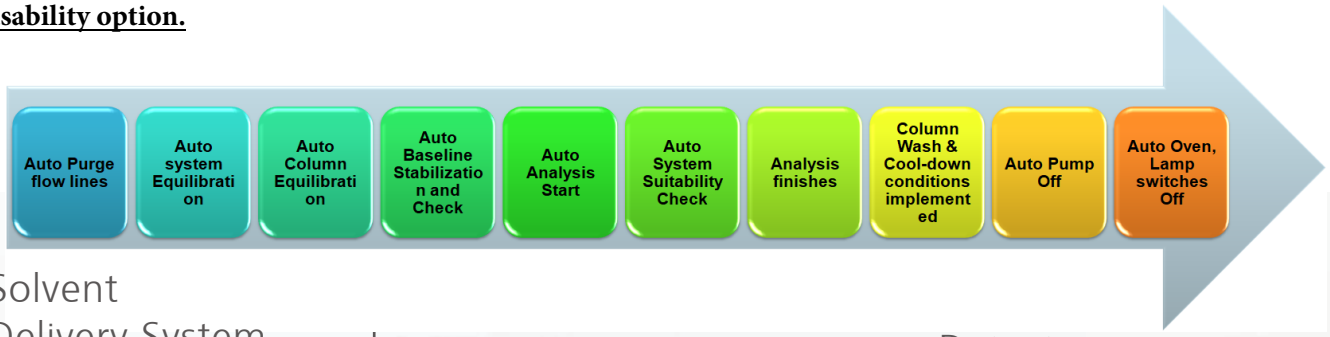
Rugged system design guarantees higher efficiency and maximum productivity

Key Features

Packed with industry proven capabilities, P-Series provides established and accessible solution for your regular liquid chromatographic needs.

Rugged system design maximizes productivity and performance ensuring reliable and reproducible results are delivered in time, which translates into higher Return on Investment.

Automatic System Preparation" function (ASP) of our system which allows a complete automation with unattended usability option.



Solvent Delivery System

The LC-20AD offers the fastest solvent delivery performance in the world. With **an automatic pulsation-correction mechanism and high-speed micro plunger driving**, it achieves **pulse-free solvent** delivery

- Accurate gradient solvent delivery

Detector

Experience highly sensitive measurement and stable analysis through the entire wavelength range. **Noise and drift are minimized** by the fully temperature controlled optical system and flow cell. The **signal-to-noise ratio is enhanced** by an improved optical system and a high-order digital filter

- i-PDeA | Intelligent Peak Deconvolution Analysis
- i-DReC | Intelligent Dynamic Range Extension Calculator

Autosampler

The SIL-20AC HT is a total volume injection-type autosampler that enables high-speed injection and multi-sample processing.

- Precise sample injection
- Sample Carryover Reduced to an Absolute Minimum

Column Oven

Large capacity oven compartment with **Precise Temperature Control** at sub-ambient temperature

SHIMADZU
Excellence in Science

Technical Report

Eliminating the Effects of Room Temperature Fluctuations Using the Advanced TC-Optics Function in the SPD-M40 Photodiode Array Detector - Improving Baseline Stability and Analytical Precision

Hidetoshi Terada[1], Masato Watanabe[1]

Abstract:

Because of the detection principles involved, photodiode array detectors are affected by the environment in which they are installed. Consequently, room temperature fluctuations can cause baseline fluctuations. To eliminate the effects of room temperature fluctuations, the SPD-M40 includes a triple temperature control function (Advanced TC-Optics), which independently controls the temperatures of the detector cell, light source lamp, and spectrometer. As a result, baseline stability is obtained even when there are large room temperature fluctuations, enabling high analysis precision in high-sensitivity analyses, and in analyses over an extended period.

Keywords: Photodiode array detector, triple temperature control function, Advanced TC-Optics

1. Effects of Ambient Temperature Fluctuations on Photodiode Array Detectors

Due to the single-beam configuration*1) of photodiode array (PDA) detectors, their operating principles make them more likely to be affected by temperature fluctuations during measurements than UV-VIS detectors, with their double-beam configuration.*2)

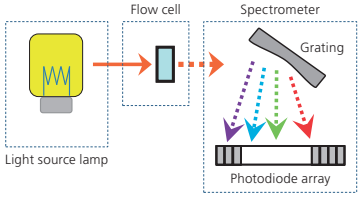


Fig. 1 Illustration of Detection by a Photodiode Array Detector

*1) Single-beam configuration: Light from the light source enters the cell directly, and then enters the detection unit.
*2) Double-beam configuration: Light from the light source is split into sample and reference light beams, with the sample beam entering the sample cell, and the reference beam used to correct for drift caused by the instrument.

Fluctuations in the surrounding air temperature where the PDA detector is installed can disrupt baseline stability by changing the light absorbance at measurement wavelengths. Such fluctuations can be caused by the following factors.

(1) Variations in source lamp light intensity
(2) Variations in mobile phase and target component absorbance inside the cell*3)
(3) Variations due to shifts of spectra (in the wavelength direction)

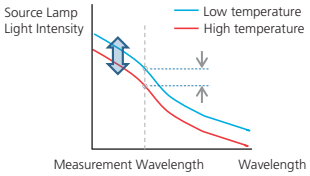


Fig. 2 Illustration of Temperature Effects on Source Lamp Light Intensities

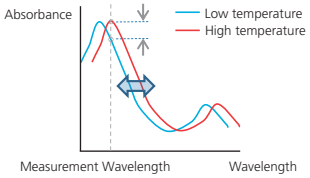


Fig. 3 Illustration of Temperature Effects on Spectra

*3) Temperature fluctuations can cause variations in the absorption spectra of mobile phases or target components inside the cell, in either the absorbance or wavelength direction, or in both directions.

2. SPD-M40 Temperature Control Method

The SPD-M40 features an Advanced TC-Optics triple temperature control function, which not only controls the cell temperature, as available on previous models, but also controls the temperature of the light source lamp and the spectrometer independently. (Fig. 4)

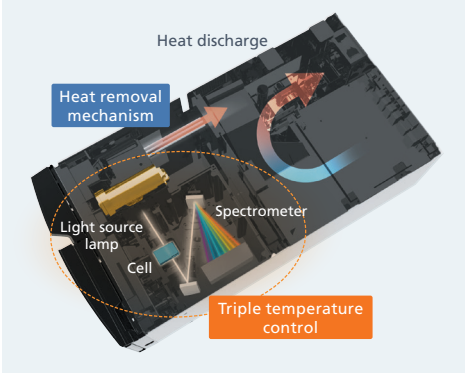


Fig. 4 SPD-M40 Triple Temperature Controlled Locations

The benefits obtained from controlling the temperature at each location are summarized in Table 1 All of these benefits help reduce detector absorbance fluctuations caused by fluctuations in the ambient temperature, so that HPLC analysis can be performed with a stable baseline, even if ambient temperatures fluctuate.

Table 1 Benefits of Temperature Control at Each Location

Temperature Controlled Location		Benefit
(1)	Light Source Lamp	Stabilizes source lamp light intensity
(2)	Cell	Inhibits changes in absorption spectra due to temperature variations in mobile phases or target components
(3)	Spectrometer	Inhibits absorbance changes due to shifts of spectra

Additional baseline stabilization and noise reduction are achieved by using a unique heat removal mechanism that removes heat from the light source lamp, an element that generates large amounts of heat.

1 Analytical & Measuring Instruments Division

3. Effect of Ambient Temperature Fluctuations on the Baseline

Fig. 5 shows PDA detector baseline fluctuations caused by intentionally varying the ambient temperature in a thermostatic chamber. Analytical conditions and ambient temperature settings conditions are shown in Table 2. In addition to the SPD-M40, the SPD-M20A, which is Shimadzu's previous model, and another Vendor's PDA Detector were also verified in the same manner.

Due to the triple temperature control function, the baseline fluctuation in response to a 10 °C change in ambient temperature was an extremely small 0.2 mAU or less for the SPD-M40, ensuring excellent baseline stability. As a result, HPLC analysis can be performed with a stable baseline characterized by minimal undulations, even if the room temperature varies where the system is installed.

Table 2 Analytical Conditions

Column	: None	Cell temperature	: 40 °C
Mobile phase	: MeOH	Ambient temperature	: 20 to 30 °C (profile indicated in Fig. 5)
Flowrate	: 1.0 mL/min		
Detection	: 260 nm		

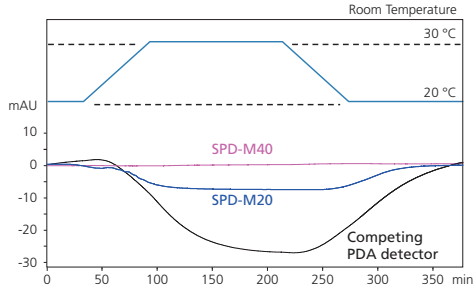


Fig. 5 Baseline Fluctuations in Response to Changes in Ambient Temperature

4. Effect of Ambient Temperature Fluctuations on Quantitative Analysis

To confirm the effect of baseline fluctuations on quantitative accuracy, samples were successively injected and analyzed as the ambient temperature was varied over 5 °C. Analytical conditions and ambient temperature settings conditions are shown in Table 3.

Table 3 Analytical Conditions

Mobile phase	: MeOH / Water = 70/30
Flowrate	: 0.2 mL/min
Column	: Shim-pack HRC-ODS (3.0 mmI.D. x 250 mmL)
Column temperature	: 40 °C
Detection	: 273 nm
Cell temperature	: 40 °C
Sample	: 5 mg/L Caffeine
Injection volume	: 1 µL
Ambient temperature	: 20 to 25 °C (profile indicated in Fig. 6)

The resulting chromatograms are shown in Fig. 6.

It is evident that the SPD-M40 baseline was unaffected by room temperature fluctuations, as the peaks were detected against a stable baseline that is essentially flat. In contrast, large baseline fluctuations affect peak detection against baseline drift.

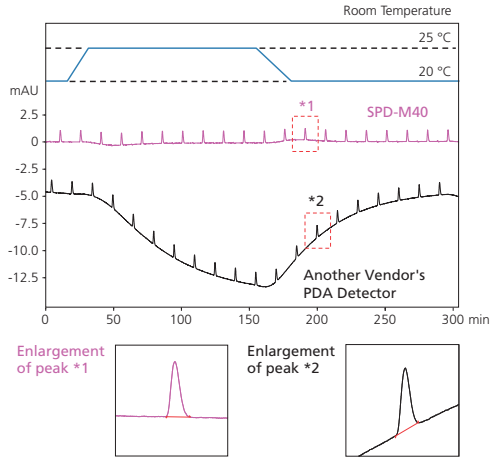


Fig. 6 Effect of Ambient Temperature Changes on Peak Integration

Table 4 indicates the reproducibility of peak area values for the peaks detected in the chromatograms above. The stable baseline with the SPD-M40 enables accurate peak integration, and provides good reproducibility even if room temperature fluctuations occur.

Table 4 Peak Area Reproducibility with Ambient Temperature Fluctuations

	SPD-M40	Another Vendor's PDA Detector
Peak Area Reproducibility (%RSD, n = 20)	0.62	1.87

5. Conclusions

- The SPD-M40 minimizes the effects of room temperature fluctuations where it is installed by using a triple temperature control function (Advanced TC-Optics), which independently controls the temperature of the detector cell, light source lamp, and spectrometer.
- The Advanced TC-Optics function minimizes baseline fluctuations, even when the room temperature fluctuates where the system is installed.
- The detector enables highly precise analysis by ensuring that the peaks can be detected against a stable baseline even if the room temperature varies. This is especially helpful for the quantitative analysis of trace amounts of target components, and in analyses over an extended period.

First Edition: August, 2019

Shimadzu Corporation
www.shimadzu.com/an/

SHIMADZU
Excellence in Science

Technical Report

Improved Linearity and Quantification Using the SPD-M40 Photodiode Array Detector

- Analytical Intelligence Part 4 -

Masato Watanabe[1], Hidetoshi Terada[1]

Abstract:

In principle, stray light generated during the UV-VIS and PDA detection process has a great influence on the linearity of the detector's response linearity. This report explains the influence of stray light upon detection and introduces the SPD-M40 photodiode array detector, which completely reduces the influence of stray light and achieves a linearity of 2.5 AU as a specification value (typical value is more than 2.5AU). Furthermore, in the low signal range, noise reduced noise has improved the detection accuracy of low concentrations, enabling the quantification of a wide concentration range. This enables simultaneous analysis and quantification of major components and impurities with different concentration ranges.

Keywords: Dynamic range, linearity, absorbance, stray light, noise

1. Principle of UV-VIS and PDA detectors

Unlike a UV-VIS detector, which separates light spectrally from a light source and irradiates the flow cell with only a specific wavelength to measure the absorbance of the target component, a PDA detector directly irradiates the flow cell with light from a light source containing various wavelengths (white light) and separates the light spectrally after passing through the flow cell. The optical flow diagrams are shown in Fig. 1.

A PDA detector can simultaneously measure the absorbance and the absorption spectrum, and can be used not only for quantitative analysis, but also for qualitative analysis.

2. Effect of stray light on absorbance

In general, absorbance is expressed in terms of the intensity of incident light on the flow cell and the intensity of transmitted light through the sample cell, according to Lambert-Bert's law.

$$A = -\log\frac{I}{I_0}$$

A : Absorbance
I : Real-time light intensity transmitted through the flow cell
I_0 : Incident light intensity

If the unexpected light is emitted by the spectroscope, the correct absorbance cannot be measured. Unexpected light during detection is commonly referred to as "Stray Light". The influence of stray light on the absorbance is expressed by the following equation.

$$A = -\log\frac{I+\Delta}{I_0+\Delta}$$

Δ: stray light intensity

If the absorbance in the flow cell is high, the transmitted light intensity from the cell will be small. In such cases, the effect of stray light intensity on the absorbance is more pronounced.

Fig. 2 illustrates the influence on the absorbance of stray light when the ratio of stray light intensity to incident light was changed to 0 - 0.5%. In cases when the stray light intensity is larger, the calculated absorbance value is smaller than the ideal value, and the linearity will be affected especially in the region exceeding 2AU.

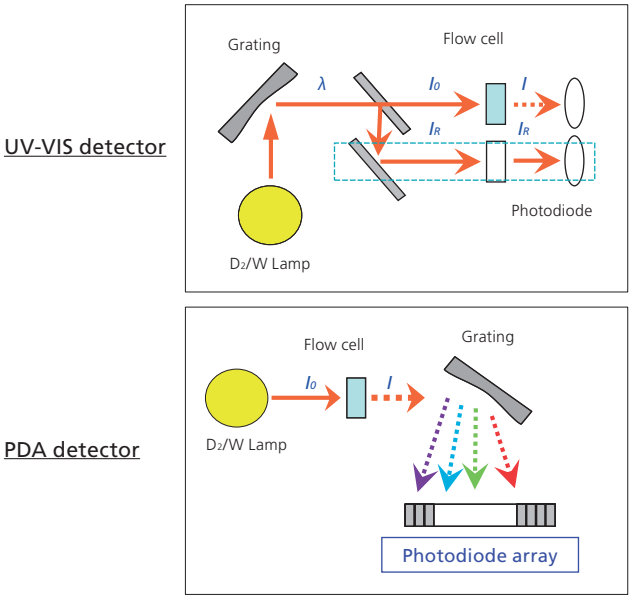


Fig. 1 Principle of UV-VIS and PDA detectors

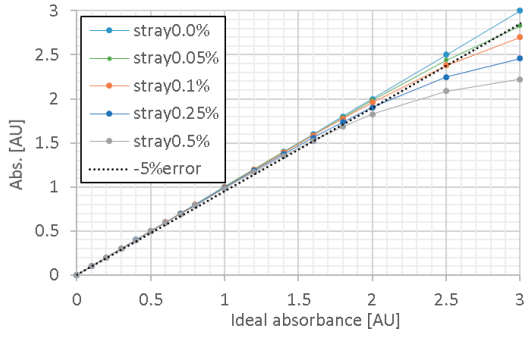


Fig. 2 Effect of stray light on absorbance

1 Analytical & Measuring Instrument Division Life Science Business Department LC Business Unit

Fig. 3 shows the effect of stray light intensity on absorbance as error rate using the results of Fig. 2. For example, when trying to obtain an absorbance linearity error within 5%, if the stray light has an intensity of 0.25% with respect to the incident light, the upper linearity limit is 2 AU; if the intensity is 0.1%, the upper limit is 2.5 AU.

Thus, the intensity of stray light greatly affects the quantitation of the target component.

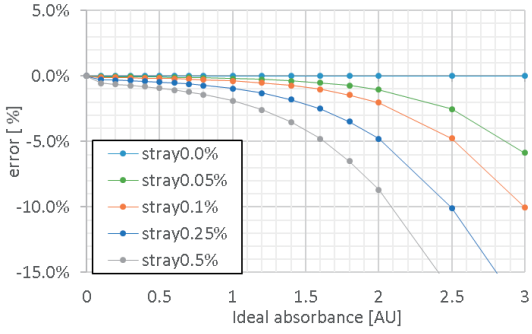


Fig. 3 Stray light intensity and absorbance error rate

3. Causes of stray light generation and reduction

Causes of stray light include reflection and scattering of light by the optical element itself and dirt attached to the optical element, reflection and scattering of light at the spectrometer, and unexpected reflection and dispersion of light at the grating.

In particular, a PDA detector emits white light from the lamp to the cell, and the transmitted light is dispersed and detected, so there is generally more stray light than for a UV-VIS detector.

Designed to reduce the effect of these causes of stray light, the SPD-M40 reduces overall stray light to a third of that in previous PDA detectors. It thereby achieves a linearity of 2.5 AU as a specification value, comparable to that of a UV-VIS detector (the actual value is typically more than 2.5 AU).

4. Noise reduction

The factor that predominantly determines the linear upper limit of absorbance is stray light. In contrast, the lower limit is primarily determined by the noise of the detector response. The SPD-M40 minimizes noise through e.g. optimization of the electrical system layout.

Fig. 4 shows a comparison of detector noise between the SPD-M40 and a conventional detector. When the time constant is small, the noise value is reduced significantly.

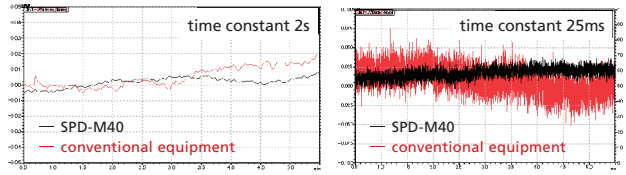


Fig. 4 Noise reduction

5. Improved dynamic range

Fig. 5 shows a chromatogram of a standard solution of ketoprofen, prepared by adjusting the analytical conditions and concentration to obtain a peak height with approximately 2.5 AU. Fig. 6 shows the calibration curve within a wide concentration range of 0.5 - 800 mg/L. With the SPD-M40, the linearity specification value is 2.5 AU; however, in practice, the value is significantly better. By reduced noise, it has become possible to simultaneously analyze high-concentration main components and trace impurities of 1 mAU or less with high accuracy. The coefficient of variation of the area value was 1% or less, even for the impurity with content that is about 0.1% quantified by area percentage, and good reproducibility was achieved.[1)]

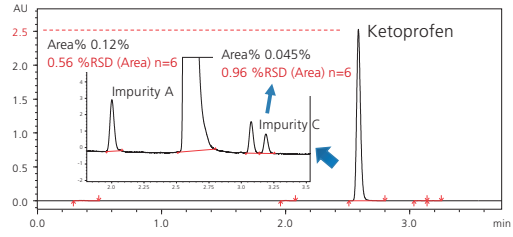


Fig. 5 Ketoprofen and impurity analysis

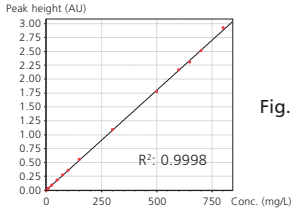


Fig. 6 Linearity of ketoprofen

6. Conclusion

- Stray light generated in the detection process has a significant effect on a detector's linearity range.
- The SPD-M40 photodiode array detector is designed to completely reduce the effects of stray light and offers wide linearity.
- In addition, it features significantly reduced noise. As a result, it is effective for analysis from low to high concentrations.

1) Application News No. L 538 "Impurity Analysis in Pharmaceutical Products with the Advanced Photodiode Array Detector SPD-M40"

First Edition: May, 2019

Shimadzu Corporation
www.shimadzu.com/an/

SHIMADZU
Excellence in Science

Technical Report

High-precision analysis of the photodegradable compound Naproxen using the UV cut-off filter of the photodiode array detector SPD-M40

Kohei Kawabata[1], Takato Uchikata[2], Keiko Matsumoto[2], Hiroyuki Nishi[1]

Abstract:

Analysis using a photodiode array (PDA) detector makes use of a broad spectrum of wavelengths, allowing qualitative analysis of a wade range compounds. However, since the light irradiated on a sample includes ultraviolet light (UV light) in the short wavelength region, there is the concern that UV light may cause photolysis of photodegradable compounds. The SPD-M40 is equipped with a UV cutoff filter* which blocks UV light in the short wavelength region. This suppresses the photolysis of components in the PDA and enables highly-accurate analysis.

Keywords: Photodiode array detector, UV cut-off filter, Naproxen

1. Photodegradable Compounds

Photodiode array (PDA) detectors make use of light over a wide range of wavelengths and can be used for qualitative and quantitative analysis of a variety of compounds. Since ultraviolet light (UV light) is included in the short wavelength region, it may cause photolysis in the analysis of photodegradable compounds. There have been many reports on the analysis of photodegradable compounds, especially pharmaceuticals (Table 1) .

Table 1 Reported cases of photodegradable compounds

Compound type	Compound name	References
Non-steroidal anti-inflammatory drugs	Diclofenac	Packer J.L. et al., 2003, Aquat. Sci., 65, 342-351.
	Ibuprofen	Jacobs L.E. et al., 2011, Water Res., 45, 4449-4458.
	Naproxen	Hsu Y.H. et al., 2006, Biomed Chromatogr., 20, 787-793.
	Sulindac	Kawabata K. et al., 2018, Chromatogr., 39, 139-146.
Calcium channel blockers	Nifedipine	Hayase N. et al., 1994, J. Pharm. Sci., 83, 532-538.
	Amlodipine	Ragno G. et al., 2002, J. Pharm. Miomed. Anal., 27, 19-24.
Steroid hormones	17β-estradiol	Lin A.Y-.C. et al., 2005, Environ. Toxicol. Chem., 24, 1303-1309.
	Testosterone	Young R.B. et al., 2013, Environ. Sci. Technol., 47, 8416-8424.
Vitamins	Vitamin C (Ascorbic acid)	Mori Y. et al., 1969, J. Jpn. Soc. Food Nutr., 22, 12-16.
	Vitamin B12 (Cyanocobalamin)	Taylor R. et al., 1973, Arch. Biochem. Biophys., 156, 521-533.

When photodegradable compounds decompose in PDA detectors, their quantitation may be inaccurate.

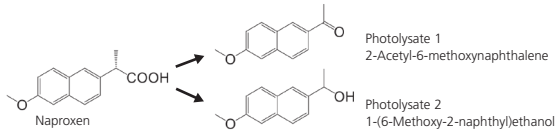


Fig. 1 Photolysis of photodegradable compounds (Naproxen)[1)]

2. SPD-M40 UV Cut-off Filter

The SPD-M40 uses a UV cut-off filter to block short-wavelength UV light. This suppresses the decomposition of compounds in the flow cell to aid in the accurate quantitative determination of target components.

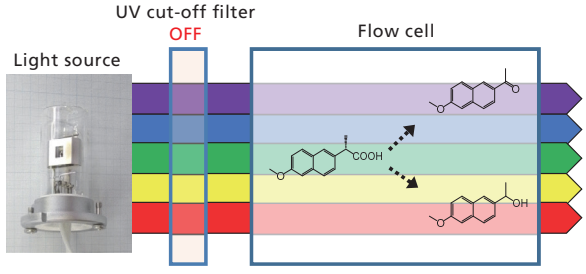


Fig. 2 Flow cell without a UV cut-off filter

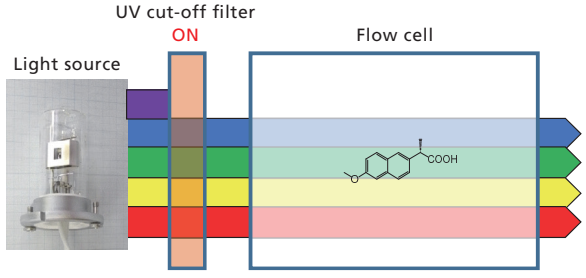


Fig. 3 Flow cell with a UV cut-off filter

1 Yasuda Women's University, Faculty of Pharmacy
2 Shimadzu Corporation, Analytical & Measuring Instruments Division

*This function was developed based on feedback from Lion Corporation.

Fig. 2 shows a illustration of a flow cell without a UV cut-off filter. Some of the target compounds irradiated with UV light in the flow cell are photodegraded and converted to photolysates. Fig. 3 shows an image of a flow cell using a UV cut-off filter. When the UV cut-off filter is used, the flow cell is not irradiated with high-energy short-wavelength UV light and photolysis of the target compound detected is suppressed.

3. Effect of the UV Cut-off Filter On the Calibration Curve of Naproxen

Naproxen samples were analyzed both without and with a UV cut-off filter and the results are shown in Fig. 4 and Fig. 5 respectively.

Table 2 Analytical conditions for Naproxen samples

Column	Shim-pack VP-ODS (150 mm × 4.6 mmI.D., 5 µm)
Temperature	40 °C
Mobile phase	50 % MeOH (including 0.1 % acetic acid)
Flow rate	1.0 mL/min
Injection volume	20 µL
Detection wavelength	230 nm

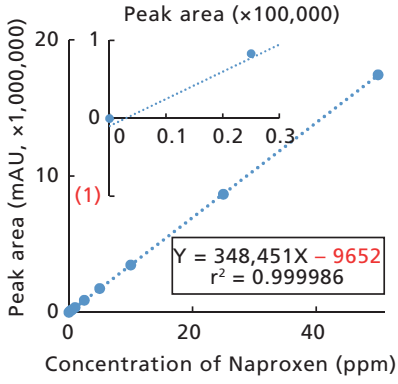


Fig. 4 Calibration curve without a UV cut-off filter

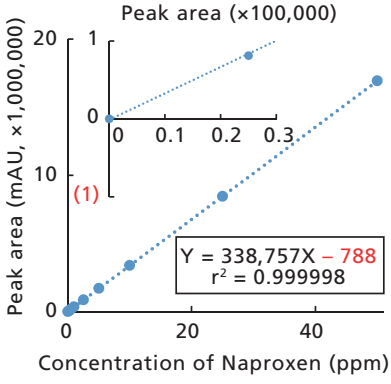


Fig. 5 Calibration curve with a UV cut-off filter

When the UV cut-off filter was not used, Naproxen was photodegraded in the low concentration region, resulting in a very negative intercept on the calibration curve. The use of the UV cut-off filter is demonstrated to mitigate these effects. It can be seen that the use of UV cut-off filters for PDA detector analysis allows accurate quantification of photodegradable pharmaceuticals.

4. Effect of the UV Cut-off Filter When Changing Analytical Conditions

In general, the lower the concentration of the sample solution, the higher the photolytic reactivity. In the analysis of Naproxen samples, it was investigated whether the UV cut-off filter could suppress photodegration which might occur when the injection volume of sample was reduced. The results are shown in Table 3. They indicate that the UV cut-off filter mitigated the drop in the intercept value of the calibration curve by suppressing photodegradation.

Table 3 Dependence of the calibration curve of Naproxen on injection volume with and without a UV cut-off filter

Injection volume (µL)	Without UV cut-off filter		With UV cut-off filter	
	Gradient	Intercept	Gradient	Intercept
5	91794	-16321	83854	-2973
10	173067	-10561	168200	-1801
20	344560	-8414	337882	-719
40	688032	-2826	663833	5499

In addition, decreasing the pump flow rate increases the time that the sample remains in the flow cell. Table 4 and Fig. 6 show the analysis of whether the UV cut-off filter could suppress the extra photodegradation. The results indicate that the UV cut-off filter suppressed photodegradation of Naproxen in the low concentration region, especially under low flow rate conditions, which improved the accuracy of the calibration curve.

Table 4 Dependence of the calibration curve of Naproxen on flow velocity with and without a UV cut-off filter.

Flow rate (mL/min)	Without UV cut-off filter		With UV cut-off filter	
	Gradient	Intercept	Gradient	Intercept
0.25	1399666	-182475	1359458	-8904
0.5	700124	-33047	677326	-4975
1	350301	-9970	338615	-1137
2	175124	-1355	170787	1954

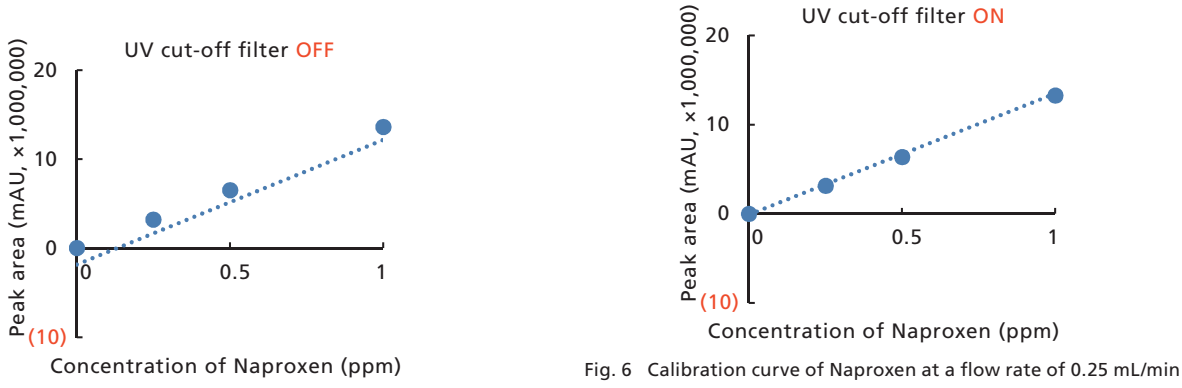


Fig. 6 Calibration curve of Naproxen at a flow rate of 0.25 mL/min (low concentration region)

5.5. Conclusions

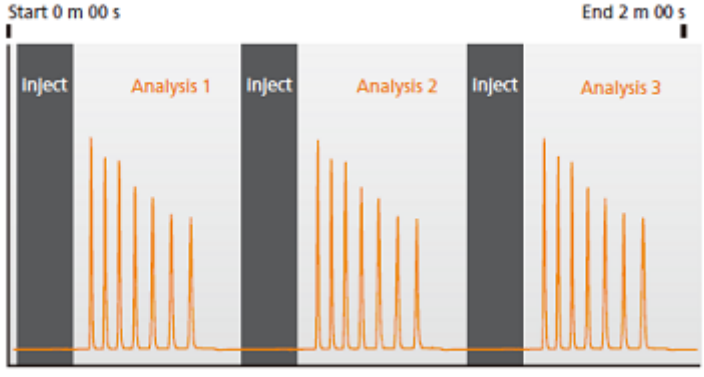
- The SPD-M40 uses a UV cut-off filter that does not transmit high-energy UV light in the short wavelength region.
- The UV cut-off filter suppresses photolysis when photodegradable compounds are analyzed. In particular, it is effective even at low con-centrations where photolysis progresses easily and enables accurate analysis of small-volume photodegradable samples.
- Even when analytical conditions such as injection volume and flow rate are changed, the UV cut-off filter is effective at preventing photolysis, enabling highly-accurate analysis.

P-Series All Round HPLC System

P-Series All round HPLC is the first network-ready HPLC system that meets the demands of today's advanced users. P-Series features the world's first Web control, fastest sample injection, and highest detection sensitivity performance. Modular components of the P-Series interact with the precision of an integrated system and, unlike specialized systems, P-Series offers the flexibility to perform many analytical tasks with one piece of high-performance equipment – QA/QC, Mass Spec Front end, multi-dimensional chromatography, on-line sample clean up, analytical method development among many others.

Genuine High Throughput

With sample injection movement of just 10 seconds P-Series reduces the total analysis cycle time, not simply the time for the HPLC analysis itself.



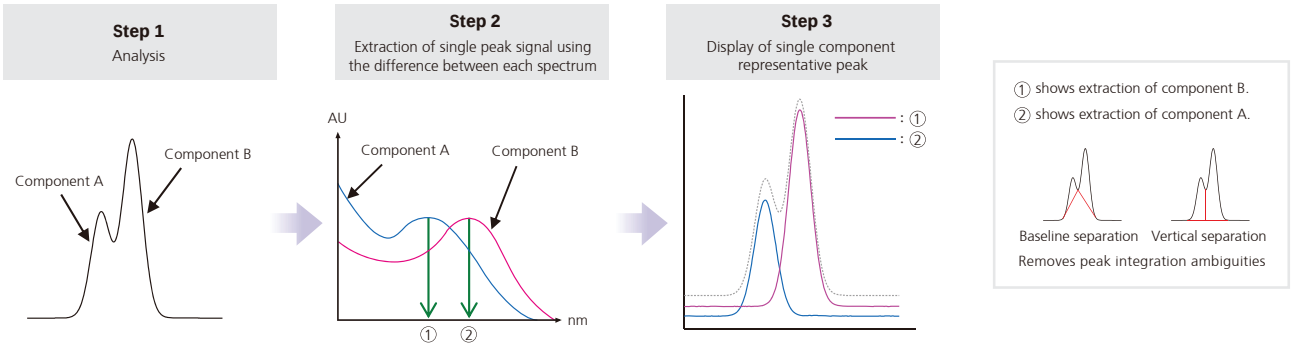
Ultra-fast analysis of 7 components in 30-second cycles

Detection Mode

i-PDeA | Intelligent Peak Deconvolution Analysis

Enables the extraction of a single peak from co-eluted peaks by utilizing differences in spectra. The new separation method removes discussion of integration methods for co-eluted peaks. The also helps detect impurity peaks in a target peak. i-PDeA also helps detect impurity peaks in a target peak.

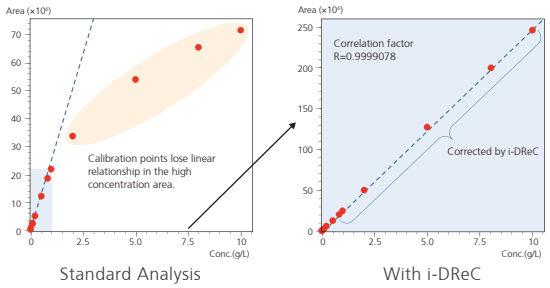
CLICK HERE



i-DReC | Intelligent Dynamic Range Extension Calculator

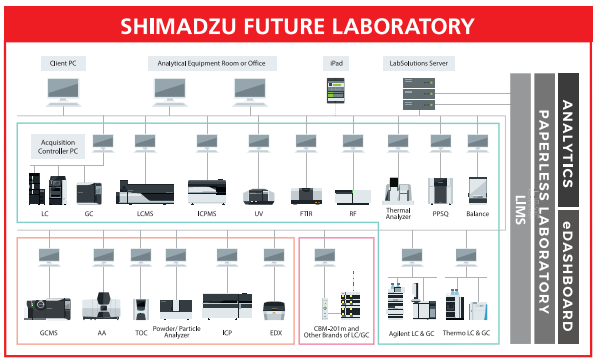
The i-DReC dramatically extends the linear dynamic range of calibration curves, enabling reliable quantitation of high concentration samples without need for sample dilution and reinjection, which would otherwise be required

CLICK HERE



Integrated Informatics Biosphere

Completely expandable Informatics Biosphere which can range from connecting one chromatographic instrument to integrating entire lab.



Compliance

- Centralized Data Security and Administration
- Lab process coverage from sample management to COA
- Electronic signatures for paperless environment

Ease of Use

- Connect different types of instrument
- Remote Access and Operation
- Data process and review from any PC in the network

CLICK HERE

Specifications

P-Series System Controllers

CBM-20A

	CBM-20A	CBM-20Alite
Connectable units	Solvent delivery units: 4 max.; Autosamplers: 1; Column ovens: 1; Detectors: 2 max.; Fraction collectors: 1; Sub-controllers: 2 max.	Solvent delivery units: 4 max.; Autosamplers: 1; Column ovens: 1; Detectors: 2 max.
Number of connectable units	8 (expansion possible up to 12)	5 (including the unit incorporating the system controller)
Data buffering	Approx. 24 hours for one analysis (at 500-ms sampling rate; available only with LabSolutions)	
Event I/O	4 inputs, 4 outputs	2 inputs, 2 outputs
Analog boards	Up to 2 boards can be mounted.	Mounting not supported.
Operating temperature range	4 to 35˚C	
Dimensions, weight	W260 × D420 × H140 mm, 5.5 kg	W120 × D100 × H20 mm, 0.5 kg
Power requirements	AC 110 V, 230 V, 100 VA, 50/60 Hz	Supplied from unit

P-Series Pumps

LC-20AD

	LC-20AD
Solvent delivery method	Parallel-type double plunger
Plunger capacity	10 µL (with increment of 0.0001 mL/min)
Maximum Operating Pressure	40 MPa
Flow rate setting range	0.0001 to 10.0000 mL/min
Flow rate accuracy	No more than ±1% or ±2 µL/min, whichever is greater
Flow rate precision	No more than 0.06% RSD or 0.02 min SD, whichever is greater
Gradient type	High-pressure mixing/low-pressure mixing
Gradient accuracy	+/- 1%
Gradient precision	0.1% RSD max.
Constant-pressure solvent delivery	Supported
Plunger rinsing mechanism	Automatic rinsing
Safety measures	Liquid-leakage sensor, high-pressure/low-pressure limits
Operating temperature range	4 to 35˚C
Dimensions, weight	W260 × D420 × H140 mm, 10 kg
Power requirements	AC 110 V, 230 V, 150 VA, 50/60 Hz

P-Series Degassing Units

DGU-20A3R /20A5R

	DGU-20A3R	DGU-20A5R
Number of degassed solvents	3	5
Degassed flow-line capacity	400 µL	
Operating temperature range	4 to 35˚C	
Dimensions, weight	W260 × D421 × H72 mm, 3.9 kg	W260 × D421 × H72 mm, 4 kg
Power requirements	Supplied from LC-20AD	

P-Series Autosampler

SIL-20AC HT

	SIL-20AC HT
Injection method	Total-volume sample injection, variable injection volume
Injection-volume setting range	0.1 to 100 µL (standard), 0.1 to 2,000 µL (option)
Number of processed samples	175 (1 mL vials), 105 (1.5 mL vials), 50 (4 mL vials) 192 (two 96-well MTP/DWP), 768 (two 384-well MTP/DWP) Also, ten 1.5 mL vials in addition to each of the above.
Injection-volume accuracy	1% max (specified conditions)
Injection-volume precision	RSD: 0.3% max. (specified conditions, typically 0.2% RSD max)
Sample Carryover	0.005% max. (specified conditions, typically 0.0025% max)
Number of repeated injections	30 per sample
Needle rinsing	Set freely before and after sample injection.
Sample cooler	Block cooling/heating, used together with dehumidifying function, 4 to 40˚C
Operating pH range	pH1 to pH14
Operating temperature range	4 to 35˚C
Dimensions, weight	W260 × D500 × H415 mm, 30 kg
Power requirements	AC 110 V, 230 V, 300 VA, 50/60 Hz

P-Series Column Oven

CTO-10AS *VP*

	CTO-10AS *VP*
Type	Block heating
Cooling method	Electronic cooling
Temperature setting range	4 to 80˚C
Temperature control precision	±0.1˚C
Applicable columns	25 cm (2 column max; Optional column switching)
Function	Change of temperature setting
Safety features	Leak sensor, temperature fuse, temperature upper limit
Dimensions, weight	W130 × D420 × H415 mm, 12 kg
Power requirements	AC 110 V, 230 V, 120 VA, 50/60 Hz

P-Series Detector

SPD-40

	SPD-20A (UV)	SPD-M40 (PDA)
Light source	Deuterium (D2) lamp	Deuterium (D2) lamp, Tungsten lamp
Number of diode elements	–	1024
Wavelength range	190 to 700 nm	190 to 800 nm
Bandwidth, slit width	8 nm	1.2 nm (high-resolution mode), 8 nm (high-sensitivity mode)
Wavelength accuracy	± 1 nm max.	
Wavelength precision	± 0.1 nm max.	
Noise	0.5×10^{-5} AU	4.5×10^{-6} AU
Drift	1×10^{-4} AU/h	0.4×10^{-3} AU/h
Linearity	2.5 AU (ASTM standard)	
Functions	Dual-wavelength detection in the range 190 to 370 nm and upwards of 371 nm, ratio-chromatogram output, wavelength scanning	
Cell	Optical wavelength: 10 mm, Capacity: 12 µL, Pressure: 12 MPa Optional Cells Available	
Cell temperature control range	5˚C above room temperature to 50˚C	19 to 50˚C, 1˚C Step (up to 50˚C)
Operating temperature range	4 to 35˚C	
Dimensions, weight	W260 × D420 × H140 mm, 13 kg	W260 x D500 X H140 mm, 12 kg
Power requirements	AC 110 V, 230 V, 160 VA, 50/60 Hz	AC 110 V, 230 V, 150 VA, 50/60 Hz

RID-20A

	RID-20A (S228-65306-58)
Reflective index measurement range	1 to 1.75 RIU
Noise level	≤ 2.5 nRIU (2.5×10^{-9} RIU max)
Drift	≤ 0.1 μRIU/h (1×10^{-7} RIU/h max)
Range	A mode: 0.01 to 500 μRIU P and L modes: 1 to 5000 μRIU
Response	No filtering, 0.05 to 10 sec, 11 steps
Polarity switching	With a switch
Zero adjustment	Auto zero, auto optical zero, baseline shift functions
Maximum operating flow rate	20 mL/min (150 mL/min with an option)
Temperature control of cell unit	30 to 60°C (0.01°C steps)
Cell capacity	9 μL
Material in contact with liquid	SUS316L, quartz, PTFE, Al_2O_3, ETFE
Maximum operating pressure	0.4 MPa (4 kgf/cm²)
Operating temperature range	4 to 35°C
Dimensions and weight	W260 × D420 × H140 mm, 12 kg

Note: Hexafluoroisopropanol (HFIP) cannot be used as the mobile phase.

RF-20A/RF-20Axs

	RF-20A (S228-65304-58)	RF-20Axs (S228-65305-58)
Light source	Xenon lamp	Xenon lamp, low-pressure mercury lamp (To check wavelength accuracy)
Wavelength range	0, 200 to 650 nm	0, 200 to 750 nm
Spectral bandwidth	20 nm	
Wavelength accuracy	±2 nm	
Wavelength precision	±0.2 nm	
S/N	Water Raman peak S/N 1200 min. Low background S/N > 9000	Water Raman peak S/N 2000 min. Low background S/N > 12000
Cell capacity	12 μL, 2 MPa (approx. 20 kgf/cm²), SUS316L, PTFE (fluororesin), quartz	
Cell temperature control range	—	4 to 40°C, 1°C steps
Cell temperature setting range	—	(Room temperature – 10°C) to 40°C
Functions	Four-wavelength detection, wavelength scanning	
Safety measures	Liquid-leakage sensor	
Operating temperature range	4 to 35°C	
Dimensions and weight	W260 × D420 × H210 mm, 16 kg	W260 × D420 × H210 mm, 18 kg

ELSD-LT III

	ELSD-LT III (S228-65900-58)
Nebulizing Method	Siphon splitting
Light Source	Semiconductor laser
Detector	Photodiode
Temperature Setting Range	Room temperature to 100 °C
Nebulizer Gas	Air or nitrogen*
Mobile Phase Flow Rate (Standard Nebulizer)	0.2 to 2 mL/min
Operating Temperature Range	4 to 35 °C
Operating Humidity Range	20 to 85 %
Dimensions and weight	W 250 × D 530 × H 330 mm, 15.5 kg

* Supply gas at a pressure of about 350 kPa. An air compressor may also be used.
A filter (P/N: S228-45528-92) is also available for filtering out moisture and other matter from the compressor.

Shimadzu (Asia Pacific) Pte Ltd.

www.shimadzu.com.sg/an

Shimadzu (Asia Pacific) Pte Ltd., July 2020