C190-E241

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)

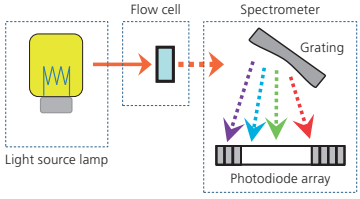

Fig. 1 Illustration of Detection by a Photodiode Array Detector

*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)

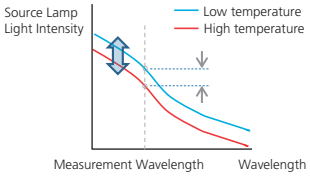

Fig. 2 Illustration of Temperature Effects on Source Lamp Light Intensities

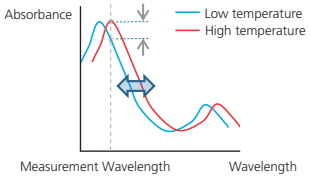

Fig. 3 Illustration of Temperature Effects on Spectra

*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.

1 Analytical & Measuring Instruments Division

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)

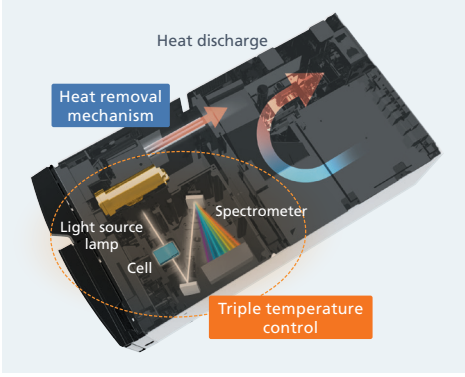

Fig. 4 SPD-M40 Triple Temperature Controlled Locations

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.

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		

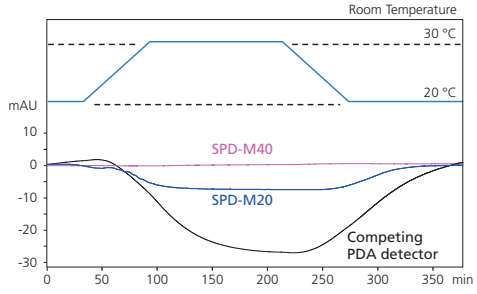

Fig. 5 Baseline Fluctuations in Response to Changes in Ambient Temperature

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.

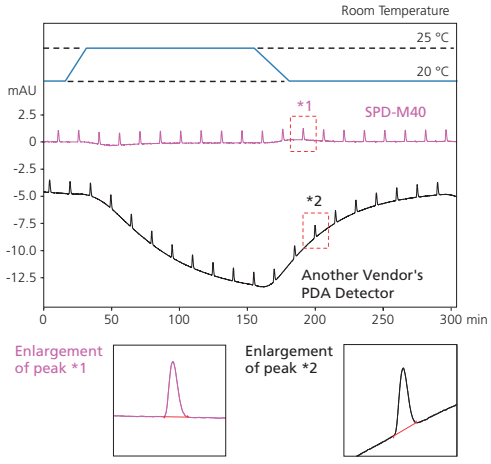

Fig. 6 Effect of Ambient Temperature Changes on Peak Integration

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

Shimadzu Corporation

www.shimadzu.com/an/