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Technical Explanation

Introduction to Key Features and New Capabilities of the F-7100 Fluorescence Spectrophotometer

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1. Introduction

A fluorescence spectrophotometer is an instrument that measures the fluorescence produced by a sample irradiated with optical excitation such as ultraviolet radiation. Fluorescence spectrophotometers are higher-sensitivity analytical instruments than absorption spectrophotometers, which measure light absorption by the sample. Because only fluorescent substances are detected, preprocessing can be used to convert only specific sample components to fluorescent substances, allowing outstanding selectivity for samples with microscopic volumes. Applications of fluorescence spectrophotometers include analysis of pharmaceuticals and foodstuffs—including various types of vitamins and additives—and biochemical studies in areas of clinical medicine including analysis of amino acids. These instruments are also considered valuable tools with a wide range of uses in fields such as analysis of materials such as dyes, fluorescent whitening materials, white LEDs, and display components.

We have recently developed the F-7100 fluorescence spectrophotometer (Figure 1), an instrument based on the previous-generation F-7000 model[*1] with improvements in basic performance. The high sensitivity (signal-to-noise ratio) of the instrument—the single most important measure of spectrophotometer performance—is approximately 1.5 times greater than that of the previous-generation model.[*1] The Xe lamp—a consumable—boasts a lifetime some 5 times longer than that of the previous-generation model[*1].
The software has also been improved: we have added functionality to correct day-to-day variations, support for the recently much-discussed task of fluorescent fingerprint analysis, and greater user-friendliness.

[*1] F-7000 fluorescence spectrophotometer

Fig. 1 F-7100 fluorescence spectrophotometer

2. Features of the F-7100

In this section we discuss three key features of the F-7100.
(1) Best-in-class high-sensitivity detector system
The F-7100 retains the highly reliable optical system of the long-selling F-7000 while achieving higher sensitivity through the adoption of a high-brightness Xe lamp and improvements to the detector optical system.

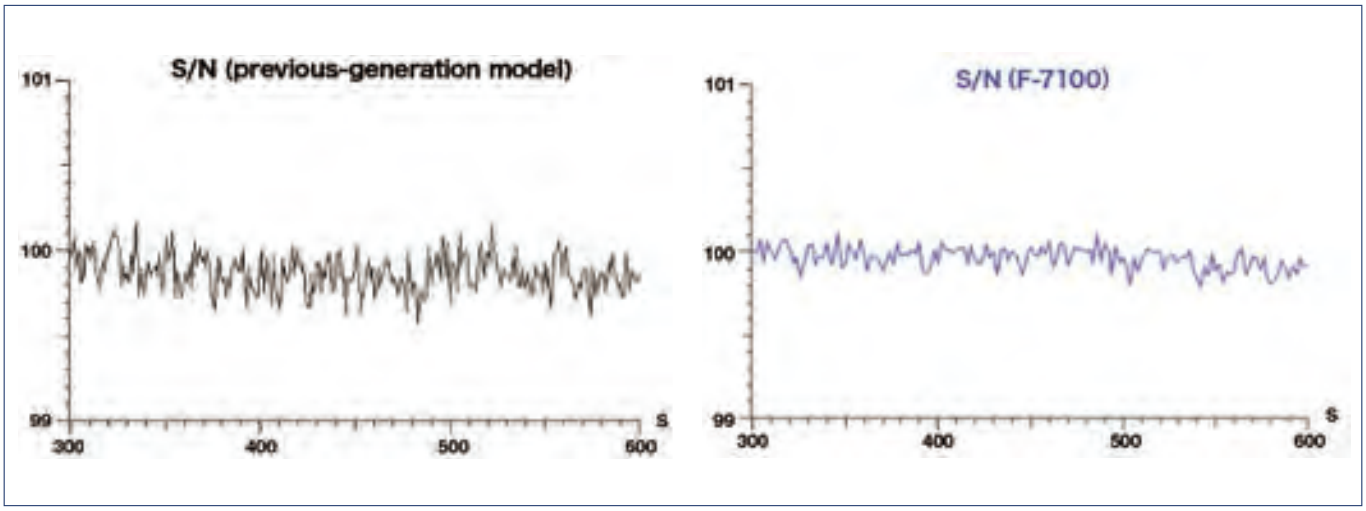

Fig. 2 Comparison of signal-to-noise ratio for Raman scattering in water

Figure 2 compares the signal-to-noise ratio of the F-7100 to that of the F-7000 for a measurement of Raman scattering in water. As shown in the figure, compared to the previous-generation model[*1], the high-sensitivity F-7100 achieves a 1.5 times improvement in signal-to-noise ratio, allowing detection of even ultra-weak signals with a low noise level.

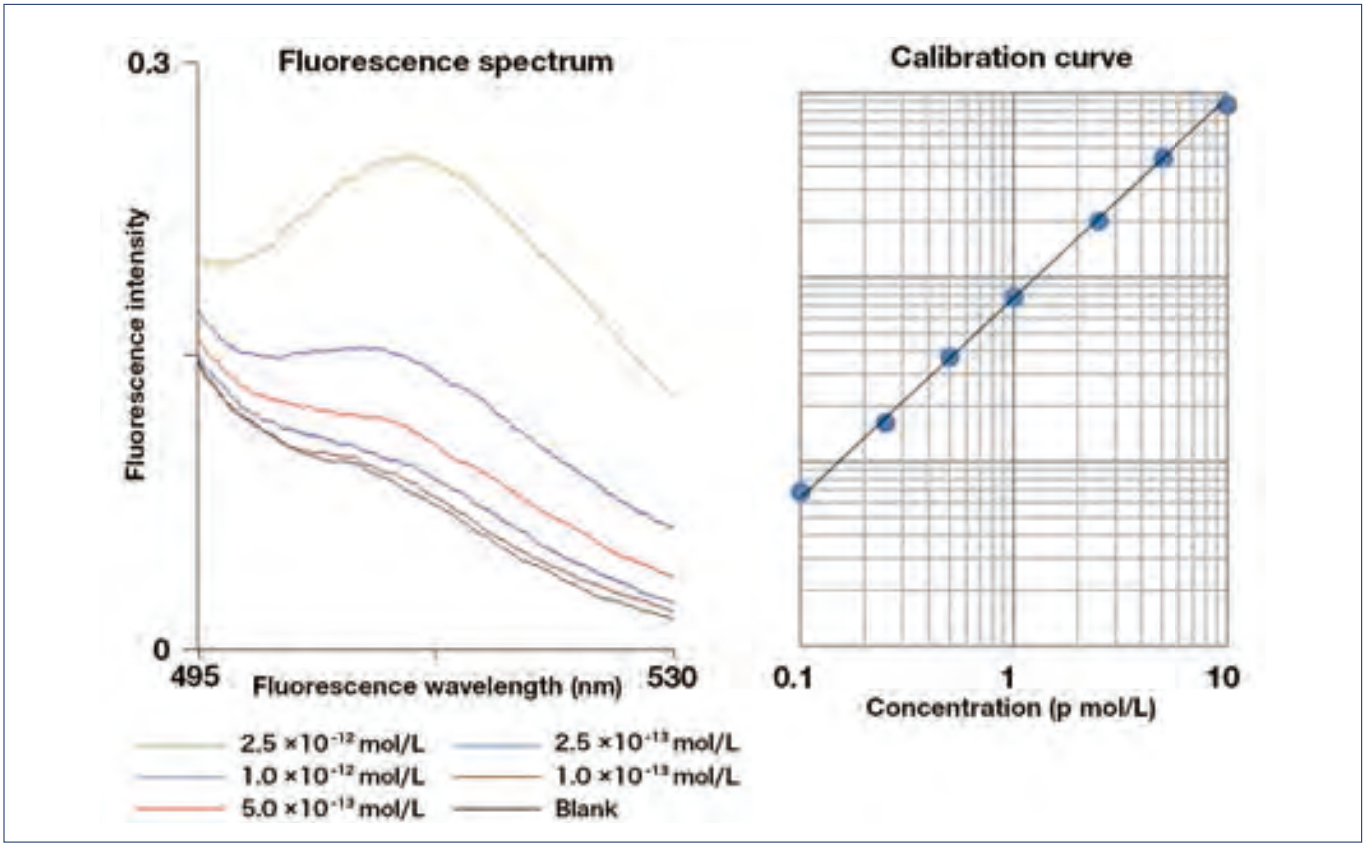

Fig.3 Measurement of ultratrace quantity of fluorescein

Figure 3 shows an example of a high-sensitivity measurement of fluorescein. The F-7100 successfully detects fluorescence at concentrations on the order of 1×10^{-13} mol/L (sub-picomolar) relative to blank samples (pure water). A good calibration curve is obtained even for ultratrace sample volumes.

(2) Best-in-class long-lifetime light source

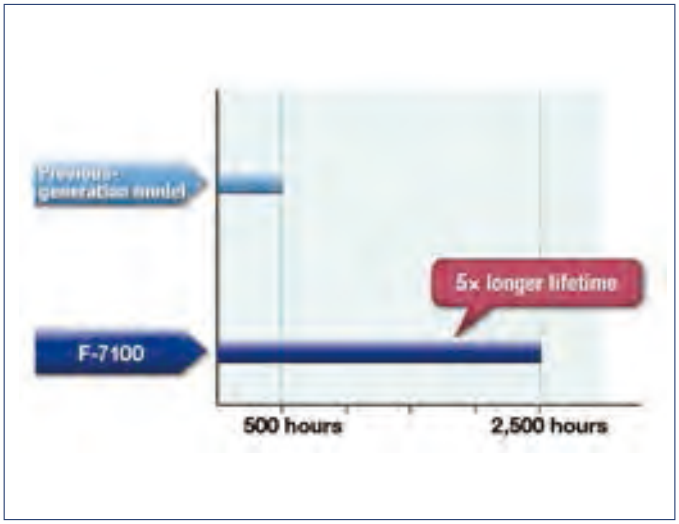

Fig.4 Comparison of lamp lifetimes[*2]

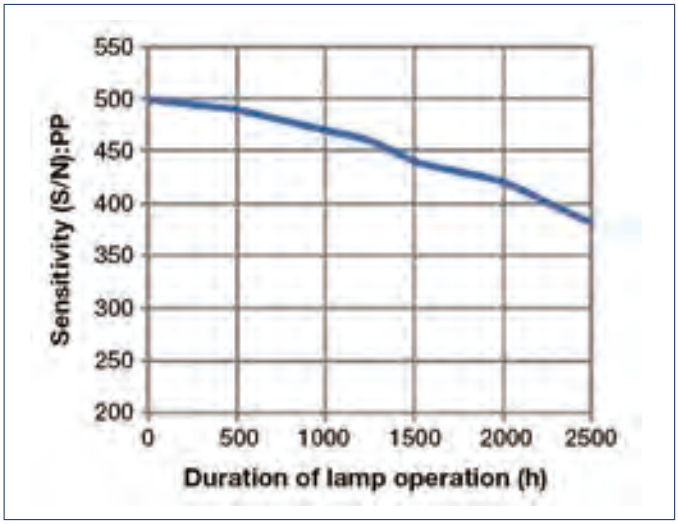

Fig.5 Sensitivity (S/N: PP) vs. duration of lamp operation[*4]

By adopting a new Xe lamp[*3] and improving the lamp illumination power supply, we have succeeded both in increasing the brightness and extending the lifetime of the light source. The longer lamp replacement cycle reduces the cost of consumables and the labor required to replace and adjust the lamp (Figure 4). The high-quality design of the F-7100 and the ample robustness incorporated into its specifications ensure that the high sensitivity of the instrument is retained throughout the entire lifetime of the lamp (Figure 5).

[*2] Compared to the useful lifetime (recommended replacement time) of the standard Xe lamp (P/N: 650-1500) used in the F-7000 fluorescence spectrophotometer.
[*3] The useful lifetime of the dedicated Xe lamp (6 months or 500 hours guaranteed)
[*4] Sensitivity verified by measurements of Raman scattering in water; 6 hours of daily use; lamp turned on and off (total of 420 repetitions)

(3) Improved functionality of FL Solutions software

1. Fluorescence intensity standardization to correct day-to-day variations

This feature corrects day-to-day and long-term variations in the fluorescence intensity. The fluorescence intensity is affected by variations in lamp brightness, room temperature, the state of the optical system, and other factors. The resulting intensity fluctuations are corrected by measuring the fluorescence intensity of a reference substance and subsequently converting the fluorescence intensity measured for experimental samples using this reference. This ensures that intensity measurements—even if made on different days—are intuitively comparable.

In addition to correcting day-to-day variations for a single instrument, reference calibration values are useful for comparing intensities measured by different instruments; examples include measurements of humus in environmental water (quinine sulfate calibration), measurements of chlorophyll in water (fluorescein calibration), and specified values for reagent purity (quinine sulfate calibration).

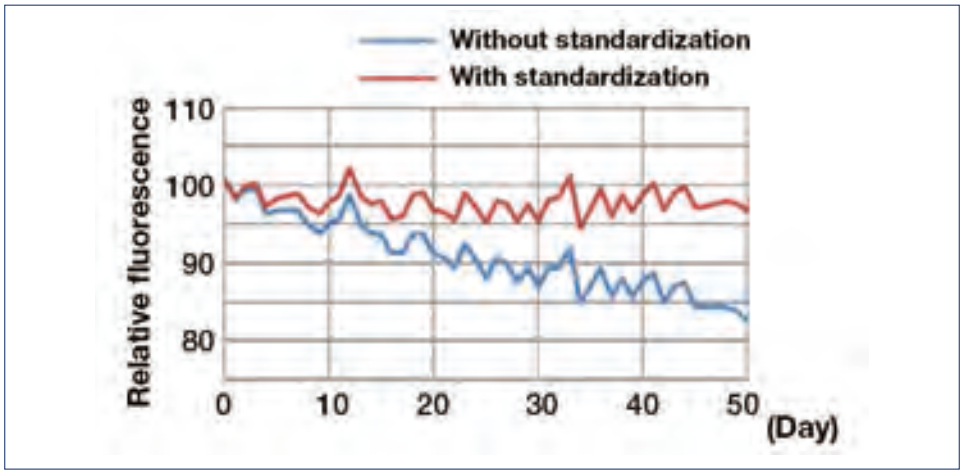

Fig.6 Day-to-day variations in fluorescence intensity with and without standardization[*5]

[*5] Note: Data shown are reference values only; actual results may vary depending on the operating environment.

2. Enhanced output features: exporting data to facilitate multivariate analysis

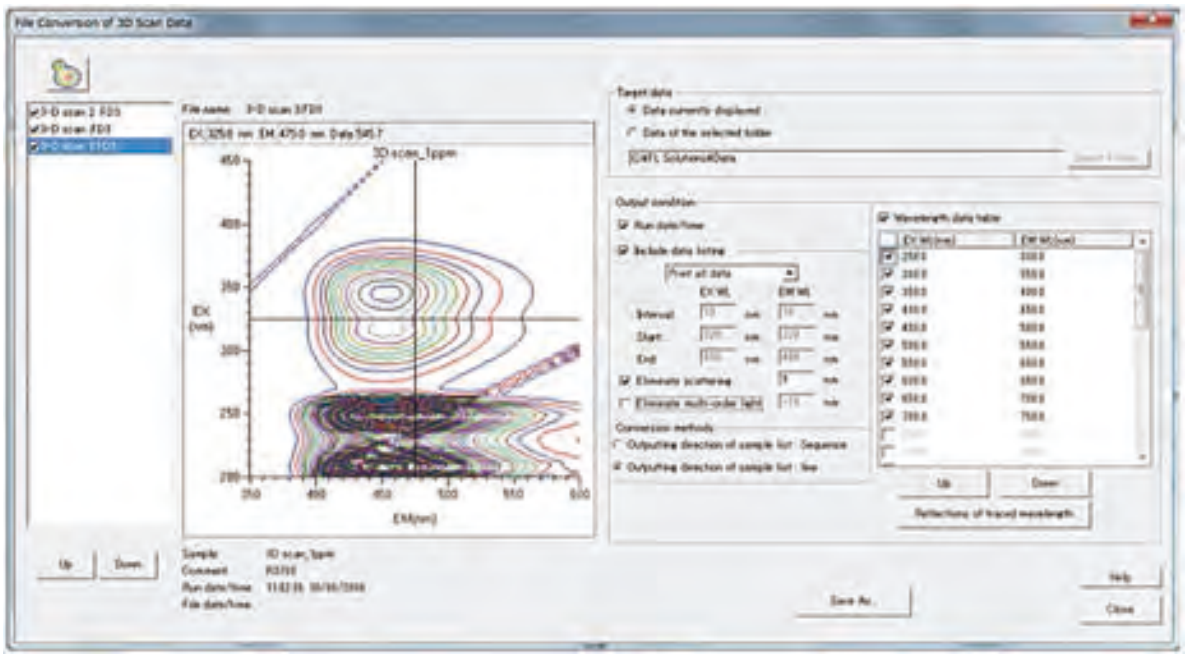

Fig.7 Batch conversion of 3-dimensional measurement data to file

● Batch conversion 3-dimensional measurement data to file

Fluorescent fingerprint analysis—a subject of intense current interest—requires multivariate analysis of large quantities of 3-dimensional fluorescence spectral data. With the batch conversion of 3-dimensional measurement data to a file —a new addition to the software accompanying the F-7100—it is now possible to aggregate multiple 3D fluorescence spectra for output to a single Excel spreadsheet. The software also supports outputting in matrix format, enabling easy export of data to commercial software for multivariate analysis.

● Support for wavelength-specific data tables for 3-dimensional measurement results

By storing data for wavelengths of interest in wavelength-specific data tables, it is possible to export only necessary wavelengths to Microsoft Excel®.

● Removing multidimensional light from data output

To allow data for 2-dimensional light regions—which is not needed for multivariate analysis of 3-dimensional fluorescence spectra—to be excluded from the Excel output, a new option has been added: **Remove multidimensional light.** By combining this with **Remove scattered light**, which removes data for wavelengths shorter than the excitation wavelength, it is possible to easily export to Excel only those portions of the data that are necessary for analysis.

3. Summary

In this article we have presented the key features and new capabilities of the F-7100. Fluorescence analysis finds applications in a wide range of fields, including industrial materials such as LEDs and solar cell components, food testing, life sciences, and biotechnology research and development. In the future, we will continue to develop and commercialize new accessories, software, and applications to meet these and other marketplace needs.

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