Practical Methods of UV Measurement During Process

By Mike Stephenson

It is now recognized throughout the UV industry that to expand the applications and opportunities for the UV process there is a fundamental need for effective and well-understood process control. To achieve this, it is essential to effectively measure the UV source. In the laboratory, this can be easily accomplished using spectroradiometry. However, very different challenges are presented under the varying field conditions, which can be encountered in industrial processes.

There is a great deal of difference between making UV measurements in the uniform and controlled conditions of the laboratory bench compared to carrying out measurements of variable UV sources in the field. Such measurements are commonly made in difficult and often hostile UV process environments.

The fundamental parameters of the UV to be measured are the irradiance and the wavelength. These parameters, usually uniform in the laboratory, are never thus over time and in field conditions. There is a great deal of difference between making UV measurements in the uniform and controlled conditions of the laboratory bench compared to carrying out measurements of variable UV sources in the field. Such measurements are commonly made in difficult and often hostile UV process environments.

Inherent degradation over time of UV sources is the most obvious variable but many others come in to play when the UV source is used in the field environment. Contamination of the UV optics, variable cooling, change in reflectance, absorbance or filters are just some of the variables, which can influence the effective UV in the process.

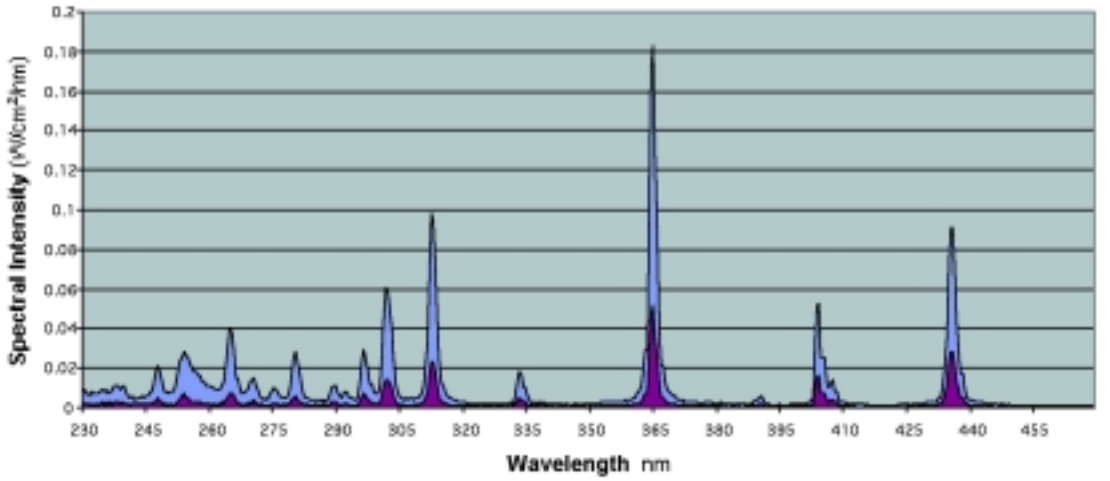
There are a number of instruments, developed over the years, which can be employed to measure the UV source. The spectroradiometer is highly accurate and provides detailed spectral and irradiance information. However, being large, cumbersome, complex in operation and expensive, their usefulness has been confined to the laboratory and basic research. They are impractical for use in the field environment of the UV process.

For this reason, the band pass radiometer has become ubiquitous for field UV measurements. It is small, simple to operate and low in cost. However, to achieve these desirable traits the radiometer compromises in accuracy and detail. It remains, for field purposes, a simple indication of relative output of non-specific wavelength.

UV radiometers vary widely in their calibration. Being a broadband light measuring device, it can be quite accurately calibrated on a known light source of known spectrum, traceable to national standards. However, it is well known, but not generally well

FIGURE 1

Comparison of spectral data from new UV lamp to a used lamp (lower graph) Shows the loss of critical shortwave range of 240-280 nm



Monitored by spectroradiomer on press.

acknowledged, that as soon as a different light source of differing or unknown spectrum is to be measured in the field (as is usually the case), the UV radiometer instrument becomes effectively uncalibrated. This explains the reasons no two radiometers are likely to measure the same in the field when *not* measuring a conveniently smooth calibration lamp—the spectra differ. Often it can be the case that radiometers differ in their readings by as much as a factor of 10.

New Developments in UV Field Measurement

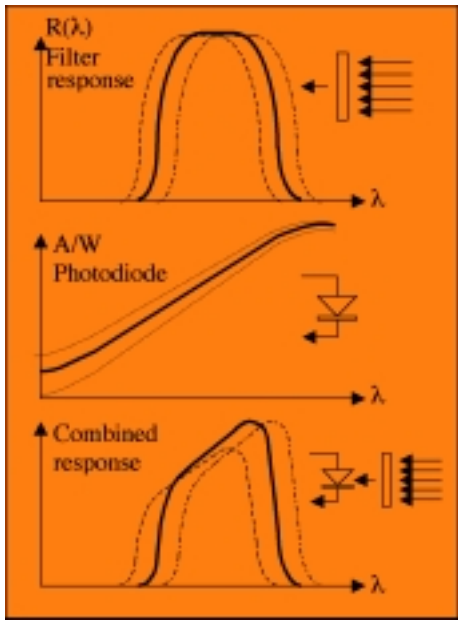
Since a spectroradiometer measures the precise irradiance and spectral distribution of a UV source this would appear to be the best solution for measuring the UV source, as it does in the laboratory. However, for field measurements this can be impractical due to size, complexity and cost of the equipment.

To overcome these difficulties, there have been two recent developments in

FIGURE 2

Elements of radiometer wavelength variability resulting in unknown spectral response against an unknown UV light source

Band pass filters vary in their spectral response both inherently and due to temperature effects. Their response also degrades over time.



UV measurement. When combined, these two developments can achieve the twin objectives of calibrated spectral irradiance with simplicity of use and low cost. These new developments are as follows:

- **UV Process Sensor.** This can be installed on-line for continuous UV monitoring.
- **Miniature Spectroradiometer.** This is a compact, fully portable instrument with spectroradiometric optics. It can be used independently or used for cross-calibrating the UV process sensor in situ.

On-line Sensor

The new optical system of this unit eliminates the use of interference band pass filters, which degrade with time and are temperature dependent. Two-channel measurement is provided by wide band gap photodiodes for full UV waveband (220-390 nm) and UVC (220-280 nm) solar-blind. The radiation source can be captured at the point of delivery using a probe fitted with a high temperature cosine diffuser.

Used as a simple radiometer, the unit provides 0-10 volt analogue output signals for each waveband proportional to the UV radiation seen in the process. Measurements can be related to a programmable baseline of 100% and trip points set when the UV is outside limit.

In addition, the unit has full digital, serial communications via RS485, two-wire network. Up to 32 sensors can be networked for multi-UV source processes and Visual Basic software is provided to suit current Windows platforms.

Miniature Spectroradiometer

This instrument has spectro-radiometer optics measuring the full UV range from 230-470 nm. It can be used independently to provide full spectral and irradiance data of UV at the process. It can also be equipped with an identical probe as the on-line sensor. In this way both instruments can replicate the identical UV measurement and the on-line sensor can then be cross-calibrated.

The spectroradiometer can be programmed to integrate the UV irradiance in the same sensing ranges as the on-line sensor. This calibrated measurement can then be transferred to the CPU (central processing unit) of the on-line sensor to calibrate it *in situ* during the UV process.

FIGURE 3

On-line, UV process sensor with UV probe for access to UV source

Effective UV Process Control

By combining these two elements of an on-line sensor with a portable programmable spectroradiometer, the twin objectives can be achieved of providing a calibrated on-line measurement with a simple, low cost sensor.

The goal is in sight of achieving effective UV process control in the field by continuous monitoring of the spectra and irradiance of UV sources across the varied fields of UV applications. The following recent examples demonstrate the ways in which the spectroradiometer and the on-line sensor can be of benefit in defining, characterizing and controlling the UV process.

Monitoring an Optical Fiber UV Coating Process

A UK-based optical fiber coating company uses the spectroradiometer fitted with a probe to monitor the UV delivered to their UV coatings on its Draw Tower lamps. By taking measurements every 10 minutes, they were able to track the degradation of the UV reaching their process. The graph in Figure 5 shows this degradation during the course of the fiber draw. The diminution of the UVC and UVA ranges arises from the contamination of the quartz tube through which cure is affected. This is clearly demonstrated by

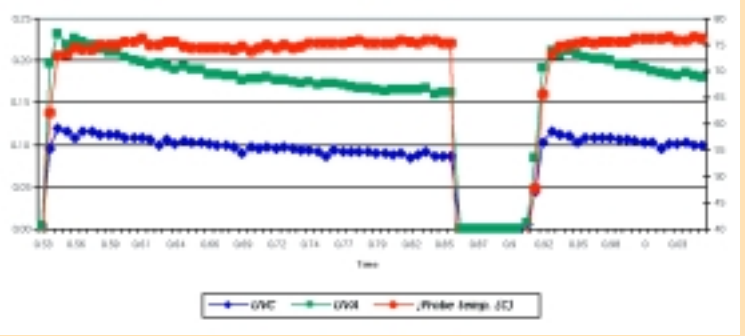
FIGURE 4

Miniature programmable spectroradiometer

Provides wavelength and irradiance data for cross-calibration of the on-line process radiometer. Includes UV probe to replicate the measuring point.

FIGURE 5

Time series from a UV process tracking the UV irradiance in UVC and UVA ranges. Temperature at the probe tip is also monitored.



the return to higher rates of UV output for the next draw due to replacement of the contaminated quartz tube.

Cincinnati Printer Monitoring Multiple UV Presses

Multi-Color Corporation of Ohio is a quality label printer. They have two Comco Web presses and a Komori Lithrone sheet fed printer. They have 26 UV lamps fitted to three presses. The company's commitment to quality persuaded them of the necessity to monitor various lamp systems to ensure consistency of print cure quality. They use the miniature spectroradiometer to routinely and manually measure the UV output from their lamps. The spectroradiometer is equipped with two different probes to access all 26 lamps. Each lamp position is fitted with a locator device to ensure consistent reproducibility of the measurements.

Automatic On-Line UV Monitoring on a Sheet Fed Printing Press

UK-based Field Packaging produces high quality print for the food packaging industry. It has recently used the spectroradiometer to manually check the UV output on its Komori offset printing presses. This has enabled the company to effectively manage the replacement of UV lamps in its interdeck and end of press UV driers.

Field Packaging has now installed a new Man Roland press. It has been fitted with fully networked on-line UV monitoring system for the 15 interdeck and end of press UV lamps.

The system consists of 15 on-line sensors as described in Figure 3 and they can be cross-calibrated in situ using the miniature spectro-radiometer (Figure 4). The probes are fitted with a self-cleaning air flow to prevent contamination of the UV window. The 15 sensors are networked together via serial communications and the UV lamps monitored continuously in real time. The method anticipates the necessity for lamp changes and avoids unplanned downtime. The computer data also provides an effective record for quality control since print batches can be referred back to the UV conditions at the time of printing.

NIST Monitors UV on Weathering Sphere

A unique UV weathering machine has been developed at The National Institute of Standards and Technology (NIST) in Maryland. The machine has been designed to overcome the problems with conventional weathering chambers in providing a uniform UV irradiance to the weathering specimens. It utilizes a 2m-diameter integrating sphere to distribute the UV to 32 weathering ports where individual experiments can be carried out.

NIST has used the spectroradiometer to evaluate the uniformity of spectral output both within and between the weathering ports and has found its design provides excellent uniformity in both respects. A variety of filters can be fitted to each of the weathering ports to assess the effect on the specimens of various spectra. The spectroradiometer can also be used here to measure the precise filtered spectrum reaching the specimen.

NIST will install a network of miniature spectroradiometers to directly and continuously monitor the UV at various points around the sphere. This will enable NIST to evaluate the temporal variations in UV flux. ◗

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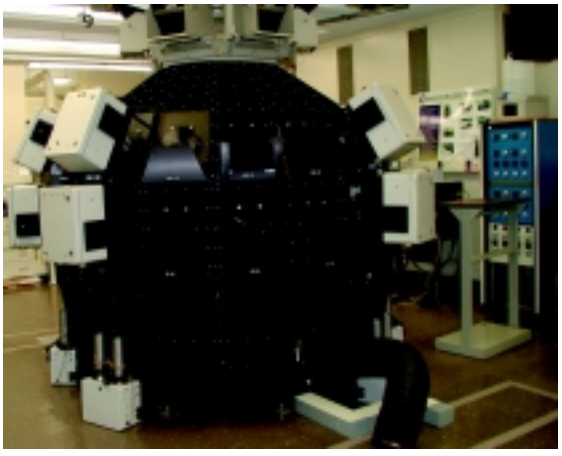

UV weathering sphere developed at the National Institute of Standards and Technology (NIST) monitors effects on specimens of varying spectra.