UV SPECTRORADIOMETRY

Effective Field Measurements of the UV Process

by

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1 Abstract

UV Curing processes emerged during the 1970's primarily for the curing of inks and varnishes in the printing industry. Development of the process was largely "hit and miss" with experimental work carried out in order to establish the relevant variables in the curing processes that worked in practice.

More recently, UV practitioners have become increasingly aware of Quality Assurance and the need to establish quantifiable methods of characterising the UV process and to monitor UV processes in the field.

Monitoring the cure of a UV material in real time is not as yet practical for manufacturing UV processes so the need arises to monitor other variables of the process in order to establish effective process control and quality assurance.

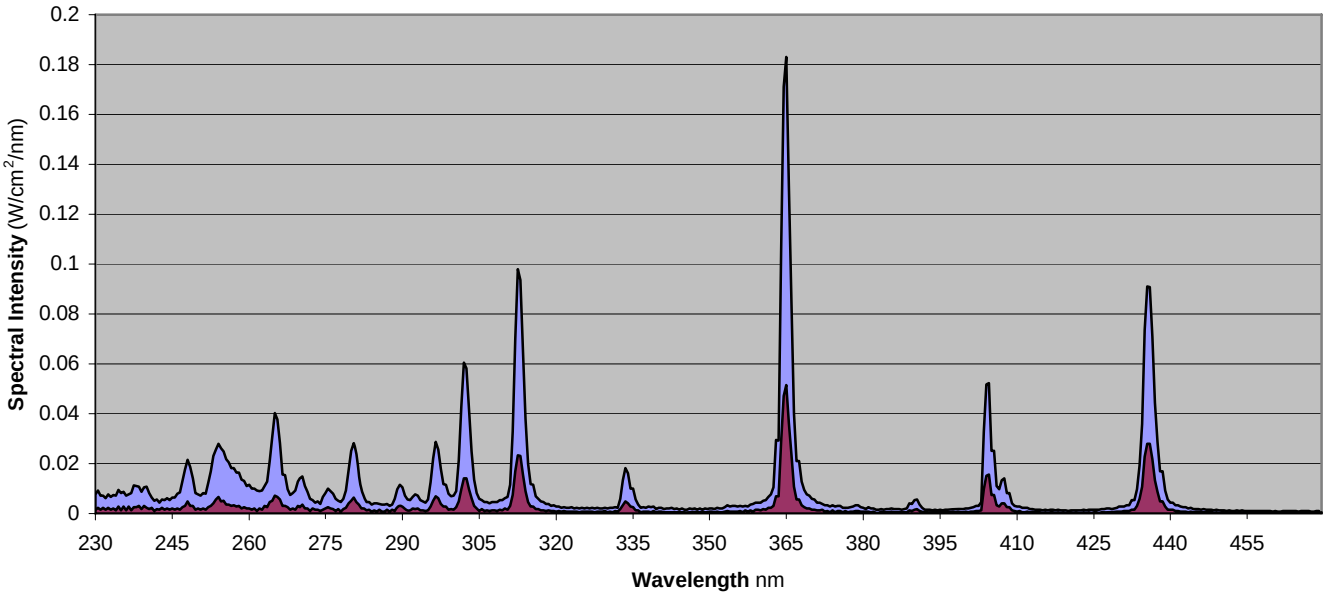
This paper reviews the variables in the UV process and describes practical methods of measuring, in real time, those variables which affect the quality of the cured product and in particular the spectral and irradiance characteristics of the UV lamp source.

It is now recognised throughout the UV industry that to implement UV process in new applications there is a fundamental need for effective and well-understood process control. To achieve this it is essential to effectively measure the UV source under the varying field conditions which can be encountered.

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 variable UV sources in the field under 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. Contaminations of the UV Optics, variable cooling, change in the substrate in process all contribute to variable, **effective** UV in the process.

Figure 1. Comparison of spectral data from new U.V. lamp
to a used lamp (lower graph). Especially shows the loss of critical shortwave range
of 240 - 280nm a key area monitored by SOLA-CHECK on press



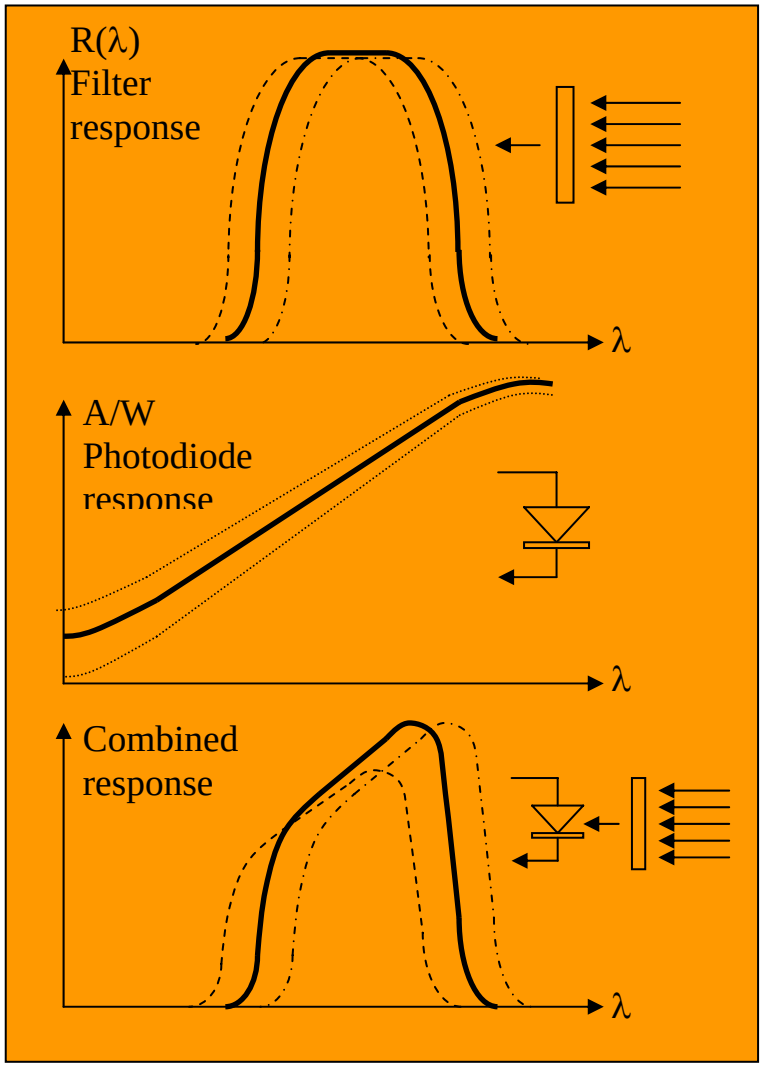
There are a number of instruments developed over the years which can be employed to measure the UV source. The Spectroradiometer is highly accurate and provides detailed spectral and irradiance information. However, being large, cumbersome, complex in operation and expensive, their usefulness has been confined to the laboratory. 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 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 unknown 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 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.

Figure 2.

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



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 this difficulty there have been 2 recent developments in UV measurement. When combined these 2 developments can achieve the twin objectives of calibrated spectral irradiance with simplicity of use and low cost. These 2 new developments are as follows:

1. UV Process Sensor. This can be installed on-line for continuous UV monitoring

2. Programmable SpectroRadiometer. This is a compact, fully portable instrument with spectroradiometric optics used for cross-calibration in the field of the Process Radiometer above.

Figure 3.

On-line, UV Process Sensor with UV probe for access to UV source

Figure 4.

Programmable SpectroRadiometer providing wavelength and irradiance data for cross-calibration of the On-line Process Radiometer. Includes UV probe to replicate the measuring point.

METHODOLOGY

The On-line Sensor (for continuous monitoring the UV process)

The new optical system of this unit eliminates the use of interference band pass filters which degrade with time and are temperature dependent. 2 channel measurement is provided by wide band gap photodiodes for full UV waveband (220nm to 390nm) and UVC (220 to 280nm) solar-blind. The radiation source can be captured using a probe and cosine diffuser.

Used as a simple radiometer the unit provides 0 to 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 is provided with full digital, serial communications via RS485, 2 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.

The Programmable SpectroRadiometer (for calibrating the On-line Sensor)

This instrument has spectroradiometer optics measuring the full UV range from 230nm to 470nm. It is equipped with an identical probe as the On-line Sensor. In this way both instruments can replicate the identical UV measurement.

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 of the On-line Sensor to calibrate it on the UV Process.

Effective UV Process Control

By combining these 2 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 very varied fields of UV applications. Typical data produced by such a monitoring system are shown in the graph below. This data can be used to define, characterise and control the UV process

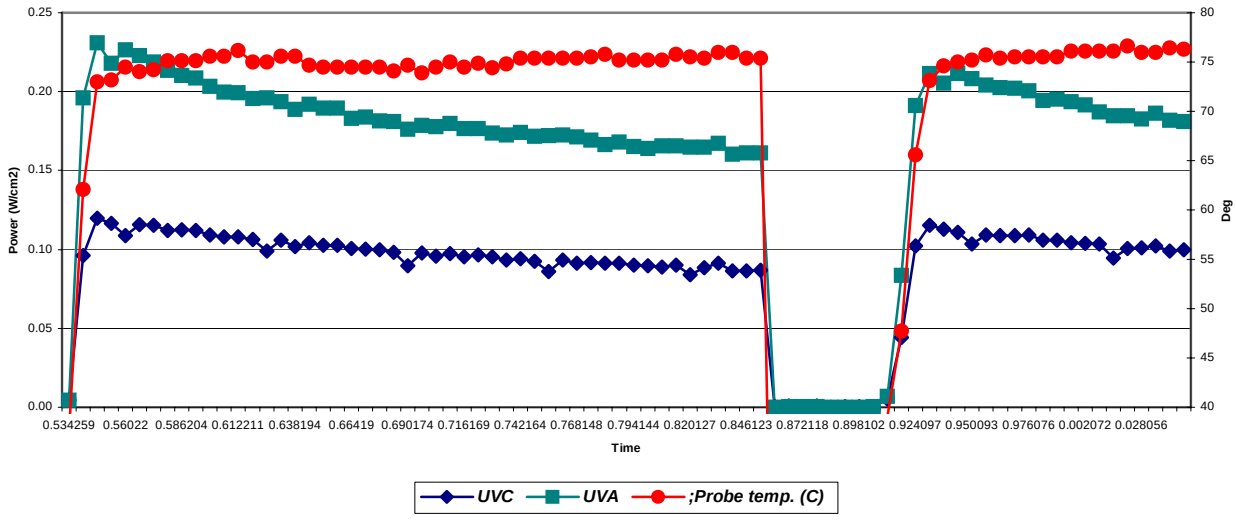


Figure 5. Time series from a UV process tracking the UV irradiance in UVC and UVA ranges. Temperature at the probe tip is also monitored.