IST INTECH

UV LED CURING SPECIALISTS

WHITE PAPER

Understanding UV

Understanding UV Part 1:

The Two Key Concepts

Understanding UV Part 1:

The Two Key Concepts

UV is sometimes shrouded in mystery, but this doesn't need to be the case – this paper aims to outline the basic elements of UV technology, why you need to know it, and what you should be asking. Once armed with this foundational knowledge, a bespoke UV provider that understands how UV interacts and integrates with each stage of the printing process will take you the rest of the way.

Partnering with UV specialists that take a consultative and flexible approach to your UV requirements early on in the process will benefit the development of a smooth and effortless integrated solution. This allows for UV needs to be considered alongside every other crucial element of the machine design and result in a bespoke UV solution that works in harmony with every other technical aspect of your system. UV solutions aren't 'one size fits all', and a perfectly tailored system starts by including the UV early in the process, and understanding the 'UV ABCs', starting with the two key parameters that must be understood to facilitate a successful UV integration – **dose** and **intensity**.

What is UV?

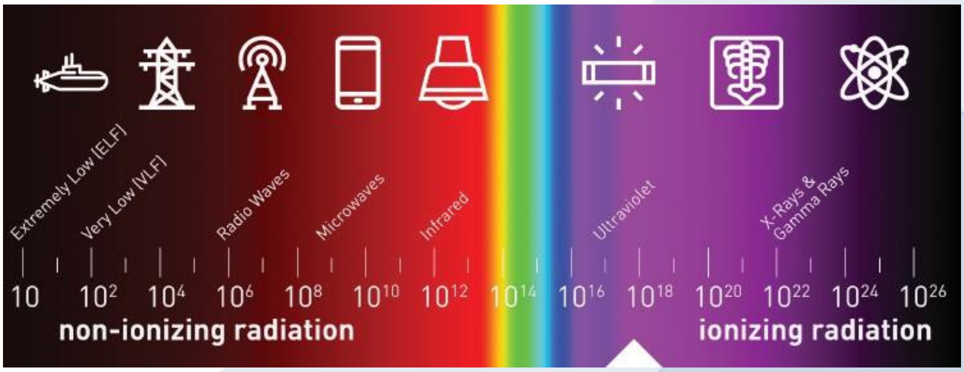

Figure 1: The electromagnetic spectrum

Note the electromagnetic spectrum – Light emitted with a wavelength between 200 and 400nm (nanometres 10^{-9}) is regarded as UV Light. The human eye is able to see light down to around 400nm, just above the UV spectrum. Therefore, UV LED's that emit light at 395nm are very close to visible light and the eye can perceive it and sees it with a purple hue. This is why when you think of UV light, you may be imagining a purple colour. High intensity UV light acts on photo reactive initiators in the chemistry, and these in turn cause the monomers to polymerise.

Common types of UV system include: arc lamps, which contain mercury, are similar to fluorescent tubes and emit a broad band of UV as well as infrared (approx. 65 percent) and about 15 percent visible light; microwave lamps which are similar to arc lamps, but the mercury is heated by microwaves similar to the oven in your kitchen; and UV LED, which is simply a light emitting diode similar to those used in a flashlight, but made with different materials to emit light in the UV wavelength, and the light is generated by passing an electrical current through the diode.

UV Lamp Spectral Output

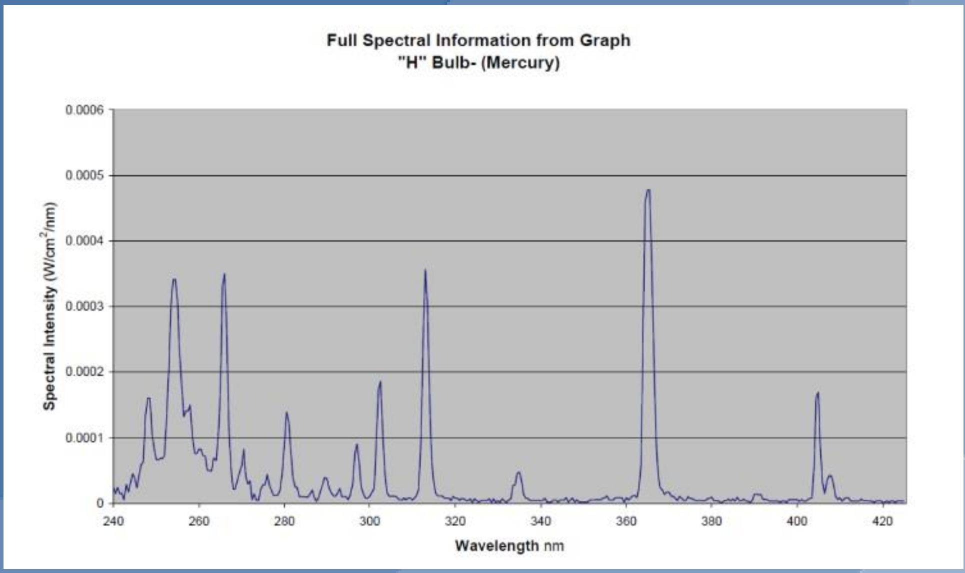

Figure 2: UV lamp spectral output

UV Spectral Output

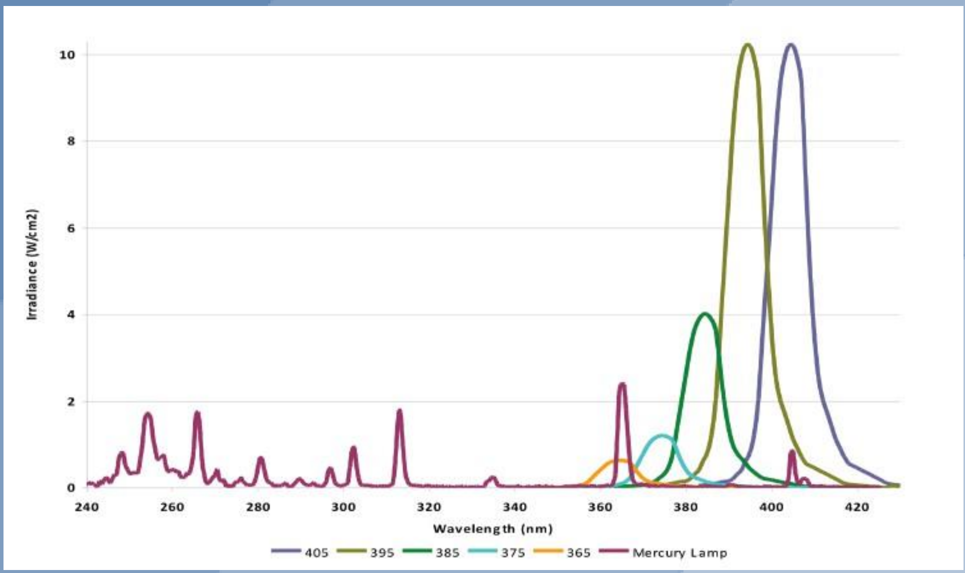

Figure 3: UV spectral output

- **Irradiance**, also referred to as **dose**, relates to the amount of light. This is measured in Joules per Square Centimetre (J/cm²)
- **Peak Irradiance**, also referred to as **intensity**, relates to the brightness of the light. This is measured in Watts per Square Centimetre (W/cm²).

It's not difficult to see why **dose** and **intensity** are the preferred terms – **irradiance** and **peak irradiance** are easily confused.

Finding the Cure

'Curing' is often misinterpreted as 'drying', but this is not correct. Knowing how much **dose** and **intensity** is imperative to understanding the curing process. In order to cure a chemistry, a minimum level of **intensity** is required for a period of time to cure, so the Intensity multiplied by the time gives the **dose**. Curing is a chemical reaction as opposed to evaporating a solvent from a chemistry, and in UV curing the substrate must be exposed to a high-intensity UV light source, or it will not polymerise (solidify).

Reactions can occur upon exposure to lower levels of intensity such as sunlight, but may not continue to 'full cure', either because the light is not powerful enough to penetrate the full thickness of the chemistry or because oxygen at the surface of the chemistry inhibits the reaction ('Full cure' is defined by the process and there are various ways to test this, however the only real way of measuring this is to count the double bonds created in the reaction, by using an Infrared Spectroscopy process, which can only be achieved in a laboratory).

Dose and Intensity

Here are two examples of light sources to illustrate **dose** and **intensity**. The laser pointer like the ones you might see illuminating a target for a rifle shot in a war film, is a very bright light, visible from a long distance, highlighting the surface at which it is aimed. The light from the laser pointer may be powerful, but it would be no good for lighting a room – it's a highly **intense** light source. A security floodlight on the other hand gives out a considerable amount of light, literally flooding an area with it, but the light isn't particularly bright compared with the beam of a laser pointer or a spotlight at the theatre. These examples are a simple of way of differentiating between amount of light and brightness of the light.

The Hosepipe Example

Imagine you have a hose pipe and you need to fill up the bucket. If it takes you one minute to fill the bucket, it stands to reason that if you need to fill two buckets, it will take two minutes. This is like the **dose** needed for UV curing – dose is dependent on time, so the amount of time that the chemistry is exposed to the UV light source.

If you need to fill the bucket quicker, you could use a higher pressure in the hose – here, the pressure is equivalent to **intensity**. However, if your hose has too much pressure, the water stream could be too powerful and instead of filling the bucket you'll knock it over (This is also a risk in UV curing, overwhelming the chemistry before it has the chance to react – another reason why calling in the experts is crucial!).

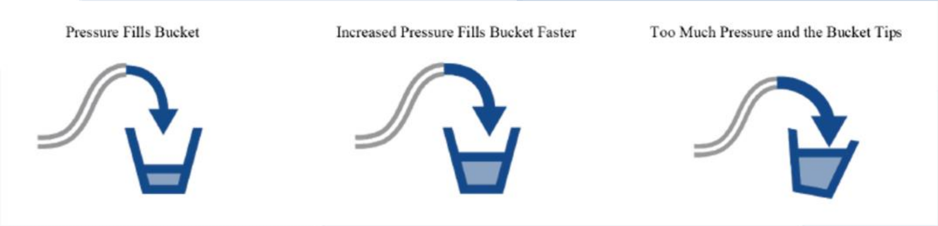

Figure 4: Hosepipe example – intensity

Intensity (Peak Irradiance) is dependent on distance. If no optical enhancements* are made, intensity drops with distance between UV light source and the substrate. However, it remains constant with speed variations.

*Optical enhancements could be shaped reflectors or lenses, depending on the light source these range from simple formed pieces of reflective material to highly complex machined lenses.

Dose

Dose (Irradiance) is the amount of UV light that is present, so in our Hosepipe example if you have a bigger diameter hose pumping the liquid at the same pressure, you will get a larger volume of liquid over a given time period. So, UV Dose is proportional to time (speed), but is not related to distance, if it is not lost beyond the curing area.

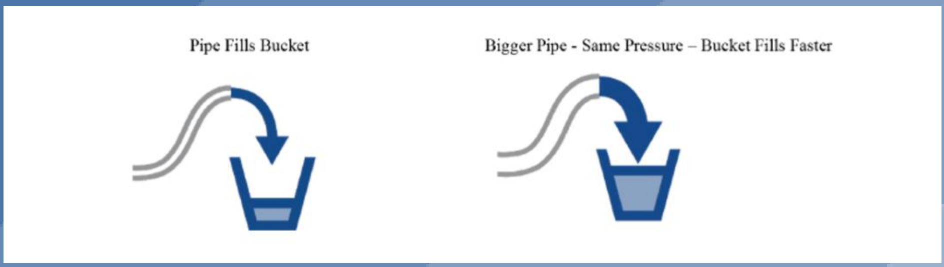

Figure 5: Hosepipe example – dose

The Maths

Peak Irradiance (Intensity) x Time = Irradiance (Dose)

If a light source has a 0.1m (10 cm) opening in the direction of travel and the speed of the machine is 0.1m per second (m/sec) (10 cm/s), the a point on the substrate will take 1 sec to traverse the opening. Assuming the Intensity is 0.1 W/cm², 0.1 W/cm² x 1 sec = 0.1 J/cm². If the speed is increased to 0.2 m/sec then the dose will be halved to 0.05 J/cm². (As these are very small numbers, they can often be expressed in 'milli' numbers. So, 0.1W/cm² is more often seen expressed as 100 mW/cm².)

Need to Know: Questions for Your Suppliers

Knowing what you need to ask is half the battle. With non-disclosure agreements abundant in the industry, open collaboration can be curtailed and a free exchange of information can, unfortunately, be a challenge. That's why understanding the details that you as a customer need to know is essential, and we have outlined some starter questions below, and why they are important.

1. **What is the dose and intensity required to cure the chemistry? Now** that you are equipped with insight into what dose and intensity means and why it's important, you will know it is an important question to raise with your supplier, and that it is vital to know the answer for both. If it's LED, you will also need to know the optimum wavelength.

2. **What instrument should be used to measure this?** Not all radiometers read the same, due to the way in which they filter the light on the sensor. This makes it crucial to know which instrument was used to define the dose and intensity required to cure a chemistry. Imagine two pairs of sunglasses, while they have a similar function, they may have slightly different lenses and be filtering light differently. A milliwatt on one instrument may not measure a milliwatt on another. This will be further illustrated in a forthcoming IST INTECH report looking closely at radiometers.

IST INTECH Ltd
10 Wates Way, Banbury,
Oxfordshire, OX16 3TS, UK
+44 (0)1869 233611
mail@istintech.com
www.istintech.com

3. **Are there any other chemical properties to consider?** Flexibility, adhesion, surface hardness, and substrate type are all properties that can be affected by UV **dose** and **intensity**, so ensure that you discuss all of these with your supplier Different substrates, surface hardness complex shapes, all of these factors will impact **dose** and/or **intensity**, so ensure these are conversations you are having with your supplier.

The information outlined in this paper is very much the tip of the iceberg when it comes to UV, but will have equipped you with the basics of the technology and guide you on the first step of your UV journey. UV is not 'one size fits all', and a flexible partner that can support and advise you at every stage will be a significant advantage when it comes to evaluating your UV requirements. IST INTECH has the experience and expertise to help you continue along the path, demystifying and simplifying the process while tailoring our solutions to a customer's exact specifications.

For more information contact **mail@istintech.com**

IST INTECH Ltd
10 Wates Way, Banbury,
Oxfordshire, OX16 3TS, UK

+44 (0)1869 233611
mail@istintech.com
www.istintech.com