Utilizing Radiation Curing for Hot Melt Acrylates

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As adhesives become more prevalent and accepted in industry, the more varied the formulations have become and by corollary, the more diverse the curing mechanisms. One of the curing methods that has gained traction, is radiation curing. Specifically, using the UV band in the electromagnetic spectrum to provide photonic energy that triggers a very fast reaction, namely photopolymerization (crosslinking). In this particular case, the adhesives contain a photo initiator which when exposed to UV light, generate a very reactive species which start to create C-C bonds. The 'cure' is defined as the % of C-C bonds, the higher the %, the better the 'cure'.

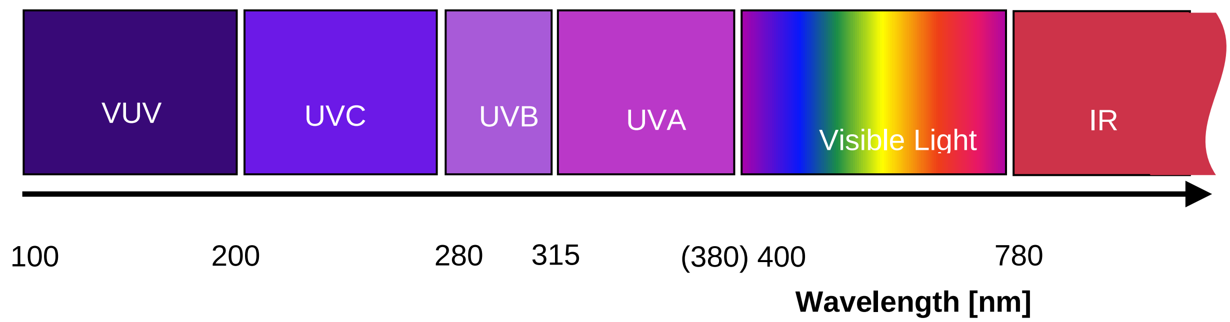

Figure 1. UV Bands in the Electromagnetic Spectrum.

As radiation curing is very fast, it lends itself well to continuous production processes, such as converting reels of material through a machine that applies, say, a pressure sensitive adhesive for tapes … the same principle applies for printing ink onto a reel of material and is widely used in graphic arts production. As the adhesive is cured right away, the converted material can be handled immediately ready for the next downstream process.

For the scope of this presentation, the radiation curing is provided by a classic UV lamp (medium pressure arc) which produces an output spectrum that is dependent on the dopant (additive) which is used in the bulb. For example, a mercury doped bulb will produce a UVC (*see figure 1*) rich spectrum (short wavelength/high energy) and an iron doped bulb will produce a UVA rich spectrum (long wavelength/less energetic). Generally speaking, both dopants will produce output in the UV range of 200 – 400 nm (the dopants determining which wavelengths the photonic energy is concentrated in. This allows photo-initiators to be activated at their specific wavelengths and in turn drives a desired reaction.

The two variables that are generally considered when defining output of UV is dose (in mJ/cm²) and intensity or peak (measured in mW/cm²) in a given band (UVC, UVB, UVA). Dose is energy density, or put another way, the amount of energy available to create the photopolymerization reaction and the subsequent C-C bonds and is time (speed) related. Intensity is how 'bright' the output is and becomes important with heavier coat weights or opaque (or colored) adhesive where the energy needs to be driven through the layer to ensure throughcure. Although the bulb is an important component in the UV system, this is half of the story. The other important component is the reflector as around 65% of the bulb's energy is reflected and focused an inch or two from the face of the lamphead (*see figure 2*).

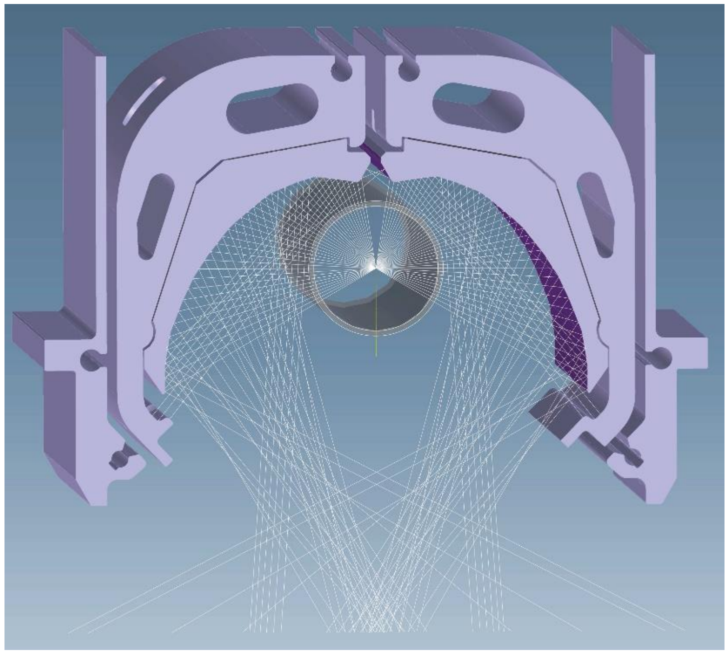

Figure 2. Reflector.

A typical UV arc bulb will produce a mixture of UV, visible light and IR (heat), the latter is usually not desirable and is mitigated in a number of ways in the (water-cooled) lamp head. The reflector is dichroic which allows the shorter wavelength UV to be reflected and the longer wavelength IR to be passed through to the water cooling channels in the lamp geometry. The material, geometry and coating of the reflector are a critical piece of the system design and are usually highly engineered with precisely defined reflection characteristics.

A good illustration of a UV adhesive application is hot melt UV acrylates, which are often used to produce a variety of pressure sensitive tapes. These can be simple single sided affixing tape through to complex double sided high tack construction tapes which use a variety of carriers. The hot melt adhesive is usually applied with an extrusion mechanism (slot die) that meters the adhesive with relative accuracy onto a moving web of material (carrier or liner), such as in a converting line. The applied adhesive is then transported under UV lights with a UVC rich spectrum which activates the formulation to produce the desired adhesive characteristics (*see figure 3*). A second web can be introduced onto the adhesive before being rewound at the back of the machine. This type of adhesive requires high precision of UV output, specifically dose, to ensure the tape characteristics (balanced properties target). In this application the dose is monitored with a highly accurate sensor and is linked into the UV system's power setting to create a closed loop power control (*see figure 4).*

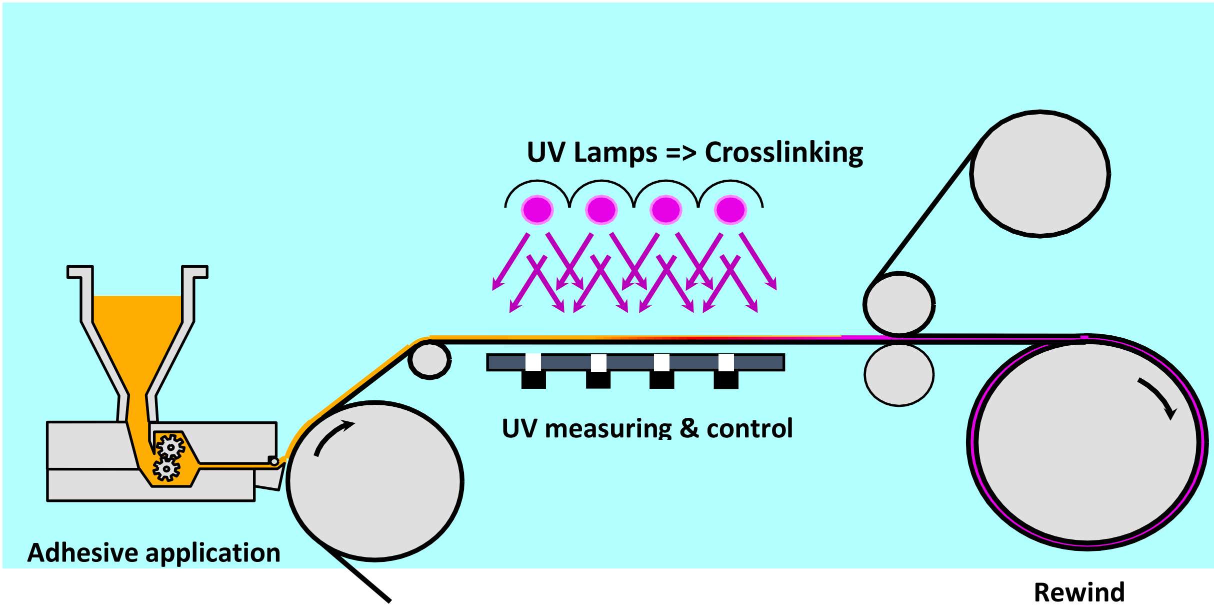

Figure 3. Hot melt UV acrylate application.

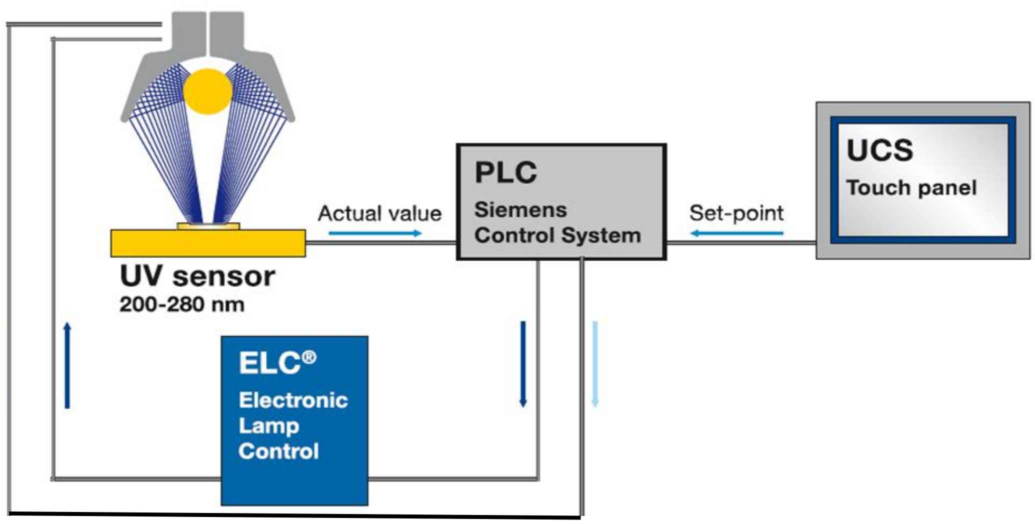

Figure 4. Closed Loop Dose Control

One common question that gets asked from companies that are considering UV adhesives is how to check the 'cure'. As previously mentioned, this is generally defined by the percentage of C-C bonds present and this is usually measured with FTIR (and similar instruments) which are not usually in the arsenal of most converters. However, there are a number of inferred tests that check shear strength, tack, mechanical bonding etc (*see figure 5*) and are widely used as an empirical measure for QA. Although this is a very simplistic snapshot, there are well defined and established processes and methods, which give a strong indication of the 'cure'.

As with all new methods and processes there is a discovery and research phase, especially as these curing systems are installed on critical production lines. The UV curing mechanism has been operating in the adhesive field for nearly thirty years and is well understood. There is an extensive application lexicon as well as development resources readily available at UV equipment and adhesive manufacturers.

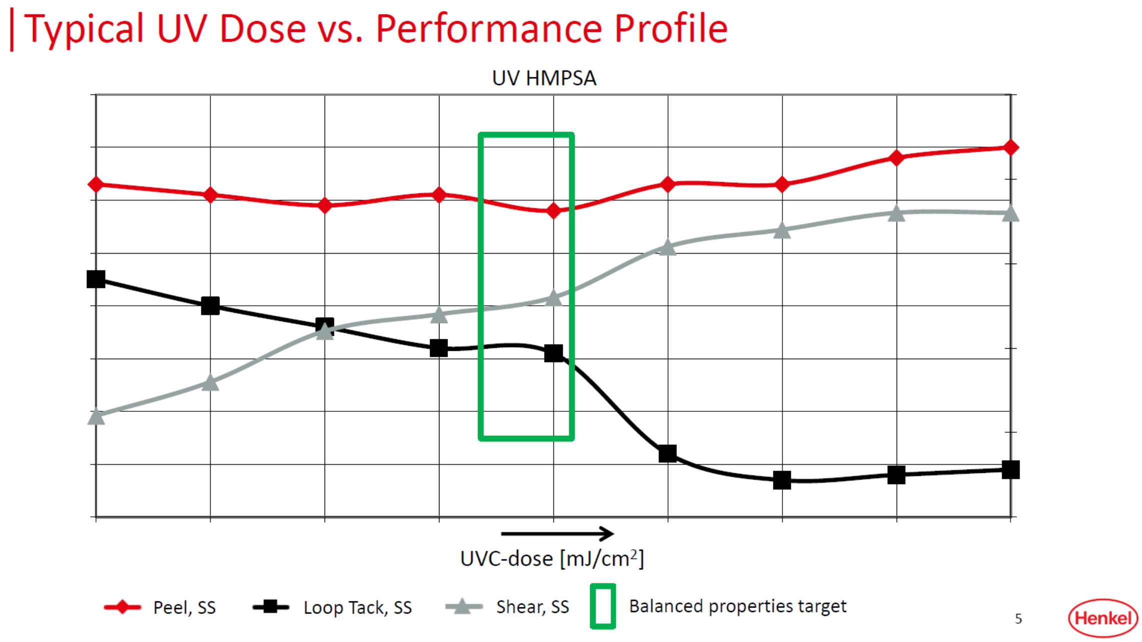

Figure 5 – Balance of properties.