UV Light Selection Requires Fitting Lamp to Application

By Clai Bachmann
Vice President
Dymax Corp.
Torrington, Connecticut 06790

Ultraviolet (UV) curing structural resins have gained widespread acceptance in an ever-increasing range of OEM applications. Manufacturers of a diverse range of medical, electronic, automotive and consumer products have found this new assembly technology indispensable in reducing processing time, lowering per-unit costs, improving overall product quality and providing an avenue to new and innovative design solutions.

Along with these new products, however, comes the need for understanding the UV systems and their capability for curing structural adhesives, sealants and coatings. Proper UV light source selection requires not only comprehension of the properties of the light itself, but also matching of the lamp to the specific resin and application parameters. Failure to select the correct lamp generally will mean improper or incomplete curing of the resin.

It is critical that the adhesive or coating be matched to the specific application requirements. A reliable supplier will have the in-house technical service support to help in such an evaluation. A secondary, and no less critical, prerequisite is the corresponding match between lamp, adhesive and application.

While today’s generation of structural resins are far more versatile, their optimal curing is still affected by four factors: wavelength of the UV-light spectrum; intensity of the light on the adhesive, coating or sealant; whether the chosen light “footprint” is spot, beam or flood; and whether the assembly process is manual, semi-automated or fully automated.

Wavelength Characteristics

Adhesives must absorb UV light in order to activate their curing properties. Matching of spectral output of the UV lamp with the spectrum at which the resin absorbs light is the determining factor in whether a particular UV lamp will adequately cure a specific adhesive or coating.

As illustrated in Figure 1, the optical region of the electromagnetic spectrum is clearly defined into ultraviolet, a narrow band of visible light and a belt of infrared radiation. Figure 2 represents an exploded view of the UV spectrum, illustrating absorbance curves for Dymax UV adhesives as compared to typical UV inks and coatings. The UV spectrum extends from 200-400 nm wavelengths; Dymax adhesives and conformal coatings absorb 100% light at 365 nm.

There exists in the marketplace some continuing confusion between today's...
Custom Lamp Arrangements

On occasion, there are situations where standard lamp sources are not adequate for a particular application. While the standard lamps frequently can be incorporated into industrial processing systems, custom systems can be designed and installed. This greatly multiplies the opportunities for design innovations and unique process improvements that provide substantial process benefits and overall finished product quality.

Conclusion

Great advances in UV curing, coating and sealing operations have been made since the earliest UV inks and coatings were introduced some years ago. However, the technology of applying the proper structural resins and matching them with the proper UV lamp requires additional knowledge and familiarity.

Your supplier of structural adhesive compounds can help with lamp and resin selection based on the particulars of your own assembly or application needs to assure proper light-to-cure intensity. When done properly, tangible benefits can be found over alternative assembly methods, particularly downstream of the assembly and manufacturing process.

To help the reader, we have assembled a basic guide to help with lamp selection (Table 1). The cure speed values shown in the matrix are typical and are based on historical application data and laboratory validation tests. Each application, however, is unique, and cure speeds must be determined individually for each.

Figure 5 (top left). The Dymax-patented high-intensity spot unit integrates an adhesive dispenser with a UV light source. This example of spot-type lamp intensity is ideal for curing small drops or beads of adhesive. Figure 6 (top right). A flood lamp offers a large cure area for curing many parts at once. Flood lamps generally lower light intensity and emit less heat, thus they are ideal for bonding heat sensitive plastic parts. Figure 7 (above). The areas of maximum intensity for each of three types of lamps: flood light, focal beam and spot source. Because the lamps are compact, they are ideal for mounting over conveyors.

### Table 1 — Lamp types/intensities

<table>
<thead>
<tr>
<th>Application type</th>
<th>Aerobic acrylic adhesive type by cure rate</th>
<th>Moderate intensity flood, 35 mw/cm²</th>
<th>Higher intensity spot, 200 mw/cm²</th>
<th>Higher intensity flood/beam, 150 mw/cm²</th>
<th>Highest intensity beam, 500+ mw/cm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bonding UV transparent surfaces (2-mil gap)</td>
<td>Fast</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>&gt;1</td>
</tr>
<tr>
<td></td>
<td>Moderate</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>&gt;1</td>
</tr>
<tr>
<td></td>
<td>Slow</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>&gt;1</td>
</tr>
<tr>
<td>Sealing and potting to ½ in.</td>
<td>Fast</td>
<td>30</td>
<td>10*</td>
<td>15</td>
<td>&gt;5</td>
</tr>
<tr>
<td></td>
<td>Moderate</td>
<td>60</td>
<td>15*</td>
<td>30</td>
<td>&gt;6</td>
</tr>
<tr>
<td></td>
<td>Slow</td>
<td>90</td>
<td>30*</td>
<td>60</td>
<td>&gt;10</td>
</tr>
<tr>
<td>Coating (5 mil, tack-free film)</td>
<td>Fast</td>
<td>30-45</td>
<td>NA</td>
<td>5-20</td>
<td>&gt;3</td>
</tr>
<tr>
<td></td>
<td>Moderate</td>
<td>NA</td>
<td>NA</td>
<td>30</td>
<td>&gt;5</td>
</tr>
<tr>
<td></td>
<td>Slow</td>
<td>NA</td>
<td>NA</td>
<td>45-60</td>
<td>&gt;10</td>
</tr>
<tr>
<td>Tacking (⅛ in. diameter × ⅛ in. height)</td>
<td>Fast</td>
<td>NA</td>
<td>5</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Slow</td>
<td>NA</td>
<td>10</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

*Adhesive drop diameter less than ½ in.
NA: Not applicable for the application
UV structural adhesives, coatings and sealants and the earlier UV inks and coatings. Early UV technology focused on inks and very thin coatings designed to cure rapidly upon exposure to high-intensity, medium-pressure mercury vapor lamps. These lamps emit UV light with a majority of the energy produced from 200-320 nm. The UV inks, therefore, were designed to match this energy/frequency relationship. Since the energy of short wavelength light does not penetrate the ink formulations easily, light dissipates rapidly. This is shown in Figure 3, which charts the spectral output of these style lamps. These materials (including a broad range of inks, can coatings, high-gloss UV finishes and hard coats) are restricted to very thin applications.

The technology of modern structural adhesives, coatings and sealants, such as Dymax products, uses longer wavelength light for curing. Thus, they are capable of rapid cure rates and coatings to greater depth than heretofore available. This superiority regarding the depth of coating, along with resin properties of high adhesive strength, toughness and durability, has made available wide application versatility in bonding, potting, tacking and sealing. Use of the short-wave curing equipment, suitable for traditional inks and coatings, will result in slower cure rates, diminished depth of cure and increased surface tackiness. Figure 4 represents the wavelength configuration and concentration from 320-380 nm that is necessary for optimum cure of UV structural adhesives and coatings. Among UV curing lamps with an appropriate spectral output to cure UV structural resins are the Dymax Light-Welder PC-2, PC-3, PC-5, PC-12 and any Fusion Systems high-intensity electrodeless lamp with a “D” bulb.

**Light Shape or Pattern**

The optimum shape of pattern of light emitted by a lamp for any specific application is called its “footprint” and depends upon the size and geometry of the bond area and other process requirements.

Typically, spot source lamps with light guides are used for hand-assembly operations, such as tacking wiring or components to PCBs. Light guide lamps also are useful for curing on automated production lines in areas where obstructions may prevent light from a focused or flood source from reaching the adhesive. Spot source lamps with light guides are only practical for curing small drops or beads of adhesive (Figure 5).

Flood lamps offer a large cure area but generally lower light intensity. They emit less heat as well and are usually the product of choice for bonding heat sensitive plastic parts such as those common to medical disposables. The large area of flooded light also is useful for curing many parts at once. This is illustrated in Figure 6, showing placement of glass under a lamp.

Focused beam lamps are designed for maximum intensity and are generally the product of choice for highest speed curing.

Figure 7 illustrates the areas of maximum intensity for each of the three types of lamps discussed above. In addition, the small, compact size and weight of these lamps allow for easy in