Designing in light curing adhesives - a holistic approach to adhesives in medical device assembly

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Introduction

By taking a holistic view of designing in light curing adhesives during the early stages of a project, it's easier to build a good process. This involves considering the entire bonding process at the design stage, including everything from substrates to joint design, surface preparation, quality control, application, and cure. Changing or being flexible about any one of these choices can help optimise the process — a small variation can open the door to a new adhesive and a large process improvement.

Fastening options for medical devices include heat sealing, welding, solvent bonding, mechanical interlocks, and adhesives. The advantages of adhesives compared with alternative methods include the distribution of load or stress, the elimination of joint fatigue, improved impact resistance, and good aesthetics.

Generically, UV curing adhesives are resilient and tough — with high tensile, shear, and peel strength, and a cured hardness range of Shore A80 to D80. Medical device manufacturers can consider them as a structural bonding agent for multiple substrates, from glass, to metal, to many types of plastic, including those used in certain medical device assemblies like PEEBAX or PEEK. These adhesives are tested to ISO 10993 and USP Class VI, and are compatible with typical sterilisation methods.

Figure 1 – UV curable adhesives can significantly reduce assembly processing time and costs

Light curing adhesives are extensively used in medical device manufacturing due to their process advantages, finding applications in products like catheters, syringes and needles, anesthesia masks, reservoirs, tube sets, and medical electronics assembly. One key benefit is that they cure in seconds, "on demand", on exposure to the correct wavelength of UV light. They reduce the need for jigs and tooling, reduce work in progress freeing up factory space, and are single part which means no mixing and reduced waste.

Design considerations
A recommended approach when designing a device which needs bonding is to consider both a) the functional nature of the bond (strength and robustness), and b) processability. Make sure that the adhesive application and cure is achievable within the constraints of the product geometry and production time. The highest possible strength adhesive bond will be useless if the bonding process turns out to be too expensive or takes too long.

To design in a UV light curing material, start with selecting bondable substrates. This typically means avoiding very low surface energy materials like PTFE or polyolefins, although if these are desirable for functionality you can consider surface treatment to improve wettability. Most UV curing materials have poor adhesion to rubbers and silicones, although the latest hybrid cyanoacrylate/UV adhesives can be considered for these substrates.

Another important consideration is bondline design. The adhesive needs some space of its own, so friction fit joints aren't usually suitable – the adhesive will not work if it is squeezed out of the joint. Consider an optimal bondline gap of around 0.125 mm. However, UV curing adhesives are available in a wide viscosity range, from wicking and self-levelling grades to thixotropic pastes, and have the ability to cope with bondline variations and the need to gap fill if necessary.

Figure 2 – Dual curing cyanoacrylate adhesives can be considered if parts of the bondline are not visible

Light of the correct wavelength must reach the entire bondline for the adhesive to cure — so in most cases, one of the substrates will need to be clear so that the bondline is visible. If this is not possible, there are products on the market that are dual cure, like Born2Bond™ Light Lock, which offers a cyanoacrylate surface cure as well as UV light curing, meaning the material will cure interfacially in opaque areas.

Many polymers contain UV blocking agents to prevent yellowing and embrittlement from ambient UV light. Adhesives which use a synergistic combination of UV and visible light to cure can be specified to ensure cure speed and depth for bonding these plastics.

Implementation
UV curing adhesives are easy to implement due to their "on demand" fast cure, solvent-free single component formulation, and choice of viscosity. They can be applied using a wide variety of dispensing techniques with repeatable precision, and are readily automatable.

There are two main types of UV curing lamp: broad spectrum (mercury arc lamp) and narrow spectrum (LED). UV curing lamps based on LED technology offer lower energy consumption, stable output intensity and instant on/off, so are growing in popularity and have become the default choice. Modern UV curing adhesives have been formulated to cure with the narrow spectrum of LED UV curing lamps, and many are wavelength specific. For example, Dymax MD® 1405M-T-UR-SC needle bonding adhesive is optimised to be LED curable at 405 nm wavelength light. Adhesive choice needs to be considered in line with substrate transmission characteristics.

Yields are typically high because the process is very controllable and repeatable. Because cure happens rapidly, you can implement quality assurance procedures immediately after assembly, or even in-line. Because there are few variables, locking down and validating the process is readily achieved.

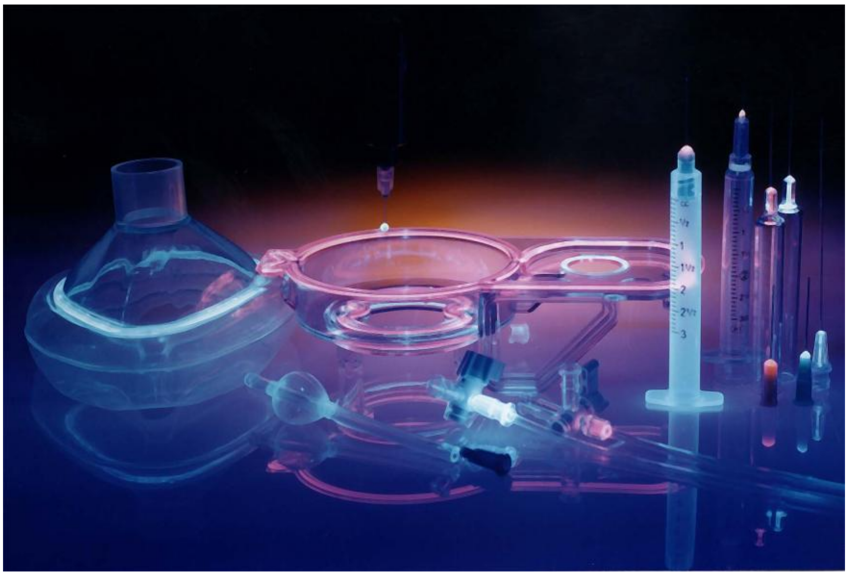

Figure 3 – UV curable adhesives have been used in many types of disposable medical device

Medical device manufacturers can gain both functional and process benefits from using light curing adhesives. To make the most of these benefits, consider how to implement them at the design stage, by specifying substrates and bondline design to facilitate their use. Bonding with UV light curing adhesives is usually a robust, reliable, and validatable process, offering high quality and productivity.

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