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## Cyberbond - UV and Light Curing Adhesives

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### UV and Light Curing Adhesives

#### 1. The System

UV and Light Curing Adhesives are one component, solvent free and mainly cold curing systems. These products cure quickly by means of UV-light. Generally the whole system functions in the following way: a liquid adhesive called monomer is filled with photo-initiators. When these initiators are activated by light they turn into so-called radicals and the polymerization process starts. Most UV adhesives are acrylic or epoxy based.

There are three main systems:

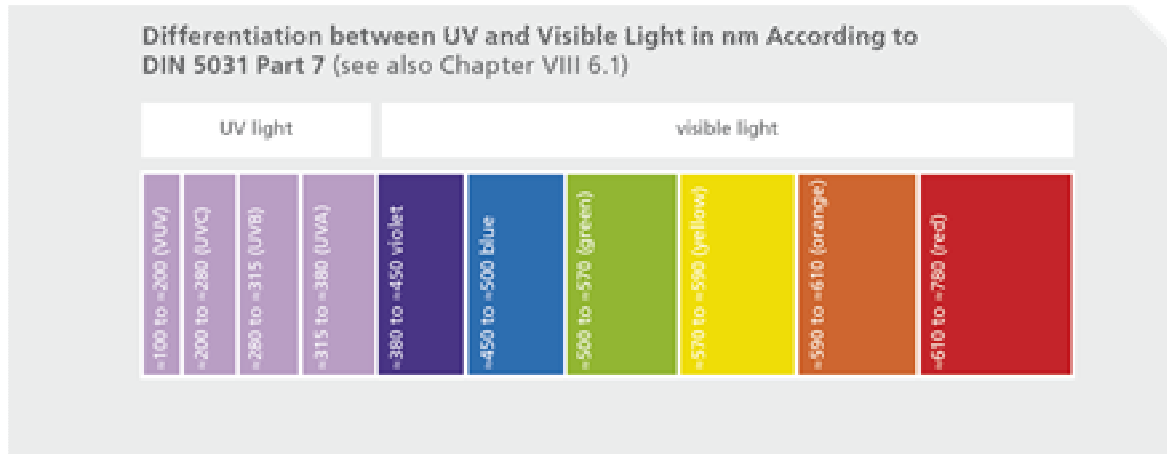
- The product is applied to one of the mating parts. The two parts are assembled and then illuminated by UV light. Advantages of this radical system are as follows: Self determined open time for fixing parts, a very fast setting time after illumination and a high final shear strength. A limitation of this system is that at least one mating part has to be transparent and not block UV rays.
- The second system is called cationic bonding. Firstly, the adhesive is applied and activated sufficiently by UV light. Then the parts are positioned and left to cure. Final strength is achieved without the need for further use of UV light and at room temperature. An advantage of this system is that the parts do not have to be transparent, nor do they have to allow UV rays to pass through them. A disadvantage is that the open time after illumination becomes short and total polymerization time is longer than previously described.
- Thirdly and also popular are UV adhesives that are combined with secondary adhesion systems. From the Cyberbond range there are two different combinations available; firstly there is an UV/anaerobic system where visible parts are polymerized by UV light, and the parts not exposed to UV light cure due to the absence of air and metal contact. Secondly, there is an option to cure the adhesive at a later stage by applying heat. This variation is very time and energy consuming and only applicable to certain substrates.

UV curing systems cover a very special field within the adhesive world. For example, glass bonding is impossible to achieve with Cyanoacrylates due to ageing problems and epoxies are just too slow. For these reasons UV products are absolutely pre-destined for glass to glass or glass to metal applications and can be found in industries such as furniture manufacturing.

When using anaerobic adhesives to fix threads any surplus adhesive outside of the joint always remains liquid. By using an UV/Anaerobic product the fixing process can be achieved in the same way, but any surplus anaerobic product, which for example may be used to cover or mark the head of a thread can now be cured with UV light. Other typical applications for UV adhesives are the sealing of switches and relays that are used in the electronics industry and in single-use medical products. (e.g. bonding needles into syringes).

## 2. UV Light and Light Spectrum (DIN 5031 part 7)

UV light distances itself from visible light as follows:



Type of radiation

harmless range of wavelength

*X-Rays, Gamma-rays*

$< 100 \text{ nm}$

UVC	$\left\{ \begin{array}{l} \text{V(acuum)UV} \\ \text{F(ar) UV} \end{array} \right.$	100 – 200 nm
		200 – 280 nm
UVB		280 – 315 nm
UVA		315 – 380 nm

Visible light

380 – 780 nm

*Infrared, Microwave, Radiowaves*

$> 780 \text{ nm}$

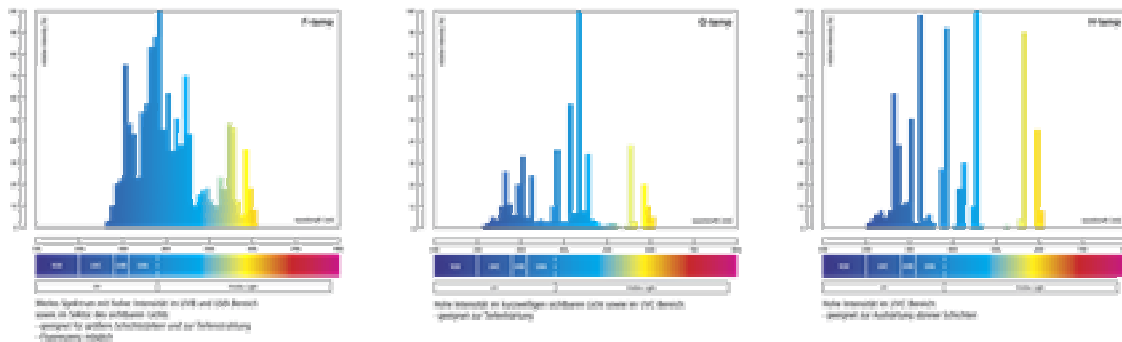
The wavelength decreases from VUV to visible light constantly. From an environmental and health point of view UVA is preferred to UVB. Most UV adhesives contain photo initiators that perform best in the wavelength between 200 to 500 nm. Filters can be used to absorb the wavelengths that are not needed or wanted. For this reason it is very important to work with the most suitable and correctly adjusted machines. Also, good hygiene of the working environment is of the utmost importance.

## 3. Lamps in Use

### 3.1. Traditional Lamps

As for UV lamps, they differentiate as follows

- Iron doped lamp (F-lamp)  
This lamp represents the largest spectrum of the three versions in industrial use. It achieves a high intensity in UVA, UVB and also in the visible light area. The F-lamp is ideal for surface and depth curing purposes.
- Gallium doped lamp (G-lamp)  
This lamp reaches its highest intensity in the visible light and UVC area. It is very suitable for deep curing processes.
- Mercury doped lamp (H-lamp)  
Recommended lamp for use in the UVC area to dry surfaces or to cure thin layers.



The three charts show the optimal characteristics of the various lights. With the aid of the adhesive table above the correct choice of lamp can be made for each product. But that said, it should be remembered that the right choice of the adhesive / lamp combination is also very much dependent on the material of the parts to be bonded. Due to the fact that even transparent parts (plastics or glass) can absorb either more or less UV light, photo-initiators are designed which perform particularly well with visible light. In this instance a visible light-curing adhesive (380 – 500 nm) in combination with a G-lamp would be the best choice. The adhesive layer itself can also absorb UV light; thus a visible light curing system would be required, especially when the adhesive layers are thick.

### 3.2. LED Technology (also see chapter LINOP)

In terms of curing adhesives with UV light, within LED technology the wavelength range is much more focussed than the more common lamps. There are 365, 395 and 420 nm LEDs available; Cyberbond has made a decision to work with the 395 wave length due to various reasons (see chapter 6). The advantages of LED technology are as follows:

- extraordinary long service life of the lamp
- switching the lamp on and off does not negatively influence it's long life expectancy
- instant UV light emission at the rated value when switched on
- light does not generate heat or ozone / air ionization
- minimal power consumption
- very small in dimension, but extremely powerful in performance

LED lights emit cold light only and they do not generate heat. Therefore, they are predestined for use on thermo sensitive parts.

## 4. Equipment

### 4.1. Traditional Devices: Flood Light and Spot Light

Generally speaking there are two different types of traditional light devices. Firstly, there is the option of applying light in the form of a spot or secondly, by means of a floodlight. The spot format is used when the application area is less than 1 cm<sup>2</sup>. The advantage of this device is that a very high intensity can be reached without generating too much heat at the lamp!

A floodlight is normally used when larger areas are to be illuminated. Equipment is available which is suitable for parts up to 100 cm<sup>2</sup> and even higher.

These systems, the spot and the floodlight work with one of the aforementioned lamps. In every application, one factor that has to be considered carefully is, that UV lamps create a lot of heat. Approximately 30 % is real UV light and 50 % is heat, mainly infrared. Therefore, consideration should be made when trying to bond heat sensitive parts to using special reflectors, in order to filter IR and to reduce the temperature by approximately 30-50%.

Another drawback is their ageing. After 1,500 hours most of these lamps have to be replaced due to them lacking the necessary efficiency to cure a UV product reliably. Performance monitoring of these lamps should be carried out at regular intervals.

### 4.2. Cyberbond's LED Technology

Overall LED Technology is superior. There is no doubt that this technique will at least replace the traditional spotlights completely.

Cyberbond offers the **LINOP U 400** system, which runs the **Cyberlite4** LED lamp. Four of these Cyberlites can be controlled in parallel but if required each with different intensity. This can be important if for instance, there is a need to cure different sized glue spots at the same time. The **LINOP U 400** can connect up to 4 lamps in parallel. With the aid of a **LINOP Splitter**, one could even control up to 12 LED lights. Used this way it is possible to not only illuminate areas of approx 30 x 30 mm but also multiples of this format, depending on the arrangement of the lamps.

The LINOP U 400 has another big advantage over traditional lamps. The control unit does not contain an LED lamp. The LED lamp and some electronic controls are assembled within the Cyberlite4 unit. Therefore, there is no requirement for cooling the control unit itself. Should there be a requirement for such an array of LED lamps in a housing, due to the electronics involved great consideration would have to be given to cooling as such an arrangement creates enormous heat.

Another advantage of the Cyberbond design is that fibreglass light guides are not needed. These light guides are expensive, sensitive to damage and relatively stiff. In contrast, the Cyberlite is assembled exactly where you need it and a fine cable connects it to the housing.

All this keeps costs down and makes the handling very easy.

The whole LINOP U 400 system is PLC compatible.

## 5. Adhesion Process

Besides the type of lamp, respectively light intensity, the following influences the polymerization process:

- Distance of the lamp from the adhesive,
- Thickness of adhesive layer,
- Illumination time,
- Transparency of the parts,
- UV light absorption of the mating parts,
- Age of the lamp.

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Various industrial applications are possible:

- Bonding,
- Retaining,
- Fixing,
- Sealing,
- Potting and encapsulating,
- Coating and marking.

## 6. Dispensing UV Products



Application of the products needs to be considered. These products can be easily dispensed manually from user-friendly bottles (20g, 100g, and 500g) or of course automatically.

With the LINOP Dispensing Equipment, Cyberbond offers a complete range of individual application systems that are easily integrated into semi or fully automatic production lines. It is very important that all tubing and adapters are such that they do not let UV light shine

through. Dispensing of the adhesive should not coincide exactly with exposure to the light.

## 7. Cyberbond UV Products

### 7.1 Wavelength

Cyberbond offers a range of UV- and light curing acrylates equipped with photo initiators that are within the wavelength range of 300 - 420 nm. At Cyberbond the **395 nm lamp** is preferred. Why this wavelength?

Seemingly the 395 nm wavelength offers the best compromise. On the one hand, it already works within the visible light area and with this it can penetrate transparent UV light blocking parts. On the other, in terms of pre-polymerization due to daylight it is not as sensitive as a 420 nm product, where the working environment has to be darkened. Also, one should consider the premature ageing of the bottle if used inappropriately.

Another criterion is that the wavelength of 395 nm when offering the Cyerblite4 LED light in combination with the LINOP U 400 curing unit is easily achieved and maintained.

### 7.2. The System of the Cyberbond Product Programme

Firstly, the selection of an adhesive is dependent on what has to be bonded. Usually there are combinations of plastic-to-plastic, plastic to metal, glass-to-glass or glass to metal. There are different formulated products for these different applications. The Cyberbond product line distinguishes between the following:

- Medicine,
- PETG,
- PC,
- PMMA and
- Adhesives for glass.

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This classification is to be used as a simple starting point as there are so many possible combinations of varied materials. That said, UV products do have general-purpose performances. Especially Cyberbond U 351, as this grade shows very good all round properties.

The choice of product naturally depends on the result we expect. Viscosity and the flowing behaviour of the adhesive become very important. For instance, should the adhesive penetrate or should it remain where it was applied? One needs to point out that at the moment, due to the physical properties of these products, viscosities of  $< 100 \text{ mPa}\cdot\text{s}$  are not currently achievable, which does limit penetration anyway.

Optical impression is an important factor also. Things to consider here include; is it necessary to realize a completely colourless and transparent product? Or is an adhesive coating or marking required? UV adhesives can be manufactured fluorescent. This can be particularly advantageous when used in a semi-automatic production process, as they offer optical identification. Other considerations for use could be; is the production process fast and therefore demands a quick system or will a slower one fit better? Is it necessary that the surface be tack free after cure? Should the adhesive layer be hard or flexible? Are medical approvals required? Etc.

## 7.3. Cyberbond in Single-use Medical Products

Cyanoacrylates are commonly used in the assembly of medical instruments. For instance, they are used for the bonding of needles into plastic syringes. These medical products are tested before use. Therefore, it is thoroughly favourable if one can be assured that the adhesive is not dangerous for human beings and animals before use on a medical product. There are a large number of approval norms such as: FDA (US Food and Drug Administration), USP (United States Pharmacopoeia) and the ISO 10993 standard.

The norm ISO 10993 however, consists of a large number (20) of different tests. The most important aspect is the biological compatibility, which is the compatibility of an article on or inside a body.

Cyberbond has developed U 303 and U 306, which are two UV products from the medical range. These are approved as follows:

### **ISO 10993-5: Test for in vitro cytotoxicity**

In an Agar diffusion test it is checked to see if the product destroys a cell culture.

## 8. Rationalization

Although UV- and light-curing adhesives initially seem relatively expensive compared to other bonding techniques, good rationalization can be achieved, as only a few drops are necessary to achieve a reliable bonding.

- UV adhesives are easily and economically applied with the aid of a LINOP dosing device
- The optional use of the LINOP dosing equipment is relatively in-expensive
- Energy consumption (when LED technique is used) is relatively low
- UV adhesives are one-component and therefore do not require elaborate mixing
- UV-adhesives react within seconds after initiating with light
- Bonded parts can be immediately used again in the production process, as the reaction of the adhesive is so fast; a buffer station can be used to aid process
- Different materials can be bonded in a fast, clean and safe manner
- Fluorescent systems can be used as a safety mechanism within the process
- The use of a thixotropic UV-adhesive makes the joining of vertical parts very easy, as the adhesive stays exactly where its applied and does not run
- UV-adhesives are easily stored and can be transported worldwide without restrictions  
They are classed as solvent-free and not regarded as hazardous goods

## 9. Potential Dangers of UV Adhesives

### 9.1 Composition of Adhesives

UV and Light Curing Adhesives are one component and solvent free adhesives. Relatively, these products consist of high amounts of differing raw materials. For this reason the individual products can provoke different dangers.

One aspect we would like to point out is that: Within Europe the classification of products with hazardous potential is graded in the Material Safety Data Sheet (MSDS). Please see chapter: “What to consider when bonding?” in this book. If you review sections 2 and 3 of a MSDS, you will find all the chemicals listed that are considered as hazardous within a product. Of relevance to the UV product is section 15. Here the classification of the whole formulated product can be found.

We would like to emphasise again, that the marking of the various precaution sentences will probably change from the year 2011 on. For a transition period both precaution systems are going to be kept valid.

### 9.2. Precautions

- Only use in well ventilated areas
- Install suitable exhaust systems within the work area
- Apply a small amount of material. Enough to achieve the desired result and where appropriate use a LINOP dosing system (see LINOP programme in this booklet or under [www.cyberbond.eu](http://www.cyberbond.eu))
- Wear suitable glasses and gloves that have UV protection

#### Liability limitation

Mentioned statements and information refer to the current state of technique, to laboratory results and personal experience. For these no claims nor guarantees can be enforced.