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LIGHT-ACTIVATED ADHESIVES

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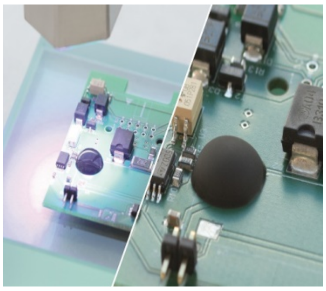
- SCOPE: An introduction to light-activated adhesives, and how to process them

First there was light-cured adhesives (commonly referred to as “UV adhesives”), then there was light-activated adhesives, and now we have dual-cured adhesives. Of these, light-activated adhesives are the least known and probably the most demanding to work with, in terms of how they are processed, but they offer one significant benefit that the others do not: they can be used to bond non-transparent parts together without using heat as part of the curing mechanism.

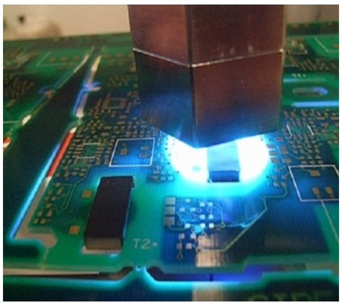


“UV adhesives” is the generic term used when referring to an adhesive that requires high-intensity light for curing. A significant proportion of these adhesives actually use light in the visible spectrum (VIS) for curing. A very relevant example is Polycarbonate – most grades of Polycarbonate block UV light (i.e. light that is below 400nm in the electromagnetic spectrum), so a true UV adhesive cannot be used to bond Polycarbonate parts together. Yet there are many instances where “UV adhesives” do work - it is actually the VIS component of the Photoinitiator that is used to achieve the cure!

Regardless of where on the spectrum the Photoinitiator lies, the simple fact is that one of the parts being bonded must be transparent, to allow for 100% cure of the adhesive. No one likes having uncured adhesive in their products on a long-term basis, especially as a number of these adhesives are based on acrylic acid (rendered harmless by curing).

Recent developments in the last 3 - 5 years have resulted in a wide range of dual-curing adhesives that get around this problem. These adhesives, as indicated by the name, contain two curing mechanisms – light (whether UV or VIS), and either humidity or heat. Light and humidity cured adhesives are limited by the fact that the majority of the adhesive in the bond area must be cured by light, and also by the fact that the humidity portion of the adhesive cures at a (slow) rate of 2mm / 24hrs (similar to silicone adhesives), which can be time-consuming.

Light and heat cured adhesives do not suffer from these limitations, however the minimum cure temperature for these adhesives is 80°C, which in effect means setting the oven to ~ 83 - 85°C to avoid any potential cold spots in the oven. This is strongly recommended for this type of adhesive, because if the adhesive does not see 80°C, the heat-cured portion of it will never cure, regardless of how long the bonded parts are in the oven. The time to cure at elevated temperatures can also be a factor, as it can take up to one hour at 80°C. This can be reduced by curing at 150°C for 10 minutes, for example.



For applications where cycle time does not allow for lengthy heat cure stages (even when carried out off-line), or where one of the materials being bonded is sensitive to temperatures even as low as 80°C (as a lot of new, low-cost plastics tend to be), then serious consideration needs to be given to light-activated adhesives.

The theory is simple: dispense the adhesive onto substrate A, illuminate it with high intensity light for a short period of time, place substrate B onto the adhesive, and voila!, the adhesive will eventually be fully cured and the non-transparent substrates will be bonded together with no uncured adhesive in the joint

In practise, it’s a bit more complicated. The act of illuminating the adhesive with light, called activation, provides enough energy to the adhesive to commence the curing process. If too much energy is provided, there will not be enough time to place the second substrate before a skin forms on the surface of the adhesive. Once this happens, it is then impossible to bond the substrates.

The time it takes for the skin to form on the adhesive is called the open time, and is measured from when the illumination ceases to when the skin forms. Increasing the energy provided to the adhesive, whether by increasing the intensity of the light or by illuminating for longer, reduces the open time.

Unfortunately, this is not a linear relationship as other factors such as substrate material, colour, smoothness and reflectivity, all have an impact on the open time. It must be measured for each application, and cannot be transferred across applications. But a very good starting point will be provided in the technical data sheet from the adhesive manufacturer.

For example, the technical data sheet for DELO KATIOBOND 4594 states that an open time of 13 seconds results from an illumination time of 4 seconds when using a DELOLUX 03 lamp with a light intensity of 55 - 60 mW/cm^2, measured at the adhesive. Reducing the activation time will increase the open time, and vice versa. But the extent to which the open time changes will have to be measured! Also, the substrate used was, for standardisation purposes, a piece of waxed cardboard. Changing any of these factors, such as the lamp or the substrate material, affects the open time, which must then be re-measured.

Once the substrates have been joined, full cure will take place over time because 100% of the adhesive has been illuminated prior to joining. If left sitting on a bench, for example, the adhesive will be fully cured 24 hours later, with maximum bond strength. However, this is usually not practical for manufacturing purposes, so accelerating the cure is very often desirable.

There are a couple of ways to do this: first, by adding heat to the assembled parts. This can seem contradictory as light-activated adhesives are used for the very purpose of eliminating heat from the process! But even the addition of low levels of heat can have a significant effect on the cure speed. As a general rule of thumb, for every 10° increase in cure temperature, the cure time is halved (the converse is also true!). So increasing the temperature of the bonded parts to even 45°C can reduce the final cure time to 6 hours, while also ensuring that there is sufficient handling strength in the adhesive to safely carry out the next process on the assembly.

An alternative way to accelerate the cure depends on the geometry of the parts being bonded. If the two parts are identical in X & Y, then this is very difficult to achieve. However, if there is even a slight difference between the parts, for example 0.5mm, then ensuring that a fillet of adhesive is visible around the joint means that a second light cure process can be carried out immediately, significantly increasing the bond strength and allowing the assembly to be moved on to the next process.

So in summary, apply, illuminate, cure - what could be simpler???

Other advantages / tips:

Light-activated adhesives are not as reactive as dual-cured adhesives, so frozen storage is not needed. Also, because of this, they can be supplied in larger containers, thereby reducing the cost / gram.

If the substrate on which the adhesive is dispensed is metal, then it will be necessary to heat it up slightly, to say 35°C. This is because the heat that is generated within the adhesive during the activation process will be conducted away from the adhesive by the metal, and so will slow down the reaction significantly, or may even prevent it completely.