

UV CURE: THE MICROWAVE POPCORN OF THE COMPOSITES INDUSTRY

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Abstract

Recent developments in the area of UV cured fiberglass resins and gel coats may provide significant advantages to composite parts manufacturers. These advantages lie in the area of greater speed, better efficiency and the significant reduction in styrene. Interest in this later advantage has spurred commercialization of UV cured composites where regulatory pressure has required a different approach than traditional peroxide cure mechanisms.

Change

What is more timeless than popcorn? I love popcorn and my kids love popcorn – and probably most people you know love popcorn.

When I was a kid we made Jiffy Pop popcorn. Jiffy Pop (“as much fun to make as it is to eat”) came packaged in a foil pan with a foil top that expanded like a giant balloon as the popcorn was cooked over the stove. You had to be very careful not to overcook Jiffy Pop – a process that took about 10 minutes. Today, my kids eat microwave popcorn that takes about 3 minutes to make.

The popcorn tastes the same. Just the method of making it has changed. It’s faster to make popcorn today, safer too. There’s also less chance to really burn the popcorn (or burn down the house).

Microwaves have replaced the flame.

Similarly, UV light combined with photosensitive chemicals are replacing peroxides in composites. The final product “tastes the same” – the same fiberglass properties can be achieved faster and safer with UV than thermally cured composites.



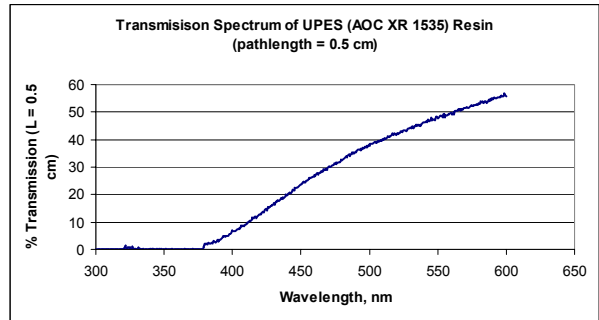
UV has replaced peroxides.

The change has been met with some of the same objections that I suppose microwave popcorn advocates faced – there’s new equipment to be purchased, new processes to learn – change is sometimes not embraced by all.

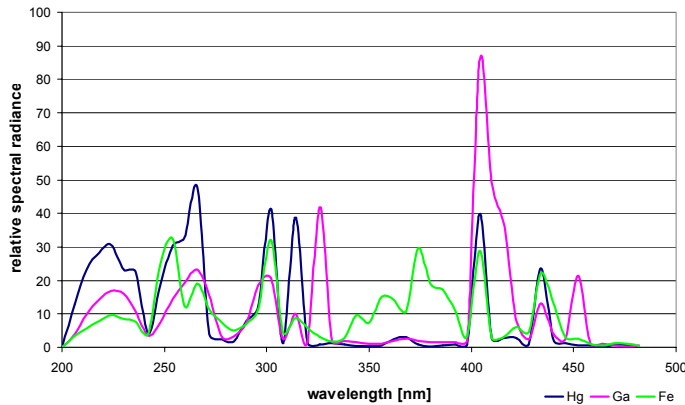
But clearly UV composites have already begun to prove their commercial potential, as the first installations have been successfully launched.

I. Suitability of Composite Resins for UV

The transmission spectrum of existing resins is an ideal match for the transmission spectra of commercially available UV sources and photoinitiators required to drive the UV process. All of the widely used commercial resins have similar properties, namely that they do not absorb light in the UV spectral region (below 400nm) making them an ideal substrate to work with. As can be seen, most UV lamp sources including mercury and mercury doped medium pressure lamps have output in the 200-400nm band. In fact most investigations show that longer wavelength lamps are particularly well suited for composites since the depth of penetration of the longer wavelength (gallium and iron doped lamps) work particularly well.



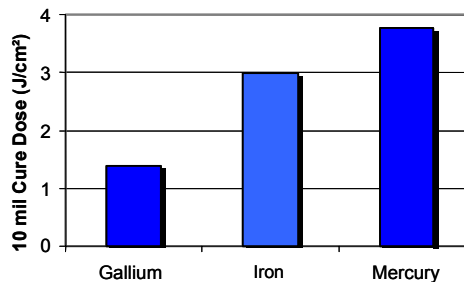
Various suppliers of photoinitiators are currently developing longer wavelength products since there are industrial hygiene benefits associated from moving away from the shortest wavelength UV sources if practicable. The figure below indicates the effect of wavelength on the curing of a white gel coat that is 10 mils thick (.010"). It is clear from the data that there are advantages to longer wavelength in gel coats as well as resin curing.



Of course the use of fillers or extenders as well as a variety of pigments could degrade the performance of the curing system if the additives have significant absorption in the 200nm – 400nm UV range. Normally if such a formulation is anticipated it is recommended to undertake laboratory trials to ensure the desired cure profile can be obtained and document the expected cure system parameters (peak irradiance, wavelength, and dose).

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Effect of Lamp Type on Curing of a White Gel Coat

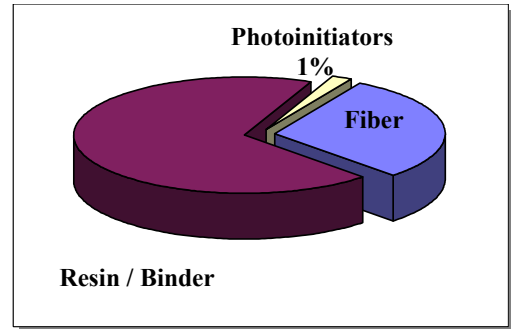


II. Advantages of UV Curing Systems for Composites.

There are several advantages to UV curing compared to traditional peroxide cure mechanisms. Some of these advantages are production related benefits and some are health and safety benefits.

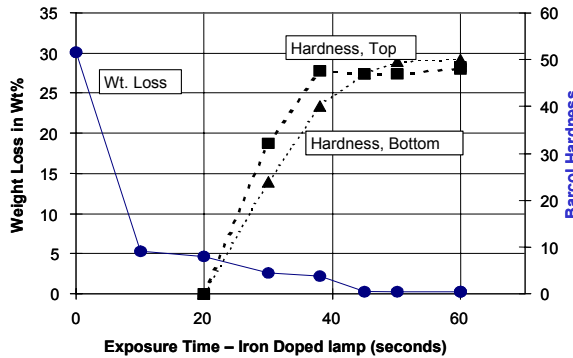
1. Unlimited Resin Pot Life.

Unless the UV cure resin is exposed to a high intensity UV light source, the resin will not cure. This means the resin can be kept stable indefinitely in manufacturing. It allows unused resin to be stored, and applied resin to be finessed without concern over cure. The cure process is also unrelated to temperature so that the resin may be used in a wide range of conditions including cold temperatures that might normally hinder traditional manufacturing.



2. Speed of Cure.

The curing of photo-cured UV resins are rapid processes, especially when compared to traditional thermal cure processes. Days of curing time are reduced literally to minutes, the limitation being that of being able to expose the entire substrate to the UV lamps source. Investigations show that upon exposure to high intensity UV, the resin reaches nearly full cure in approximately 40



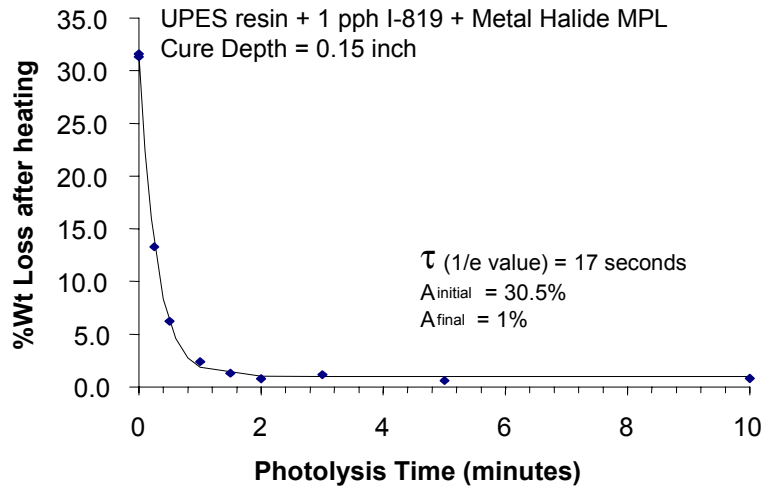
seconds. Further exposure to UV appears to have no deleterious effect on the substrate so that there is reasonable process latitude. Even relatively low level UV power sources such as UV LED arrays exhibit full cure in a matter of minutes after exposure making them attractive for applications where a few minutes of cure time is acceptable. In any case the speed of photo-cured reactions is significantly faster than by traditional curing and is likely to find acceptance where

reduction in work in process, it's exposure to contamination and production throughput is of interest.

3. Reduction in Styrene Emissions

The rapid conversion of resin in the photo-cured process greatly reduces the evaporation of styrene, minimizing HAPS emissions. Pollution Prevention sources nationwide have now taken to recommending UV cure as a means to reduce styrene emissions for composite manufacturers.

As can be seen in the accompanying data nearly all volatile emissions cease after less than two minutes of exposure to high intensity UV light. Recent changes in the regulatory environment, particularly with the South Coast Air Quality Management District (SCAQMD) have accelerated development of UV curing systems to help meet increasingly more stringent rulemaking.

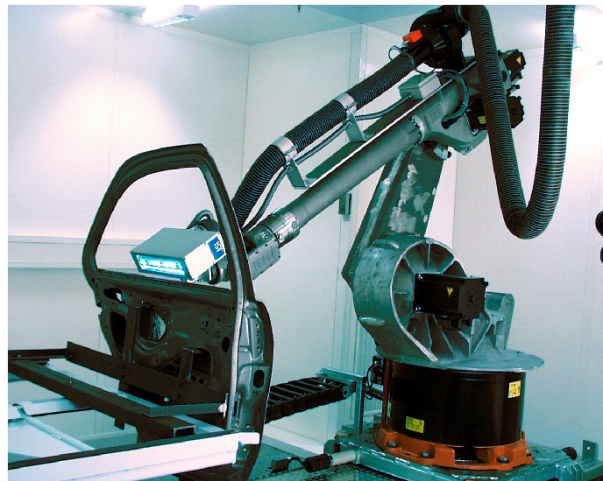


III. Next Steps – Where to go from here.

UV cured composite technology is now a commercially viable alternative to traditional cure systems. Composite parts are being made today using these techniques and are providing significant benefits to companies who have adopted the technology.

As with all new technology the early adoption curve is slow in the beginning, but the positive benefits already being realized promise to bring rapid acceptance, especially as manufacturers seek environmentally friendly alternatives to reduce styrene emissions

The UV industry has required some innovative thinking itself, since to make UV composites work the proper equipment is required. While the current lamps work in principle, UV has always been an industry that has targeted smaller, high production, high speed, line-of-sight (mostly flat) substrates. Most composite parts are 3-dimensional, larger components. The very high intensity lamp modules appropriate for curing DVDs or optical fibers may not be the most efficient choice for curing a trunk lid, or bumper fascia. Currently lamp suppliers are testing new configurations which may be suitable for composite applications. For complex geometries for example, robotically articulated lamps may be attractive. Lamp suppliers are also able to package lamps of lower power output for composites because even if cure times reach a few minutes it is still markedly quicker than current cure times.



The biggest obstacle remains those faced by the microwave popcorn industry – some new equipment, training and open-mindedness. But given the overwhelming benefits to reap in terms increased production, lower scrap, better resin utilization and the impact on worker health and environment there is little doubt that UV cure composites should be popping along well in the next few years.