JOULES
ANGSTROM
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THERE'S NO SUCH THING AS "OVERCURING"

First of all, the concept that one could cure an ink "too much" is alien. From a formulation and a chemical perspective, "too much" indicates you could go beyond 100%. That is impossible. There is nothing beyond 100% curing, and, as a matter of fact, there *isn't even 100% curing.*

The reason for this is simple: as the ink or coating is exposed to UV light, it begins to polymerize, rapidly. The UV light alone is not energetic enough – no matter how high you turn it up - to cure the main components of the ink, i.e. the monomers and oligomers. However, the UV energy is strong enough to react with the photoinitiator molecules that are present. This causes them to fragment (cleave) and become very energetic themselves. These high energy fragments then interact with the oligomer molecules, causing their reactive sites to become energized as well. These energized sites on the molecular chains then crosslink with one another, and the result of this is that the motion of the chains is hindered very rapidly.

Since motion is important in getting these sites close enough to one another to react, you can see how it is quite likely that the ink will be almost solidified prior to every last one of the reactive sites being able to crosslink.

"100% cured" implies that all the possible reactive sites and molecules in the formula indeed *react.* Since the restricted motion that results as curing progresses is likely to prevent this from occurring, nothing is ever "100% cured". The goal, therefore, is to get the ink or coating cured *enough* so that it demonstrates the proper performance characteristics.

So, everyone talks about ink being "fully cured", but in the real world, this means that the ink is cured ENOUGH. Since 100% curing is physically impossible, the words "fully cured" cannot be construed to equal "100%".

An important reason that adequate curing is necessary is because of migration concerns. Even an ink made with low (order of) migration components, such as those specified by Nestle, will present migration concerns if the ink is not cured *enough*. Enough, of course, is the degree of curing at which, in the normal mode of use of the printed item, less than 10 ppb (parts per billion) of any component of the ink can maneuver its way out of the ink and into a food item. The higher the degree of curing, the more that everything is "locked up" in the cured matrix – and the less likely it is to exhibit migration.

Printers talk about turning lamp intensities down so as not to "overcure" the inks, but what are they really talking about here? I see it as one of two possibilities:

1. High lamp intensities are more likely to rapidly cure the ink surface. When this happens, the crosslinked surface of the printed material acts as a filter to additional incoming light – which can screen out the wavelengths needed to effect through-cure. The surface will lose gloss due to shrinking and then subsequently being pulled and deformed by the deeper layers of partially-cured ink. In the limit, the ink will appear to exhibit poor adhesion to nonporous substrates – when in reality, the true problem is poor through-cure. In this case, you have not "overcured" the ink, but rather preferentially cured the ink surface and undercured everything below.

2. Ink formulations do not "overcure", but rather, cure to the degree to which they can, given the functionality and reactivity of the components in the ink, and the intensity and wavelength of the light source used to cure the ink. Let's give an example to demonstrate this: In printing on an OPP film, let's say you usually run your 600 W lamps at 75% power and the press at 700 fpm. But the ink has poor MEK resistance afterwards. Clearly, it is not cured enough. To increase the UV dosage the ink experiences, you turn the lamps up to 85% and the press speed down to 500 fpm. And now, though the MEK resistance has improved, the ink appears to be brittle compared to the prior condition. Bending the substrate causes the ink to crack, whereas in the prior scenario, it does not. Is the ink overcured? In a word – no. The initial scenario clearly is undercured – however, the latter scenario is optimal curing *for that ink formulation.* The fact that the ink ended up being brittle merely indicates that the composition of the ink – the monomers and oligomers which comprise that ink – form a very rigid matrix. To get a more flexible matrix suitable for printing on plastic substrates, different components would have to be used. "More flexible" does not automatically mean "less cured" – it relates, rather, to the actual structure of the oligomer molecules and whether they have the freedom to bend when they are reacted as fully as possible in the process.

Let's address another problem that is sometimes called "overcuring", but isn't: color burnout. This can sometimes happen with a class of pigments called "basic dye complexes" (alkali blue-containing, true rhodamine-containing, for example) or with fluorescent pigments. What happens is this: during curing, the color of the print experiences a shade shift. This can be a lightening or possibly a darkening (depending on the pigment chemistry). The reason this happens is that dye-based pigments are more susceptible to reaction with UV light (vs non-dye-based pigments). The UV light energy causes the dye portion of the pigment molecule to fall apart; when this happens, the color of the pigment is altered or lost. Since the most important variable in the color of a pigment is the pigment's structure – any changes in this will affect the shade and intensity of color that is reflected to the observer.

Of course, non-dye-based pigments are also sensitive to UV light, too – but over a much longer time horizon – so they can pass through the brief exposure during curing and not experience a detriment in their color.

And what about undercuring, while we are on the subject of curing in general? Of course, unlike "overcuring", undercuring is a *bona fide* issue. A point I wanted to make here is that adding more photoinitiator to the ink will improve curing only to a point: adding photoinitiator beyond this point will actually compromise the integrity of the ink film. The reason for this is that if you have an excess of energized photoinitiator molecules in the ink, the likelihood of them reacting with one another rather than with the monomers and oligomers is higher. As is the likelihood of a multitude of them reacting with just a few monomer or oligomer chains, and creating much-shorter chain networks. Either of these outcomes do not make strong, flexible, well-crosslinked ink films. So – more photoinitiator may not always be the right answer.

Remember that *preferential surface curing* masquerades as poor adhesion, and can be addressed by either turning lamp intensities down, or press speeds up – however, if either of these avenues is not giving you adequate curing – use an ink which has a better balance of surface and through-cure photoinitiators for the amount of laydown involved in the job.

Talk to us about your curing requirements and issues, and we will get you on the path to success!