

INERTED UV CURING MAKING NOISE

It's been long known that the UV curing of formulated resins, liquids and solids is inhibited by the presence of oxygen, and, of course, this is the same oxygen (21%) that sustains life on our planet.



The marketplace and the concerns for more demanding product performance are forever requiring more of the UV curable providing supplier. As such, better performing UV



adhesives, coatings, and inks are constantly being sought. Because of this, some are looking to the UV curing of products in an inert environment in order to improve on today's product property limitations and reach for tomorrow.

Photo courtesy Gidue

UV curing, as we know it, has been successfully commercialized producing a relatively large, growing annual volume of UV curable products, (based mainly on acrylic ester resin chemistry) curable by free radicals, that start a cross-linking process, resulting in virtually instant (cure) polymerization.

There is also cationic chemistry, wherein a different set of monomers and oligomers are required along with a different photo-initiator, which forms an acid catalyst when impacted by UV light to start a cationic chemical reaction. Cationic UV chemistry is not affected by curing in air (oxygen) and unlike free radical chemistry, the cationic curing mechanism continues after UV light exposure ends. Cationic use however, remains limited.

In free radical UV curing, oxygen inhibition presents a basic problem. The effective UV

curing of free-radical chemistry systems is compromised by oxygen functioning as a free radical, eliminating the excited states of photo-initiators. This occurs as oxygen reacts with the reactive free radicals from a curable product's photo-initiator package and the resins to be polymerized. The action occurs at the interface of a UV curables surface and the oxygen laden air above it, where the curing/conversion of reactive groups is reduced; leaving the curable products surface uncured or poorly cured.

This UV curing issue in air has been overcome by using powerful UV light sources, generally, closely focused medium pressure mercury lamps, and reactive photo-initiator additions. The result is that free radicals are formed faster, and the polymerization reaction is faster than the cure slowing inhibition due to oxygen's presence, thereby producing acceptable cure levels. (It's known that there is a limit to the effective % amount of photo-initiator that can be used above which UV curing does not continue efficiently even under increases in applied UV energy.)

Successful UV product curing in air comes at a cost. First of all, curable formulations require excessive and expensive, free radical generating photo-initiator additions, and reaction resin components. Additionally, more powerful lamps are necessary to overcome the effects of oxygen inhibition of the UV cure, and the process typically generates undesirable odors.

In terms of photo-initiator savings, it is being speculated that there could be a reduction from the now used 8-15% to less than 2% in UV inks for curing in oxygen-free conditions. Further, it is thought that the accuracy of the curing process will be improved as will the cure speed.

Advantages of UV cure inerting

- Food Industry compatibility
- Minimized odor
- Lower photo-initiator levels
- Faster cure speeds
- Thinner coat weights
- Improved adhesion
- New substrates
- Better optical clarity
- Improved chemical resistance
- New finishes and surface effects
- Lower UV energy requirements
- Less powerful UV lamps
- Possible easier de-inking & recycling
- Deeper cure of coatings & pigmented inks & coatings

Inerting Processes

The concepts being explored simply involve the minimization of oxygen in the UV curing zone. Depending upon the sophistication of the UV curable chemistry employed and specific product application requirements, the need for a curing environment range of from <50ppm of oxygen to 2-5% oxygen is being considered

There is also the inerting gas to consider. Some are looking at inerting with nitrogen, while others are looking to carbon dioxide.

There are a number of ideas that abound as to how to accomplish the relatively oxygen free curing chamber environment.

One such design looks to using a nitrogen knife angled toward the substrate entrance into the cure chamber in-order to scrub oxygen from the substrate surface. Further flooding of the substrate in the cure zone assures that the required ppm rate is sustained with the minimum of nitrogen used.



Photo courtesy of Eltex Innocure
Expectations are that the volume required will be far less than that

Another innovative process looks to using electron and ion current to remove the air boundary layer on a substrate, replacing it with a low volume layer of nitrogen.

required of a more or less conventional nitrogen flooding chamber design.

Yet another developed process is using an atmosphere of carbon dioxide (CO₂) to provide a means of inerting for the curing of UV coatings on wood flooring and three dimensional objects, such as furniture.

Carbon dioxide is interesting as an inerting gas because it is heavier than air (1.5 times heavier), which makes it possible to form heavy gas lakes in a vessel or container, with O₂ levels of less than 1% achieved. CO₂ is a non-polluting, non-toxic gas that is readily available. Using its heavier than air property means that potentially less gas will be lost than in inerting chamber processes with substrate transport systems.

As indicated earlier, lower UV energy intensity requirements exist for inert environment curing. Potentially curing times and the number of lamps required can be reduced as well. Alternately, the lamp to substrate distance could be increased, if desirable.

Lower lamp power requirement leads to the potential use of other types of lower energy UV lamps, including long life, low energy consuming UV LED's.

In conclusion, a number of different entities are looking at UV curing in inert environments to take advantage of a seemingly attractive number of potential benefits. Some are already demonstrating their advanced, process accomplishments in commercially adaptable schemes. The bottom line is the expectation that lower UV curable & energy costs will offset the costs of inerting, while providing attractive improved products.

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