μ MicroCoat Technologies, LLC
1316 Somerset Drive McKinney, TX 75070
+1-972-678-4950 Fax +1-214-257-8890

The UV Curing Process

UV curing describes the use of ultraviolet (UV) or visible light to polymerize a combination of monomers and oligomers onto a substrate. The UV material may be formulated into an ink, coating, adhesive or other product. The process is also known as radiation curing or radcure because UV is a radiant energy source. The energy sources for UV or visible light cure are typically medium pressure mercury lamps, pulsed xenon lamps, or, halogen lamps. The coatings cured with these light sources are usually clear or translucent, though thin opaque coatings are also possible.

Three Compelling Reasons to Convert to UV Technology

- Improved Productivity: Since most systems are solvent-free and require less than 30 seconds of exposure, the productivity gains can be tremendous compared to conventional coating techniques. UV conveyor speeds of 1,000 ft/min. are common and the product is immediately ready for testing and shipment.
- Suited for Sensitive Substrates: Most systems do not contain any water or solvent. In addition, the process provides total control of the cure temperature making it ideal for application on heat sensitive substrates.
- Environmentally and User Friendly: Compositions are typically solvent-free so emissions and flammability are not a concern. Light cure systems are compatible with almost all application techniques and require a minimum of space. UV lamps can usually be installed on existing production lines.

UV Curable Compositions

- Monomers are the simplest building blocks from which synthetic organic materials are made. A simple monomer derived from petroleum feed is ethylene. It is represented by: H2C=CH2. The symbol "=" between the two units or atoms of carbon represent a reactive site or, as chemists refer to it, a "double bond" or unsaturation. It's sites like these which are capable of reacting to form bigger or larger chemical materials called oligomers and polymers.

- A polymer is a grouping of many (i.e. poly-) repeat units of the same monomer. The term oligomer is a special term used to designate those polymers which often can be further reacted to form a large combination of polymers. The unsaturation sites on oligomers and monomers alone will not undergo a reaction or crosslinking.
- In the case of electron beam cure, the high energy electrons interact directly with the atoms of the unsaturated site to generate a highly reactive molecule. If UV or visible light is utilized as the energy source, a photoinitiator is added to the mixture. The photoinitiator, when exposed to light, generates free radical or actions which initiate crosslinking between the unsaturation sites.

Components of UV formulations may include the following:

- **Oligomers**: The overall properties of any coating, ink, adhesive or binder crosslinked by radiant energy are determined primarily by the oligomers used in the formulation. Oligomers are moderately low molecular weight polymers, most of which are based on the acrylation of different structures. The acrylation imparts the unsaturation or the "C=C" group to the ends of the oligomer.

- **Monomers**: Monomers are primarily used as diluents to lower the viscosity of the uncured material to facilitate application. They can be monofunctional, containing only one reactive group or unsaturation site, or multifunctional. This unsaturation allows them to react and become incorporated into the cured or finished material, rather than volatilizing into the atmosphere as is common with conventional coatings. Multifunctional monomers, because they contain two or more reactive sites, form links between oligomer molecules and other monomers in the formulation.
- **Photoinitiators**: This ingredient absorbs light and is responsible for the production of free radicals or actions. Free radicals or actions are high energy species that induce crosslinking between the unsaturation sites of monomers, oligomers and polymers. Photoinitiators are not needed for electron beam cured systems because the electrons are able to initiate crosslinking.
- **Additives**: The most common are stabilizers, which prevent gelation in storage and premature curing due to low levels of light exposure. Color pigments, dyes, defoamers, adhesion promoters, flatting agents, wetting agents and slip aids are examples of other additives.

Technology Myths

- While well established in many industries, some are still unfamiliar with UV processing, which may represent a different way of thinking about curing inks, coatings and adhesives-- and may also cause myths and misconceptions about the technology. Addressed below are common misunderstandings about UV.

Misconception 1: UV materials are dangerous

- Overall, UV materials are much less toxic than solvent based and some of the ingredients in water-based systems they replace.

UV ………….

- has a very high or almost no flash point
- emit little to no volatile organic compounds or Hazardous Air Pollutants
- has very low systemic toxicity
- as a class are not carcinogens (recent long-term skin painting tests showed no carcinogenic effect, and the test materials showed no systemic toxicity)
- are not fetal or reproductive toxins
- are not regulated as RCRA hazardous waste
- do not appear on any Community Right To Know list
- Moreover, UV curing materials are not absorbed through the skin like solvents, and they have very low vapor pressures, making inhalation less likely. Good industrial hygiene practices, knowledge of safe handling procedures and worker training are essential for safe handling of any chemical. When these principles are followed, experience has shown that UV curing technology is safe.

Misconception 2: The UV light used in UV curing is a significant hazard

- The biological effects of exposure to ultraviolet light resemble the typical symptoms of sunburn. We are all familiar with sunburn, so anyone who might be inadvertently exposed to excessive ultraviolet light would be quickly aware of it. The American Council of Government and Industrial Hygienists (ACGIH) and National Institute for Occupational Safety and Health (NIOSH) have established exposure limits for UV light, that are easily met with shielding to minimize escape of ultraviolet light into the workplace.

Misconception 3: Energy cure preparations are more expensive then conventional coatings

A quick comparison of the cost per gallon is usually the misleading reason that energy cured 100% solids materials are considered higher cost. A more realistic approach is to look at actual applied cost per dry mil (or per item coated or adhered). The following is an actual example:

Assumption 1: Transfer efficiency is the same for both coatings (rollcoat application).

Assumption 2: The same coating thickness will be applied.
Constants used: Application of 1604 square feet per gallon per mil.
Coating A (thermoplastic conformal coating): Total solids by volume 32.62 % with a cost per gallon of material of $13.67.
Coating B (energy cured conformal coating): Total solids by volume of 99.69 % with a cost per gallon of material $35.00
Cost of Coating A in $/SQ. FT/Dry mil 0.0262.
Cost of Coating B in $/SQ. FT/Dry mil 0.0219 or a **savings of approximately 17%.**

Misconception 4: UV finishes are prone to cracking and yellowing

- While this may have been true several years ago, the rapid growth and advancement of the industry (with many chemical companies offering new raw material products) and resulting advances in UV chemistry give the formulator a number of chemical classes from which to choose.

- With this flexibility, the industry is now able to easily meet customer requirements and develop products that best fit customer applications--including requirements for non-yellowing and resistance to cracking. In fact, on certain poor weathering substrates like extruded vinyl, UV clear coats are used to prevent premature yellowing as well as improve stain and abrasion resistance. In another example, the headlights on your car have a UV coating to prevent scratches, cracks, and yellowing.

Misconception 5: UV equipment is too expensive

- Over the last few years, the prices of capital equipment have come down considerably. In addition, when considering capital equipment costs, one must also look at:
- **a) Space:** A drying oven for a conventional thermal cure may extend for 50 to 100 feet, a space consumption in the neighborhood of 500 to 1000 square feet. At a floor space cost of only $0.50/ft2/month, that costs $3000-6000 per year. The equivalent UV "dryer" would require 50 to 100 square feet.

  b) Energy Consumption: One of the most significant cost factors when comparing thermal cure to UV cure is the energy cost. A large gas dryer ("oven") consumes 1.10 MBTU/Hr (and requires large blowers) for the same production capacity achieved with a UV dryer requiring only 82 kW total:
  ENERGY CONSUMPTION
  THERMAL - GAS:
- 1.50 MBTU/hr x $3.60/MBTU = $ 5.40/hr
  Blowers:56 kW x $0.07/kW-hr = $ 3.92/hr
  300 days/yr x 16/day x $9.32 = **$44,736/yr**
  UV-ELECTRIC:
- 5.6kW/Lamp x 12 lamps
  x $0.07 kW-hr = $ 4.70/hr
  300 day/yr x 16 hr/day x $4.70 = **$22,560.00/yr**
- **c) Productivity:** UV users enjoy an increase in up-time and productivity due to the nature of the chemistry (doesn't skin over in applicator, no clean up between

shifts/weekends, faster start-ups). Increased productivity means more profit dollars which quickly pay for any initial capital equipment costs.

- Other areas of cost savings come from reduced parts in process and shorter processing time which directly relates to lower inventories. Quicker cure allows for fewer particles to contaminate the surface finish, which directly relates to rework and scrap costs.

- There are both tangible and intangible benefits to deciding to go to UV curing. When factoring these benefits into the selection criteria, UV typically becomes the most economical and environmentally safe solution!