SGIA

Screenprinting & Graphic Imaging Association International

Screen Printing Ultraviolet Inks

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I'm a totally dedicated proponent of screen printing; but if you take screen printing and relate it to lithography, letter press, gravure, and other media of printing, we're a small industry. We are probably growing on a percentage basis faster than the other media. We're becoming more sophisticated, more mechanized, more professional, more businesslike; but we are still a small industry. Obviously, I have a point to make here, and that point is that we as manufacturers, again, are a part of the total spectrum of the coating, paint, and varnish industry; we're small. If you compare us with Sherwin Williams (house paints) or IPI (offset ink), our volume is small. There have been many situations where we know that a given raw material manufactured under certain specifications could probably do wonders for us in screen printing, that would allow us the availability to design an ink that would be a super product. But when we go to someone like Rohm and Haas or duPont and say, "Hey, we want you to build this product for us," they say, "Fantastic! How many train car loads of raw materials do you need?" We're a small industry.

What I'm saying is basically that the raw materials we need in designing screen printing inks are those raw materials and resins and components that were basically designed for other uses—for other media of printing, for house paint, for offset printing. We have to take these raw materials, these basic ingredients, shuffle them around, and try to put together a package that will work in screen printing. This is hard to do sometimes.

One of the most distinct areas that we as screen printers are outstanding in, is our ability to print on anything that sits still long enough to pull a squeegee. When you look at all the combinations of substrates and the chemistry involved in all those substrates that you print on, it encompasses an unbelievable amount of chemistry involved in making an ink work. Take the raw materials problems we have as a manufacturer and the fact that we have to design an ink for you to print on all these unbelievably wide range of materials and the fact that we're not a $100 million-a-year company and our volume in making a particular line of ink is small, it becomes very difficult for us to have everything on the shelf that you want. Our sales growth is not large enough to put people in research and development. What I'm again saying is that we are a small industry.

UV coatings are not new; they've been around for awhile. Other media of printing have looked at them. Let's look at offset. Probably a lot of you are wondering if UV is such a hot item, if this is the way to go, why doesn't offset printing, why doesn't lithography use it across the board? Why aren't all offset printers using ultraviolet? Right now most offset printers are printing, drying, and stacking the material as fast as the equipment will handle the substrate. Just for speed in itself in the process of printing it, stacking it, and shipping it, UV is not that advantageous to them. Most of the big offset printers have multi-web printers, web and sheet four color presses, etc.; those machines were so designed that there's not enough room between stations to put UV reactors or UV lamps to cure the UV inks. They have a lot of money invested in printing presses that may have to be scrapped in order to print UV. UV inks are more expensive, and the offset printer does not appreciate an increase in ink cost.

Now there are certain applications in offset where UV is applicable. For example, in metal decorating where heretofore they've been running a thermosetting ink that requires long tunnels with a lot of heat. This is now being done UV, in cases such as the beer can. If we take screen printing and we look at the basic nature of our business and the state of the art and where it is, it is my opinion that ultraviolet curable inks are more adaptable to screen printers than any other media of printing. I will tell you why I feel this way.

But first, in order for us to basically understand the advantages of UV ink and the UV system, I think it is important that we realize what kind of a physical or chemical change takes place in an ink, when we go from a liquid state to a solid state. To do this, I'd like to give a short chemistry lesson to describe that. Conventional coatings, conventional screen inks, the ones which we are using now and that we know today, are broken down into two basic categories: They are either solvent evaporative or they are a chemical reactive.

Figure 1 is a breakdown of a solvent evaporative coating. This type of ink is one of the most familiar to you because this is probably the largest volume of screen ink in use. We have three basic components in this system: the resin, the solvent and the additive. The resins, the raw materials, in this particular coating would be vinyls, acrylics or lacquers. Anything that is solvent evaporative is really considered a lacquer-type coating. What we are doing here is taking a resin, which may be in a powder or granular (solid) state, and we solubilize this with solvent. We break it down and make a liquid out of it. Then we usually add more solvent, maybe two or three various combinations of solvents. Then we put in the additive, which can be pigment, plasticizer or what have you. But in this kind of ink system, it converts from a liquid to a solid only and solely by evaporation of a solvent. Once the solvent leaves the mass, it renders a dry film. The resin goes back to a solid state.

Figure 1

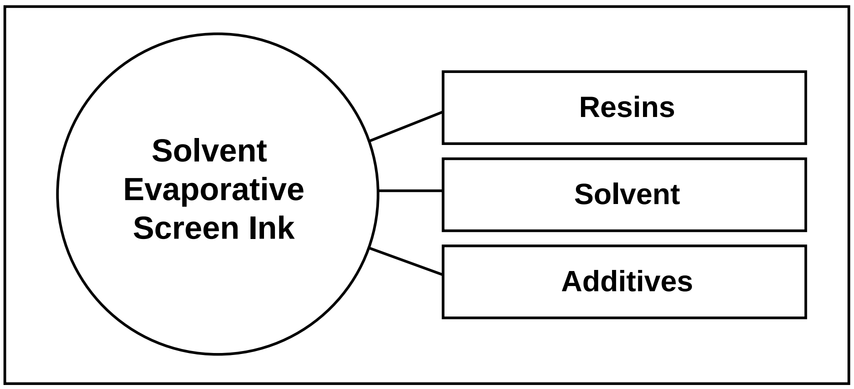


Figure 2

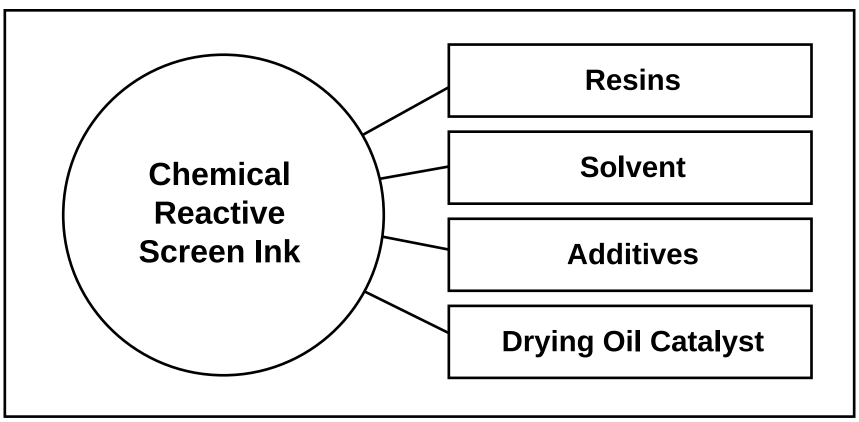
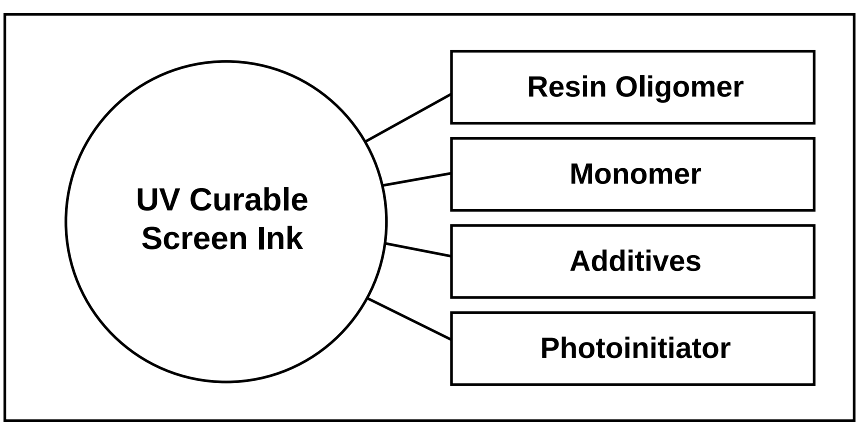


Figure 3



The other type is the chemical reactive, and this I will basically refer to as an enamel. (See Fig. 2) We have resins, again we have solvent, again we have additives, but we also have drying oils and/or catalysts. Let's take one portion of that at a time. We have a resin, a synthetic resin, that we again break down in solvent. We use a solvent in this case to liquefy the mass, to give you a viscosity that you can print with. Then we add the additives which are the pigments, maybe some plasticizers, etc. Then we put a drying oil into the mass. We have an oxidation reaction, which converts the process from liquid to solid. The chemical reaction between oxygen, the drying oil, and the resin yields a very reactive and unstable chemical animal called a radical. These radicals are capable of immediate reaction and propagation of polymerization. In other words, they convert by chemistry, by the reaction of oxygen in the drying oil. The resin converts, it polymerizes, it becomes a dry film. The solvent expels; it is evaporated. It only plays a part in viscosity in printing. It has nothing to do with actually curing or drying the mass.

There are some variations of this chemistry. We can put in a catalyst; that can be like a thermosetting enamel, one that takes heat to initiate a reaction. Some of these can be strictly an air-dry, some of them take heat, some take a combination of heat and air or heat and oxygen and a catalyst to kick it over.

The new chemistry is UV photoreactive. You start out (again) with resins, and in place of the solvent we have a monomer. We also have additives and a photoinitiators.

Where we have resins in Figure 3, you will see the word oligomer. In the case of UV, these resins are quite different from the ones we use in the solvent evaporative coating because they are reactive. They will chemically react with other portions of the chemistry, in this case a monomer. The monomer is a chemical of low molecular weight. We use this, in a sense, to replace the solvent. This breaks down the viscosity so that we can print with it. But it has a very distinct function other than just being a solvent or diluent. It is a very definite part of the chemistry. Everything in a UV curable coating has a functional part because it is 100% curable. Everything in this package converts; it becomes a solid.

Then we have the additives; basically we are talking about the same type of additives again—pigments, etc. The UV process of curing is set off with a photoinitiators. This acts as the radical. It is a promoter; it starts the chain reaction. It is a compound which is light sensitive, which means it captures light. The photoinitiator molecule receives a certain dose of light and becomes energetically excited. These excited molecules undergo spontaneous fragmentation on two or more radicals, and this initiates a chain reaction which polymerizes the whole mass. And that's a UV coating.

As far back as I can remember one of the demons in the screen printing industry has been the solvent. When we design an ink system to work on a particular substrate and we get the right combination of resins, plasticizers, pigmentation, the proper viscosity, and we get the adhesion we want, our problem from here on out is going to be the solvent. Ninety percent of the problems that you are going to have will be related to solvents; they always have been. We use a lot of petrochemical solvents in the manufacture of our inks. You complain that the ink is not drying down the conveyor. From one day to the next there is a variance. This is the solvent. You say that it is drying in the screen. This is the solvent. You say that it is bubbling; the substrate you are printing on is soaking up the solvent: How can we get it out?

All these problems are related to solvents. We manufacture an ink that works beautifully in July. Take the same solvent down to Florida and we have problems. Variations in temperature and in humidity present these problems. Denver, Colorado, is another animal; out there we have an altitude factor; the boiling range of solvents is entirely different from what it is in New Orleans, Louisiana. Compound that with the difference in humidity between Denver and New Orleans and you add another set of variables. Solvent: That's our problem.

Now look what the government is doing to us. They say we can't use this; you have got to get rid of this particular solvent. You are getting too much out here in the atmosphere. You can't use this any more, and they only want you to use 5% of that. We have gotten to the point where we can't ship a lot of solvents by air. It is a problem; we are going to have to do something about it—we know that and you know that. It's coming to the point where petrochemical solvents are not only going to be harder to get and more expensive, but when we get them, we are not going to be able to use them! The government is going to put us out of business. We have got to develop another means of building a screen printing ink. In our opinion, one of the ways of doing this lies in the photoreactive process, building an ink that is photoreactive. In our case, ultraviolet curable.

There is another thing that we have to take into consideration. We as screen printers do more than just print pretty colors for effect. Our inks are decorative coatings in many cases. Our inks have to do a lot more than just "look pretty." They have to withstand die cutting, bending, forming; you want gasoline resistance, you want petrochemical resistance, you want abrasion resistance, you want something that is going to last five years outside, you want something that is very flexible, you want something that you can't get off with a crow bar, you want something you can drive a truck over, and you want this to work on 10,000 different pieces of material.

This takes time; it takes a lot of time in assuring that we have these variables defined. Getting adhesion is one thing, but getting the product resistance and the end performance that you and your customer need is another thing. You have heard many of the advantages and I'm not going to belabor the point. You have heard that it is economically advantageous; that it will be particularly advantageous to us as screen printers because it saves space (and space is so precious to us today). What you are now doing with your automated printing equipment and having to do with 12, 15, 18 meter (40, 50 and 60 foot) conveyors, you can do in 2, 2.5,3 meters (6, 8, 10 feet). The cost of running these gas dryers (that are 18 meters long) is getting expensive; it is costly, and we are expelling too much solvent. UV will eliminate that. Speed is a factor. Machine speed is not so important as total processing speed, which will be cut way down. We do not have to worry about handling the material four or five times from one print station to the next. We are going to be able to drop it in a box a few feet from where we printed it, and ship it. Conservation of energy is something we have all talked about. We all know it's coming; we are going to have to abide by it. To convert (dry) our inks that are now so full of solvent it takes a lot of air, a lot of gas, a lot of electricity, a lot of money. UV eliminates a lot of this.

"Printability" relates back to your problems with solvents. Provided the ink is manufactured right to start with, and your screen duplicates your positive, the UV ink will print what your screen has, and it will do it consistently. As UV inks are 100% solid, there is nothing to evaporate; therefore, the viscosity will not change. You have had this problem many times before when you are running a long run (particularly when you are printing very fine copy). What you are doing is working the ink back and forth, evaporating the solvent out of it, changing the viscosity of the ink, getting a different deposit every 50 to 75 sheets. We can take a UV ink and a given screen and run it all day long and get the same duplication. Whatever the screen has, you will get consistently. Cleanliness is a big factor, particularly those of you who are running enamels or long drying cycles, rack drying. You know yourself that it

Cost — UV vs. Conventional Inks

Conventional	UV
Ave. 40% Solids	100% Solids
79threads/cm (200 threads/inch)Mesh Yield: Dry Film of 13 microns (0.5 mil) mil)	79threads/cm (200 threads/inch)Mesh Yield: Dry Film of 32 microns (1.25
At 13 micron Yield: 36 Sq. Meters/ Liter (1,500 Sq. Ft./Gal)	At 13 microns 92 Sq. Meters/Liter (3,750 Sq. Ft./Gal)

is very difficult to eliminate dust particles from flying around the air. In printing UV, because we drop it right into the curing unit, it is going to come out dry (cured), and we won't have a lot of time to expose the printed matter to surface contamination.

UV inks are more expensive, probably 2 to 2 and 1/2 times more expensive on a per-gallon unit or a weight basis. In our conventional coatings, whether they be solvent evaporative or chemical reactive, on an average, we have about a 40% solid. In other words, the rest of it is solvent. Whereas in UV, as it is a 100% solid, you are getting roughly 2 and 1/2 times the amount of usable materials. If we take a 79 threads/cm (200 threads/inch) mesh screen, a solvent evaporative coating may yield a 13 micron (0.0005 inch) dry film. The same mesh in a UV is going to yield 25 and 37 micron (0.001 and 0.0015 inch) dry film. So if we want to duplicate dry film thickness, we have to run the UV through at a much finer screen mesh. On a square foot basis the UV inks are comparable to what you are now buying.

How will this relate to you, and what will be expected of you as screen printers to become involved with ultraviolet curable screen inks? First, in order to cure these UV inks, you must have a reactor or curing unit. We prefer to call the (dryer) unit a reactor as again there is a very definite reaction that takes place in converting a UV ink from a liquid to a solid. Caution should be exercised in purchasing the proper unit for your particular needs. For any heat sensitive substrate extreme caution should be taken to assure proper performance. In view of the temperatures generated by the UV lamp, many units are too hot running and will permanently distort your substrate. There is more to designing and building a UV reactor for general screen printing than placing a UV lamp over a conveyor belt.

You will be exerting tighter controls and procedures in working with UV. When printing an existing black vinyl ink, you may use anywhere from a 67 to a 122 threads/cm (170 to a 310 threads/inch) mesh fabric. The difference in the mesh means variations in printing quality, opacity and of course, a difference in drying times.

With a UV black, designed to render optimum opacity through a 165 threads/cm (420 threads/inch) mesh, you will print the ink through this mesh and only this mesh. A coarser mesh, or a dull squeegee will deposit a heavier layer of ink that will not cure. The UV light will not be able to penetrate the more dense mass, irrespective of exposure time in the unit. As the light will only penetrate down through the mass so far, a top cure will occur. The ink will also not have proper adhesion as the bottom surface of the ink has not been cured.

The photographic stencil will play an even more important role in UV application. Dealing with 100% solids and in the case of printing very fine copy, a thick stencil will render a very thick deposit. A 25 and 37 micron (0.001 and 0.0015 inch) thick indirect stencil will give you a set of very fine copy that will feel like Braille. The thinner the stencil, the better the print. As UV inks will never dry in the screen, they will print and continue to print those minute pinholes in the screen. A gallon of ink will yield fantastic mileage, but is expensive and you do not want to be sloppy and waste ink. Maintaining tighter inventories and color control with off-shade colors is going to be very important. If you need five gallons of a special color of UV and you end up mixing up seven or eight, you may end up with $150-$200 in ink you can't use. Make sure you wash the screen properly when you are through printing. A slight residue of UV ink left in the screen that is stored in a well lighted room will convert in time and be unsalvageable.

With existing solvent-based inks our cost for putting a product line on the shelf averages 50 thousand dollars. With UV, as the raw materials are higher we could be looking at 150 thousand dollars for the same quantity of ink.

We must be sure we have the right product and assured of enough sales to justify a move of this magnitude. Again, because of the complexity of our business, the many variables in substrates, we must start in a few select areas. Even with UV inks, we are not going to have one ink to do all things.

We, as manufacturers, are going to concentrate with users that are first of all large enough to justify getting involved. You must buy a reactor, new fabric, etc., and have enough volume of one type of an application to justify going UV. If you are a small general screen printer, we are not going to have those small quantities of UV ink in several different formulations for all of the many substrates that you print.

When you commit to a reactor (UV curing unit) you can only print UV with that unit.

We are confident UV is at least one answer to improving our product, simplifying our processing of these products and at the same time produce a product that will comply with the controls and regulations that are going to be imposed, along with helping to conserve the world's natural resources. UV is fun to print; to see sheets coming off a high speed press and stacking up in a matter of 2 to 3 meters (8 to 10 feet) is something we have all dreamed about.