

Going for the Gold

The story of a three-year journey to find a better way to flexographically print gold foil images.

By Milton Meshirer

In the Beginning...

There was pure gold! Gold defined enduring beauty and brilliance! The impression it made when applied to a surface was incomparable. The ancients made foil of it and used it to cover their most precious possessions including burial caskets, thrones, documents, sculptures, idols, temples and other items. Pure gold was, and to this day remains, a rare material, used only where its cost can be justified.

After thousands of years, a process was developed by which a low-cost metal would impart the appearance of pure gold foil. The solution was vacuum plated aluminum, coated with transparent yellow lacquer. At the heart of this process is a natural phenomenon that occurs when aluminum is placed in a vacuum and heated to its melting point resulting in vaporization. As a vapor, aluminum condenses onto a cold surface to produce brilliant, polished thin films. Applying a transparent yellow lacquer over the condensed aluminum produces an amazingly close imitation of gold foil. Following these inventions was the discovery that if the aluminum is coated with an adhesive and the plastic-aluminum interface with a release agent, the aluminum can be made to release from the plastic film and transfer to another surface. Using this system, almost any image can be reproduced and look like printed metal foil. Simply place the lacquered aluminum adhesive side down on the substrate; press with a heated, patterned die to activate the adhesive; remove the film and the image of the patterned die in polished metal will be faithfully reproduced on the substrate. Presto, you have produced an image that looks exactly like printed gold!

Understanding the Process

This process is called hot stamp foil printing. Unfortunately for flexo press operators, this wonderful process has some serious drawbacks.

- A split-second dwell time is required in order to allow enough heat to reach the adhesive's activation temperature, thus limiting the maximum speed at which a press can be run. Additionally, fluctuations in temperature of the heated die due to cooling and heating cycles

while printing can result in inconsistent print quality.

- The press speed must be adjusted to satisfy the requirements of both the ink, which needs time to dry and the adhesive, which needs time to reach its activation temperature.
- The rotary hot stamp die represents a considerable cost (average \$2,000) added to the cost per unit of the item printed, making short runs impractical.
 - a. Any design or content change of the printed item requires a completely new die.
 - b. Printing on a separate press (off-line) simplifies the process but represents an additional operation and added expense.

In June 1997, we considered the possibility of creating an ideal adhesive, which would:

- Print like ink on a flexo press at room temperature.
- Require only an inexpensive polymer plate (\$15) rather than an engraved metal die.
- Be non-flammable.
- Have no organic solvents, which would evaporate (VOCs).
- Be easy to clean up.
- Dry within a matter of seconds in two stages—tacky and hard.
- Be low in viscosity.
- Perform consistently.
- Have good long-term shelf stability.
- Be effective at a wide range of press speeds.
- Never skin over.
- Maintain the same viscosity in an open pan without drying.
- Adhere to previously printed ink.
- Accept inks printed after the cold foil application.

We reviewed the history of hot foil stamping, and the attempts made over the past ten years at providing the printing industry with a suitable alternative. Some of these were unique enough to have been granted patents. Most depended upon the application of an adhesive which was printed, dried and later activated by heat, pressure or solvent. Some were simply water-based tacky adhesives. None were commercially successful.

The adhesive technologies considered were:

- Hot melt
- Water based
- Solvent based
- UV

Hot melt adhesives print well, are low in cost and can be printed using a heated steel mesh rotary screen with the desired pattern. These were ruled out because they require application at 350 °F, are difficult to clean, and require the use of a costly rotary steel screen and other specialized equipment.

Water-based adhesives are low in cost, can be easily printed with low-cost polymer printing plates, but they dry on rollers, are hard to clean, skin over and thicken up as the press continues to run.

Solvent-based adhesives are easily printable, but were ruled out primarily because they contain volatile organic compounds (VOCs).

Accepting the UV Challenge

UV-curable adhesives met all of the requirements. Liquid at room temperature, they do not dry out or skin over, are easy to clean, and do not generate VOCs. Their main disadvantage was that they cost more than the others, but when considered in the context of all of the costs involved in producing an image in printed foil, the adhesive represents an insignificant portion of the total.

UV-curable materials fall into two types of chemical reactions. One is called *free radical* and the other is called *cationic*. An important difference between them is that a free radical reaction ends instantly when the UV light is removed, whereas a cationic reaction, once initiated, will continue even after the light is removed. Thus an adhesive of the free radical type that reaches a tacky stage at the moment the UV light exposure stops will always remain tacky. However, an adhesive of the cationic type that has reached a tacky stage will continue to cure after the UV light is gone and can become a "permanent" adhesive.

Our goal in mid 1997 was to develop a cationic adhesive that will become tacky a fraction of a second after UV exposure, but will continue to harden and become a permanent adhesive several minutes later.

Developing a cationic UV-reactive adhesive with an initial tack, proceeding to a hard final surface, did not sound like a daunting project. Any number of already known cationic compounds could be made to work. This, we thought, will be easy. However, we were about to learn, where a flexo press is involved, nothing is easy.

The problems began just as soon as the first samples went out. A press operator requested a sample of adhesive to run on his press. Accustomed to working with screen printers,

we mistakenly assumed that a flexo press would be able to run with similar material. We brought a sample having the viscosity of heavy syrup. "That's what you call a printable adhesive?" exclaimed the printer. "Here is what we run on a press!" He held up a can of water-thin ink, his face conveying amazement that anyone could be so ignorant.

OK, so it's back to the lab, along with the growing apprehension that this project may not be quite the pushover it had at first appeared to be.

Tacky UV adhesives are generally based on rubber-like resins (oligomers) and tackifiers. These are excellent adhesives, but they are high in viscosity. Diluting them with a monomer reduces the viscosity, but monomers are poor adhesives. As you add more and more monomer, the tack quality gets worse and worse. Just about the point where the viscosity is low enough for flexo press application, the tack disappears entirely.

Trial and Error

Back in the lab again, the formula was reconstructed. Finally, we presented the press operator with another sample of adhesive. It was not as thin as he had wished, but it was acceptable and he ran it on his press. The press rolled and everyone ran to the other end to see the gold printed image appear. However, what we saw was blank paper! The operator loudly announced, "Your stuff is no good! It doesn't work at all!" Exhibiting the patience of a Motor Vehicle Department employee at closing time, he immediately started to empty our adhesive out of the press. We quickly stopped him and told him to wait while we examined the results.

Examination of the image showed that an abundant amount of printed adhesive had been deposited onto the paper, but it was hard and tack-free. Having an understanding of the chemistry, the solution was immediately obvious to us. The adhesive reaches a tacky stage before it completely cures. If it contacts the foil while it is tacky, the process will work and foil will transfer. If it completely cures, the adhesive will have no tack and there will be no transfer. We had over cured the adhesive and it was already hard when it contacted the foil. To reduce the amount of cure we must either diminish the power of the UV light or reduce the exposure time by increasing the speed of the press.

We told the press operator to repeat the trial and to increase the press speed. He started up the press and he gradually increased speed—80 ft/min then 85, 90, 100, 125, 150 then 200 ft/min and still nothing! Suddenly at about 250 ft/min, bits of gold appeared here and there on the paper. As the operator continued to increase the press speed, the image filled in more; and at 275 ft/min, almost miraculously the gold image appeared, gloriously brilliant and complete. The operator continued to increase the press

speed and at 300 ft/min the image began to fade again, gradually getting worse until at 325 ft/min the image was gone and we were looking at blank paper again. We retrieved a sample of the printing done at 275 ft/min and the image looked great! We were excited and impressed with the results.

The company owner walked over and picked up the sample. We watched him silently while he pulled out a magnifying glass and carefully examined the printed image. Finally he looked up, frowned and said, "Awful!" He tossed the paper into a dumpster. As he walked away, he shouted to his operator, "Get that stuff out of the press and get the regular job back on!"

Subsequent conferences with the owner and lab studies revealed the following problems:

- Although not readily visible to the human eye, under magnification one could see jagged edges all along the borders of the printed image.
- Areas, which appeared to be solid, actually contained thousands of tiny pinholes and occasional gaps.
- When the adhesive is over cured, it becomes too hard and dry. If the adhesive is under cured, it is too weak to develop sufficient tack to transfer foil. To be successful, the press has to be run at just the right speed. Assuming that we could overcome all of the other deficiencies, this alone would make the adhesive unacceptable.

We realized that we had a lot to learn about printing. Having expertise in chemistry was not going to be enough. To solve the problem of printing foil using UV-cured adhesives, we were going to need a hands-on understanding of flexo printing.

The Learning Curve

From November 1997 through 1999, we made numerous trips to the facilities of printers, and stood by and watched while they tested dozens of formula variations. However, judging the effectiveness of different adhesive formulas was frustratingly difficult as press characteristics and operator skill proved to be quite variable.

We examined all sorts of lab machines designed to replicate the conditions found on the press floor, but none of them were found to be completely satisfactory.

We then purchased a lab system combining a 10-inch 600W/In UV light mounted over a conveyor capable of speeds up to 550 ft/min. To this we added an especially designed set of variable speed and pressure nip rolls. We hoped that this equipment would enable us to evaluate various adhesive formulas and produce samples identical to those created while running a flexo press. Ultimately, we concluded that it was simply not possible to reproduce the exact result of a flexo press.

Therefore, we bought a press. A brand new press equipped with a broad assortment of optional features including \$60,000 worth of UV lights.

Printers consider the purchase of a machine, which occupies several hundred square feet of space; requires a considerable amount of electricity and exhaust systems; and costs from \$200,000 to more than \$1 million, as the justifiable acquisition of a highly productive, moneymaking unit. However, to an adhesive company, this represents a major research and development investment and a very serious commitment to solving a problem.

So, we became printers—right? Wrong! What we managed to do was mess up a perfectly fine press *trying* to be printers.

A flexo press is basically a very simple system. It is a rubber stamp glued onto a cylinder. The stamp gets ink on it, the cylinder rotates, and the stamp prints an image over and over. That's essentially the whole thing.

To examine the process a bit more closely, there is a little tray with a roller half submerged in ink, the *fountain roller*. The roller picks up the ink and transfers it to another roller that has tens of thousands of imperceptibly small holes in it called an *anilox roller*. The holes fill up with ink and a squeegee called a *doctor blade* wipes off the excess. Then the ink is transferred out of the holes and onto a rubber-like synthetic polymer called the *printing plate*, which prints the image as it rotates. The entire mechanical unit, the ink tray, all of the rollers and various controls is called a *print station*. Simple, right?

Things change radically for the worse when real-world conditions are encountered. An average press is about 40 feet long, starts with an *unwind unit*, followed by four to eight or more *print stations* and ends with a *die-cutting station* and *rewind station* in the rear. Above the press are additional unwind and rewind rollers used for lamination. Each *print station* has a different color ink and a complete set of controls, which allow the operator to adjust the position and pressure of the rollers including the one holding the printing plate. A roll of paper is mounted onto the *unwind station* and its leading edge is threaded up and down, over and under dozens of rollers until it reaches the other end of the press at the *rewind station* where it is glued to a cardboard core. The press is turned on, the rollers start to turn and paper moves from one end of the press to the other where it is rewound. The inks quickly spread onto numerous rollers and transfer to the *printing plates*. The image of each *printing plate* is reproduced on the paper. Each image is a different pattern and a different color. Combined they constitute the final picture. Each image must print precisely where it is supposed to or the final picture will look blurred. Lining up the plate cylinders on a running press is a job requiring skill and experience.

The conditions that separate the amateurs from the pros arise when normal operating speeds are reached and the paper is traveling through the press at 200 or 300 ft/min while the rollers are spinning at 600RPM. At that point, while under the control of an experienced press operator, everything runs smoothly for hours on end, turning out an immaculately printed product with very little fuss. But with a chemist running things, the ink for no apparent reason suddenly gets itself airborne and splatters all over everything, the whirling cylinders refuse to stay aligned and the paper tears itself to shreds every 30 seconds. That's on a good day!

A bad day is when you look down and find that you are standing with one foot in the ink tray that you placed on the floor and forgot about.

As the weeks passed, chemistry was put on hold and printing became the challenge. Although eventually we tamed the monster, we never reached the level of expertise necessary to be able to conclude whether poorly printed images were due to adhesive failure, bad foil or lack of printing skill.

The next move was to seek the assistance of a professional press operator, a step we took in mid-1999 when we consulted with Michael J Rivera. Thereafter, new formulas were created and run on the press, and the results exam-

ined. These results were evaluated and improved upon, and gradually progress was made.

In addition to learning about printing, we discovered that we had much to learn about foils. Foil companies produce diverse foils. The aluminum may range from holographic to polished-flat, and is available in different degrees of thickness and density. To be considered acceptable, the adhesive had to work under all conditions, on all presses, print on all surfaces at any speeds and with all foils.

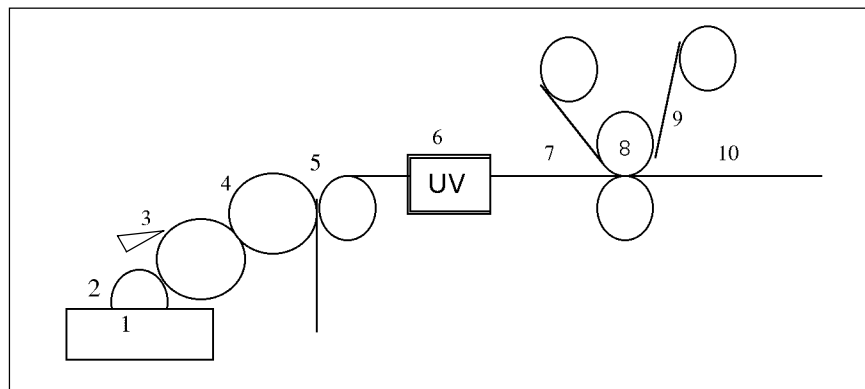
Months of testing passed until we finally succeeded in creating an adhesive that met most of our requirements. We sent samples to a number of printers; the only complaint was that press speed was too limited.

We ultimately created three versions of a formula. One transferred foil well from 60-180 ft/min, the next from 175-275 ft/min and the third 280-400 ft/min. By mid-2000, sporadic reports from customers of successful print jobs were beginning to filter back to us.

Glue into Gold

Currently, there are two different processes in use to do cold foil printing. To distinguish the two processes we refer to them as the *dry cold foil printing process* and the *wet cold*

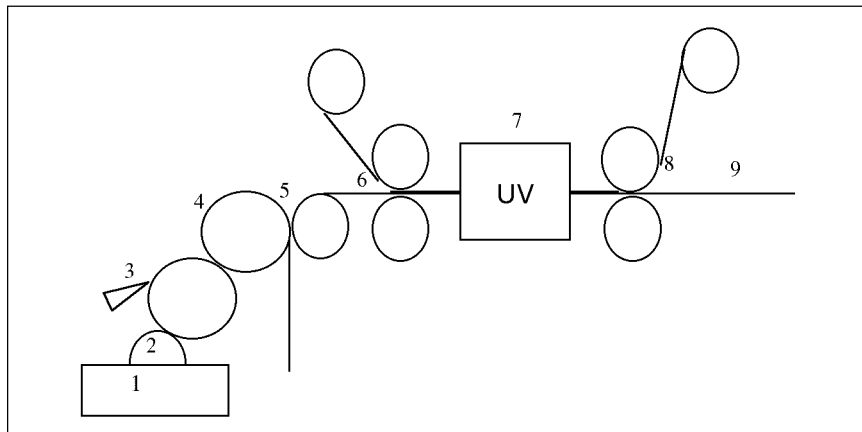
Figure 1: Dry cold foil printing process (cationic)



1. Adhesive is picked up on the fountain roller.
2. Adhesive is transferred to the anilox roller.
3. Doctor blade squeegees off excess adhesive.
4. Adhesive is transferred to the printing plate.
5. Image of printing plate is transferred to the paper.
6. Paper passes under the UV light, adhesive starts to react.

7. Adhesive continues to react and become tacky.
8. Paper and foil are laminated. The pressure of the nip rolls force the foil to adhere to the partially cured pressure sensitive adhesive.
9. Paper and waste foil are separated.
10. Image of foil remains on the paper and adhesive continues to cure to a hard finish.

Figure 2: Wet cold foil printing process (free radical)



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| <ol style="list-style-type: none"> 1. Adhesive is picked up on the fountain roller. 2. Adhesive is transferred to the anilox roller. 3. Doctor blade squeegees off excess adhesive. 4. Adhesive is transferred to the printing plate. 5. Image of printing plate is transferred to the paper. 6. The wet adhesive is covered by foil. The nip rollers force the adhesive into the foil. | <ol style="list-style-type: none"> 7. A percentage of UV light penetrates the foil. The adhesive cures and the foil are laminated to the paper in the pattern of the printing plate. 8. Paper and waste foil are separated. 9. Paper, with finished image printed in gold, continues through the press. |
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foil printing process. Figures 1 and 2 are examples of the press configurations.

Cationically cured adhesives (the dry process) are not compatible with inks that contain ammonia or amine components. These adhesives should not be mixed with or printed over inks of this type. In some cases, the adhesive will tolerate an ammonia-containing ink once the ink is thoroughly dry and the ammonia has evaporated off. Rollers, trays, printing plates or tools that have been previously used with ammonia or amine-containing ink should be thoroughly cleaned with a suitable solvent before use. Unlike the cationically cured adhesives, the adhesives used in the wet-lam process are free radical curing. They are unaffected by ammonia or amine and are compatible with inks of this type.

Adhesives applied at room temperature with a flexo press will soak into any unfilled or uncoated paper so if this type of paper is used a filler or varnish must be applied before the adhesive is printed. This is not always necessary for adhesives applied by screen-printing as the adhesive's higher viscosity retards penetration.

Great Expectations

Cold foil stamping is now commercially feasible for a wide range of applications. Many major foil companies provide special grades of foil designed to print using this technique. Cold foil may be printed successfully on most substrates including polyethylene, vinyl (PVC), most

cast-coated papers, and clay-coated papers as well as semi-gloss and silk papers. It has been used effectively over most types of inks including UV inks. Although at present it does not match hot stamp printing, it is perfectly acceptable where the printing is not held to the highest standard of quality. It is an excellent choice for low volume or low-cost print applications such as inexpensive labeling and packaging. Improved results are anticipated as better materials, equipment and printing techniques evolve over time. ■

Acknowledgements

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Additional Materials

Cold foil printing can have many press configurations. A number of them are illustrated in "The Handbook on Cold Foil Printing" available at no cost from Beacon Adhesives, (914) 699-3400 or www.Beacon1.com.

An excellent article on cold foil printing, written by Jeff Peterson, is also available in the supplement section of the June 2001 issue of Inside Finishing Magazine.

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