Comparison of 1K UV Primer vs. Conventional 2K Primers

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The objective of this article is to compare the properties of a one-component (1K) UV primer versus conventional two-component (2K) primers used in the automotive refinish industry. A 1K UV urethane primer will be compared against a 2K urethane primer and 2K epoxy primer. The comparisons between the primers will be adhesion to metal substrates, humidity resistance, stone chip resistance, chemical resistance, and film hardness. The curing sources for the UV primer were lights that only produce wavelengths in the UVA and UVV range. The use of other UV wavelength ranges (UVB and UVC) is not feasible in refinish repair. These comparisons will illustrate the advantages of UV chemistry and will allow the user to understand the potential advantages of a UV primer and the possible effects on the industry.

BACKGROUND OF AUTOMOTIVE REFINISH COATINGS

Most of the conventional refinish coatings commercially available consist of two-component (2K) materials. These materials have been standard in the industry for over 20 years. These materials have been used due to their chemical resistance, exterior durability, and speed of cure. Some of the limiting factors of 2K materials are the limited pot life, mixing of materials, and application window. When using two-component chemistry, there is more waste generated from not knowing how much material is needed for each repair. Waste is also generated from the clean-up of the application equipment after use. There is also time spent mixing material and having to clean application equipment after each of the application steps.

Another concern with conventional refinish coatings deals with consistency. With an air-dry coating, temperature and humidity have an effect on

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the cure of the coating. If the coating is under-cured in any of the steps, there could be factors such as adhesion loss, dieback, swelling, and appearance imperfections that are not seen for several days. When this happens, the repairs usually have to be repeated, taking up more valuable time.

With UV technology being applied to automotive refinish applications, the issues of time, waste, and consistency can be overcome. UV will allow the user to be assured that a repair has been done correctly, in a relatively short amount of time, with minimal waste.

COMPARISON OF CHEMISTRY FOR 1K UV PRIMER VS. CONVENTIONAL 2K PRIMERS

In this article, the areas of comparison between the two systems are chemistry, system product properties, and performance.

Comparison of Chemistry

With UV coatings, the major vehicles consist of oligomers, which can be urethanes, epoxies, polyesters, or other modified systems. These oligomers contribute the major film properties and can be combined to balance hardness, flexibility, weatherability, and wear properties; whereas with conventional coatings, the main properties of the coating come from the resin. These resins usually are higher molecular weight materials that have the physical properties of the resins built in the backbone of the resin. These resins leave the formulator with less formulating latitude.

Another difference is that UV coatings use monomers to reduce the viscosity of the coating for application. These monomers react to help form the film upon initiation of the crosslinking. These monomers help to modify the film properties for improved adhesion, water resistance, solvent resistance, hardness/flexibility, and even cure speed. In conventional 2K systems, solvents are used to reduce the viscosity for spray applications. These solvents do not contribute to the film properties and they are volatile, which contributes to the volatile organic compounds (VOC) of the coating. Today, a major concern of the government is the amount of VOC in a coating system due to the issue of air pollution. Solvents have no importance in 2K coatings except as carriers for delivering the coating to the substrate.

The last chemistry comparison involves additives and pigments. With UV coatings and 2K coatings, the same flow, level, mar, and slip additives can be used in both systems. The major difference between the systems is that UV coatings contain photoinitiators. These are necessary in order to initiate the crosslinking of the film. With conventional 2K systems, the coatings may contain some type of catalyst that increases the reactivity of the two-component chemistry. Another major difference is the pigments used in the two different systems. With UV coatings, the pigments have a major effect on the cure of the coatings. Certain pigments absorb the UV light and will affect the cure depth of a film. With UV coatings, the pigments have to be carefully chosen for the particular UV light source that is used to cure the coating. With 2K materials, the pigments have no effect on the cure depth and are not as critical.

Comparison of Product Properties

The systems evaluated were a 1K urethane UV curable coating, a 2K urethane coating, and a 2K epoxy coating. These coatings were evaluated over cold rolled steel (CRS), galvanized, and aluminum substrates. All three of the systems were applied direct to the metal substrates without any metal treatment on the surface. With the 2K coatings, three different cure methods were evaluated. The methods were air dry at room temperature, bake for 30 min at 140°F, and IR cure for 10 min. These cure procedures were completed based on the recommendation of the manufacturer. With the 1K UV coating, three cure procedures were performed. The first procedure was a 2-min cure with a UVA light source at a cure distance of 10 in. The second procedure was IR for 3 min followed by the UVA light cure for 2 min at a cure distance of 10 in. The last cure procedure was curing with outdoor sunlight for 2 min on a late March day in northwest Ohio.

The initial viscosity for all the coatings was 18 to 22 sec on a Ford #4 cup. The 1K UV primer was applied in one coat, while the 2K coatings were applied with two coats. The film builds of all the systems were between 2.5–3.5 mils. The 1K UV primer had no pot life while the 2K urethane had a pot life of 40 min and

Figure 1—Initial adhesion of systems.

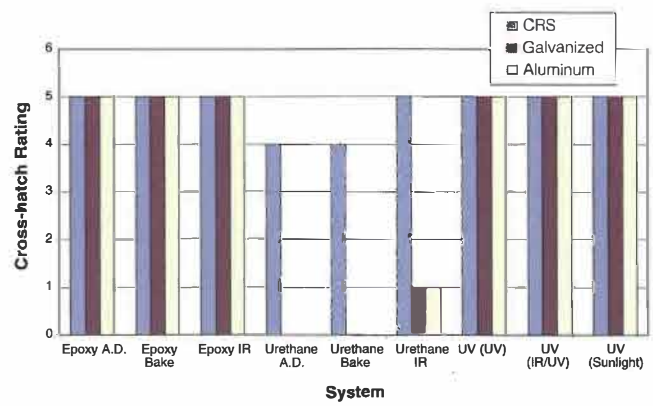


Figure 2—Ten-day humidity adhesion of systems.

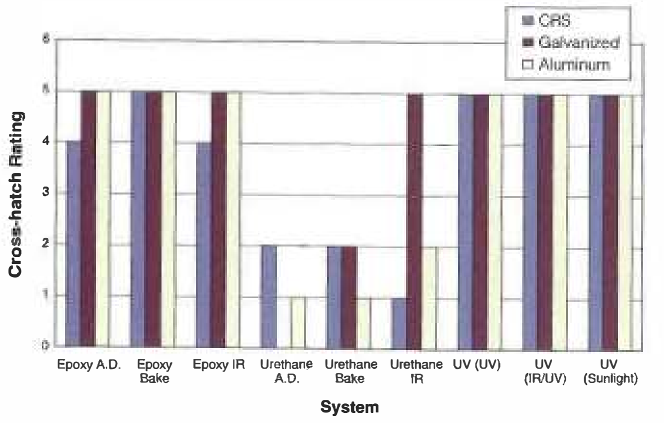


Figure 3—Stone chip resistance of systems.

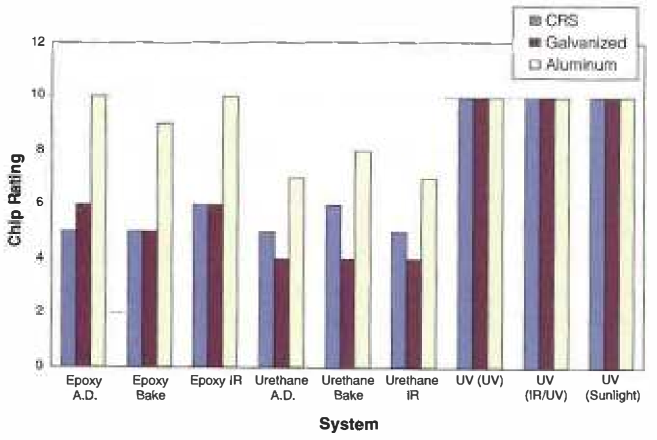
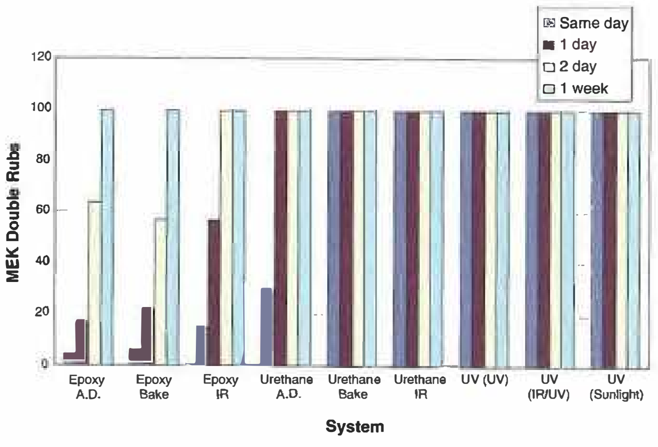


Figure 4—Solvent resistance of systems.



the 2K epoxy had a pot life of 10 hr. The VOC of the systems were 1.7 lb/gal for 1K UV primer, 4.4 lb/gal for the 2K urethane primer, and 4.8 for the 2K epoxy primer.

Comparison of Film Performance Properties

The nine different systems were evaluated for initial adhesion, 10-day humidity resistance, chip resistance, solvent resistance, and film hardness. Films were allowed to cure for one week before being subjected to testing. With the solvent resistance and film hardness testing, the films were evaluated at same day, 1-day, 2-day, and 7-day periods, to evaluate performance over time and to determine extent of cure.

The nine systems were:

- 2K epoxy air dried
- 2K epoxy baked 30 min
- 2K epoxy IR cured for 10 min
- 2K urethane air dried
- 2K urethane baked 30 min
- 2K urethane IR cured for 10 min
- 1K UV cured with UVA light cure for 2 min
- 1K UV cured with IR for 3 minutes and UVA light cure for 2 min
- 1K UV cured with sunlight exposure for 2 min

The different coating systems were evaluated for initial adhesion using the ASTM D 3359 Method B procedure. The adhesions of the different systems over all three substrates are shown in *Figure* 1. Adhesion rating of 5 is a perfect adhesion, while an adhesion rating of 0 is complete adhesion loss. The 1K UV system and 2K epoxy system showed perfect initial adhesion with all three substrates, while the 2K urethane system had good adhesion to CRS, but had failure with galvanized and aluminum.

Once these materials were subjected to humidity testing (*Figure* 2), using the ASTM D 2247 testing procedure, some of the epoxy systems lost adhesion to CRS. The urethane systems gained some adhesion with galvanized and aluminum but were still very poor and lost some of the initial adhesion on CRS. All of the UV systems still maintained perfect adhesion after humidity exposure, thus showing the water resistance of the films.

The different coatings systems were evaluated for chip resistance (*Figure* 3), using the ASTM D 3170 procedure. A stone chip rating of 10 is no chips in a film, while a rating of 0 indicates 250 or more chips in a film. The 1K UV systems all had perfect stone chip resistance. The 2K epoxy systems showed the second best for stone chip resistance with perfect chip over aluminum, but average performance over the other two substrates. The 2K urethane systems had average stone chip resistance over all the substrates.

The three different coatings were evaluated for solvent resistance (*Figure* 4), using ASTM D 5402. All of the systems were evaluated at same day, 1 day, 2 days, and 7 days after the initial cure procedures. Methyl ethyl ketone (MEK) was used for the solvent and the test was performed as double rubs. If after 100 rubs there was no failure in the film, the tests were determined to be completed. If the film was completely removed before 100 rubs, the number of rubs was recorded at the point of failure.

From the solvent resistance results, the 2K epoxy systems took over two days to be chemically resistant even with an IR cure. The 2K urethane took one day to be chemically resistant with the air dry system but was chemically resistant the same day with the other cure systems. The 1K UV systems were completely chemically resistant, the same day as cure with all three cure approaches. The 1K UV system that was cured with sunlight was chemically resistant the same day. This helps to show a major advantage that UV coatings have even with slight UV exposure.

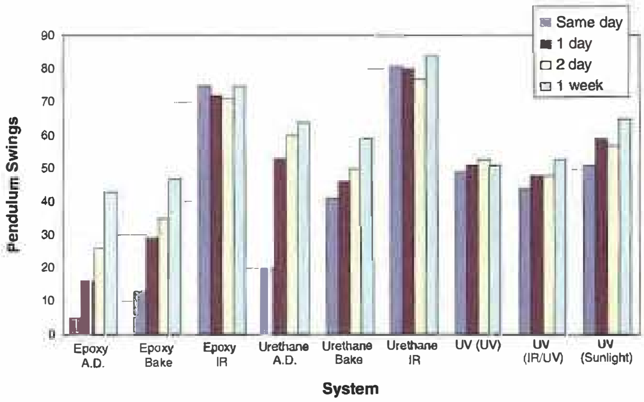
The three different coatings were measured for film hardness (*Figure* 5), by using the ISO 1522 procedure, which is the König Pendulum hardness test. All of the systems were evaluated at same day, 1 day, 2 days, and 7 days after the initial cure procedures. The values recorded were the number of pendulum swings for each film.

From the pendulum hardness results, the 2K epoxy systems that were air dried and baked changed over a week and were considerably more flexible than the same coating that was IR cured. The 2K urethane systems had the hardest film with the IR cured system, while the air dry and bake were slightly lower. As with the epoxy systems, these films also changed slightly over a week. The 1K UV systems had approximately the same hardness over time with the system cured by sunlight having slightly harder films. This helps to show the consistency of the UV films over time and that the film properties are constant, independent of the cure method.

CONCLUSION

In conclusion, there is a tremendous potential for UV coatings to be used in the automotive refinish market. UV technology offers application advantages such as elimination of mixing of materials and pot life concerns, allowing the user to have an unlimited application window. From the ecological aspects, UV coatings in refinish will lower VOC emissions and reduce material and cleaning waste. The major advantages of using UV coatings in refinish are the production time-savings and the reduction of poor quality repairs. UV technology also offers performance advantages like film performance in exterior environments. UV technology provides completely cured films that lead to quicker chemical resistance and films that do not change properties over time. The next challenge for the UV industry will be to make UV technology the safe future for automotive refinish coatings.

Figure 5—Pendulum hardness of systems.



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