Development of a Low-temperature Methylene Chloride-free Paint Stripper Safe for Aluminum Surfaces

By Patricia Pulido

A methylene chloride-free paint stripping technology that effectively strips powder paints from steel and aluminum surfaces at temperatures of 100 to 140 °F has been developed. This stripper performs as well as or better than methylene chloride-based and hot alkaline strippers on various powder paints. The development satisfies pressing needs for industries seeking an environmentally safe alternative to effective hot alkaline and chlorinated solvent strippers. This stripping technology offers significant advantages for manufacturers who need to remove organic coatings from parts and assemblies.

Since 1997, OSHA and the EPA have issued regulations that place serious restrictions on the use of methylene chloride, the solvent used in most cold stripping operations and which poses regulatory, environmental, health and safety drawbacks. The main goals in developing this new stripper were to meet regulatory restrictions, and to surpass the performance of traditional industrial strippers now in use.

This new technology,* is able to deliver the equivalent or superior performance with respect to conventional chemical strippers (highly alkaline or acidic) at lower temperatures. It offers the following features and advantages:

Diphase System

The new paint stripper combines solvency and alkalinity actions associated with conventional chemical strippers. Circulation is needed because it is a diphase system. The greater the circulation, the faster the stripping time. Proper circulation can reduce strip times by approximately 30 percent.

There are various methods available for effective monitoring of the bath solution and performance. Because of the diphase nature of the product, performing a split test can control the process. This test involves sampling the circulated bath (taking enough product to fill a 100-mL graduated cylinder), allowing it to settle for approximately 30 min. The sample should then exhibit a split.

A distinct top layer on the graduated cylinder should be observed to end at the 55-mL mark, and a second distinct layer should begin after that (45 mL total bottom amount). If the top or bottom layers do not reflect these amounts, the bath is replenished until the correct ratio of 55:45 is obtained.

A second way to control the bath is to determine its total alkalinity. Replenishment is necessary if the titration points fall below a certain number. To make up volume lost during processing, the two components are added at a 1:1 ratio after confirming the control values—diphase nature and total alkalinity.

Paint Stripper Systems Comparison

The new multi-metal paint stripper was compared to other low temperature alkaline strippers on steel substrates. For aluminum and galvanized substrates, a methylene chloride-based stripper and a hot alkaline stripper were used for comparison.

Several panels of these various substrates were powder-coated with four different types of powder paints at three levels of dry film thickness. The panels were pretreated with a molybdate-accelerated iron phosphate before painting. The tested paint systems included black polyester, black epoxy-polyester hybrid, black polyurethane and black epoxy powder. All powder paints were cured according to the manufacturer's specifications. The stripping operation was performed in a laboratory-scale bath. The time required to achieve 100 percent strip was recorded, using 1, 2 and 3 mils of powder paint panels. The temperature categories were 100, 120, 140 and 160 °F (the data representing strip time for 3 mils of paint are listed in Table 1).

At much lower operating temperatures, the new stripper was comparable to a similar low-temperature alkaline stripper for removal of all paints tested. At higher temperatures, the epoxy, which is the most difficult to strip, was removed faster by the new stripper. The new stripper removed polyester faster as well.

An additional study was performed to evaluate performance time. The new stripper was compared to a methylene chloride-based stripper and a hot alkaline stripper on alumi-

* Eurostrip, Oakite Products, Inc.

Feature	Advantages
Operating temperatures of 100°–140°	Lower energy costs
No reportable SARA 313 ingredients	Cost-savings related to handling and disposal
Milder pH, and high flash point	Safety and health advantages
Multi-metal safe (*e.g.,* aluminum, brass, copper, steel and stainless steel)	Eliminates the use of two products in industries where multi-metals are processed
Methylene chloride-like stripping mechanism (paint peels off in layers)	Allows for recycling, decreases waste volume and ensures long bath life
Easy to use and control	Lower processing cost

	Low Temperature Alkaline Stripper				New Stripper			
Paint	**100°**	**120°**	**140°**	**160°**	**100°**	**120°**	**140°**	**160°**
Epoxy	120	40	13	10	60	30	7	5
Hybrid	25	15	9	7	27	25	8	6
Polyurethane	24	16	8	5	17	8	6	5
Polyester	23	13	10	6	45	15	6	3

Table 1
Time in Minutes Required for Complete Stripping of Three Mils of Powder Paint on Steel Substrate at Various Temperatures (°F)

num panels. The same four types of powder paints were used at a dry film thickness of 3 mils. The hot alkaline stripper was used at 70 percent by weight with mild agitation at 140 and 160 °F. The methylene chloride-based stripper was used at room temperature. It should be noted that the use of the new paint stripper ensures metal compatibility that hot alkaline strippers do not offer. Its unique chemistry makes it safe to use on a variety of substrates. Most non-ferrous metals, such as aluminum and zinc, tend to react with highly alkaline chemical strippers. Traditionally, these metals are stripped in cold systems that employ chlorinated solvents; however, these operations are not desirable because of related toxicity issues and disposal regulations.

The new, methylene chloride-free paint stripper exhibited substantial reduction in stripping time without attacking or discoloring the metal surface (the results are listed in Table 2).

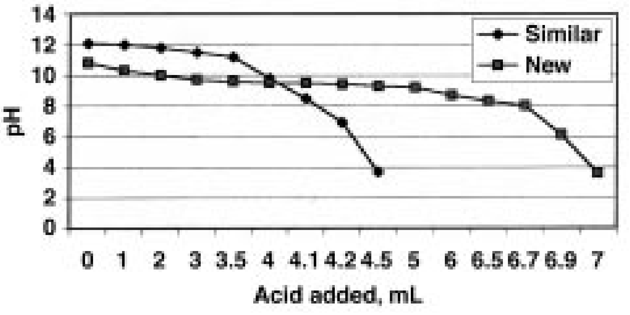
One of the major advantages of the new stripper is that the alkaline aqueous layer contains a strong base with large buffering capacity. To demonstrate this characteristic, titration curves between this new stripper vs. a comparable alkaline stripper were generated (see figure). Sample solutions (100 mL) of one percent by weight of each of the strippers were prepared and titrated with 0.5 N acid to neutrality and even lower.

The new stripper has a lower starting pH compared to the traditional alkaline stripper. Its pH remains more stable, resisting change or loss of alkalinity over a longer period of time and despite increased soil loading. Because it is milder, it can be used on multi-metal substrates in addition to steel.

Effect of Alkalinity

The alkalinity of the stripper varied incrementally from half the standard amount to double. The strip times on polyester powder paint were recorded and are listed in Table 3.

This study demonstrates that the solvent component of the stripper alone works (very slowly), inasmuch as there is some paint removal with no alkalinity. As the alkalinity decreases, stripping effectiveness increases. It was noted that even when



Titration curve of new stripper vs. curve of typical hot alkaline stripper.

Table 2
Time Required for 100% Strip of Three Mils Of Powder Paint on Aluminum Substrate

Stripper	**Temp**	**Polyester**	**Hybrid**	**Polyurethane**	**Epoxy**
Hot Alkaline	140	1 hr	~1 hr	1.5 hr	~4 hr
Hot Alkaline	160	—	—	—	1.5 hr
Methylene chloride	Room	1.5 hr	~1 hr	~3 hr	~4 hr
New Stripper	140	15 min	10 min	5 min	15 min
New Stripper	160	6 min	5 min	3 min	6 min

Different paint strippers & paint systems
Temp °F

the alkalinity is lower than usual, stripping times are almost the same. A surplus of alkalinity beyond the standard amount affects strip times by making them significantly longer.

Effect of Solvent Concentration

The effect of the solvent layer was studied by decreasing the solvent layer from 50 percent (as recommended) to zero percent with water. Panels painted with polyester powder paint were immersed in six different dilution baths. The time required for 100 percent strip is noted in Table 4.

This study demonstrated that there is no paint removal after two hr without solvent action. As the concentration of the solvent increases, so does the stripping time; however, after 30-percent solvent concentration, any increase in solvent has little or no effect on the strip time. The new technology effectively utilizes the synergistic action of the solvent and alkaline components of the formulation.

Findings

The new stripper effectively strips powder paint coatings from many types of substrates, including aluminum, brass, copper and steel at lower temperatures and in a fraction of the time when compared to traditional paint stripping systems. Operation at lower temperature affords many benefits, such

Table 3
Effect of Alkalinity on Strip Times Of Polyester Powder Paint

Alkalinity, mL 1 N HCl	**Strip Time, min**
0	1320
11	3.3
14	3.3
16	4
19.5	4
20.5	4
24	5.3
25	9
34	> 60

Table 4
Effect of Solvent Concentration on Strip Times For Polyester Powder Paint

Solvent, %	**Strip Time, min**
50	5
40	5
30	7
20	12
10	37
0	> 120

as energy and water conservation. Both the alkalinity and the solvent source are necessary for the paint stripper to work. The performance of the paint stripper is comparable to that of conventional chemical paint strippers, namely methylene chloride and hot alkaline strippers.

Future Work

The paint sludge produced is extremely fine and may clog conventional filtering systems, such as filter bags. In order to extend bath life and to optimize the system, ultrafiltration and centrifugal filtration are being evaluated. Development and improvements of the technology continue in the areas of solution controls and metal compatibility.

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Pulse Plating

Continued from page 37

electrochemistry as delineated in the previous paragraph.

The above considerations neglect effects from electroactive species in solution. Such additives usually adsorb or otherwise react with the cathodic surface. They modify the surface by masking or reacting with characteristic areas and effects including halide-induced anodic corrosion (and the reverse, cathodically), specific terrace surface adsorption (driving differential surface growth), and kink or step coordination, which blocks terrace advance, resulting in a different crystal presentation. Many metals behave similarly with certain generic additives but the absolute effects depend on the metals' interatomic dimensions and characteristic lattice-bonding configurations (hexagonal, tetragonal, cubic, etc.). So, the subject of influences of additives on pulse and pulse reverse plating will need to be specific to work done on a particular metal in a particular plating solution with particular plating conditions under the influence of particular additives. P&SF

A Comparative Study of Halogen & Methanesulfonic Acid Electrotinning Processes

Continued from page 56

6. M. Ichiba, H. Kubo & Y. Yomura, *Proc. Sixth Int'l Tinplate Conf.*, 28, London, September (1996).
7. G.A. Federman, D.W. Thomson, M.P. Toben & N.D. Brown, U.S. patent 5,174,887 (1992).
8. R.N. Steinbicker, *Proc. AESF Continuous Steel Strip Plating Symp.*, 175, Dearborn, MI, May 1993.
9. M. Eisenberg, C.W. Tobias & C.R. Wilke, *Chemical Engineering Progress Symposium Series*, Vol. 21, No. 16, p. 1 (1955).
10. B.L. Bramfitt & M.H. Longenbach, *Proc. IMS*, 45, (1969).
11. S.J. Shaffer, J.W. Morris Jr. & H.-R. Wenk, *Proc. Symposium Zinc-Based Steel Coating Systems: Metallurgy and Performance*, G. Krauss & D.L. Matlock, Eds., 129, Detroit, MI., October (1990).
12. CRC Handbook of Chemistry and Physics, 53rd Ed. (1973).
13. J. Lempereur, L. Renard, A. Weymersch & B. Cauwe, Proc. Fourth Int'l Tinplate Conf., 75, London, October (1988).
14. L. Longley, K. Williams & T. Thomas, *Iron and Steel Making*, **24**(1), 90 (1997).
15. R. Winand, *Hydrometallurgy*, **29**, 567 (1992).
16. J.A. Sinsel, R.N. Steinbicker, D.H. Kah & R. Clausius, *Proc. Third North American Tinplate Conf.*, Rosemont, IL, October (1994).
17. H. Ogata, T. Kikuchi, N. Morito & T. Ichida, Proc. Fifth Int'l Tinplate Conf., 316, London, October (1992).
18. B. Colinet, Proc. Sixth Int'l Tinplate Conf., 64, London, (September 1996).
19. N. Kaneko & H. Nezu, *J. Appl. Electrochem.*, **19**, 387 (1989).

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