

# Novel Hybrid Pretreatment For Powder Coatings

By Dr. Maggie Zhu

Formulated with a combination of silicon compounds and metal oxides in a water-based product that is environmentally safe, this proprietary pretreatment is designed to provide consistent performance for a broad range of metals and powder paints.

**Powder coat paint has demonstrated outstanding durability and high performance** when applied on correctly prepared substrates. An effective pretreatment of the metal substrate is a requirement for powder coat paint performance. In addition to performance, pretreatment also impacts cost and the environmental impact of the powder coating process. At the Powder Coating Summit held in Columbus, Ohio, June 18-19 (*editor's note*: see page 29), I presented a comparison of a hybrid pretreatment with other currently available pretreatments. This hybrid pretreatment has been formulated using a combination of silicon compounds and metal oxides in a water-based product that is environmentally safe, and

provides excellent performance and consistency. The information from that presentation is discussed in more detail in this article.

## A Little Background

Historically, two conventional pretreatments have been used: one containing phosphates such as zinc/iron phosphates, and the second containing hexavalent chromium. These have been used for years on multiple metal substrates to promote adhesion of powder coatings. The toxicity and environmental impact of these pretreatments have led to their use becoming increasingly regulated in recent years. Consequently, there has been a push to develop alternative pretreatment technologies which eliminate

chromates and phosphates. A second driver to this change has been the push to reduce costs by reducing energy consumption and waste production. The criteria applied by the powder coating industry for acceptance of a suitable replacement product include:

Adhesion and corrosion resistance is equal or better than conventional pretreatments on a range of metal substrates and under a broad range of powder coats

Contains no hazardous materials such as ( $\text{Cr}^{6+}$ ,  $\text{Ni}^{2+}$  and  $\text{Zn}^{2+}$  etc.) present in the chromate- and phosphate-based pretreatments

The pretreatment process is simpler than phosphating, and uses less energy than conventional pretreatments

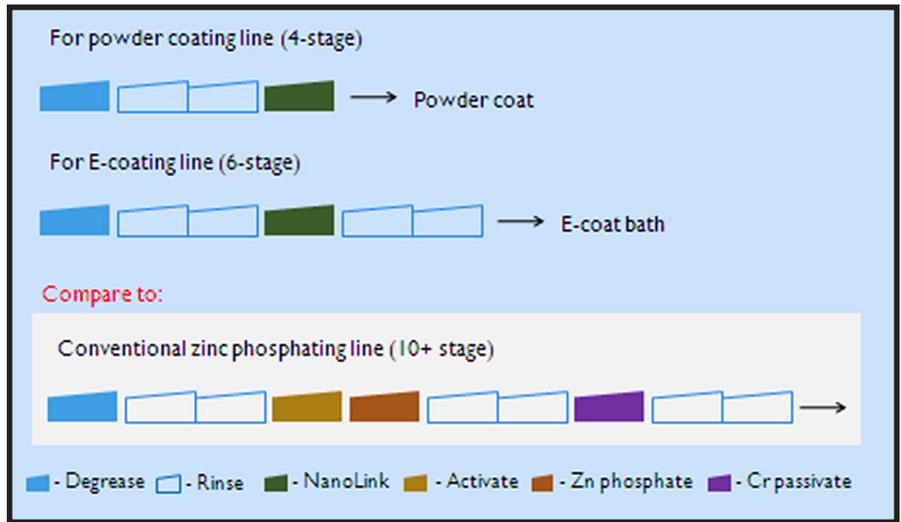
Ecosil Technologies has completed the development of a novel pretreatment technology, called “SILSBOND,” with support of the National Science Foundation Small Business Innovative Research (SBIR) program. The pretreatment products based on this technology have been demonstrated to be an effective replacement for conventional pretreatments in both laboratory and industrial settings.

### Process Comparison

Compared to conventional pretreatments, the application of this proprietary novel pretreatment onto a metal surface is simpler, requiring fewer process stages. Metal components to be treated are first degreased and cleaned, and then are immersed or dipped into a diluted solution for 1 minute at room temperature, followed by drying-in-place. The cleaning and rinse of the metal prior to pretreatment is particularly important for this novel pretreatment due to the much thinner coating thickness, and pre-rinsing with deionized or reverse osmosis treated water is highly recommended.

This is typical for most pretreatments, as stated by Kevin Biller, who says that “Powder coatings are the premier technology for exceptional durability and corrosion resistance, however all bets are off if the substrate is not adequately cleaned and pretreated. I have witnessed colossal failures of perfectly fine powder coatings due to inadequate metal preparation.”

No deionized water post rinse is needed for this novel pretreatment, which is a required step for



**Figure 1.** This figure shows the comparison of process layout between Ecosil's proprietary novel hybrid pretreatment and conventional zinc phosphate.

all conventional pretreatments and for most non-phosphate pretreatments such as zirconium-based pretreatments. Figure 1 compares the process configuration of a SILSBOND pretreatment line with a conventional zinc phosphate line. This shorter process provides reductions in

both capital and operating costs, and reduces the floor space required for the process line. Iron phosphate requires fewer process steps than zinc phosphate, but is still more than required by the novel hybrid pretreatment.

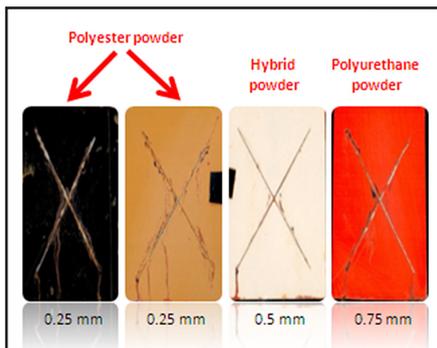
Table 1 compares the novel hybrid coating with phos-

Characteristic	Iron phosphate	Zinc phosphate	SILSBOND coating
pH	4.5 – 5.5	2.8 – 3.5	nat. pH (5.0), pH adjustment not necessary
Composition	Iron phosphates	Phosphates of Zn, Fe, Mn, Ni, Co	Advanced Si compounds, blending with inorganic substances
Temp. (°F)	100-140	105 -135	Ambient
Sludge	Moderate	High	minimal
Post rinse	Very import	Optional	Not necessary
Process	5 steps	> 8 steps	4 steps

**Table 1.** This table shows a comparison of Ecosil's proprietary novel hybrid pretreatment with phosphate-based pretreatments.

Characteristic	Market-leading non-phosphates	SILSBOND coating
pH	4.5 – 5.5	nat. pH (5.0), pH adjustment not needed
Composition	Zr-based, or Silane-based, or Zr/silane mixed	Advanced Si compounds, blending with inorganic substances
DIW post rinse	Needed to eliminate flash rust issue	Not needed, NOT sensitive to flash rusting
Sealing	May need additional sealer to enhance the performance	“Self-sealing”
Process	5 steps	3-4 steps
Corrosion protection	Better than Iron phosphate	Better than Iron/Zinc phosphate

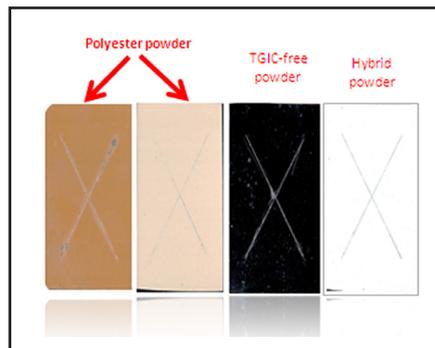
**Table 2.** This table compares Ecosil's proprietary novel hybrid pretreatment to other non-phosphate based pretreatment products.



**Figure 2.** This figure shows powder coated CRS panels after 500 hours of neutral salt spray exposure (ASTM B117).



**Figure 3.** This figure shows powder coated AA 6061-T6 aluminum alloy panels after 3,000 hours of neutral salt spray exposure (ASTM B117).



**Figure 4.** This figure shows powder coated hot-dip galvanized steel panels after 90 cycles of GM 9540P.

phate-based pretreatments from a number of different aspects. In addition to reducing the number of processing steps, it does not need pH adjustment when the process bath is prepared and is effective over a fairly broad pH range of 3-6. Further, the pretreatment bath does not require heating, and produces a minimal amount of sludge. Application can be either by immersion, spraying, or dipping.

Table 2 compares the process requirements of the novel hybrid pretreatment to other commercial non-phosphate based pretreatments. Advantages include no pH adjustment, no flash rust as is often the case with metal oxide (Zr) based formulations, and the multifunctional self-sealing quality. Corrosion prevention has generally been shown to exceed iron and zinc phosphate under powder coatings, and to approach, and in some cases equal that of zinc phosphate with a non-chromate sealer applied.

### Performance Properties

This novel hybrid pretreatment forms an extremely thin nano-structured film that provides excellent paint adhesion

and corrosion resistance of painted metal systems. The coating thickness typically ranges from 10 nm to 50 nm, at least one order of magnitude thinner than conventional pretreatments. This compares to a typical zinc phosphate coating thickness of between 3-5  $\mu\text{m}$ , and a chromate coating of around 1  $\mu\text{m}$ .

Novel hybrid pretreatment has been demonstrated to be a versatile pretreatment that performs well when used on a range of metals and powder coating types. It has also performed well as a sealer to replace chromate sealers on phosphate and non-phosphate pretreatment products. Corrosion performance on different metals and with a variety of powder coats are shown in Figures 2, 3 and 4. The paint delamination distances from the scribes are listed below the test panels. All the test panels exhibit little or no paint loss after accelerated corrosion tests. This exceeds the performance of conventional pretreatments and existing silane-based pretreatments that have variable performance when used with different paint types. These test results have been confirmed through

field trials using the novel hybrid pretreatment with a range of powder paints.

### Cost Comparison

A comparison of the cost elements of zinc phosphating pretreatment with the proprietary novel hybrid pretreatment is presented in Table 3. The

	Zinc Phosphating	SILSBOND
Coverage (sqm/kg)	30-40	150-250
Chemical pack	(1) phosphates	SILSBOND
	(2) accelerator	None
	(3) activator	None
Operation temperature	40-45C	Ambient
New pretreatment line investment	> 8 tanks	4 tanks
Labors	5 workers	2 workers

**Table 3.** This table shows a comparison of process cost between the proprietary novel hybrid pretreatment and zinc phosphate pretreatment.

novel hybrid pretreatment offers benefits over zinc phosphating in a number of areas, including a dramatically increased metal surface coverage that reduces chemical usage cost, a simplified chemical pack which reduces cost and the possibility of error in mixing the chemicals, ambient temperature operation which reduces energy cost, reduced waste disposal cost, reduced capital cost, and reduced operating and

labor cost. The estimated annual cost saving ranges from 20 percent to 40 percent compared to the conventional zinc phosphate pretreatment, depending on the specific product and process.

### Conclusion

Like Kevin Biller said at the PC Summit, “The entire powder coating industry is looking for alternatives to the conventional pretreatment technologies that create hazardous effluents. Chromates have been on the radar screen for years and more recently processors are seeking ways to replace zinc and phosphate based chemistries.”

There is simply no question that novel metal pretreatments will continue to lead the way to reduced environmental impact and operating costs of the powder coating process. What is particularly encouraging about

the introduction of this hybrid technology is its ability to provide comparable corrosion resistance to zinc phosphate while also overcoming some of the limitations of earlier phosphate free pretreatment products.

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### Acknowledgment:

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## MINICASE STUDY:



A steel wheel manufacturer that originally used a five-stage iron phosphate pretreatment line with a sealer wanted to reduce energy cost in the third stage, eliminate sludge production, nozzle plugging problems and to improve rinse water quality. By changing the cleaner/pretreatment combination, and applying the proprietary novel hybrid pretreatment as a sealer, the customer successfully eliminated sludge and nozzle plugging, eliminated heat in the pretreatment stage and achieved cleaner rinse water (lower conductivity). Performance of 1,000 hours of salt spray exposure was achieved with this process.