

Development of a Novel Bumper Adhesion Promoter

Corky KAMEI*

Kazuo IGARASHI*

Michael WISEMAN*

ABSTRACT

A new type of adhesion promoter for bumper painting was developed to eliminate conventional primer spray application. The importance of this new material allowed for reduced cost and improvement in process efficiency. The new adhesion promoter is a waterborne emulsion incorporating chlorinated polyolefin, a key enabler of adhesion of base coat to thermoplastic olefin. As a consequence of the material design, the adhesion promoter can be applied as a final rinse, resulting in the primer spray application to become unnecessary. Furthermore, the primer spray booth became available for additional topcoat application, increasing production volumes. Overall, this material has proven to meet rigorous testing, and has been successfully implemented in mass production.

要 旨

バンパ塗装ラインにおいて既存のプライマ塗装工程を廃止することでコストを低減すると共に効率を向上させるために密着付与剤を開発した。

これは熱可塑性オレフィン樹脂の密着に大きな役割を果たす塩素化オレフィンを含有する水系エマルジョンである。これを水系脱脂の最終工程で塗布することでプライマ工程が不要になり、プライマブースを上塗りブースに転用することで大幅な増産が可能となった。

この材料を用いた塗膜は各種の厳しいテストにおいて良好な性能を示した。

1. Introduction

In the past five years, there has been a large move towards using thermoplastic olefins (TPO) substrates by OEMs for bumper fascias. The drive towards lower cost, reduced weight, and higher environmental consciousness has been paralleled by coatings materials development.

In general TPO, having low surface energy, is a difficult substrate to paint while meeting severe exterior specifications. Earlier systems used trichloroethane vapor (TCE) to clean and swell the substrate in order to accept paint materials. Due to environmental regulations, and hazardous nature of TCE, solvent washing has virtually been eliminated from Japan, North America, and Europe. Since the elimination of the solvent cleaning, various methods have been used to overcome the nonpolar substrate characteristics. Some examples of such methods include, an aqueous degreasing followed by an adhesion promoter, flame treatment, and plasma treatment. However, the overall output of the manufacturer, and the environmental restrictions usually dictate the type of TPO surface activation process.

In North America, the conventional approach to painting TPO bumpers has been aqueous degreasing and then applying a solvent borne primer; followed by base

coat, and clear coat. The cure can vary depending on the substrate materials. However, typical cure is over 100 degrees Celsius. In general, OEM bumper paint process has not changed drastically for several years.

Primers have been the source of attack due to the typical high VOC content, and the lack of intrinsic value to the customer. Consequently, the energy to abate VOC and to apply the paint is a burden that no OEM desires. Currently, waterborne primers are available, and have been used successfully. These waterborne systems still require an application step that is energy consuming. OEMs, paint, and substrate suppliers have researched various methods to change primer application.

Although there has been a desire to eliminate primer, the majority of the research has been focused on making base coats directly adhere to TPO. Unfortunately, this approach has two main concerns. First, each base coat color development would potentially be affected to enable direct adhesion to the substrate; less freedom in color selection. This becomes a very difficult task when considering the number of colors and the frequent color and model changes. Second, TPO is naturally nonconductive. This would reduce base coat application transfer efficiency, the most costly item. Most attempts to eliminate primer spray application have been ineffective or unreasonable.

* Honda R&D Americas, Inc.

2. Function of Primer

Primer has three functions: to promote adhesion, to assist in appearance, and if necessary, to promote conductivity for high volume situations.

In general, TPO has a low surface energy, preventing paint to adhere properly. Both additives in the substrate and primer allow for chemical and mechanical bonds to occur. The primer contains chlorinated polyolefins that have both functions as a long chain polymer to entangle itself with the TPO, and chemically reactive sites for chemical bonds.

Appearance of the bumper is generally noted after the application of the topcoat. The appearance can be defined in two different ways: color and smoothness. Although the topcoat has a major role in the final appearance, smoothness and color below the base coat may influence the outcome in mass production.

Since TPO is naturally nonconductive, primer can add function as a conductive base. Therefore, the base coat and clear coat transfer efficiency increases by means of electrostatic application; optimizing the materials cost. However, this may be a function of the operating parameters. Therefore the spray methods and the operator efficiency plays a critical role. In general conductivity and transfer efficiency is dependent on the various manufacturing demands specific to each facility.

3. Development Approach

Adhesion promoters for TPO have three key resins: Chlorinated polyolefin (CPO), Polyurethane (PUR), and Acrylics. Most importantly, CPO penetrates into the TPO to achieve the necessary adhesion. The other two key resins, Polyurethane and Acrylics have film building and reinforcing function. Figure 1 illustrates the resin system concept. Solvents carry these resins. For HX, mostly water is used and a small amount of other solvents. In addition, some additives are necessary for smooth mass production, such as a defoamer. The HX formulation breakdown is clarified in Figure 2.

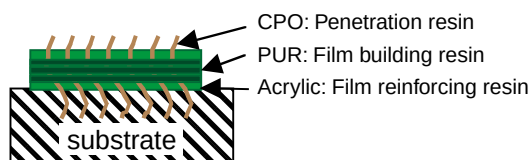


Fig.1 Schematic of resin function

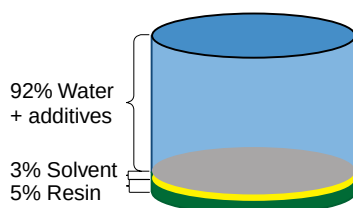


Fig.2 HX formulation

The main function of HX is to promote adhesion of base coat to substrate. By testing a variety of resin combinations, a window was developed for the resin ratios. This window is quantified in Figure 3. In addition to the resin balance, the total resin content was formulated for optimal physical properties and appearance; demonstrated in Table 4. Tests determined that the Acrylic resin should be around 10% of the resin content, and the remaining should be the CPO and PUR for best gasahol resistance, and good adhesion. Additional testing showed that higher resin content resulted in better adhesion. However, the higher solids level changed the wetting properties of the materials, leading to sagging appearance failures, shown in appearance column of Table 5.

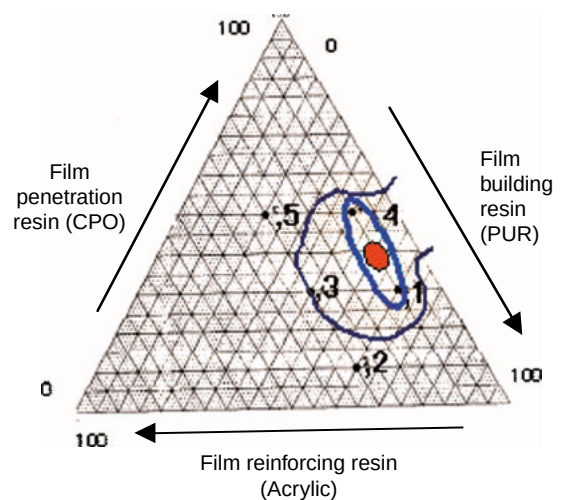


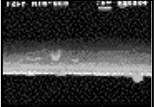
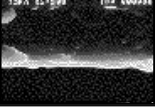
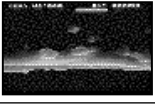
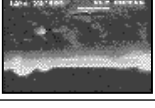
Fig.3 Resin ratio investigation

Table 4 Confirmation of various resin ratios

Formulation	Resin	Resin wt%	Initial adhesion on 90°	Initial adhesion 45°	Hot water 80°Cx3hr	Gasahol (E10)
①	CPO Acrylic PUR	30 10 60	100/100	25/25	100/100	120min
2	CPO Acrylic PUR	10 30 60	100/100	25/25	100/100	21min
3	CPO Acrylic PUR	30 30 40	100/100	25/25	100/100	55min
④	CPO Acrylic PUR	50 10 40	100/100	25/25	100/100	120min
5	CPO Acrylic PUR	50 30 20	83/100	25/25	98/100	45min

Mass production trials further tuned the materials to meet optimal appearance. Evaluation of the surface after HX application determined the roughness should be less than 1.0 μ m. The trials and microscopic investigations, in Table 5, resulted in the final HX resin concentration to be 5 weight percent

Table 5 HX Solids versus appearance

%NV HX	Microscope photo	Film thickness	Appearance		Adhesion		Overall
			dry HX only	HX + topcoat	100/100 90°cut	25/25 45°cut	
2%	cannot measure	—	OK	OK	OK	OK	OK; meets expectations
4%		0.20μm	OK	OK	OK	OK	OK; meets expectations
6%		0.40μm	Acceptable	OK	OK	Very Good	OK; meets expectations
8%		0.75μm	Not good	Not good	OK	Very Good	Not good; not acceptable
10%		1.25μm	Not good	Not good	—	—	—

At the 5% HX solids concentration, the physical properties were acceptable on current regular modulus TPO, “A”, and on high modulus TPO, “B”, with a functional group additive. This functional group is an additive to assist in paint adhesion. Accordingly, the high modulus TPO without the functional group additive, substrate “C”, showed some adhesion weakness. Table 6 shows the comparative results and substrate “C” with failures in high pressure washing and gasahol tests. Therefore, for future model developments and high modulus tool design, the high modulus TPO with the functional group additive is recommended. This functional group additive is currently used, and is adaptable to high modulus TPO without changing the physical properties drastically.

In addition to physical properties, accelerated

weathering results were positive. For this research, typically incorporated UV absorbers, and hindered amine light stabilizers were removed from the topcoat formulations, to instigate degradation of the paint system. Without the UV package, the HX layer had no protection against weathering. However, as Figure 7 shows, there was no significant degradation of appearance, or adhesion. The concluding formula was set to meet physical properties as well as show a smooth appearance, and good workability. Although UV absorbers, and hindered amine light stabilizers were removed for testing, they are critical additives for the overall protection from weathering of color and durability of the paint. This accelerated testing showed that the HX material would not adversely be affected by UV penetration in a worse case scenario.

Table 6 Physical properties confirmation

Test materials				Adhesion		High pressure wash (n=2)	Water soak		Humidity		Gasahol (min)
Substrate	Primer	Topcoat		90°	45°		Appearance	Adhesion 90°	Appearance	Adhesion 90°	
Specification				100/100	>20/25	0mm	>8VS	100/100	>8VS	100/100	>30min
Current substrate	A	5% HX	Beige metallic	100/100	25/25	0mm	8VS	100/100	8VS	100/100	60min+
High modulus with functional group	B	5% HX	Beige metallic	100/100	25/25	0mm	8VS	100/100	8VS	100/100	60min+
High modulus no functional group	C	5% HX	Beige metallic	100/100	13/25	12.5mm	8VS	100/100	8VS	100/100	8min

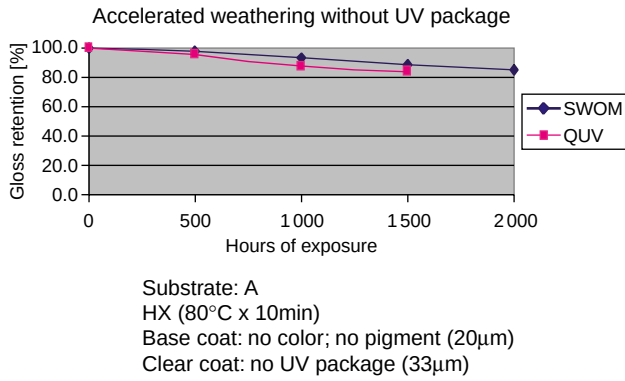


Fig.7 Weathering

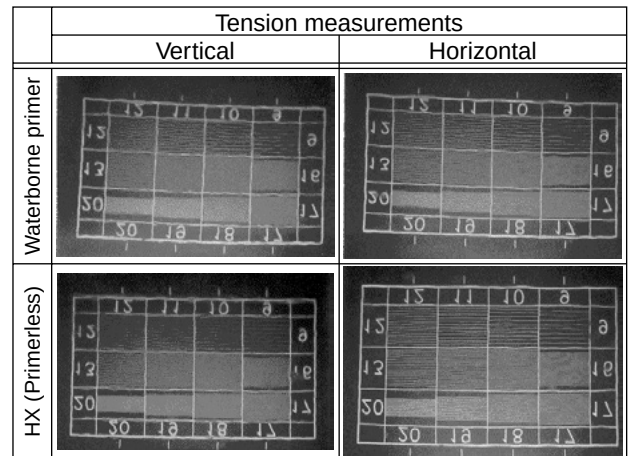
4. Test Results

Both bumpers and test plaques were evaluated according to the Bumper Coating Specifications, on current bumper substrate (A) and high modulus with functional group (B) met current levels of chemical, physical, and weathering properties.

HX was developed to meet rigorous exterior physical properties. However, appearance, could only be measured accurately on line under mass production conditions. Appearance requirements were set to be equivalent to the original primer system. Base coat hiding power and color were not affected by the lack of color by HX. All colors on the current pallet were tested by filmbuild wedge method, where higher amount of paint is applies to one end compared to the other to show a gradient in film thickness. Figure 8 illustrates the certain film thickness of the paint will hide the substrate or black and white indicator below. The definition each

hiding point is dependent on the color of the base coat, and the color of the substrate below. The “process hiding”, “black and white hiding”, and the “line film thickness” were defined for a variety of colors. In most cases the current base coat application was sufficient to hide the substrate color. Therefore, matching the color of body to bumper and base coat material usage was not a concern.

Another appearance related issue was the leveling ability and smoothness of the bumper surface after topcoat. Under mass production environment, the HX bumpers showed an equal or improved appearance according to tension measurements. In Figure 9, the tensionmeter photographs determine the DOI by the



Judgement Criteria

Clarity indicated DOI in these photos. Non continuous lines indicate the DOI rating

Fig.9 Appearance-tensionmeter measurements (D.O.I.)

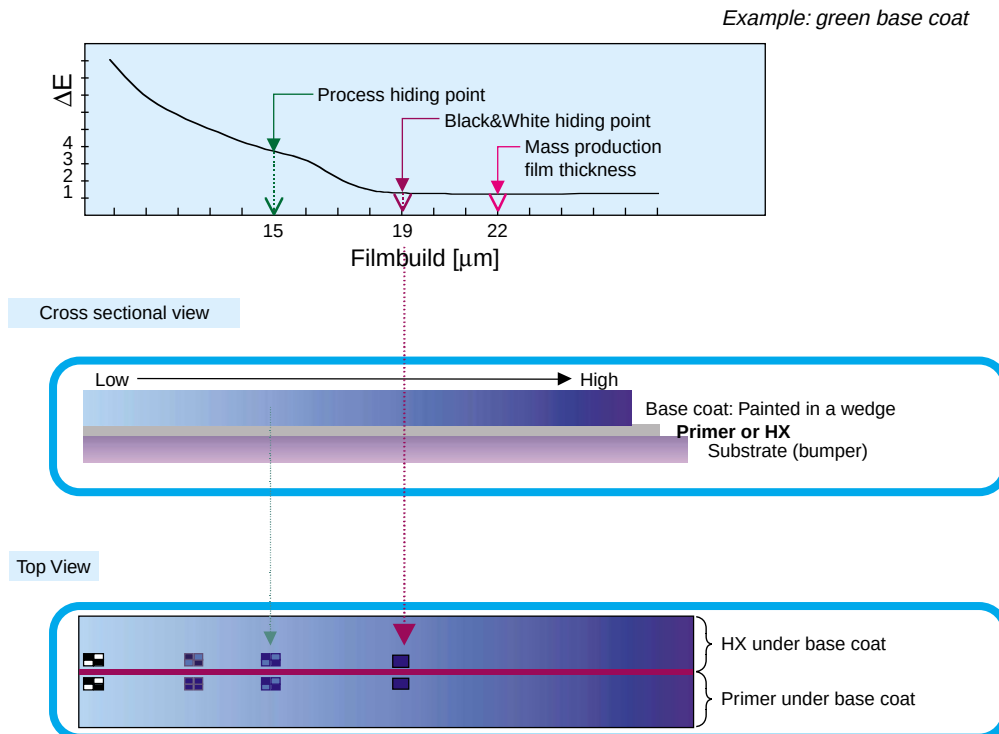


Fig.8 Appearance-hiding

degree of clarity of the lines photographed. Experts judged visual appearance, and all agreed the appearance meets or exceeds current mass production bumpers.

5. Application Process

The material properties and the design of the formulation allow HX to be applied similar to a final rinse. These attributes include the viscosity, and solids content. In conventional North American mass production processes bumpers are cleaned by aqueous power wash. As a final stage of pretreatment before topcoat, a surface conditioner is applied to aid in the uniform removal of water from the substrate. It is in this stage that HX can be applied instead of surface conditioner. The HX solids concentration is such that the material wets evenly. Also, the solution in HX is mostly water; greater than 90%. Therefore, the liquid properties also behave similarly.

Another benefit to the HX material is the ability to be recycled. Material not deposited on the surface of the bumper is recollected and reapplied. In addition, the degradation of the material is monitored and controlled. This effectively keeps waste and cost low.

After the HX is poured throughout the part, it is cured at 80 °C for 10 minutes. The heat allows the material to dry and function as an adhesion promoter for the base coat. Furthermore, this cure fits into current hot air blow after pretreatment to dry off the bumper prior to paint. No additional equipment is necessary to cure the HX.

Conceptually, as Figure 10 shows this process is simple. HX adhesion promoter being applied within pretreatment allows for current primer areas to be converted into more valuable topcoat areas. The cost of rerouting the conveyors and added application equipment is far less than a new line build.

6. Conclusion

HX adhesion promoter was shown to have excellent physical properties. The primary development was around the resin content and concentration. The developed material meets current requirements and performance of mass production bumpers for physical properties. Controlling the resins enabled appearance to be optimized to meet targets.

Currently, the mass production process has achieved the goals set forth. A dramatic increase in production capacity, and decreased unit costs, has proven this materials development a success. In addition unit emissions of VOC were reduced due to the elimination of the primer spray. In conclusion, Honda strives to be the industry leader of environment and process efficiency.

7. Acknowledgements

The HX system would not have been possible without the contributions by Honda of America Manufacturing Technical Planning, Honda de Mexico, and Nippon Bee Research of America.

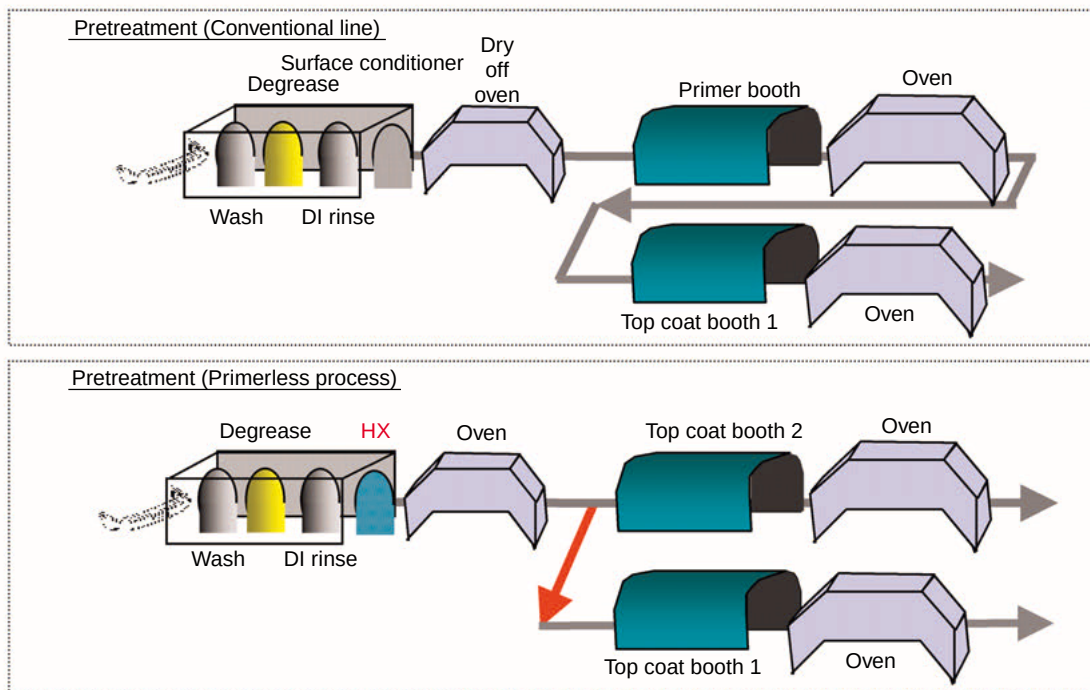
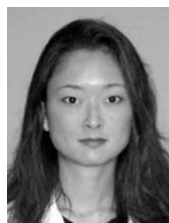


Fig.10 Process Comparison

■ 著 者 ■



Corky KAMEI



Kazuo IGARASHI



Michael WISEMAN