An Introduction to Autophoretic® Coatings

Now part of the

AQUENCE

Coatings Technology Platform
What is autodeposition?

Autodeposition is a method of applying a layer of anti-corrosive paint to metal using a chemical reaction. Henkel provides autodeposition products under the brand names Autophoretic® Coating Chemicals and Aquence® Coatings Chemicals.

The autodeposition process has been in commercial use since 1975, and has grown to include more than 130 commercial installations in 22 countries. Since its inception, this simple and reliable industrial coating process has coated billions of square feet of surfaces for a wide variety of applications.

There are as many similarities to electro-less plating and conventional painting techniques. Electro-less plating provides many unique features that enable the coating of components not possible by other systems.

How does autodeposition work?

The process consists of four basic steps:

1. Clean the metal
2. Apply the coating
3. Rinse off any unreacted material
4. Oven dry

The unique step is the coating bath itself, where a dispersion of a paint emulsion at low solids (usually around 4-6% w/w) is made. A “starter” solution of acidified ferric (Fe³⁺) fluoride is added to the bath. The coating emulsion is stable in the presence of ferric ions, but unstable in the presence of ferrous ions (Fe²⁺). Therefore, if ferrous ions are produced at the surface, local paint deposition will occur on the metal surface, which is then baked to produce a coating. This process is illustrated in Figures 1 and 2.

If you immerse a component made from ferrous metal (shown as the grey oblong above) into the bath, there is surface attack from both the ferric fluoride and the acid. This results in the liberation of ferrous ions that will destabilize the emulsion locally at the metal surface, causing the paint layer to be deposited.

Figure 2 illustrates iron trapped in the deposited paint film so that the deposited coating is made up of latex (emulsion), pigment and iron. This unique combination is the reason autodeposition coatings provide an exceptionally hard, yet flexible, coating. The deposited iron gives a pencil hardness of 5-6H, yet the coating will not crack even when folded and crimped to 0-T bend.
How do I control the coating thickness?

Coating thickness is controlled in a number of ways. Because the coating depends on the diffusion of ferric ions to the surface and ferrous ions from the surface, the deposition rate slows down over time and will self-limit to a certain extent, as illustrated in Figure 3.

This process is not the only way of controlling the coating thickness. Mixers are used in the paint bath to agitate the bath and bring fresh chemistry to the surface. This means that increasing or decreasing the mixer speed can significantly affect the number of microns deposited.

The deposition rate also can be impacted with the addition of an activator to increase the reactivity of the bath.

An interesting feature of the process is the stability of the bath. There are no heavy anti-corrosive pigments in the bath to cause sedimentation. The acidic nature of the bath also means it does not suffer from bacterial attack. This means that the ACC® bath can be left without agitation; for example, over shut down periods without harm.

The typical process

Autodeposition lends itself to production using chain conveyor systems, hoist systems and “power and free” mechanisms. Theoretically, no electrodes are necessary for the process so flood coating is possible.

A typical autodeposition coating process consists of seven stages plus oven curing:

1. Alkaline spray cleaner
2. Alkaline immersion cleaner
3. City water rinse
4. De-ionised water rinse
5. Autodeposition immersion
6. City water rinse
7. Reaction rinse

Oven cure, depending on ACC product type.

A photograph of a typical programmable hoist line is shown in Figures 4 and 6. A schematic of a typical conveyor line is shown on the front cover, as well as in Figures 5 and 7.

What performance can I obtain?

Performance depends of the product type and requirements. For example, ACC 800 Series is a low-bake product widely used for metal, rubber and plastic composites. ACC 900 Series is designed for use in areas subjected to higher operating temperatures, and is suited for use as a primer under powder coatings and liquid baking enamels.

Typical performance properties are listed in Figures 8 and 9. Performance is affected by many variables, including surface cleanliness, rust and surface hardness. Therefore, Henkel provides a free test coat of components, enabling customers to evaluate the process and its performance.
Typical autodeposition equipment layout for hoist operations

Figure 4

Typical autodeposition equipment layout for conveyor operations

Figure 5
Typical programmable hoist installation

Figure 6
Photograph courtesy of the Autocoat Company Limited, UK

Typical monorail conveyor installation

Figure 7
Typical product performance characteristics of ACC® products

**Figure 8 (Metric)**

<table>
<thead>
<tr>
<th>TEST</th>
<th>Autophoretic® 915/E3</th>
<th>Autophoretic® 866/2150</th>
</tr>
</thead>
<tbody>
<tr>
<td>RESIN TYPE</td>
<td>EPOXY/ACRYLIC</td>
<td>PVDC</td>
</tr>
<tr>
<td>FILM THICKNESS</td>
<td>15-25 Microns</td>
<td>12-25 Microns</td>
</tr>
<tr>
<td>1mm CROSS HATCH ADHESION</td>
<td>NO FAILURE</td>
<td>NO FAILURE</td>
</tr>
<tr>
<td>GLOSS @ 60°</td>
<td>40 - 80</td>
<td>5 - 10</td>
</tr>
<tr>
<td>PENCIL HARDNESS</td>
<td>H - 3H</td>
<td>4H - 7H</td>
</tr>
<tr>
<td>T Bend Test</td>
<td>1T</td>
<td>0T</td>
</tr>
<tr>
<td>HUMIDITY (1000 HOURS)</td>
<td>PASS</td>
<td>PASS</td>
</tr>
<tr>
<td>WATER SOAK (240 HOURS)</td>
<td>PASS</td>
<td>PASS</td>
</tr>
<tr>
<td>CYCLIC CORROSION SAE J2334</td>
<td>40 cycles</td>
<td>40 cycles</td>
</tr>
<tr>
<td>NEUTRAL SALT SPRAY SCRIBE</td>
<td>500 Hours</td>
<td>500 hours+</td>
</tr>
<tr>
<td>HUMIDITY</td>
<td>1000 HOURS</td>
<td>1000 HOURS+</td>
</tr>
<tr>
<td>TEMPERATURE RESISTANCE</td>
<td>220°C</td>
<td>&lt;120°C **</td>
</tr>
<tr>
<td>CURE TEMPERATURE</td>
<td>Two Zone</td>
<td></td>
</tr>
<tr>
<td></td>
<td>a.65 - 75°C</td>
<td>100 - 110°C</td>
</tr>
<tr>
<td></td>
<td>b.175 - 200°C</td>
<td></td>
</tr>
</tbody>
</table>

Note: Initial cured film performance on UMA 1800 test panels, coated in our laboratories to appropriate DFT. Performance on production parts or other substrates may vary.

**Figure 9 (U.S. Standards)**

<table>
<thead>
<tr>
<th>TEST</th>
<th>AUTOPHORETIC® 915/E3</th>
<th>AUTOPHORETIC® 866/2150</th>
</tr>
</thead>
<tbody>
<tr>
<td>RESIN TYPE</td>
<td>EPOXY/ACRYLIC</td>
<td>PVDC</td>
</tr>
<tr>
<td>FILM THICKNESS (MILS)</td>
<td>0.6 – 1.0</td>
<td>0.5 - 1.0</td>
</tr>
<tr>
<td>CROSS HATCH ADHESION</td>
<td>NO FAILURE</td>
<td>NO FAILURE</td>
</tr>
<tr>
<td>GLOSS @ 60°</td>
<td>40 - 80</td>
<td>5-10</td>
</tr>
<tr>
<td>PENCIL HARDNESS</td>
<td>H - 3H</td>
<td>4-7H</td>
</tr>
<tr>
<td>REVERSE IMPACT</td>
<td>60 - 80 IN-LBS.</td>
<td>120-160 IN-LBS. (0.5-0.7MILS)</td>
</tr>
<tr>
<td>MANDREL TEST (GM9503P)</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>HUMIDITY (1,000 HOURS)</td>
<td>PASS</td>
<td>PASS</td>
</tr>
<tr>
<td>WATER IMMERSION (240 HOURS)</td>
<td>PASS</td>
<td>PASS</td>
</tr>
<tr>
<td>GM 9540P SCRIBE</td>
<td>40 cycles</td>
<td>40 cycles</td>
</tr>
<tr>
<td>SAE J2334 SCRIBE</td>
<td>40 cycles</td>
<td>40 cycles</td>
</tr>
<tr>
<td>NEUTRAL SALT SPRAY SCRIBE</td>
<td>500 hours</td>
<td>500+ hours</td>
</tr>
<tr>
<td>NEUTRAL SALT SPRAY SCRIBE NO SCRIBE</td>
<td>1000 HOURS</td>
<td>1000 HOURS+</td>
</tr>
<tr>
<td>TEMPERATURE RESISTANCE</td>
<td>425°F</td>
<td>&lt;250°F **</td>
</tr>
<tr>
<td>CURE TEMPERATURE</td>
<td>Two Zone</td>
<td></td>
</tr>
<tr>
<td></td>
<td>150-165°F and 350-395°F</td>
<td>210 - 220°F</td>
</tr>
</tbody>
</table>

Note: Initial cured film performance on ACT cold rolled steel panels, ARP10354 to appropriate DFT. Performance on production parts or other substrates may vary.

**Temperature resistance of Autophoretic® Coatings is dependent on exposure duration and airflow conditions. Life cycle testing for parts is recommended.**
New Aquence® Coating Products

Henkel Aquence® 925G is a new epoxy/acrylic urethane coating that provides the performance advantages of autodeposited epoxy-acrylic urethane coatings, and features a lighter color base for top coating with powder and liquid paints.

Applications include any ferrous metal part or structure requiring superior cyclic corrosion protection, thermal stability and good top coat ability. The ability of Aquence® 925G to provide a lighter color primer base and precise film thickness enables decreased paint consumption and improved top coat color control.

**Film Properties:**

<table>
<thead>
<tr>
<th>TEST</th>
<th>Aquence® 925G/E2</th>
</tr>
</thead>
<tbody>
<tr>
<td>FILM THICKNESS (MILS)</td>
<td>0.5 – 1.0 (12.7 – 25.4 µ)</td>
</tr>
<tr>
<td>CROSS HATCH ADHESION</td>
<td>NO FAILURE</td>
</tr>
<tr>
<td>GLOSS @ 60°</td>
<td>30 – 50</td>
</tr>
<tr>
<td>PENCIL HARDNESS</td>
<td>H - 3H</td>
</tr>
<tr>
<td>COLOR</td>
<td>Light to Dark Gray</td>
</tr>
<tr>
<td>REVERSE IMPACT</td>
<td>60 - 120 IN-LBS.</td>
</tr>
<tr>
<td>STONE CHIP (-30° C)</td>
<td>PASS</td>
</tr>
</tbody>
</table>

**Anti-Corrosion Properties:**

<table>
<thead>
<tr>
<th>TEST</th>
<th>Aquence® 925G/E2</th>
</tr>
</thead>
<tbody>
<tr>
<td>GM 9540P SCRIBE (20 Cycles)</td>
<td>Average Total Scribe Creep</td>
</tr>
<tr>
<td>SAE J2334 SCRIBE (20 cycles)</td>
<td>3 mm</td>
</tr>
<tr>
<td>NEUTRAL SALT SPRAY SCRIBE (504 hours)</td>
<td>3 mm</td>
</tr>
<tr>
<td>SALT SPRAY NO SCRIBE (1000 hrs)</td>
<td>&lt;5% Rust</td>
</tr>
<tr>
<td>STONE CHIP (-30° C)</td>
<td>PASS</td>
</tr>
<tr>
<td>HUMIDITY (1,000 HOURS)</td>
<td>NO FAILURE</td>
</tr>
</tbody>
</table>

The information contained herein is based on information believed to by Henkel to be accurate at the date of testing. No guarantee of performance is given. Additional or updated information may be obtained by contacting Henkel Corporation.
Future Aquence® Products

In 2008, Henkel Aquence® 930 coating will debut, delivering enhanced corrosion performance to demanding applications such as vehicle frames and chassis components. Aquence® 930 has achieved 1000 performance hours on Neutral Salt Spray (NSS) testing and performed similar to Cathodic E-Coat (CED) + zinc phosphate pre-treatment on automotive OEM cyclic corrosion tests. This epoxy-acrylic urethane coating has excellent thermal stability, top coat ability and flexibility. Its best-in-class environmental footprint is further improved with even lower Volatile Organic Compounds (VOCs) and the elimination of Hazardous Air Pollutants (HAPs).

**Film Properties:**

<table>
<thead>
<tr>
<th>TEST</th>
<th>Aquence® 930/E3</th>
</tr>
</thead>
<tbody>
<tr>
<td>FILM THICKNESS (MILS)</td>
<td>0.5 – 1.0 (12.7-25.4 µ)</td>
</tr>
<tr>
<td>CROSS HATCH ADHESION</td>
<td>NO FAILURE</td>
</tr>
<tr>
<td>GLOSS @ 60°</td>
<td>30 – 50</td>
</tr>
<tr>
<td>PENCIL HARDNESS</td>
<td>H - 3H</td>
</tr>
<tr>
<td>COLOR</td>
<td>Black</td>
</tr>
<tr>
<td>REVERSE IMPACT</td>
<td>60 - 120 IN-LBS.</td>
</tr>
<tr>
<td>SOLVENT RESISTANCE (MEK )</td>
<td>&gt; 100 MEK-DR</td>
</tr>
<tr>
<td>SAE J400 Gravelometer (-30°C)</td>
<td>Pass ASTM D3170 (2-4A)</td>
</tr>
</tbody>
</table>

**Anti-Corrosion Properties:**

<table>
<thead>
<tr>
<th>TEST</th>
<th>Aquence® 930/E3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1008 hrs NSS, ASTM B-117</td>
<td>Average Total Scribe Creep</td>
</tr>
<tr>
<td>3mm total creep</td>
<td></td>
</tr>
<tr>
<td>40 Cycles GM 9540 P</td>
<td>3mm total creep</td>
</tr>
<tr>
<td>40 Cycles SAE J2334</td>
<td>3mm total creep</td>
</tr>
<tr>
<td>1008 hrs NSS, ASTM B-117 after heat soak</td>
<td>6 mm total creep</td>
</tr>
<tr>
<td>(48hrs in 204°C)</td>
<td></td>
</tr>
<tr>
<td>240 hrs Humidity, D1735</td>
<td>0.8 mm creep from X scribe</td>
</tr>
<tr>
<td>Water soak FLTM BI 104-01</td>
<td>No adhesion loss, 120hrs</td>
</tr>
</tbody>
</table>

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Where is it used?

Autophoretic® Coatings provide the same level of functional performance experienced with baking enamels, electro-plating, electro-coating and powder-coating technologies. Henkel directly maintains or licenses technical, manufacturing and business development support for this unique technology in every region of the world. A sample of typical commercial applications is noted below.

Commercial Market Applications

Automotive Parts
- Shocks/Struts
- Suspension Components
- Brake Components
- Engine Components
- Engine Cradles
- Interior Components
- Steering Components
- Chassis/Frames
- Trailer Hitches/Tow Bars
- Window Brackets
- Seating Components
- Under Dash Brackets
- Safety Restraint Components
- Bumper Rails

Appliance Parts
- Electric Motor Housings
- Condenser Coils
- Compressors
- Heating Radiators
- Brackets
- Pulleys
- Driveshafts

Metal Furniture Parts
- Slides
- Frames
- Chair Bases
- Dividers
- Drawers

Agricultural/Construction Equipment
- Cabins
- Frames
- Wheels
- Track Rollers
- Various Components

Agricultural and construction applications from India, Korea and Europe
What unique benefits will “A-Coat” provide?

The autodeposition coating process has a number of unique features and benefits:

1. **No throwing power limitations**

   Autodeposition is not limited by electrical shielding – wherever the liquid wets, it will coat. At Alf Engineering in Nasik, India, the autodeposition coating line paints chassis frames for the Mahindra Scorpio SUV. Alf Engineering has selected autodeposition coatings to give long term corrosion protection to the inside and outside of the chassis frames.

   *Photo courtesy of Alf Engineering, India*

   For coaters of small parts – particularly Trade Coaters or Job Shops – ACC® can cope with much higher jig (rack) loading, as the process is not affected by electrical shielding or current density problems. Compared to sprayed processes, the benefits of higher jig loading can be extensive. The photograph (below right) shows the high capacity loading that can be achieved with ACC®.

2. **Ability to coat complex assemblies**

   The oven baking schedule for ACC® 866 is 100-110 °C (210–220 °F), a temperature at which most rubber and plastics remain undamaged. This means rubber and metal anti-vibration mountings can be coated without damage to the rubber, and rubber seals remain undamaged.

   *Photo courtesy of Autocoat Ltd.*

   This benefit of ACC® means that complex assemblies can be painted fully assembled rather than as components.
3. Metal profile reproduction

SEM photos show a uniform, tight autodeposited wet film and consistent coating thickness around the edge of a razor blade.

Autodeposition coating conforms to the shape of the metal surface, and is not affected by variances in electrical energy at high and low areas of complex parts. This feature means ACC® provides exceptional edge protection compared to other paint processes. Screw threads often do not require masking when using ACC®, offering a significant advantage over other coatings.

4. Abrasion resistance

Parts subject to heavy mechanical wear will benefit from the ACC® process due to its exceptional hardness of and its direct bond to the metal.

Automotive seat track slide coated with ACC® 866

Because of its exceptional wear resistance, ACC® is used on automotive seat tracks, drawer slides and some applications traditionally served by electroplating.

5. Environmental benefits

ACC® paint products are water based, have very low or no Volatile Organic Compounds (VOC) and can meet all known clean air legislation requirements.

All ACC® paint products contain no heavy metal anticorrosive pigments, allowing for no settlement problems and enabling facilities to be completely closed over shutdowns.

ACC® 800 and 900 series products do not require toxic, heavy-metal based pretreatments and therefore do not contain chrome, strontium, zinc, manganese and/or nickel.

6. Additional benefits

Health and safety
- No flammable or explosive chemicals in process.
- Less risk of employee exposure to process.
- Fewer limitations on process location.

Energy and cost savings
- Lower energy demands because no electricity is needed to drive the deposition of the coating.
- No electrical contact needed.
- Rack build-up is very slow.
- Decreased rack stripping costs.

Conclusion

- The autodeposition coating process is a simple and reliable industrial finishing system. It has a long and global record of providing uniform protective coatings to the automotive, metal furniture, agricultural equipment and appliance industries.
- Autophoretic® and Aquence® Coatings provide remarkably uniform coatings that provide unique advantages, including coating complex metal and non-metal assemblies and conducting post forming operations on coated parts.
- Autophoretic® and Aquence® Coatings are exceptionally hard yet flexible films that compete in functional performance with balking enamels, electro-plating, electro-coating and powder-coating technologies.
- Autophoretic® and Aquence® Coating Products provide unique energy, environmental and worker-friendly
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