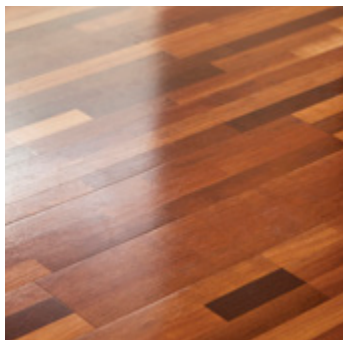


DYNOL™ superwetting surfactants

AN INNOVATIVE PORTFOLIO OF SUPERWETTING SOLUTIONS



**The secret weapon:
DYNOL™ superwetting
surfactants**





.....
**A range of solutions to help you
solve your most difficult-to-wet
problems**
.....

Evonik is an industry leader in offering specialty additive solutions to the coatings, inks, adhesives and various other industries. Our unique defoamers, dispersants and wetting agents provide the formulator with solutions that are quick, efficient and easy to deploy. We are now able to offer an extensive array of superwetters to help you solve even your most difficult-to-wet surface problems. Such wetting challenges are often compounded by application under demanding conditions, such as high coating speeds or rapid drying. Our offerings include both siloxane-based and siloxane-free products, products that provide exceptionally low dynamic and low equilibrium surface tensions and products that can aid in film coalescence.



Superwetting – coating difficult-to-wet substrates

Formulators have long used surfactants to reduce the surface tension of formulations to enable the formulations to wet the surface to which they are applied, whether these are paint formulations applied to dry-wall, ink formulations applied to foil, or adhesive formulations applied to textiles. As the surface tension of water is 72 mN/m, and typical substrate surface energies are in the realm of 35-45 mN/m, in order to reduce the surface tension of aqueous formulations a wide variety of surfactants, whether nonionic, anionic or cationic, are well known and commonly used.

But what happens when the surface tension of the substrate falls well below the typical 35 mN/m range where traditional surfactants are no longer effective? Such low-energy surfaces might include plastic, wood or even poorly prepared or oil-contaminated metal surfaces. For these situations, the chemist often turns to a limited number of options, such as silicone surfactants and fluorosurfactants. However, the

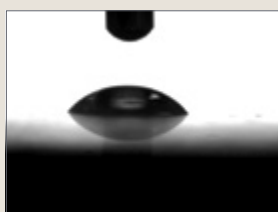
undesirable attributes of these two solutions (such as re-coatability issues or down-stream contamination) make these options less than desirable in many situations.

Figure 1 depicts the extremely low contact angles achieved with a 0.1 wt% solution of organic superwetter DYNOL™ 360 surfactant on low energy substrates compared to a traditional siloxane surfactant often used for wetting. On

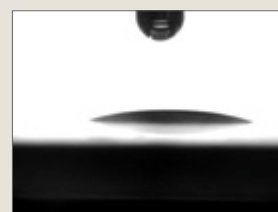
the oily metal surface, DYNOL™ 360 surfactant provided a lower contact angle and superior wetting. Similarly, DYNOL™ 360 surfactant provided low contact angles on other hydrophobic substrates like polyethylene and polycarbonate. The ability of DYNOL™ 360 surfactant to wet the surface very quickly and provide low contact angles allows formulators to develop coatings that can effectively wet out the most difficult-to-wet substrates.

FIGURE 1

0.1% Surfactant aqueous solution, oily metal surface, 10 sec wetting time, 23 °C

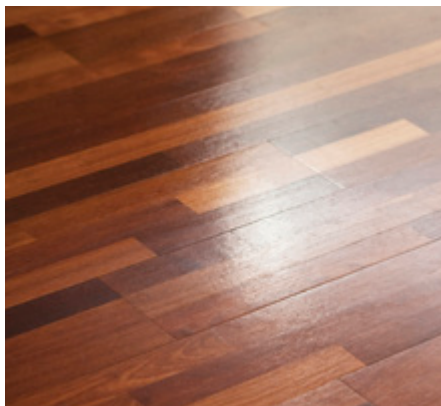


Traditional siloxane surfactant



DYNOL™ 360 surfactant

Don't forget to consider both the dynamic and the equilibrium components of surface tension



Equilibrium surface tension, or the surface tension that is measured when a solution attains an equilibrium state, is a familiar physical property to most

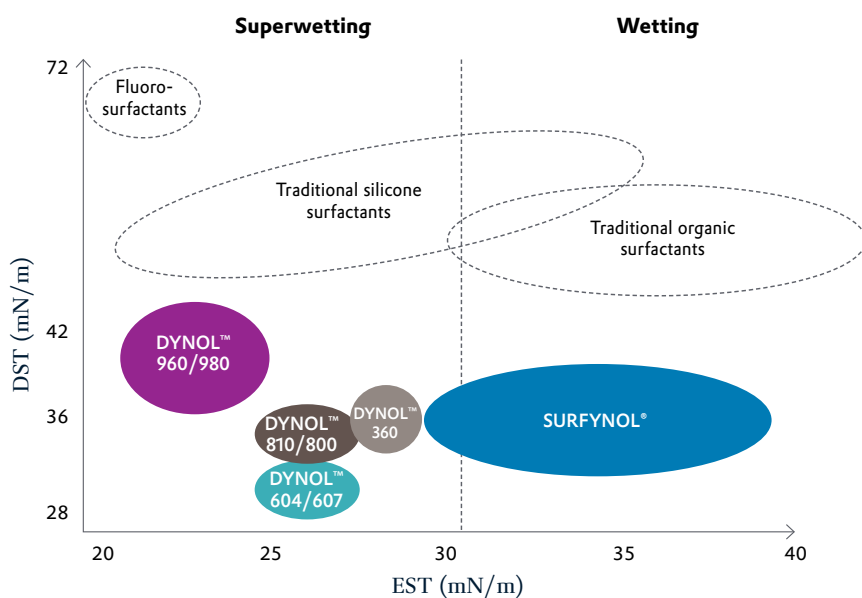
formulators. However most processes are far from equilibrium situations, whether it is a coat of paint being sprayed onto a wall, a fountain solution providing dampening to a printing plate, an adhesive being roller-applied to a release-liner, or even the changes occurring in the last few seconds as a carrier medium evaporates from a coating. For these situations it is the dynamic surface tension that plays a major role in enabling the formulation to perform as intended.

While traditional silicone surfactants and fluorosurfactants can achieve very low

equilibrium surface tensions, their dynamic surface tension reduction is often lacking because they are unable to quickly migrate to the new interfaces that are created under dynamic conditions. Evonik has designed the architecture of the surfactant molecules to offer a portfolio of products that can provide a variety of low equilibrium and dynamic surface tensions. In addition, many of these products have been designed to be no foam or low foam and to aid the coalescence of films by reducing the minimum film formation temperature (MFFT).

FIGURE 2

Comparison of dynamic and equilibrium surface tension behavior of the DYNOL™ superwetter surfactants with that of other well-known surfactants



A PORTFOLIO OF SUPERWETTING OPTIONS TO CHOOSE FROM

Evonik is proud to offer four different classes of superwetters, the DYNOL™ 300, 600, 800 and 900 series. Each of these products has different attributes based on the nature of the superwetting surfactant molecules employed, resulting in a portfolio of superwetters that can solve almost any difficult-to-wet surface challenge.



DYNOL™ SUPERWETTING SURFACTANT FAMILY ATTRIBUTES

COATING TYPE	300 Series	600 Series	800 Series	900 Series
Lowers MFFT/aids coalescence	++			
Flow & leveling				++
Very low/zero foam	+	D604	++	
Siloxane free	++	++	++	
Provides lowest DST	+	++	++	
Provides lowest EST				++
APE free	++	++	++	++

++ Primary recommendations

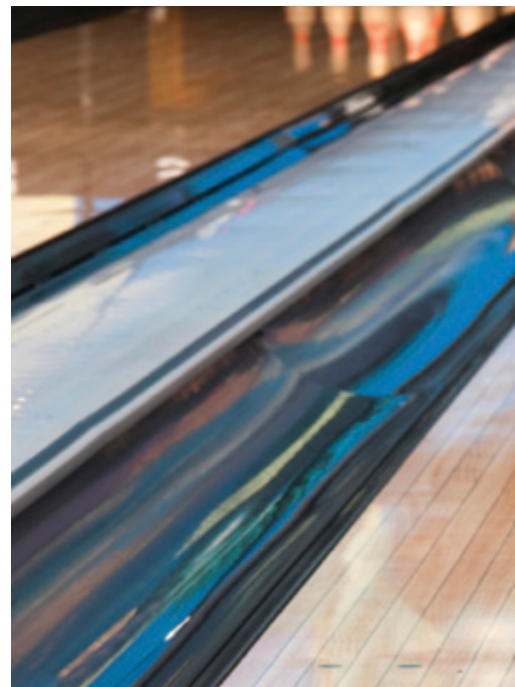
APPLICATION SELECTOR GUIDE

COATING TYPE	360	604	607	800	810	960	980
Wood coatings	++		++	++	+	+	++
Plastic coatings	++			++	+	++	+
Inks and flexible film substrate	+			+	++	++	+
Overprint varnishes					+	+	++
Metal coatings	+		+	+	+	+	++
Adhesives – film & PSA	+		++	+	+		
Adhesives – wood	++				+		
Adhesives – lamination	+			++	++		
Epoxy systems			+	+	++	++	++
Fountain solutions	++		+	+	+		
Curtain coatings	++			++	++	+	+
Primers	+			++	+		
Architectural coatings	++			++			++
Industrial coatings	+	+		+		+	++
Auto – CED	+		+	+			
Auto – primer	+	++	+	++			
Auto – base coat	+	++	++	++	+		
Auto – clear coat	++	+	++	+		+	++
Auto – uni coat	++	+	++	+		+	++
Auto – plastic coat	++	++	++	++	+	+	++
APPLICATION TYPE							
Brush/roller	++			++		++	+
Airless/air assisted spray	+			++		+	++
HVLP/conventional spray	++	++	+	++	++	++	+
Curtain coating			++			+	++
Flow/dip			++			+	++

++ Primary recommendations
+ Secondary options

DYNOL™ 300 SERIES SURFACTANTS

In order to formulate low-VOC waterborne coatings, the formulator must carefully select the optimum wetting package. With less solvent to help flow, leveling, and appearance of the coatings, formulating defect-free systems presents quite the challenge. The DYNOL™ 300 series of superwetting surfactants can be used in a wide range of resin chemistries, including one- and two-component systems. This family of products can be part of your strategy to reduce formulation VOCs by improving coalescence, reducing the minimum film formation temperature and providing excellent substrate wetting without generating foam.

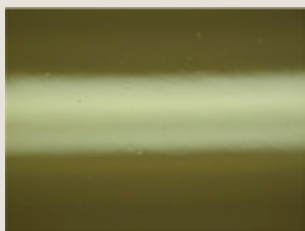


DYNOL™ 360 surfactant

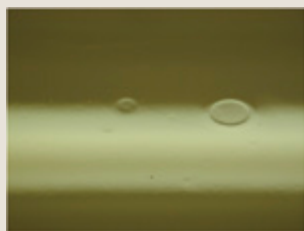
DYNOL™ 360 surfactant is a low-foam, superwetting and coalescing surfactant for difficult-to-wet substrates. This surfactant can aid in the formation of low-VOC coatings by lowering minimum film formation temperature (MFFT). Additionally, DYNOL™ 360 surfactant has broad utility and is recommended for use in many waterborne applications including low-VOC plastic and wood coatings and fountain solutions. This unique, multifunctional additive is designed to provide superior dynamic surface tension reduction and wetting, outstanding defect-free foam control and excellent stability in systems ranging from pH 3–13.

FIGURE 3

Improved properties on polycarbonate



0.99 wt% DYNOL™ 360 surfactant
0.1 wt% silicone defoamer



0.99 wt% silicone surfactant
0.17 wt% silicone defoamer

Figure 3 highlights the poor surface appearance of a typical clear coat formulation on polycarbonate. The surface defects seen with the silicone surfactant/defoamer combination consists of significant cratering in the film. In contrast, the DYNOL™ 360 containing system provides a defect-free and transparent surface while decreasing the amount of needed defoamer.

Figure 4 details how DYNOL™ 360 surfactant can aid in the formulation of low-VOC coatings by lowering the MFFT. The addition of less than 1% of DYNOL™ 360 surfactant to a urethane acrylic hybrid resin provided significant MFFT reduction. Using DYNOL™ 360 surfactant did not detrimentally effect coating performance and it can enable formulators the flexibility to reduce the amount of solvent in their system while maintaining coalescence and excellent physical properties.

Fountain solutions are used in lithographic printing to dampen the printing plate to prevent the non-image area from accepting ink. DYNOL™ 360 surfactant is a more efficient and effective multifunctional wetting agent than the traditional surfactants used in fountain solutions because it can greatly reduce surface tension under both equilibrium and dynamic conditions and control foam better than the traditional surfactants as well. **Figure 5** shows how DYNOL™ 360 surfactant provided better foam control than traditional surfactants while being nonaggressive to the printing press and its components.



FIGURE 4

MFFT reduction in a urethane acrylic clear coat

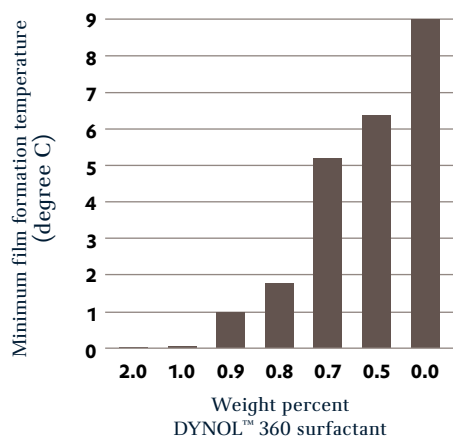
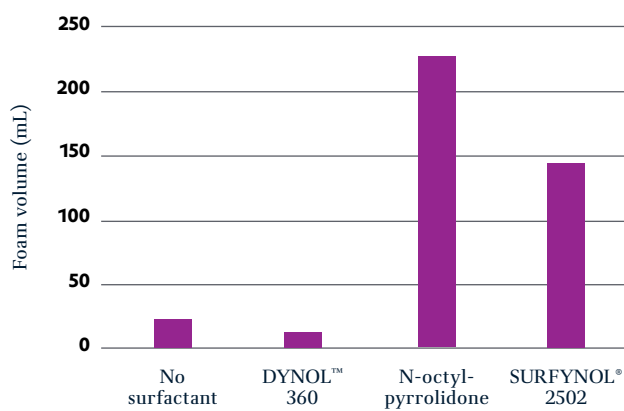


FIGURE 5

Foam control in air sparge test in press-ready fountain solution concentrate (containing 1 wt% surfactant) diluted to 4.7 wt% in water



DYNOL™ 600 SERIES SURFACTANTS

The DYNOL™ 600 series surfactants are designed to provide wetting performance not achievable with traditional surfactants. Their ability to provide low equilibrium and dynamic surface tension and to rapidly migrate to newly formed interfaces during application enables coatings with excellent coverage over low-energy or contaminated surfaces. Additionally, due to their hydrophobic nature, the non-silicone DYNOL™ 600 series superwetting surfactants are lower in foam, eliminate water sensitivity and intercoat adhesion issues often seen with nonacetylenic surfactants.



DYNOL™ 604 surfactant

DYNOL™ 604 surfactant is designed to promote substrate wetting of waterborne systems such as coatings, inks and adhesives by effectively lowering both the equilibrium and dynamic surface tension of aqueous systems at a very low use level. DYNOL™ 604 surfactant can be used in a wide range of resin chemistries including acrylics, 1 or 2 component polyurethanes and even epoxy systems. DYNOL™ 604 surfactant is ideal for hydrophobic surfaces such as old paint layers and treated plastic surfaces and finds multiple uses in automotive applications from electrodeposition coatings to primers to top-coats. In these systems, DYNOL™ 604 surfactant can provide long-lasting defoaming and wetting in a continuous circulating system while providing exceptional application and performance.

Compared to a traditional fluorosurfactant, silicone surfactants or an acetylenic-based SURFYNOL® surfactant, DYNOL™ 604 surfactant can achieve lower dynamic surface tension reduction. Additionally, as seen in **Figure 6**, DYNOL™ 604 surfactant generated less foam than the alternative fluoro-based and silicone-based surfactants and rapidly broke foam that did form to leave a foam-free system.

DYNOL™ 607 surfactant

Based on Gemini surfactant technology, DYNOL™ 607 surfactant offers multifunctional performance as a low-foam wetting agent that can provide the excellent equilibrium and dynamic surface tension reduction associated with the DYNOL™ name while also demonstrating improved ease of incorporation and formulation compatibility over DYNOL™ 604 surfactant. Tests based upon comparative wetting performance data have shown DYNOL™ 607 surfactant to be an excellent replacement to conventional fluorosurfactants and a cost effective, nonpersistent alternative to new fluorosurfactant technology. As shown in **Figure 7**, DYNOL™ 607 surfactant effectively lowered dynamic surface tension and eliminated retraction when the floor polish was applied to PVC tiles with a sponge.

FIGURE 6

Ross-Miles foam comparison of high performance surfactants

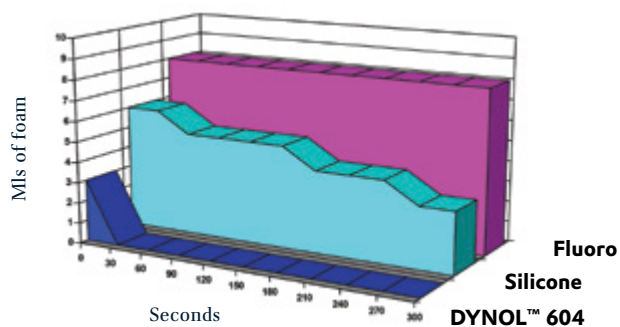


FIGURE 7

Elimination of retraction in floor polish



Fluorosurfactant



DYNOL™ 607 surfactant

Figure 7 shows photographs of a floor polish applied with a sponge to PVC tiles, demonstrating that DYNOL™ 607 surfactant eliminated retraction compared to a fluorosurfactant. The formulation contained an orange dye to facilitate visual observations.

DYNOL™ 800 SERIES SURFACTANTS

The application of waterborne coatings and inks on difficult-to-coat substrates, such as wood, plastics, films and poorly prepared metal surfaces, presents significant challenges to the coatings formulator. The DYNOL™ 800 series surfactants are targeted to maximize wetting and minimize defects like craters, fisheyes, orange peel and pinholes, while controlling foam generation in waterborne coatings, inks and adhesives. Due to their ability to reduce equilibrium and dynamic surface tensions, the 100% active, non-silicone, non-fluorinated DYNOL™ 800 series surfactants are the optimum choice under diverse application conditions.

DYNOL™ 800 surfactant

When coating wood or plastic substrates by low shear methods, DYNOL™ 800 surfactant can provide exceptional performance and a superior balance of properties compared to traditional surfactants. **Figure 8** illustrates a three-coat brush application of a model urethane-acrylic hybrid interior wood coating. By incorporating DYNOL™ 800 surfactant into this formulation, improved wetting plus superior flow, leveling and foam control is achieved compared to the coating containing a traditional silicone surfactant.



FIGURE 8

Brush applied wood coating



No surfactant



With DYNOL™ 800 surfactant



With silicone surfactant

DYNOL™ 810 surfactant

DYNOL™ 810 surfactant is specifically designed for waterborne printing inks and overprint varnishes. As seen in **Figure 9**, DYNOL™ 810 surfactant can be an excellent alternative for difficult-to-wet substrates that require good flow and leveling under high application speeds. DYNOL™ 810 surfactant can provide superior wetting and printability while maintaining excellent foam control over traditional organic, silicone and fluoro-based surfactants when it is used to print on film substrates such as oriented polypropylene or high-slip polyethylene.

Figure 10 illustrates dynamic surface tensions of the DYNOL™ 800 series surfactants compared to a traditional fluorosurfactant, silicone surfactant, and a SURFYNOL® acetylenic diol surfactant.

FIGURE 10

Dynamic surface tension comparison of surfactants

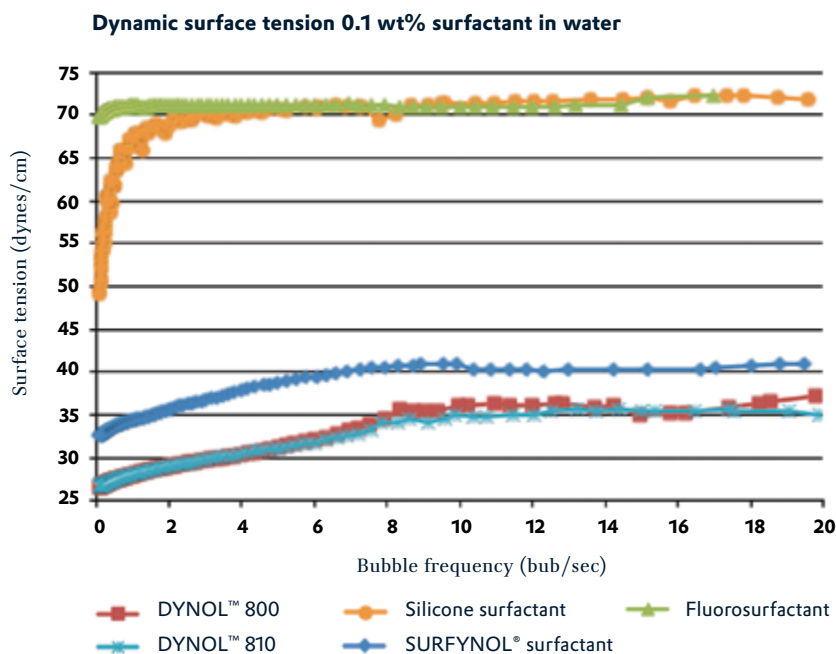


FIGURE 9

Blue packaging ink printed on polypropylene



DYNOL™ 810 surfactant



Fluorosurfactant



Silicone



Organic

DYNOL™ 900 SERIES SURFACTANTS

The DYNOL™ 900 series surfactants are superwetting surfactants based on unique siloxane chemistries. Offering superior equilibrium and dynamic surface tension reduction, the DYNOL™ 900 series surfactants play a critical role in achieving high-quality coatings under certain application techniques such as air-assisted or airless spray applied coatings and ink jet inks. Additionally, the DYNOL™ 900 series surfactants are lower in foam than traditional siloxane surfactants, making them the products of choice for applications where foam cannot be tolerated. Because of their siloxane composition, these two products also provide flow and leveling properties.



DYNOL™ 960 surfactant

For hydrophobic substrates with very low surface energies, it is often difficult to achieve perfect wetting. Efficient dynamic and equilibrium surface tension reduction are key factors affecting final wetting performance. As shown in **Figure 11**, DYNOL™ 960 surfactant offers these wetting benefits together with low foam and excellent compatibility, helping achieve a perfect appearance. **Figure 11** illustrates wetting performance of 1K polyurethane dispersion drawn down on a low surface energy PVC film at a wet thickness of 100µm. Due to the extremely low surface energy of the substrate, competitive siloxane wetting agents did not prevent dewetting of the coating, while DYNOL™ 960 surfactant enabled excellent wetting of this hydrophobic substrate.

FIGURE 11

Surfactant performance in a 1K polyurethane dispersion



Siloxane 1

Siloxane 2

DYNOL™ 960



DYNOL™ 980 surfactant

Many siloxane-based wetting agents for waterborne wood coatings do not provide adequate wetting and produce too much foam. DYNOL™ 980 surfactant, however, can provide the formulator with optimal wetting and formulation compatibility, while contributing less foam as seen in **Figure 12**. An acrylic wood coating containing 0.2 wt% surfactant was spray applied onto wood at a wet film thickness of 100µm. Compared to other siloxane wetting agents, DYNOL™ 980 surfactant offered the best crack filling and lowest foam. The unique nature of DYNOL™ 980 surfactant can provide the formulator with defect-free wetting and premium flow and leveling not observed with traditional siloxane-based surfactants.

Typical Physical Properties of DYNOL™ Superwetting Surfactants

Product	Appearance	Type	Activity (%)	Viscosity (mPa•s, 21°C)	Specific Gravity (21°C)	Flash Point (°C)	Pour Point (°C)
DYNOL™ 360	Clear, colorless to yellow liquid	Organic	100	120	1.00*	175	8
DYNOL™ 604	Amber liquid	Organic	100	290*	0.98*	164	-14
DYNOL™ 607	Clear, yellow liquid	Organic	100	205*	1.00*	244	-13
DYNOL™ 800	Clear, yellow liquid	Organic	100	230*	0.98*	188	1
DYNOL™ 810	Clear, yellow liquid	Organic	100	250*	0.97*	171	-3
DYNOL™ 960	Clear, light yellow liquid	Siloxane	100	66	1.00	157	-10
DYNOL™ 980	Clear, light yellow liquid	Siloxane	100	145	1.01	166	-8

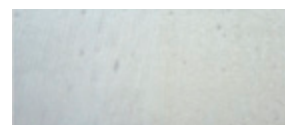
*25°C

FIGURE 12

Acrylic waterbased wood coating spray applied to wood



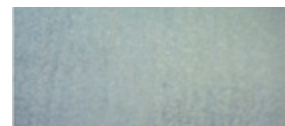
Blank



Siloxane 1



DYNOL™ 980



Siloxane 2

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