

ROSHIELD™ 4000 Resin

Self-crosslinking Acrylic Polymer for Industrial Wood Coatings

Description ROSHIELD[™] 4000 Resin is a self-crosslinking aqueous emulsion polymer that offers excellent early hardness and chemical resistance properties. These properties make it suitable for factory and field applied waterborne interior wood finishes. A key feature of this self-crosslinking technology is that it does not yellow over formaldehyde-emitting substrates and basecoats, which allows its use over a broader range of wood applications than current self-crosslinking acrylic resins. It is recommended as a clear sealer and topcoat, and can also be formulated into pigmented coatings.

Formulations based on ROSHIELD 4000 offer films with excellent appearance, early hardness, and early sandability. Its self-crosslinking chemistry is responsible for the development of excellent chemical and stain resistance.

Features and Benefits

- One-component
- Rapid development of chemical resistance properties
- Non-yellowing over formaldehyde-containing substrates and basecoats
- Excellent durability
- Excellent block and print resistance
- Excellent balance of hardness and flexibility

Typical Physical Properties (These properties are typical but do not constitute specifications).

Property	Typical Values
Appearance	Milky white liquid
Solids (by weight)	40.0%
рН	6.5 - 7.5
Viscosity (Brookfield, #3/30rpm)	50 cP
MFFT	48 °C
Density, lbs/US gal	8.8
Freeze/Thaw Stability	Keep from freezing
Heat Stability (10 days at 140°F)	Passes

Potential Applications

- Fine Furniture
- Office Furniture
- Kitchen Cabinets
- DIY Wood Varnishes
- Wood Floor Coatings
- General Wood Finishes

Performance Data <u>Clear Formulations</u>

Appearance

Clear coatings based on ROSHIELD[™] 4000 Resin have good clarity and appearance. **Figure 1** demonstrates the non-yellowing of ROSHIELD 4000 when applied over formaldehyde-releasing substrates or basecoats. Clear topcoats were applied over an acid catalyzed, solvent-borne alkyd/urea conversion varnish sealer that releases formaldehyde. On the left, the waterborne coating based on an acrylic utilizing an oxidative curing mechanism turns yellow, while at right, the coating based on ROSHIELD 4000 remains clear. The functionality employed in the oxidative curing technology reacts with formaldehyde to give yellow colored byproducts, whereas the crosslinking functionality employed in ROSHIELD 4000 does not.



Figure 1. ROSHIELD[™] 4000 Resin is non-yellowing over formaldehyde-containing basecoats.

Resistance Properties

ROSHIELD 4000 Resin has been evaluated in a clear formulation for general wood finishes and for Kitchen Cabinet Manufacturers Association (KCMA) testing. Table 1 shows the resistance properties of clear coatings based on ROSHIELD 4000 compared to the same waterborne acrylic with oxidative curing mechanism, and several commercial systems, including a nitrocellulose lacquer (NCL), which is the current solventborne coating of choice for wood furniture. ROSHIELD 4000 performs well compared to those systems. The clear coating based on ROSHIELD 4000 is observed to provide excellent resistance to several solvents, including ethanol, isopropanol, butyl acetate and acetone, after 1 hour exposure. In general, the other systems performed poorly in the 1 hour spot tests with these chemicals. The self-crosslinking mechanism in ROSHIELD 4000 has yielded good crosslinking after the one week dry time, building polymer molecular weight and providing better resistance to solvents. The good chemical resistance of ROSHIELD 4000 is also evident in the 16 hour spot tests with the other reagents. The chemical resistance of ROSHIELD 4000 is also better than the acrylic with oxidative curing, demonstrating the higher performance of the new self-crosslinking technology. ROSHIELD 4000 also passes KCMA testing as a self-sealing system, using the same formulation for sealer and topcoat. Table 2 shows results comapring ROSHIELD 4000 to other systems in KCMA testing. All of the systems pass the Shrinkage and Heat Resistance test, as well as the Hot and Cold

Check Resistance test, with no evidence of film failure. Figure 2 compares the MEK resistance of ROSHIELDTM 4000 Resin vs. the coating based on an acrylic with an oxidative curing mechanism. The self-crosslinking in ROSHIELD 4000 occurs rapidly during the cure of the coating.

Hardness Properties

Table 3 compares the systems for block resistance and Table 4 compares hardness and mandrel bend flexibility in clear formulations. Block and print resistance are important properties for an industrial wood coating. Block resistance is a key property during the manufacture and stacking of finished pieces, and print is a key property for instances where objects are placed on the surface of coated wood, such as a piece of furniture once it is placed into service. ROSHIELD 4000 has an excellent balance of block resistance, print resistance, hardness, and flexibility.



Figure 2: The chemical resistance of ROSHIELD[™] 4000 Resin develops faster than the current self-crosslinking acrylic that uses an oxidative curing mechanism, as evidenced by this plot of MEK double rubs versus cure time for coatings on treated aluminum.

Pigmented Formulations

Hardness Properties

Pigmented wood coatings are used in various applications, including architectural painting and factory finishing of articles such as moldings, joinery, and cabinetry. ROSHIELD 4000 Resin was evaluated in a pigmented coating designed to mimic architectural DIY gloss trim paints. **Tables 5 and 6** show data comparing ROSHIELD 4000 to other systems in white trim paint formulations. ROSHIELD 4000 was compared to an oxidative curing acrylic and to commercially available gloss white interior trim paints based on waterborne latex and waterborne alkyd technologies. ROSHIELD 4000 shows improved hardness development and block/print resistance versus the two commercial systems tested, demonstrating the benefit of this acrylic self-crosslinking technology.

Table 1. Comparison of appearance, adhesion, and chemical resistance of ROSHIELD[™] 4000 Resin vs. other systems in a clear gloss formulation (Formulation 4000-1)

Sealer	ROSHIELD™ 4000 Resin	Self- crosslinking acrylic (oxidative cure)	Commercial Waterbased Sealer	Commercial Solventbased NCL sealer	Commercial Solventbased vinyl-modified NCL sealer (uncatalyzed)
Topcoat	ROSHIELD 4000 Resin	Self- crosslinking acrylic (oxidative cure)	Commercial Waterbased Acrylic Lacquer	Commercial Solventbased NCL lacquer	Commercial Solventbased catalyzed lacquer
Gloss , 60°	74	78	52	92	92
Max Decistores	2	2	r	1	
Mar Resistance	3	3	5	1	2
Clarity	dood	aood	dood	aood	dood
Clarity	good	good	good	good	good
Cross Hatch Adhesion	5B	5B	5B	5B	5B
Chemical Spot Tests					
1 hour					
Ethanol	9	5	9	10	8
IPA	8	3	3	1	3
Butyl Actate	3	1	1	1	1
Acetone	9	9	9	1	9
16 hour					
Water	9	9	10	10	10
Hot coffee	10	9	9	10	10
50% Ethanol	10	9	9	10	9
409 Cleaner	9	8	7	10	10
IPA	9	10	9	9	10
7% Ammonia	6	7	5	9	10
Red Ink	8	2	6	9	10
Lemon juice	10	10	10	10	10
Grape juice	10	10	10	10	10
Mustard	5	3	3	5	4

Notes: 1) Chemical resistance rated on a 1 to 10 scale, 10 = no effect. Coatings were conventionally spray applied at 40psi in two coats on maple substrates. Coatings were allowed to dry between coats and sanded using 280 grit sandpaper. Coatings were dried for 14 days before being subjected to the testing. 2) Resistance to common chemicals was evaluated by applying spots of the chemical to the coated panel for a specified time, then cleaning the panel with clean water and a sponge, and drying prior to rating. Chemicals were applied to the horizontal surface by saturating a 2.3cm grade 3 Whatman filter and covering with a watchglass to prevent evaporation.

Table 2. Comparison of KCMA testing for ROSHIELD[™] 4000 Resin vs. other systems in a clear gloss formulation (Formulation 4000-1)

Sealer / Topcoat	ROSHIELD™ 4000 Resin	Self- crosslinking acrylic (oxidative cure)	Commercial Waterbased Acrylic Iacquer	Commercial Solventbased NCL lacquer	Commercial Solventbased catalyzed lacquer
Edge Soak	pass	pass	pass	pass	pass
Chemical Resistance					
Vinegar	10	10	10	10	10
Lemon juice	10	10	10	10	10
Orange juice	10	10	10	10	10
Grape juice	10	10	10	10	10
Ketchup	10	10	10	10	10
Coffee	10	10	10	10	10
Olive oil	10	10	10	10	10
50% Ethanol	10	10	10	10	10
0.5% Palmolive	10	10	10	10	10
Mustard (1 hour)	9	9	8	10	9
Cold Check	pass	pass	pass	pass	pass
Heat/Shrink Resistance	pass	pass	pass	pass	pass

Notes: 1) Chemical resistance rated on a 1 to 10 scale, 10 = no effect. Coatings were conventionally spray applied at 40psi in two coats on maple substrates. Coatings were allowed to dry between coats and sanded using 280 grit sandpaper. Coatings were dried for 14 days before being subjected to the testing.

07/2014, Rev. 1

Table 3. Comparison of block and print resistance for ROSHIELD[™] 4000 Resin vs. other systems in a clear gloss formulation (Formulation 4000-1)

Topcoat	ROSHIELD™ 4000 Resin	Self- crosslinking acrylic (oxidative cure)	Commercial Waterbased Acrylic Iacquer	Commercial Solventbased NCL lacquer	Commercial Solventbased catalyzed lacquer
Block Resistance (7 day dry)					
30 min at 60°C	8	7	5	8	10
16 hr RT	10	9	10	10	10
Print Resistance (7 day dry)					
30 min at 60°C	8	5	7	8	9
16 hr RT	10	10	10	10	10

Notes: 1) 10 mil wet coatings on treated aluminum were dried 7 days before being subjected to the room temperature or 60°C block test. Two 1.5 inch wide strips were cut from the aluminum panel, and placed face-to-face forming a cross. A #8 rubber stopper was placed on the cross-section of the strips, and a 1 kg weight placed on top of the rubber stopper. Block resistance was rated for two conditions, 1) after 30 minutes at 60°C, and 2) after 16 hrs at room temperature. The following 0 to 10 scale was used to rate the coatings for tack and film damage: 10, no tack/perfect; 9, trace tack/excellent; 8, slight tack/very good; 7, slight tack/good; 6, moderate tack/good; 5, moderate tack/fair; 4, severe tack, no seal/ fair; 3, 5-25% seal/ poor; 2, 25-50% seal/ poor; 1, 50-75% seal/ poor; 0, complete seal/ very poor.

Table 4. Comparison of Konig pendulum hardness and mandrel bend flexibility for ROSHIELD[™] 4000 Resin vs. other systems in a clear gloss formulation (Formulation 4000-1)

Topcoat	ROSHIELD™ 4000 Resin	Self- crosslinking acrylic (oxidative cure)	Commercial Waterbased Acrylic Iacquer	Commercial Solventbased NCL lacquer	Commercial Solventbased catalyzed lacquer
Konig Pendulum Hardness (Seconds)					
1 day	37	37	45	74	130
3 days	56	51	65	74	140
7 days	62	61	73	82	145
10 days	75	66	85	86	149
14 days	70	72	84	89	149
21 days	81	75	91	94	148
Mandrel Bend					
Pass Diameter	1/8″	3/4"	3/8″	1/4″	1/4″

Notes: Konig Hardness measurements were taken at various intervals over the course of 3 weeks and evaluated according to ASTM D4366 using a TQC SP0500 Pendulum Hardness Tester, and reported in seconds. Mandrel bend reports the smallest diameter to pass without cracking.

Topcoat	ROSHIELD™ 4000 Resin	Self-crosslinking acrylic (oxidative cure)	Commercial gloss white WB Latex	Commercial gloss white WB Alkyd
Block Resistance (1 day dry)				
30 min at 60°C	6	8	6	2
16 hr RT	9	8	7	2
Block Resistance (7 day dry)				
30 min at 60°C	10	9	10	10
16 hr RT	10	10	10	10
Print Resistance (7 day dry)				
30 min at 60°C	8	8	4	3
16 hr RT	9	9	4	3
Print Resistance (7 day dry)				
30 min at 60°C	9	9	3	1
16 hr RT	10	10	5	2

Table 5. Comparison of block and print resistance for ROSHIELD[™] 4000 Resin vs. other systems in a gloss white pigmented formulation (Formulation 4000-2)

Notes: 1) 10 mil wet coatings on treated aluminum were dried 7 days before being subjected to the room temperature or 60°C block test. Two 1.5 inch wide strips were cut from the aluminum panel, and placed face-to-face forming a cross. A #8 rubber stopper was placed on the cross-section of the strips, and a 1 kg weight placed on top of the rubber stopper. Block resistance was rated for two conditions, 1) after 30 minutes at 60°C, and 2) after 16 hrs at room temperature. The following 0 to 10 scale was used to rate the coatings for tack and film damage: 10, no tack/perfect; 9, trace tack/excellent; 8, slight tack/very good; 7, slight tack/good; 6, moderate tack/good; 5, moderate tack/fair; 4, severe tack, no seal/ fair; 3, 5-25% seal/ poor; 2, 25-50% seal/ poor; 1, 50-75% seal/ poor; 0, complete seal/ very poor.

Table 6. Comparison of Konig pendulum hardness ROSHIELD[™] 4000 Resin vs. other systems in a gloss white pigmented formulation (Formulation 4000-2)

Topcoat	ROSHIELD™ 4000 Resin	Self- crosslinking acrylic (oxidative cure)	Commercial gloss white WB Latex	Commercial gloss white WB Alkyd
Konig Pendulum Hardness (Seconds)				
1 day	19	16	5	5
4 days	33	22	7	11
7 days	46	27	8	15
10 days	57	33	9	18
14 days	67	38	9	19

Notes: Konig Hardness - Measurements were taken at various intervals over the course of 3 weeks and evaluated according to ASTM D4366 using a TQC SP0500 Pendulum Hardness Tester, and reported in seconds.

Formulating Guidelines

ROSHIELD[™] 4000 Resin can be formulated with common additives available for waterborne coatings.

Coalescents

The starting-point formulation contains a blend of coalescent and plasticizers. The plasticizer, in small quantities, gives flexibility to the film without detracting from block properties. A blend of water-miscible and water-immiscible coalescents is recommended for industrial applications. Butyl CELLOSOLVE™ Glycol Ether evaporates quickly and improves the flow of ROSHIELD 4000 while DOWANOL™ DPnB Glycol Ether remains in the drying film slightly longer and ensures good film formation.

pН

For wood coatings, formulating at lower pH helps to minimize grain raising, but can compromise stability. Add coalescents slowly to avoid the formation of grit or gel, particularly when at lower pH values (below pH 8.0). ROSHIELD 4000 should be adjusted to pH=7.5 or below for best formulation practice.

Mar Aids

The addition of Michem emulsion 39235 and Tego Glide 410 offer excellent mar and slip resistance. Levels of 5 - 6% Michem emulsion 39235 and 0.5 - 1% of Tego Glide 410 on polymer solids are recommended.

Flatting Aids

Silica flatting aids, such as Syloid 7000, are recommended for flatting coatings based on ROSHIELD 4000.

Defoamers

Tego Foamex 805 is an effective defoamer for formulations containing ROSHIELD 4000 and does not cause any surface defects. One percent total defoamer (products as supplied) on the total weight of the formulation is recommended. Care should be exercised with high levels of silicone defoamers, as they can cause craters in the film.

Wetting Aids

The addition of an additive such as Surfynol 104DPM offers good surface wetting and reduces the tendency for formulations based on ROSHIELD 4000 to crater or picture frame.

Viscosity Control

ACRYSOL[™] RM-825 or ACRYSOL[™] RM-8W Rheology Modifier can be used in formulations to control viscosity for air-assisted spray, airless spray, curtain coater and roller applications. These products are associative HEUR rheology modifiers and, as such, the addition of surfactants will change the rheology profile of the formulation.

07/2014, Rev. 1

Starting Point Formulation 4000-1

Clear Gloss Wood Topcoat Formulation Based on ROSHIELD™ 4000 Resin

Material Name	Pounds	Gallons
ROSHIELD™ 4000 Resin	626.40	71.06
Premix		
DOWANOL [™] PnB Glycol Ether	16.30	2.21
DOWANOL DPM Glycol Ether	16.10	2.02
DOWANOL DPnB Glycol Ether	25.75	3.37
RHOPLEX™ WP-1 Plasticizer	9.70	1.15
Water	50.0	6.00
Premix Subtotal	117.85	14.75
Tego Foamex 805 defoamer	4.10	0.50
Tego Glide 410 (50% in DPM) mar aid	2.00	0.24
Surfynol 104DPM surfactant	2.60	0.30
Michem Emulsion 39235 wax emulsion	16.40	1.97
Water	91.50	10.96
ACRYSOL [™] RM-825 Rheology Modifier	1.89	0.22
Totals	862.74	100.00
Levels without Additives:	Volume Solids, %:	26.4
	Weight Solids, %:	29.4
	Density (lb/gal):	8.63
	VOC (g/L):	199
Levels with Additives:	Volume Solids, %:	28.7
	Weight Solids, %:	31.6

07/2014, Rev. 1

Starting Point Formulation 4000-2

Gloss White Topcoat Formulation Based on ROSHIELD™ 4000 Resin

Material Name	Pounds	Gallons
ROSHIELD™ 4000 Resin	628	71.24
Water	30.00	3.59
Ammonia (15%)	3.00	0.38
Tego Foamex 1488 defoamer	2.00	0.24
Ti-Pure R-746 titanium dioxide slurry	275.00	14.15
Premix		
Texanol ester alcohol	51.50	6.49
Propylene glycol	5.00	0.58
Water	6.50	0.78
Premix Subtotal	63.00	7.85
ACRYSOL [™] RM-2020 NPR Rheology Modifier	20.00	2.30
ACRYSOL RM-8W Rheology Modifier	2.00	0.23
Totals	1023.00	100.00
Levels without Additives:	Volume Solids, %:	33.2
	Weight Solids, %:	45.7
	Density (lb/gal):	10.23
	VOC (g/L):	166
Levels with Additives:	Volume Solids, %:	33.6
	Weight Solids, %:	46.2

Handling Precautions	Before using this product, consult the Material Safety Data Sheet (MSDS)/Safety Data Sheet (SDS) for details on product hazards, recommended handling precautions and product storage.
Storage	Store products in tightly closed original containers at temperatures recommended on the product label.
Disposal Considerations	Dispose in accordance with all local, state (provincial) and federal regulations. Empty containers may contain hazardous residues. This material and its container must be disposed in a safe and legal manner.
	It is the user's responsibility to verify that treatment and disposal procedures comply with local, state (provincial) and federal regulations. Contact your Dow Coating Materials Technical Representative for more information.
Chemical Registration	Many countries require the registration of chemicals, either imported or produced locally, prior to their commercial use. Violation of these regulations may lead to substantial penalties imposed upon the user, the importer or manufacturer, and/or cessation of supply. It is in your interests to ensure that all chemicals used by you are registered. The Dow Chemical Company does not supply unregistered products unless permitted under limited sampling procedures as a precursor to registration.
Product Stewardship	Dow has a fundamental concern for all who make, distribute, and use its products, and for the environment in which we live. This concern is the basis for our product stewardship philosophy by which we assess the safety, health, and environmental information on our products and then take appropriate steps to protect employee and public health and our environment. The success of our product stewardship program rests with each and every individual involved with Dow products - from the initial concept and research, to manufacture use, sale, disposal, and recycle of each product.
Customer Notice	Dow strongly encourages its customers to review both their manufacturing processes and their applications of Dow products from the standpoint of human health and environmental quality to ensure that Dow products are not used in ways for which they are not intended or tested. Dow personnel are available to answer your questions and to provide reasonable technical support. Dow product literature, including safety data sheets, should be consulted prior to use of Dow products. Current safety data sheets are available from Dow.

Contact:

oomuot.		
North America:	1-800-447-4369	
Latin America:	(+55)-11-5188-9000	
Europe:	(+800)-3-694-6367	
Asia-Pacific:	(+800)-7776-7776	
http://www.dowcoatingmaterials.com		

Notice: No freedom from infringement of any patent owned by Dow or others is to be inferred. Because use conditions and applicable laws may differ from one location to another and may change with time, Customer is responsible for determining whether products and the information in this document are appropriate for Customer's use and for ensuring that Customer's workplace and disposal practices are in compliance with applicable laws and other government enactments. The product shown in this literature may not be available for sale and/or available in all geographies where Dow is represented. The claims made may not have been approved for use in all countries. Dow assumes no obligation or liability for the information in this document. References to "Dow" or the "Company" mean the Dow legal entity selling the products to Customer unless otherwise expressly noted. NO WARRANTIES ARE GIVEN; ALL IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE ARE EXPRESSLY EXCLUDED.



UNRESTRICTED – May be shared with anyone ^{●TM} Trademark of The Dow Chemical Company ("Dow") or an affiliated company of Dow ROSHIELDTM 4000 Resin / Dow Coating Materials

884-00099-0412-NAR-EN CDP 02/2013, Rev. 0