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InChemRez™ Modified Phenoxy Resins PKHM® 30 & -301 for Flexibility and Deep Draw Coatings

InChemRez™ modified Phenoxy resins PKHM®-30, and -301 are members of a series of products with all the high-performance properties of conventional InChemRez Phenoxy resins, such as InChemRez™ Phenoxy resin PKHH and demonstrate enhanced flexibility, even when crosslinked.

Available in solid form as pellets, modified Phenoxy resins PKHM-30, and -301 are soluble in a variety of typical coating solvents but exhibit far lower solution viscosities than Phenoxy resin PKHH.

Modified Phenoxy resins PKHM-30, and -301 contain more primary hydroxyl functionality. They crosslink more efficiently with a variety of crosslinkers to provide films with high chemical resistance without sacrificing mechanical properties, such as toughness and durability.

Like Phenoxy PKHH, modified Phenoxy resin PKHM-301 complies with United States Food and Dr.Jg Administration (FDA) Regulations for formulating protective coatings for use in flexible and rigid food packaging.

Performance Advantages

Modified Phenoxy resins PKHM-30, and -301 offer a number of significant advantages over Phenoxy resin PKHH and high molecular weight epoxy resins in meeting the special needs of formable coatings for the rigid and flexible packaging industry, including:

. Low solution viscosity
. Low glass transition temperature for economical baking and good gloss and leveling
. Extreme flexibility, even when crosslinked
. High formability
. Excellent chemical resistance when crosslinked.

Typical clear coat properties of modified Phenoxy resins PKHM-30, and -301 and Phenoxy resin PKHH are compared in Table 1.

Table 1. Typical Clear Coat Properties of Uncrosslinked InChemRez Phenoxy Resins [1]

Property	PKHH	PKHM-30	PKHM-301
Viscosity[2] at 25% NV, cP	2250	450	656
Tg °C	98	35	45
MEK Rubs	20	20	20
Gloss (60°)	100	100	100
Gloss (20°)	100	100	100
Crosshatch Adhesion, %	100	100	100
Reverse Impact, in-lb	>160	>160	>160
Pencil Hardness	4H	3H	3H
OT Bend	Pass	Pass	Pass

[1] Film Thickness: 0.5 mil (12 microns)
Bake: 400°F (204°C), 10 min (10 min air dry before bake)
Substrate: Cold-rolled steel
[2] In Cyclohexanone

Solubility

InChemRez modified Phenoxy resins PKHM-30, and -301 are readily soluble in ester and ketone-like coating solvents. Aromatic hydrocarbon solvents can be used as diluents together with the primary solvents. Solution viscosities of these modified phenoxies in various solvents and solvent blends are shown in Table 2.

Table 2. Solution Viscosity of InChemRez Phenoxy Resins in Various Solvents and Solvent Blends			
Solvent Blends	PKHH	PKHM-30	PKHM-301
Methyl Ethyl Ketone (MEK)	2	32	50
PM Acetate	720	192	175
Cyclohexanone	572	210	188
Diacetone Alcohol	2600	–	490
PM Acetate/Xylene: 80/20	540	170	136
Cyclohexanone/Aromatic 100: *80/20*	490	175	144
Cyclohexanone/Aromatic 100: *60/40*	420	128	120
Cyclohexanone/ Aromatic 200: *80/20*	650	264	224
Cyclohexanone/ Aromatic 200: *60/40*	890	250	256
Ethyl 3-Ethoxypropinate (EEP)/MEK:*80/20*	390	108	92
Ethyl 3-Ethoxypropinate (EEP)/MEK:*60/40*	255	110	80
Ethyl 3-Ethoxypropinate (EEP)/MEK:*50/50*	224	64	72
EEP/MEK/Aromatic 100: *60/20/20*	405	150	100
EEP/Xylene: *80/20*	480	152	148
Diacetone Alcohol/MEK: *80/20*	800	590	320
Isophorone:	1250	485	365
*Viscosity in cP at 25°C, 20% non-volatile			

Solution Stability

The low-temperature stability of Phenoxy resins in various solvents and solvent blends is shown in Table 3. The kicked-out of modified Phenoxy solutions may be restored by heating up the solution at 60°C oven for one hour then follow by a mechanical agitation to ensure the homogeneity.

Table 3. Low-Temperature Stability of InChemRez Phenoxy Resins[1] in Various Solvents and Solvent Blends			
		Davs Stable at 5°C	
Solvent	PKHH	PKHM-30	PKHM-301
Methyl Ethyl Ketone (MEK)	>30	5	15
PM Acetate	>30	2	1
PM Acetate/Xylene:*80/20*	>30	2	1
Cyclohexanone	>30	5	>30
Cyclohexanone/Aromatic 100: *80/20*	>30	14	>30
Cyclohexanone/Aromatic 100: *60/40*	>30	14	25
Cyclohexanone/ Aromatic 200: *80/20*	>30	14	>30
Cyclohexanone/ Aromatic 200: *60/40*	>30	14	>30
Ethyl 3-Ethoxypropinate (EEP)/MEK *80/20*	>30	2	1
Ethyl 3-Ethoxypropinate (EEP)/MEK *50/50*	>30	2	2

[1] 20% non-volatile

Performance Results

Crosslinked Clear Coat Properties

InChemRez modified Phenoxy resins PKHM-30, and -301 readily crosslink with typical crosslinkers for hydroxyl-functional resins. Melamine, urea-formaldehyde, and isocyanate-functional prepolymers, as well as phenolic crosslinkers, all react readily with these modified phenoxies.

The low glass transition temperatures of PKHM-30, and -301 largely contribute to relatively low baking cycles and result in films with excellent leveling and high gloss.

Tables 4 and 5 show some typical film properties for clear coatings prepared by crosslinking these InChemRez modified Phenoxy resins with a phenolic and a melamine, respectively.

Table 4. Crosslinked Clear Coat Properties[1] of InChemRez Phenoxy Resins Using Phenolic Crosslinker

Property	PKHH	PKHM-30	PKHM-301
Gloss: 60°	100	100	100
Gloss: 20°	82	93	85
MEKRubs	>100	>100	>100
Reverse Impact, in-ib	>160	>160	>160
Pencil Hardness	5H	2H	2H
Formability[2] :Visual[3]	1	1	1
Formability[2] Wt Loss, mg	0	<0.5	0
Crosshatch Adhesion, %	100	100	100
OT Bend	Pass	Pass	Pass
Blush[4]	9	10	10

[1] Film Thickness: 0.5 mil (12 microns) Bake: 400°F (204°C), 10 min Substrate: Cold-rolled steel Crosslinker: Phenolic resin BKS-7570 at 8 phr

[2] Double Draw Cup Test: 66-mm diameter disk drawn to height of 40 mm and a width of 27 mm

[3] 1=No loss of coating, 1 O=Totallo55 of coating [4] Tinplate at 4 mg/in2, 10=No Blush

Table 5. Crosslinked Clear Coat Properties of InChemRez Phenoxy Resins Using Melamine Crosslinker

Property	PKHH	PKHM-30	PKHM-301
Gloss: 60°	100	100	100
Gloss: 20°	53	56	85
MEKRubs	>100	>100	>100
Reverse Impact, in-ib	>160	>160	>160
Pencil Hardness	5H	3H	3H
Formability[2] :Visual[3]	2	1	1
Formability[2] Wt Loss, mg	4.3	1	0
Crosshatch Adhesion, %	100	100	100
OT Bend	V. Slight	Pass	Pass
Blush[4]	10	10	10

[1] Film Thickness: 0.5 mil (12 microns) Bake: 400°F (204°C), 10 min Substrate: Cold-rolled steel Crosslinker: Cyme! 370 (Cytec, Ind.) at 4 phr

[2] Double Draw Cup Test: 66-mm diameter disk drawn to height of 40 mm and a width of 27 mm

[3] 1 =No loss of coating, 1 O=Total loss of coating [4]Tinplate at 4 mg/in2, 10=No Blush

Pigmented Coatings

The performance of modified Phenoxy resins PKHM-30, -301 in pigmented coatings, compared to Phenoxy resin PKHH, is shown in the following tables. Table 6 shows the properties of coatings without crosslinking. The effects of melamine crosslinking of the same formulation are shown in Table 7.

Table 6. Performance of InChemRez Phenoxy Resins in Pigmented Coatings[1]

Property	PKHH	PKHM-30	PKHM-301
Gloss: 60°	69	78	89
Gloss: 0°	24	30	42
MEKRubs	20	10	10
Reverse Impact, in-ib	144	>160	>160
Pencil Hardness	4H	HB	H
Formability[2] :Visual[3]	3	1	1
Formability[2] : Wt Loss, mg	10.3	1.1	1.1
Crosshatch Adhesion, %	100	100	100
OT Bend	Pass	Pass	Pass

[1] Film Thickness: 0.8 mil (20 microns) Bake: 400°F *(204°C),* 1 min Substrate: Bonderite 1000
[2] Double Draw Cup Test: 66-mm diameter disk drawn to height of 40 mm and a width of 27 mm
[3] 1 =No loss of coating, 1 O=Total loss of coating

Table 7. Performance of InChemRez Phenoxy Resins in Crosslinked Pigmented Coatings

Property	PKHH	PKHM-30	PKHM-301
Gloss 60°	60	82	70
Gloss 20°	21	28	15
MEK Rubs	>100	>100	>100
Reverse Impact, in-ib	120	>160	>160
Pencil Hardness	4H	H	H
Formability [2] Visual [3]	10	2	1
Formability [2] Wt Loss, mg	98	1.6	0.9
Crosshatch Adhesion, %	100	100	100
OT Bend	Fail	Pass	Pass

[1] Film Thickness: 0.8 mil (20 microns) Bake: 400°F (204°C), 1 min Substrate: Bonderite 1000
Crosslinker: Cymel 370 (Cytec Ind.) at 4 phr and Cycat- 4040 (Cytec. Ind.) at 0.8 phr
[2] Double Draw Cup Test: 66-mm diameter disk drawn to height of 40 mm and a width of 27 mm
[3] 1 =No loss of coating, 1 O=Total loss of coating

Applications & Formulations

Coil Coating

Modified Phenoxy resin PKHM-301 readily crosslinks with Cymel 325, an amino crosslinker, as well as with various phenolic crosslinkers, at baking cycles typically used in coil coating applications. The resulting film properties suggest the use of PKHM-301 in formulating

lacquers (clear or pigmented) for interior linings of aluminum DRD cans, for closures and caps, and for general-purpose metal protection.

Table 8. Formulation Suggestions for DRD Cans		
	Parts by Weight	
Ingredients	A	B
Phenoxy Resin PKHM-301	25.00	12.5
Amino Crosslinker [1]	1.25	-
Bisphenol-A Epoxy [2]	-	12.5
Catalyst [3]	0.27	-
Phenolic Resin BKS-7570 [4]	-	2.5
Ethyl 3-Ethoxypropinate (EEP)	15.00	15.0
Cyclohexanone	45.00	45.0
Hydrocarbon Solvent [6]	15.00	15.0

Suppliers:
[1] Amino Crosslinker - Cymel 325 (Cytec, Ind.) or equivalent.
[2] Bisphenol-A Epoxy - Epikote 1007 (Shell Chemical) or equivalent.
[3] Catalyst - Nacure 5076 (King Industries) or equivalent. [4] Georgia Pacific
[5] Hydrocarton Solvent - Aromatic 100 (Exxon) or equivalent.

Film Properties

Deep-drawable, factor 1.0
Sterilization-resistant in various simulated food media High gloss

Formulation Suggestion A, applied on 250-micron aluminum HS 19 at a dry film thickness of 12 microns and baked for 1 minute at 250°C PMT, results in a high-gloss film, deep- drawable at factor 1.0 (Eriksen 224/1 Deep Drawing Cup Tester), and resistant to sterilization. Formulation Suggestion B requires a cure cycle of 1 minute at 240°C PMT to obtain the same film properties.

Table 9. Formulation Suggestion for Caps and Closures	
Ingredients	Parts by Weight
Phenoxy Resin PKHM-301	25.0
Cyclohexanone	35.0
Toluene	15.0
Methyl Ethyl Ketone	50.0
Phenolic Resin BKS-7570 [1]	3.2
Silicone Resin [2]	0.5

Suppliers:
[1] Georgia Pacific
[2] Silicone Resin - SR 882M (General Electric) or equivalent.

Film Properties [1]
15-min Chemical Spot Test [2]
Nitric Acid, 50% 0
Hydrochloric Acid, 5% 8
Cyclohexanone 5
Ethanol 10
Methyl Ethyl Ketone 9
Sodium Hydroxide, 5% 10
Dimethylethanolamine 9
Deep Drawability Passed

[1] O.25-mil (6 microns) dry film thickness on Bondelite 100 panels, baked 10 min at 400°F (204°C)
[2] 10=8est, O=Poor, test temperature @ 25°C

Table 10. Formulation Suggestion for General Metal Protection	
Ingredients (Pigment Grind)	Parts by Weight
Phenoxy Resin PKHM-301	184.00
Cyclohexanone	105.81
Toluene	70.54
Methyl Ethyl Ketone	176.35
Titanium Dioxide [1]	133.30
Brown Iron Oxide [2]	6.70
Ingredients (Let Down)	
Phenolic Resin BKS-7570 (68.4%)	23.40
Methyl Ethyl Ketone	15.00
1:1 n-Butanol/H3PO4	2.00
Toluene	87.90
Butyl CELLOSOLVE Solvent	176.00
Cyclohexanone	176.00
Dispersant [3]	1.30

Suppliers:
[1] Titanium Dioxide - Ti-Pure R-960 (Du Pont) or equivalent.
[2] Brown Iron Oxide - B 7097 (Pfizer) or equivalent. [3] Dispersant - Nuosperse (Nuodex) or equivalent.

Procedure

Dissolve phenoxy resin in strong solvents (35% solution). Charge grind ingredients to ball mill. Mill for 8 hours to disperse pigment. Add let down and mix well.

Film Properties [1]	
15-min Chemical Spot Test [2]	
Methyl Ethyl Ketone	9
Dimethylethanolamine	8
Sodium Hydroxide, 5%	10
Nitric Acid, 50%	7
Hydrochloric Acid, 5%	10
Glacial Acetic Acid	8
Latex Paint	10
OT-Bend	Pass

[1] 0.8-mil (20 microns) dry film on "8onderite" 100 Steel (0.O23-in), baked at 350°F (177°C) for 20 min
[2] 10=8est, O=Poor, test temperature @ 25°C

Heat Sealing

The excellent adhesion of Phenoxy Resin PKHM-301 to aluminum, combined with the low glass transition temperature, suggests its use as a heat-seal lacquer on aluminum foils for laminating purposes. Bond strength test results for aluminum laminates heat-sealed with PKHM-301 are shown in Table 11.

Table 11. Bond Strength of Aluminum Laminates Heat-Sealed with Phenoxy PKHM-301

Temperature °C		Laminate Bond Strength
Sealing	Baking	Newton/12 mm
160	110	4.1
	130	4.2
180	110	5.0
	130	4.9
200	110	5.5
	130	5.7
220	110	6.0
	130	6.2
240	110	6.9
	130	7.2

Test Conditions
Substrate: Aluminum, 40 microns
Lacquer: Phenoxy Resin PKHM-301 in MEK at 20% N. V. Load: 8 g/m2
Baking: at 110 and 130°C
Heat Sealing: 1 sec at indicated temperature; aluminum-to-aluminum, coating side-to-coating side

FDA Status

Phenoxy Resin PKHM-301 is approved under regulations of the United States Food and Drug Administration (FDA) for use in food contact and packaging applications.

FDA Regulations (21 CFR)	Permitted Uses
175.300	Resinous and polymeric coatings as food contact surfaces applied to metal substrates.
176.170*	Components of paper and paperboard.
177.1210*	Closures.

*Refers to 175.300 for a list of acceptable materials.

The finished coating or closure must meet the extraction specification given in the appropriate regulation above.

175.105	Adhesives used in food packaging applications which contain no extraction specification but prohibit direct contact with aqueous or fatty foods.

Product Safety

When considering the use of InChemRez Modified Phenoxy resins PKHM-30, -301 in a particular application, you should review our latest Material Safety Data Sheets and ensure that the use you intend can be accomplished safely. For Material Safety Data Sheets and other product safety information, contact Phenoxy Associates Office at 1-803-328-8025.

Emergency Service

The Chemical Manufacturers Association (CMA) maintains an around-the-clock emergency service for all chemical products.

On Mainland United States of America, phone: CHEMTREC...(800) 424-9300 (toll free).

At sea, radio U.S. Coast Guard, who can contact HELP or CHEMTREC directly. DO NOT WAIT. Phone if in doubt. You will be referred to a specialist for advice.