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Some important applications for protective and decorative coatings plasticized with AROCLOR compounds —

Wood and metal used in yachts, barges and other marine craft.

Structural steel for bridges, buildings, roofs and power-lines.

Structural materials at chemical plants, pulp and paper mills textile mills, petroleum refineries and gas works for protection against acid fumes, alkalies and gas.

Tank cars and other rolling stock and construction machinery for protecting against corrosive materials and weathering.

Equipment and stop-off lacquers used in electroplating.

Masonry floors and walls. Concrete swimming pools. Highway markings.

Cable coatings requiring fire resistance, chemical resistance, and excellent electrical properties.

Textile coatings resistant to chemicals, fire and water.

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INTRODUCTION

Monsanto produces a series of chlorinated biphenyls and polyphenyls identified by the trademark *Aroclor** for use as plasticizers and resins for chlorinated rubber base lacquers, varnishes and paints. These protective coatings are fire resistant, corrosion resistant, chemical resistant (to acids, alkalies and water), and have good electrical insulating properties.

When properly pigmented, these coatings have unusually good weatherability. Chlorinated rubber films plasticized with an *Aroclor* grip common structural materials in strong adhesive bonds and the addition of an *Aroclor* improves the flexibility and life of chlorinated rubber and plastic coatings.

The formulations suggested in this bulletin are common in commercial practice today. They are given as a starting point or guide in developing formulations that expand the outstanding qualities of these compounds.

Naming of Aroclor Compounds

The last two digits in a numbered series refer to the degree of chlorination by weight. *Aroclor* 1248 is a biphenyl with 48 per cent chlorination. *Aroclor* 5460 is a terphenyl with 60 per cent chlorination. Two special mixtures are:

Aroclor 4465—a 60:40 mixture (biphenyl to terphenyl) with 65 per cent chlorination.

Aroclor 2565—a 75:25 mixture (biphenyl to terphenyl) with 65 per cent chlorination.

The physical properties of the *Aroclor* plasticizers vary gradually with the degree of chlorination. At low percentages of chlorine, such as *Aroclor* 1221 and 1232, the compounds are clear and very fluid. At 42 per cent they resemble vegetable oil; at 48 per cent they thicken slightly and look more like a medium-grade mineral oil. At 54 per cent chlorine, the compounds are quite viscous; if a bottle containing them is turned upside down, the bubble rises slowly to the top. At higher percentages, the biphenyls become gumlike, and a fingerprint on the surface lasts several days. Then at 68 per cent chlorine, the range is complete; *Aroclor* 1268 is a white powder. The terphenyls (*Aroclor* 5442 and 5460) are both yellowish solids.

The gradual change in physical properties often allows a processor to select a plasticizer particularly suited for his operation. For example, if he wants to dry mix the plasticizer, *Aroclor* 1268 could be used. It melts at higher processing temperature and can act as a solvent-plasticizer.

*Aroclor: Monsanto Trademark, Reg. U.S. Pat. Off.

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Properties of Chlorinated Rubber

"Parlon" is a mixture of two polymers with an average chlorine content of 67 per cent made by chlorinating natural rubber. The typical properties of "Parlon" as given by the manufacturer, Hercules Powder Company, Wilmington, Delaware, are listed in Table I.

Table I. Typical Properties of "Parlon"

General	
Form as shipped	White, granular powder
Color of film	Water white
Odor	None
Clarity of film	Good
Taste	None
Moisture, per cent as shipped	0.5 maximum
Physical	
Specific gravity	1.64
Specific volume, as shipped, in cubic inches per pound	16.9
Bulking value, gallons per pound	0.0735
Index of refraction	1.554
Chemical resistance to:	
Acids, weak	excellent
Acids, strong	excellent
Alkalies, weak	excellent
Alkalies, strong	excellent
Salt spray	good
Alcohols	excellent
Ketones	soluble
Esters	soluble
Hydrocarbons, aromatic	soluble
Hydrocarbons, aliphatic	good
Oils, mineral	good
Oils, animal	poor
Oils, vegetable	poor
Electrical (clear unplasticized film*)	
Specific surface resistance, ohms $\times 10^{10}$	2,000
Dielectric strength, volts per mil (ASTM method)	2,300
Dielectric constant at 25°C. and 1,000 cycles	3.1
Power factor at 25°C. and 1,000 cycles	0.0015 to 0.0030
Power factor at 25°C. and 1,000 cycles, after immersion in water for 140 hours and surface wiped dry	0.0027

*Films used in tests were laid down from a toluene solution.

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Properties, cont'd.

Mechanical (clear unplasticized film*)	20-cp. type	1,000-cp.type
Tensile strength, pounds per square inch, dry	4,270	4,850
Tensile strength, pounds per square inch, wet	4,100	4,360
Elongation, per cent, dry	3.6	3.3
Elongation, per cent, wet	3.8	3.4
Modulus of elasticity, pounds per square inch	1.4×10^5	—
Hardness, Sward index, per cent of glass	90	—

Note: Flexibility of "Parlon" film increases with viscosity of "Parlon" used.

Thermal (clear unplasticized film*)	
Burning rate	nonflammable
Effect of dry heat on film	stable up to and at 125°C.
Softening point	decomposes at 135° to 150°C.

Physical-Chemical (clear unplasticized film*)	
Effect of sunlight	Discolors and embrittles
Effect of aging	Very slight
Effect of hot water	Blushes
Effect of cold water	None
Moisture absorption (80% relative humidity for 24 hours), per cent	0.27
Moisture vapor permeability of 0.003-inch film (grams water/square centimeter/0.01 centimeter/hour at 21°C.)	0.2×10^4

Viscosity Types

Table II. "Parlon" Viscosity Types

Viscosity Type	Viscosity Range (centipoises)
5 cp.	5 to 7
10 cp.	8 to 12
20 cp.	16 to 25
125 cp.	110 to 190
1,000 cp.	800 to 2,000

Examples of actual or suggested applications of the several viscosity types are given below:

Type	Example of Use
5 cp.	In printing inks and as a fortifier for alkyd resin enamels.
10 cp.	In high-solids finishes and as a fortifier for alkyd resin and oleoresinous varnishes and enamels.
20 cp.	As a film-former in protective coatings and as a fortifier in enamels and varnishes.
125 cp.	As a film-former in protective coatings, in paper lacquers, adhesives, and textile finishes.
1,000 cp.	As a film-former in adhesives, textile finishes and other finishes where flexibility is important.

*Films used in tests were laid down from a toluene solution.

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Solvent Compatibility

Solvents and solvent mixtures suggested for use in preparing formulations with *Aroclor* and "Parlon" are given in Table III:

Table III. Suggested Solvents for Compositions with Aroclor and "Parlon"

"Amsco Solv," B and E	Methyl ethyl ketone
Amyl acetate	Methyl isobutyl ketone
Butyl acetate	Methyl salicylate
Carbon tetrachloride	Notol
"Cellosolve"	Octyl acetate
Diacetone alcohol	"Sovasol" Nos. 74, 75
Diethyl carbonate	"Solvesso 100"
Ethyl acetate	"Tollac"
Ethylene dichloride	Toluene
Hi-Flash naphtha	"Union Aromatic Solvent" 3553-10
Methyl acetate	"Union Solvent No. 30"
Xylene	

Formulations and Properties of Chlorinated Rubber

Chlorinated Rubber Films

Aroclor 1262 and 5460, resinous types, show good compatibility in chlorinated rubber films laid down from toluene solution containing 20 per cent of the plastic in ratios of 2:1 and 1:1 ("Parlon" to *Aroclor*). The plasticizer types, *Aroclor* 1242, 1254 and 1260, also show good compatibility. Formulations and properties of films derived from both resin- and plasticizer-type *Aroclor* are listed below.

Table IV. Formulations for Aroclor Resin

Ingredient	Parts by Weight					
"Parlon," 20-cp.	16	16	16	12	12	12
Aroclor 5460	8	8	8	12	12	12
Dibutyl phthalate	—	4	—	—	3	—
Tung oil, Thermolyzed, 976	—	—	5	—	—	3.75
Xylene or butyl acetate	76	72	71	76	73	72.25

Table V. Formulations for Aroclor Plasticizer

Ingredient	Parts by Weight		
"Parlon," 20-cp.	20	20	20
Aroclor 1254 or 1260	4	7	20
Xylene	76	73	70

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Films cast from these lacquers show improved characteristics due to *Aroclor*. Some of their advantages are listed below:

Adhesion

Unplasticized chlorinated rubber films have very poor adhesion. The lacquer film containing *Aroclor* 5460 gave good adhesion to aluminum, bare steel, primed steel, galvanized iron and "Transite" surfaces. Other commercial resins, particularly oil-modified alkyd resins, gave better adhesion to glass, tin, copper, sealed wood and cellophane.

The lacquer films plasticized with *Aroclor* 1254 or 1260 gave good adhesion to "Transite," cellophane, galvanized iron and primed steel surfaces. Some of the other commercial plasticizers tested in similar films gave better adhesion to aluminum, tin, bare steel, copper and sealed wood surfaces.

Though compounds with an *Aroclor* alone possess pronounced adhesive qualities, better adhesion to all of the surfaces results if mixtures of *Aroclor* or varied contents are used.

Resistance to Aqueous Solutions

Chlorinated rubber films with *Aroclor* 1254 or 1260 (plasticizers) and *Aroclor* 5460 (resin) show satisfactory resistance to solutions of 10 per cent hydrochloric acid, 5 per cent sodium hydroxide, 5 per cent sodium chloride and water spot tests.

Film Hardness

Softer films were produced with *Aroclor* 5460 in ratios of 5:10 and 10:10 (*Aroclor*:"Parlon") than with other commercial resins in similar mixtures. Likewise, softer films result from *Aroclor* 1254 or 1260 in ratios of 2:10 and 5:10 (*Aroclor*:"Parlon") than with other commercial plasticizers at these concentrations. From these tests compounds with *Aroclor* are shown to have strong plasticizing action on chlorinated rubber.

Cold-Check Resistance

Aroclor 5460 is superior to phenol formaldehyde resins in cold-check resistance imparted to chlorinated rubber films, but not as good as alkyds modified with long oil. *Aroclor* 1260 used as a plasticizer proved somewhat better than *Aroclor* 1254.

Weather Resistance

Pigmented chlorinated rubber finishes containing *Aroclor* have consistently withstood outdoor weather tests, but unpigmented finishes do not stand up well regardless of the resin or plasticizer used.

Poor resistance to ultraviolet light is also a weakness of chlorinated rubber. Most pigments (except ultramarine blue) are usable with "Parlon" and are recommended if the coating is to be subjected to outdoor weather or ultraviolet light. However, pigment protection varies considerably. Inspection of alkyd enamels fortified with "Parlon" showed weatherability varied from 63 months with chrome green to 4 months for titanium dioxide—iron blue combinations.

Sanding and Polishing Properties

Plastic films compounded with "Parlon" and containing *Aroclor* 5460, 1254 and 1260 have shown satisfactory sanding and polishing characteristics.

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Applications

Alkaline-Resistant Coatings

Products containing *Aroclor* and chlorinated rubber are highly resistant to alkalies and moisture. Paints with combinations of *Aroclor* and chlorinated rubber are used in large quantities for concrete floors, walls, swimming pools and other surfaces. A paint formulation is given in Table VI.

Table VI. Paint Formulation for Alkaline Surface
(Parts by Weight)

Ingredient	Formulation		
	Formula 1 (basement floors)	Formula 2 (Fed. Spec. TT-P-91)	Formula 3 (swimming pools)
"Parlon," 20-cp. type	18	18	14.6
Aroclor 1254	10	10	4.4
"Rezyl 869"	8	—	—
Aroclor 5460 or "Cumar P10"	—	6	—
"Beckosol 31"	—	—	2.9
Tung oil, Thermolyzed, 976	—	—	4.4
Titanium dioxide	16	16	19.7
Zinc oxide	2	2	6.5
Silica flour	3	—	—
Carbon black	0.2	0.5	—
Xylene	42.8	47.5	—
Hi-Flash naptha	—	—	47.5
Totals	100	100	100

Chemical-Resistant Finishes

Particular care is necessary in choosing resins and plasticizers for chemical-resistant paints. Chlorinated rubber formulations with an *Aroclor* have proved outstanding for acid and alkali resistance. Five formulations are shown in Table VII.

Table VII. Formulations for Chemical-Resistant Paints
(Parts by Weight)

Ingredient	Formulation				
	1 Interior use, acids and alkalies	2 Exterior use, acids	3 Exterior use, alkalies	4 Maximum resistance, acids and alkalies	5 Soap resistant
"Parlon," 20-cp. type	16	16	16	18	12
Aroclor 5460	6.4	—	—	—	6
"Bakelite XJ-12895"	—	—	6.4	—	—
"Rezyl 807" (solids)	—	6.4	—	—	—
Aroclor 1254	8	4.8	4.8	8	—
Aroclor 1260	—	—	—	6	—
Tung oil, Thermolyzed, 976	—	4.8	4.8	—	7.7
Iron oxide	16	16	16	18	—
Titanium dioxide	—	—	—	—	18
Zinc oxide	—	—	—	—	6
Zylene	53.6	52	52	39	28
Hi-Flash naphtha	—	—	—	11	10.3
Toluene	—	—	—	—	12
Totals	100	100	100	100	100

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These formulations were applied to metal bars or panels and tested for resistance.

Formula 1 showed good resistance to 10 per cent hydrochloric acid and 5 per cent sodium hydroxide solutions.

Formula 2 gave excellent outdoor protection to metal surfaces on plants manufacturing acids.

Formula 3 performed well on exteriors of plants producing alkali.

Formula 4 had excellent resistance to acids, alkalis and salt solutions. It also showed good adhesion to glass and other surfaces.

Formula 5 proved good for resistance to warm, soapy water.

Note: No finishes with *Aroclor* or chlorinated rubber are recommended for continuous exposure at temperatures above 140° F.

Marine Finishes

The marine industry makes great use of chlorinated rubber coatings plasticized with *Aroclor* to protect wood and metal on boats, barges and other marine equipment. They possess good resistance to salt water and their hard finish deters algae and other marine growth.

A suggested formula for a white marine paint is given in Table VIII.

Table VIII. Formulation for a Chlorinated Rubber Marine Paint

Ingredient	Parts by Weight
"Parlon," 20-cp. type	20
Aroclor 1254	6
"Rezyl 869"	6
Titanium dioxide	25
Xylene	23
Hi-Flash naphtha	20
Total	100

Emulsion Paints

If chemical resistance is required on porous surfaces, *Aroclor* 1254 is often added to chlorinated rubber emulsion paints. The Hercules Powder Company reports that preferred water phases for such paints are either a 1 per cent distilled water solution of "Aerosol OT" or a 4 per cent distilled-water solution of sodium oleate. A lacquer-to-water ratio of 2.5 to 1 (by weight) is suggested for the complete emulsion. "Parlon" of any viscosity may be used. A typical paint phase for such an emulsion paint is given in Table IX.

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Table IX. Formulation for Paint Phase of Emulsion Paint

Ingredient	Parts by Weight
"Parlon"	28
Aroclor 1254	14
"Cumar P10"	10
Xylene	24
Hi-Flash naphtha	24
Total	100

Adhesives

Chlorinated rubber adhesives with an *Aroclor* were developed originally for adhering labels to acid bottles because of their general resistance to chemicals. These adhesives are also of unusual interest because they are fire resistant. A typical formulation is given in Table X.

Table X. Formulation for Chlorinated Rubber Adhesive

Ingredient	Parts by Weight
"Parlon," 125-cp. type	20
Aroclor 1254	6
Aroclor 1260	6
Toluene	68
Total	100

Paper and Textile Coatings

Chlorinated rubber coatings with *Aroclor* are worthy of consideration for specific end uses in the paper and textile coating fields. In general, this type of coating is restricted by odor and taste. Unpigmented finishes seem suitable for certain fabrics used indoors, but not for exposure to high temperatures or direct sunlight.

Electrical Coatings

Because of their desirable electrical properties, these compositions are useful for insulating and protecting electrical wire and apparatus from moisture. With selected fungistats and waxes, coatings of this type are used to protect electronic equipment in the tropics against moisture and fungi. The fire resistance of these plastics is an added dividend in the electrical field.

Printing Inks

Printing inks requiring a fast drying time and chemical resistance are often based on chlorinated rubber compositions plasticized with an *Aroclor*. These inks are especially useful on soap wrappers and boxes, bottle labels and many other commodities because of their alkali resistance.

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Other Resins and Plasticizers Compatible With Chlorinated Rubber

The resins and Monsanto plasticizers given in Tables XI and XII are compatible with chlorinated rubber, but none gives the over-all desired qualities attained by using an *Aroclor*. The strong points and limitations of each are known. If their use is necessary for specific applications in chlorinated rubber, more detailed information on them may readily be found.

Table XI. Resins Compatible with "Parlon"

"Amberol 801, 806P, ST-137, F7"

Aroclor 1262, 5460

"Aroplaz 920, 930, 935, 940"

"Bakelite" XR-3180, XR-4503, XR-4006, BR-2963, XJ-9868, BR-1329, BR-3360"

"Beckacite 1112"

"Beckamine P-138, P-254"

"Super-Beckamine 3501"

"Beckapol 1400"

"Beckosol 1 (solid), 18, 31, 34, 40, 1329"

"Beetle" Resin 227-8

"Clorafin 70"

Copal

"Cumar P10"

Dammar

"Duraplex C-45-LV, C-48, C-49, C-50-LV, C-51, C-62, D-61, D-62, E-71, E-71-A, E-73"

East India gum

Ester gum

Ethyl methacrylate

"Esterol 750"

"Formvar"

"Gelva 2.5"

"Glyptal 1247, 2450, 2454, 2458, 2464, 2466, 2500"

"Lewisol 2L, 28, 33"

Methyl methacrylate polymers

"Neville R-3, R-10"

"Pentalyn A, G, M, X"

"Petrex 1, 130H"

"Phenac 633-M"

"Rezyl 116, X315, 412, 775, 803, 807, 829, 869, 880, 1103"

Rosin

*Santolite** MPH (sulfonamide-aldehyde resin)

"Stabelite Ester 1, 2, 10"

"Stabelite" resin

"Super-Beckacite 1001"

"Syntex H1, H3, H12, 17, 213, 22, 28, 29, 32, 36"

"Teglac 15, Z-152"

"Velsicol AD6-3"

"Vinsol"

Table XII. Monsanto Plasticizers Compatible with "Parlon"

Aroclor 1242

Aroclor 1254

Aroclor 1260

Dibutyl phthalate

Diethyl phthalate

Dimethyl phthalate

Santicizer B-16 (butyl phthalyl butyl glycolate)

Santicizer M-17 (methyl phthalyl ethyl glycolate)

Tricresyl phosphate

Triphenyl phosphate

*Santolite, *Santicizer*: Monsanto Trademarks. Reg. U.S. Pat Off.

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Toxicity

Animal toxicity studies and 20 years of manufacturing and use experience indicate that *Aroclor* compounds are not serious industrial health hazards. If the materials are heated to volatilization, ventilation should be provided to prevent inhalation of vapors. This is true of other major components of the formulation as well as the *Aroclor* compounds.

Repeated or prolonged skin contact should be avoided although there are few instances of skin irritation. Human patch tests with finished products containing *Aroclor* compounds have shown no irritation. Monsanto will furnish information on specific *Aroclor* compounds upon request.

Shipping Information

Regulations	— None
Standard Containers	— Steel and Fiber (*Aroclor* 1268, 5460) drums.
Rail Classification	
Chlorinated diphenyl (synthetic resin, liquid, NOIBN)	— *Aroclor* 1142, 1148, 1154, 1160, 1162, 1168, 1221, 1232, 1242, 1248, 1254, 1260, 1268
Synthetic resin, liquid, NOIBN	— *Aroclor* 1260 mix, 1262 mix
Snythetic resin, other than liquid, NOIBN	— *Aroclor* 2565, 4065, 4465, 5042, 5060, 5442, 5460
Truck Classification	
Synthetic resin powder, NOI	— *Aroclor* 2565
Synthetic resin, lumps or solid mass, NOI	— *Aroclor* 4065, 4465, 5042, 5060, 5442, 5460

The information contained in this bulletin is, to our best knowledge, true and accurate, but all recommendations or suggestions are made without guarantee, since the conditions of use are beyond our control. The Monsanto Chemical Company disclaims any liability incurred in connection with the use of these data or suggestions.

Furthermore, nothing contained herein shall be construed as a recommendation to use any product in conflict with existing patents covering any material or its use.

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Trademark Index

Trademark	Company
"Aerosol OT"	American Cyanamid Company
"Amberol"	Rohm & Haas Company
"Amsco Solv"	American Mineral Spirits Co.
"Aroplaz"	U. S. Industrial Chemicals Co.
"Bakelite"	Bakelite Company
"Beckacite"	Reichhold Chemicals, Inc.
"Beckamine"	Reichhold Chemicals, Inc.
"Beckopol"	Reichhold Chemicals, Inc.
"Beckosol"	Reichhold Chemicals, Inc.
"Beetle" Resin	American Cyanamid Company
"Cellosolve"	Carbide & Carbon Chem. Co.
"Clorafin"	Hercules Powder Company
"Cumar"	Barrett Division, Allied Chem. & Dye
"Duraplex"	Rohm & Haas Company
"Esterol"	L. Sonneborn Sons, Inc.
"Formvar"	Shawinigan Resins Corp.
"Gelva"	Shawinigan Resins Corp.
"Glyptal"	General Electric Company
"Hercolyn"	Hercules Powder Company
"Lewisol"	Hercules Powder Company
"Neville"	Neville Chemical Company
"Pentalyn"	Hercules Powder Company
"Petrex"	Hercules Powder Company
"Phenac"	American Cyanamid Company
"Rezyl"	American Cyanamid Company
"Solvasol"	Socony-Mobil Oil Company
"Solvesso"	Esso Standard Oil
"Stabelite" Ester	Hercules Powder Company
"Stabelite" Resin	Hercules Powder Company
"Super-Beckacite"	Reichhold Chemicals, Inc.
"Syntex"	Flintkote Company
"Teglac"	American Cyanamid Company
"Tollac"	Neville Chemical Company
"Troluoil"	Anderson-Pritchard Oil Corp.
"Transite"	Johns-Manville Sales Corp.
"Velsicol"	Velsicol Corp.
"Vinsol"	Hercules Powder Company

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