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AROCLORS* As Used in Chlorinated Rubber

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Monsanto Chemical Company, St. Louis 4, Mo.

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AROCLORS, chlorinated biphenyl and chlorinated poly-phenyls, are effective plasticizers and resins for chlorinated rubber base lacquers, varnishes and paints.

These protective coatings are used where flame resistance, corrosion resistance, chemical resistance, i.e., resistance to acids, alkalies and water, and good electrical insulating properties are required.

Some of the important applications for these protective and decorative coatings for wood, metal, brick, stone, concrete and fabric surfaces include:

1. Wood and metal used in the construction of yachts, barges and other marine craft.
2. Structurel steel for bridges, buildings, roofs and power-line structures.
3. Structural materials used at chemical plants, pulp and paper mills, textile mills, petroleum refineries and gas works where protection against acid fumes, alkalies and gas is essential.
4. For the protection of tank cars and other rolling stock and construction machinery against corrosive materials and weathering.
5. To protect equipment used in electroplating and as stop-off lacquers in this industry.
6. Masonry floors and walls. Concrete swimming pools and traffic paints.
7. As cable coatings requiring nonflammability, chemical resistance, water resistance and excellent electrical properties.
8. Coatings for cloth to impart "waterproofing" qualities as well as chemical and flame resistance.

*AROCLOR-Reg. U.S. Pat. Off.

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AROCLORS AS USED IN CHLORINATED RUBBER

I. INTRODUCTION

Aroclors, chlorinated biphenyl and chlorinated poly-phenyls, are used effectively as resins and plasticizers to impart desired qualities to chlorinated rubber, such as Hercules' Parlon.

Parlon is made by chlorinating natural rubber, yielding a mixture of two polymers possessing an average chlorine content of 67 per cent.

II. PROPERTIES OF CHLORINATED RUBBER

The typical properties of Parlon as given by Hercules Powder Company, Wilmington, Delaware, are listed in the following 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	
Electrical (clear unplasticized film*)		
Specific surface resistance, ohms x 10^{10}	2,000	
Dielectric strength, volts per mil (A.S.T.M. 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	
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 x 10^5	
Hardness, Sward index, per cent of glass	90	
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*)		
Sunlight, effect of	Discolors and embrittles	
Aging, effect of	Very slight	
Water, hot, effect of	Blushes	
Water, cold, effect of	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 x 10^4	

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

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General 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

Different viscosity types of Parlon and suggested uses are given in Table II.

TABLE II. PARLON VISCOSITY TYPES

Viscosity Type	Viscosity Range (in 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:

Type	Use Examples
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.

III. SUGGESTED SOLVENTS FOR AROCLOR AND CHLORINATED RUBBER COMPOSITIONS

Solvents and solvent mixtures suggested for use in preparing Aroclor and Parlon formulations are given in the following Table III:

TABLE III. SUGGESTED SOLVENTS FOR AROCLOR AND PARLON COMPOSITIONS

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

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MIXED SOLVENTS

70 : 30	Acetone : hexane
97 : 3	Acetone : mineral spirits
83 : 17	Benzene : isopentane
41 : 7 : 35 : 17	Cellosolve : ethanol (anhydrous) : ethyl acetate : xylene
30 : 70	Cellosolve : turpentine
18 : 59 : 23	Cellosolve : turpentine : mineral spirits
64 : 36	Ethyl acetate : isopentane
30 : 30 : 40	Ethyl acetate : isopropyl acetate : Troluoil
40 : 60	Methyl isobutyl ketone : Troluoil
30 : 70	Hi-Flash solvent naphtha : turpentine
70 : 30	Methyl acetate : isopentane
85 : 15	Shell TS-28 : xylene

IV. AROCLOR AND CHLORINATED RUBBER, PLASTICS FILMS

The resinous Aroclors 1262 and 5460 show good miscibility with chlorinated rubber films as laid down from toluene solution containing 20 per cent of the plastics, using 2 : 1 and 1 : 1, Parlon : resin, ratios. Similarly, the plasticizer type Aroclor 1242, 1254 and 1260 show good miscibility in chlorinated rubber.

The properties of films derived from the following formulations containing either Parlon and resinous Aroclors 1262 or 5460, or Parlon and the plasticizer type Aroclors 1242, 1254 or 1260 were studied.

RESINOUS TYPE AROCLOR FOR PARLON PLASTICS

Ingredients	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

PLASTICIZER TYPE AROCLORS FOR PARLON PLASTICS

Ingredients	Parts by weight		
Parlon, 20-cp.	20	20	20
Aroclor 1254 or 1260	4	7	20
Xylene	76	73	70

Examination of the films cast from these lacquers revealed the following characteristics imparted by the Aroclors:

Adhesion:— Unplasticized chlorinated rubber films have very poor adhesive qualities. The lacquer film containing Aroclor 5460 gave good adhesion to aluminum, bare steel, primed steel, galvanized iron and Transite surfaces. Other commercially available resins, particularly oil modified alkyd resins, tested in similar films gave better adhesion than Aroclor 5460 to such surfaces as glass, tin, copper, sealed wood and cellophane.

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

Aroclors, alone, possess pronounced adhesive qualities. Doubtless, where the objective is to produce adhesives, by varying the Aroclor content or by using a mixture of Aroclors in the chlorinated rubber lacquers, much better adhesion to all of the surfaces would be accomplished than was the case with the type of plastics films studied.

Resistance to Aqueous Solutions:— Aroclors 1254 or 1260 used as plasticizers and Aroclor 5460 used as a resin in chlorinated rubber produced plastics films possessing satisfactory resistance to 10 per cent hydrochloric acid, 5 per cent sodium hydroxide, 5 per cent sodium chloride solutions and to water spot tests.

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Film Hardness:— Using Aroclor 5460 in ratios of 5 : 10 and 10 : 10, Aroclor : Parlon, decidedly softer films were produced than when other commercial resins were similarly used. Likewise, Aroclors 1254 or 1260 used in ratios of 2 : 10 and 5 : 10, Aroclor : Parlon, gave softer films than obtained from other commercial plasticizers, used at these concentrations. This indicates the strong plasticizing action of these Aroclors on chlorinated rubber.

Cold-Check Resistance:— Regarding cold-check resistant qualities imparted to chlorinated rubber films, Aroclor 5460 is somewhat superior to Bakelite type resins, but not as good as long-oil modified alkyds. Aroclor 1260 used as a plasticizer rates, in terms of cold-check resistance, somewhat better than Aroclor 1254 and nearly as good as the best of the other plasticizers studied for this property.

Miscellaneous Properties:— Parlon plastics films containing Aroclors 5460, 1254 or 1260 have entirely satisfactory sanding and polishing characteristics.

Weatherability:— Pigmented chlorinated rubber finishes containing Aroclors have consistently shown good outdoor weatherability. However, similar unpigmented finishes, regardless of the plasticizer or resin used and also in the absence of these additives, have been found to give poor outdoor weathering. Relatively poor resistance to ultraviolet light is a weakness of chlorinated rubber.

Most pigments, with the exception of ultra-marine blue are usable with Parlon finishes and are recommended when the coating is to be subjected to outdoor weathering or exposed to ultraviolet light. However, there is considerable variation regarding the protection offered by different pigments. Inspection of Parlon-fortified alkyd enamels showed the weatherability varied from 63 months for the enamel pigmented with chrome green to 4 months for enamel pigmented with a titanium dioxide-iron blue combination.

V. USES FOR AROCLORS IN CHLORINATED RUBBER COATINGS

A. Finishes for Alkaline Surfaces:

Aroclors, as well as chlorinated rubber, are highly resistant against alkalies and moisture. Because of these properties paints based on Aroclor and chlorinated rubber combinations are used in large quantity for application to concrete floors, walls, swimming pools, etc. Examples of this type of paint are given in Table IV.

TABLE IV. AROCLOR PLASTICIZER IN CHLORINATED RUBBER PAINTS FOR ALKALINE SURFACES

(Examples of starting formulas)

Materials	Formula 1 for basement floors	Formula 2 to meet Fed. Spec. TT-P-91	Formula 3 for swimming pools
		(Parts by weight)	
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 naphtha			47.5
Totals	100	100	100

B. Acids and Alkali-Resistant Finishes:

Particular care must be exercised in the choice of resins and plasticizers for use in chemical resistant paints. For this purpose, Aroclors are outstanding and are being used successfully in the acid and alkali-resistant chlorinated rubber formulations given in Table V.

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TABLE V. AROCLOR PLASTICIZERS AND RESINS FOR CHLORINATED RUBBER, ACID AND ALKALI-RESISTANT FINISHES

(Examples for starting formulations)

Materials	1 For interior use against acids and alkalies	2 For exterior use against acids	3 For exterior use against alkalies	4 For maximum resistance to acids and alkalies	5 For use against soap solutions
			(Parts by weight)		
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

The paints given in Table V were applied to metal bars or panels and tested. Formula 1, an interior paint, showed good resistance to a 10 per cent hydrochloric acid solution and to a 5 per cent sodium hydroxide solution. The acid resistant paint described under the heading of Formula 2 has shown excellent outdoor protection to metal surfaces on acid manufacturing plants. Similarly, paints based on Formula 3 have given good outdoor performance on alkali producing plants. Paint based on Formula 4 was found to have excellent resistance to acids, alkalies and other corrosive materials such as salt solutions. Moreover, this paint showed good adhesion to various surfaces including glass. Paint based on Formula 5 is indicated to have good resistance against warm aqueous solutions containing soap.

It should be pointed out that Aroclor and chlorinated rubber finishes are not recommended for continuous exposure at temperatures above 140°F.

C. Marine Finishes:

Aroclor plasticized chlorinated rubber coatings possess good resistance to salt water and their hard finish deters algae and marine growths from adhering to them. These qualities and good chemical resistance indicates the usefulness of these paints to protect wood and metal used in making boats, barges and other marine equipment. A suggested formula for a marine paint is given in Table VI.

TABLE VI. AROCLOR PLASTICIZER FOR A CHLORINATED RUBBER MARINE WHITE PAINT

(Starting formulation)

Materials	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

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D. Emulsion Paints:

Aroclor 1254 is used in chlorinated rubber emulsion paints recommended when chemical resistance is required on porous surfaces. Hercules Powder Company report that the preferred water phases for such paints are either a 1 per cent solution of Aerosol OT in distilled water or a 4 per cent solution of sodium oleate in distilled water. For the complete emulsion, a ratio by weight of lacquer phase to water phase of 2.5 to 1 is suggested. Parlon of any desired viscosity may be used. A typical paint phase for the Aroclor-Parlon emulsion paint contains the following ingredients:

PAINT PHASE FOR THE EMULSION

Ingredients	Parts by weight
Parlon	28
Aroclor 1254	14
Cumar P10	10
Xylene	24
Hi-Flash naphtha	24
Total	100

E. Adhesives:

Aroclor and chlorinated rubber adhesives are resistant to chemicals and were developed originally for adhering labels to acid bottles. These adhesives are also of unusual interest because of their good fire resistant qualities. A typical formulation contains the following ingredients:

AROCLOR PLASTICIZERS FOR CHLORINATED RUBBER ADHESIVES

Ingredients	Parts by weight
Parlon, 125-cp. type	20
Aroclor 1254	6
Aroclor 1260	6
Toluene	68
Total	100

F. Paper and Textile Coatings:

Aroclor and chlorinated rubber coatings are worthy of consideration for specific end uses in the paper and textile coatings fields. In general, however, the use of this type of coating in these fields may be restricted especially where freedom from odor and taste are required. Unpigmented Aroclor and chlorinated rubber finishes would seem suitable for certain fabrics used indoors, but not where they are exposed to high temperatures and direct sunlight.

G. Coatings for Electrical Apparatus:

Because of their desirable electrical properties, compositions containing Aroclors and chlorinated rubber are very useful to insulate and protect electrical wire and apparatus from moisture. When fortified with selected fungistats and waxes, coatings of this type are used to "tropicalize" or protect electronic equipment against both moisture and fungi. Moreover, the fire resistant qualities of these plastics are highly desirable for use in the electrical field.

H. Inks:

Aroclor plasticized chlorinated rubber compositions are very useful for printing inks where faster drying time and increased chemical resistance are desired. The alkali-resistant properties of such plastics suggest their use in the printing of soap wrappers and soap boxes, bottle labels and other commodities where the ink must be resistant to alkalies.

VI. RESINS AND PLASTICIZERS, OTHER THAN AROCLOR, MISCIBLE IN CHLORINATED RUBBER

The resins and plasticizers given in the following Table VII are miscible in chlorinated rubber. This was determined by the examination of films laid down from 2 : 1 and 1 : 1, Parlon : resin or plasticizer ratios at 20 per cent concentration in toluene.

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TABLE VII. RESINS AND PLASTICIZERS MISCIBLE IN PARLON

RESINS

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
Beckopol 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 MHP
Staybelite Ester 1, 2, 10
Staybelite resin
Super-Beckacite 1001
Syntex H1, H3, H12, 17, 213, 22, 28, 29, 32, 36
Teglac 15, Z-152
Velsicol AD6-3
Vinsol

PLASTICIZERS

Amylchloro naphthalene
Amyl oleate
Amyl stearate
Aroclor 1242
Aroclor 1254
Aroclor 1260
Butyl myristate
Butyl stearate
Camphor
Castor oil, raw
Castor oil, dehydrated
Castor oil fatty acid esters
Cellosolve phthalate
Coconut fatty acid esters
Diamyl naphthalene
Diamyl phthalate
Dibutyl phthalate
Dibutyl sebacate
Diethyl phthalate
Dimethyl phthalate
Fish oil
Hercolyn
Linseed oil
Methyl cellosolve oleate
Monoamyl naphthalene
Naftolen
Neville heavy oil No. 2
Nevillite oil
Oiticica oil
Palm fatty acid esters
Perilla oil
Polyamyl naphthalene
Resinous Products C-24
Santicizer B-16
Santicizer M-17
Sextol phthalate
Sextol stearate
Soya bean fatty acid esters
Soya bean oil
Thermoil A
Tributyl phosphate
Tricresyl phosphate
Triethyl citrate
Triphenyl phosphate
Tung oil, Thermolyzed, 976

The strong points and limitations of the resins and plasticizers given in Table VII relative to the properties they impart to chlorinated rubber are known. None give the important over-all desired qualities attained by the use of Aroclors. If occasion arises to consider the use of these materials in specific applications for chlorinated rubber, then more detailed information about them will be given.

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VII. GENERAL

Prior to Word War II Aroclors, used in substantial amount with chlorinated rubber, made rapid growth in the applications given in this report. During the war, scarcity of natural rubber curtailed these developments but since the war industry has been quick to resume the use of Aroclor plasticized chlorinated rubber compositions.

Their principal field of application is as lacquers, varnishes and paints where flame resistance, corrosion resistance, chemical resistance, i.e., resistance to acids, alkalies and water, and good electrical insulating properties are required.

When properly pigmented these paints or coatings have good weatherability. Although the adhesion of unplasticized chlorinated rubber films to common structural materials is poor, when plasticized with Aroclors strong adhesive bonds are obtained. Aroclors improve the flexibility and life of chlorinated rubber plastics coatings.

The formulations of Aroclors and chlorinated rubber along with their suggested uses, as given in this report, are in line with good commercial practice. Much of the data given was obtained from other firms, particularly Hercules Powder Company, Wilmington, Delaware. The information given is to serve as a guide or starting point in the development of formulations to expand taking advantage of the outstanding qualities of Aroclors as resins and plasticizers for chlorinated rubber.

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