plasticizers

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PLASTICIZERS AND RESINS

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★ *Specifications and Application Data*

PLASTICIZERS AND RESINS

Revised May, 1940

MONSANTO CHEMICAL COMPANY
St. Louis, U. S. A.

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Foreword

This booklet is prepared for the purpose of setting forth the essential characteristics of certain plasticizers and resins made by Monsanto Chemical Company. On account of the diversity of basic raw materials used as plastics and the almost unlimited uses of the finished articles, it is obvious that there is not likely to be a universal plasticizer. A knowledge of the properties imparted by each of several plasticizers, however, gives a working basis for selecting the right one for any particular purpose or making the correct combinations. We believe that the data and suggestions presented here will enable the manufacturer of articles requiring these products to make a proper selection with a minimum of time and testing.

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General

Cellulose esters and practically all resins, both synthetic and natural, have a brittleness which increases with age. To counteract this characteristic, as well as to give *workability* and *flexibility*, and *overcome shrinking* which causes cracking and shattering, plasticizers are added.

Plasticizers came into particular prominence with the development of pyroxylin and the subsequent growth of the lacquer and moulded synthetic products industries. Camphor was the first satisfactory plasticizer, and it was its use with nitrocellulose that made celluloid and moulded pyroxylin articles possible. On account of the fire hazard involved in the use of articles made of nitrocellulose, a fire retarder was necessary, and Tricresyl Phosphate came to play that role. In spite of numberless attempts to produce other compounds for the purpose, Tricresyl Phosphate still retains its place, although with improvements in nitrocellulose stabilization it is not as essential in most compositions as *formerly*.

After the World War the availability of large stocks of butyl alcohol and a process for making phthalic anhydride cheaply opened the way for Dibutyl Phthalate as a component of the new nitrocellulose lacquers just becoming so important. The combination of Tricresyl Phosphate and Dibutyl Phthalate was quite satisfactory until a host of new moulding and coating materials, composed largely of synthetic resins, were developed and requirements became much more exacting. These compositions required other plasticizers, or to be more exact, properties not imparted by the old plasticizers became essentials. Extreme lack of color, light stability, water resistance, grease resistance, non-toxicity, greater compatibility with special resins, gloss, smoothness of working, flexibility at low temperatures, non-softening at high temperatures, stability toward acids and alkalies, and numerous other properties were demanded. Cellulose acetate came actively into the plastic field and required entirely new plasticizers because, while most of the compounds proposed were compatible with nitrocellulose, very few were sufficiently so with acetate. Thus, for Tricresyl Phosphate, which is not at all compatible with acetate, must be substituted Triphenyl Phosphate which has good compatibility. Dibutyl Phthalate is not compatible in amounts sufficient to give the desired properties, and therefore Dimethyl Phthalate and Diethyl Phthalate, in spite of relatively high evaporation rates, were used.

Monsanto Chemical Company is prepared to supply a line of plasticizers covering most of the essential requirements. Standard products of proven value have been selected and additional ones developed to fit those requirements not fulfilled by the older materials. In all these products the usual high standard of quality of Monsanto products is maintained.

The requirements for resins are as exacting as for plasticizers. Two important factors in many specialty combinations are compatibility with cellulose acetate and lack of color. The Santolite resins possess both these features as well as many others which make them outstanding in the resin field.

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Plasticizers and Resins for Use with——

Alkyd Resins

Santicizers B-16, E-15 and M-17 are recommended as plasticizers in amounts of from 5% to 40% of the resin weight. Tricresyl Phosphate and Dibutyl Phthalate may also be used. The Santolites are of value for increasing moisture resistance and compatibility in lacquers. The Aroclors are compatible with alkyd resins and can be used in conjunction with them for lacquers, varnishes and enamels.

Phenolic Resins

Santicizer M-17 and Tricresyl Phosphate give the greatest flexibility. Dibutyl Phthalate, Santicizers B-16 and E-15, and Diphenyl Phthalate may also be used. None give great flexibility to the completely "cured" (C stage) resin. Santicizer 9 in amounts of from 2% to 5% may improve the workability and curing of phenolic moulding compositions. The Aroclors may be used in special cases as lubricants or in coating compositions.

Polyvinyl Acetate

Mixtures of plasticizers usually give the best results. Santicizers M-17, E-15 and B-16 are recommended as liquid plasticizers. Dibutyl Phthalate and Tricresyl Phosphate may also be used. If excessive softening is to be avoided, the solid plasticizers—Santicizer 10 and Diphenyl Phthalate—are of value. The Santolites either alone or in combination with a solid or liquid plasticizer improve workability, flexibility and adhesion. The liquid or semi-solid Aroclors give tough, flexible compositions of improved water resistance and electrical properties. The resinous Aroclors give harder, more brittle, compositions.

Polyvinyl Acetals

The proper plasticizer will depend upon the particular acetal and the intended use. For maximum flexibility, Santicizers M-17, E-15, B-16 and 8 and Dibutyl Phthalate are suggested. As solid plasticizers Diphenyl Phthalate and Santicizers 9 and 10 have merit. The Santolites and Aroclors have fair compatibility.

Polyvinyl Chloride

Santicizers M-17 and E-15 are especially efficient plasticizers. Tricresyl Phosphate, Dibutyl Phthalate and Santicizer B-16 also have good compatibility. The Aroclors are compatible but do not produce great flexibility.

Polystyrene

Santicizer B-16 and Diphenyl Phthalate are recommended. Santicizers E-15 and 9 are also suggested but are not so generally applicable. The Aroclors are compatible, the liquids having some solvent action when warm.

Santolite Resins

All of the plasticizers—both liquid and solid—may be used; one part of a liquid plasticizer to four parts of Santolite MHP will be very soft. The solid plasticizers also produce a softening effect but to a less degree. Combinations of solid plasticizers and the Santolites make efficient plasticizers for cellulose esters and ethers and polyvinyl acetates. Diphenyl Phthalate and Santicizer 10 are recommended for such combinations. Equal parts by weight of Diphenyl Phthalate or Santicizer 10 and Santolite MHP will be liquid at ordinary temperatures. Increasing the proportion of Santolite hardens the combination.

Urea Formaldehyde Resins

Santicizer 9 somewhat improves the uniformity and workability of resins of this class.

Acrylic Type Resins

Santicizer B-16 is recommended. The solid plasticizers produce less softening effect but also less flexibility.

Nitrocellulose

Tricresyl Phosphate is recommended for fire retarding and also imparts good flexibility, permanence, toughness and water resistance.

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Dibutyl Phthalate and Santicizers B-16, E-15 and M-17 are best for color stability, high flexibility and practically all properties except fire retardation. Santicizer B-16 gives the greatest film strength and Santicizer M-17 the greatest flexibility. Dibutyl Phthalate gives the least moisture resistance.

Santicizer 8 produces high flexibility, gloss, brilliance and smooth working qualities. Its color stability is of the same order as that of Tricresyl Phosphate.

Santicizer 10 and Diphenyl Phthalate impart water resistance and gloss. Both produce hard compositions when used alone so are most frequently used in combination with other plasticizers or with resins to aid flexibility.

The Aroclors act as both plasticizers and resins in nitrocellulose lacquers. Compatibility decreases as the chlorine content of the Aroclor increases. Aroclors 1242, 1254, 1260 and 5442 are most suitable and aid water resistance, adhesion, gloss and reduce the burning rate. They reduce gas permeability and tend to eliminate "corona" effect when used in high tension cable coatings. The Aroclors yellow somewhat in ultraviolet light.

The Santolite resins are valuable in all lacquers not intended for the most severe exposure to weathering. They are highly compatible, produce solutions of low viscosity and impart high gloss, good flow and moisture resistance and are essentially colorless. They may be used with any of the plasticizers, either liquid or solid. Amounts of Santolite MHP suggested are up to a weight equal to the nitrocellulose, and the quantity of plasticizer for such mixtures will be the same as that required if the Santolite were not present. Santolite K gives more water resistance than the other Santolites and produces some flexibility of itself.

Cellulose Acetate

Dimethyl Phthalate, Diethyl Phthalate, Triphenyl Phosphate, Santicizers 8, M-17, E-15 and, for some types of acetate, B-16 are all of value.

Dimethyl Phthalate produces great flexibility and is relatively cheap. A high evaporation rate and poor moisture resistance are its chief defects.

Diethyl Phthalate is almost always used in conjunction with Dimethyl Phthalate or other plasticizers.

Triphenyl Phosphate gives fire retarding (films with 20 parts per 100 of acetate will not support combustion), and produces firm, flexible films of high tensile strength.

Santicizer 8 produces tough, flexible, compositions of high gloss and with smooth working properties. Its light stability is better than Triphenyl Phosphate but not equal to the phthalate derivatives.

Santicizers M-17 and E-15 give products of high quality as regards all characteristics. They do not affect the burning rate. These plasticizers are recommended over other compounds for general use. M-17 is a better solvent than E-15 for cellulose acetate.

Santicizer B-16 is not a solvent for cellulose acetate and its retentivity varies over a wide range, being greatest with the more highly acetylated acetates. Although not recommended for general acetate work its possibilities should not be overlooked when the use of a permanent, light-stable, water-insoluble, alkali-resistant, odorless, tasteless plasticizer is required.

The Santolites are especially valuable in cellulose acetate compositions, adding gloss, adhesion and moisture resistance. They should be used with plasticizers to produce flexibility, Santolite K requiring the least amount of plasticizer.

The Aroclors are of little value in cellulose acetate because they have a low compatibility and impart no flexibility or reduction in burning rate.

Cellulose Acetobutyrate

Dibutyl Phthalate, Tricresyl Phosphate and Santicizers B-16, E-15 and M-17 are all efficient plasticizers. Suitability will depend upon the intended use of the finished goods. About 30 parts of plasticizer (by weight) to 100 parts of the acetobutyrate is usually required.

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Ethyl Cellulose

Santicizer M-17 produces maximum flexibility. Amounts up to about 75 parts (by weight) to 100 parts of ethyl cellulose may be used without producing tacky compositions. Santicizers B-16, E-15 and 8, Dibutyl Phthalate, Tricresyl Phosphate and Triphenyl Phosphate are also of value.

The Santolite resins produce flexible, tough compositions of excellent properties.

The Aroclors are very compatible and afford a means of obtaining any desired degree of flexibility or hardness. The liquid Aroclors, such as 1242, produce great flexibility while the hard, resinous Aroclors, such as 5460, produce hard compositions of unusual weathering qualities. The Aroclors are highly recommended for compositions of good water resistance, gloss, alkali-resistance, flexibility, adhesion and weathering qualities.

Benzyl Cellulose

Diphenyl Phthalate is recommended. Santicizers B-16 and E-15 and Tricresyl Phosphate are also applicable. 25 parts per 100 by weight are sufficient for normal purposes.

The Aroclors are compatible and aid alkali resistance and reduce moisture and gas permeability. The liquid and soft resinous aroclors *give greatest flexibility.*

Chlorinated Rubber

Santicizers B-16, E-15 and M-17 have special merit. Santicizer B-16 increases the adhesion and is usually preferred, although Santicizer M-17 produces greater flexibility and is not affected by petroleum hydrocarbons. From 5 to 25 parts of plasticizer per 100 are suggested although more can be used, the retentivity of Santicizer M-17 being almost 200 parts to 100 of Chlorinated rubber.

The Aroclors - both liquid and solid— are valuable for giving a wide range of properties between flexibility and hardness. Aroclor 1260 is recommended for flexibility and toughness combined with water and alkali resistance. Usually from 20 to 50 parts of Aroclor to 100 parts of chlorinated rubber are required.

Protein Compounds

(Soybean or corn protein, casein, glue).

Santicizers 8 and 9 are compatible with and give a temporary plasticizing action to most protein compounds. For more permanent results we suggest a combination of Santolite resin with a plasticizer. Polyhydric alcohols (such as glycerine or ethylene glycol) may be used with the Santicizers and Santolites without materially increasing susceptibility to water.

Addition of Santicizer 8 to glue-glycerine mixtures *increases the flexibility and water resistance.*

Neoprene

From 10% to 25% of Aroclor 1270 acts as a flame retarder when milled into Neoprene.

Natural Resins

Damar—Diphenyl Phthalate in amounts from 5 to 25 parts per 100 of Damar is recommended.

Kauri—Santicizer B-16 and Dibutyl Phthalate are suggested.

Manila—Santicizer E-15 and Dibutyl Phthalate are suggested.

Rosin—Tricresyl Phosphate, Santicizer B-16 and the Aroclors are suggested.

Shellac—Santicizers 8, 9 and B-16 are recommended.

Santicizer 8 produces great flexibility but softens the shellac. Santicizer 9 produces harder compositions. 10 parts of Santicizer 8 per 100 of shellac produces about the same degree of softness as 30 parts of Santicizer 9. Neither affects the heat curing of the shellac.

Santicizer 8 is best for mixing into melted shellac but where solutions are used, Santicizer B-16 has about the same efficiency.

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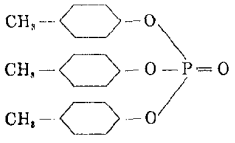
Tricresyl Phosphate

"Ortho Free"



(Para Isomer)

Specifications

Form	Clear oily liquid
Color	Essentially colorless
Specific Gravity at 20/20° C	1.165 ± 0.005
Refractive Index at 20° C	1.556 ± 0.001
Acidity (as H_3PO_4)	0.01% max.
Free Phenols (Permanganate Test)	A distinct purple color to be present after 30 minutes. (10 gram sample — 40 cc N/100 $KMnO_4$).

Containers

55-gal. one time shippers (incl.)
(approx. 500 lbs.)

Description

Tricresyl Phosphate is a practically colorless, odorless liquid weighing about 9.7 pounds per gallon. It has a high boiling point and an evaporation loss of only 0.2% in 100 hours at 100° C. Its viscosity increases rapidly at temperatures below normal until at —35° C it is a solid, transparent mass without crystalline structure.

This product is miscible with all the common solvents and thinners, and with linseed, china wood, and castor oils. Its solubility in water is less than 0.002% at 85° C and it imparts good moisture resistance to nitrocellulose films. Being a solvent for nitrocellulose, it has a high retentivity and can be used in large proportions without danger of sweating or separation. It imparts excellent flexibility and increased amounts do not cause proportionately as great a decrease in tensile strength as most other plasticizers.

Tricresyl Phosphate is the standard fire retarding plasticizer for nitrocellulose. It is compatible with most lacquer resins and gives firm, tough, flexible films of excellent weathering qualities. Although Tricresyl Phosphate has an inherent tendency to yellow in nitrocellulose lacquers when exposed to heat or light, every precaution is taken in the manufacture of Tricresyl Phosphate Monsanto to eliminate impurities which might aggravate such discoloration.

Tricresyl Phosphate has a low compatibility with cellulose acetate so when extreme fire resistance is desired in acetate compositions Triphenyl Phosphate should be used. Small amounts of Tricresyl Phosphate may be used effectively, however, in conjunction with more compatible plasticizers.

The ortho isomer, which is reputed to be the toxic element in normal Tricresyl Phosphate, has been virtually eliminated from Tricresyl Phosphate Monsanto, thereby reducing toxicity dangers to a minimum and making the product more suitable for many applications. The elimination of the ortho isomer causes no impairment in plasticizing qualities.

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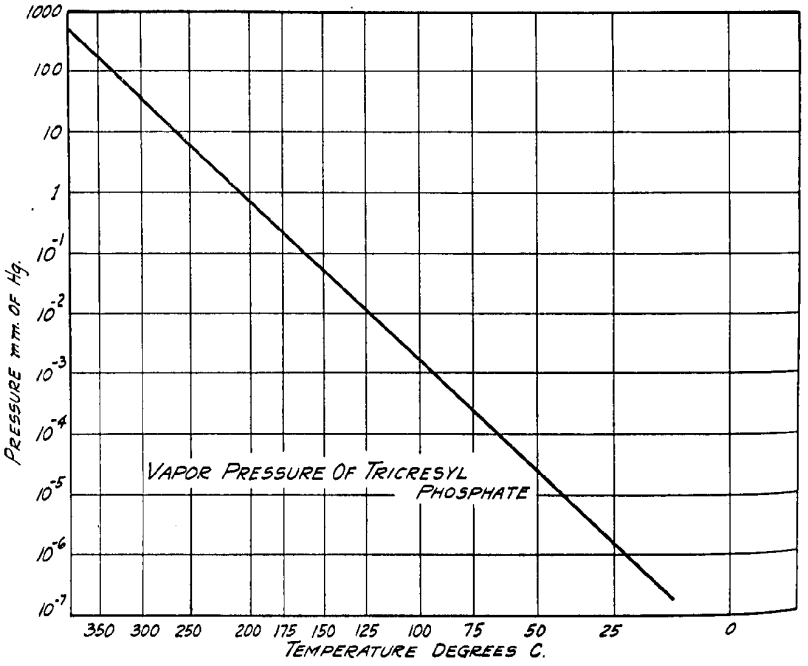
Fig. 1



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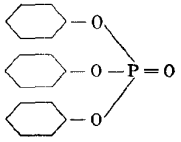
Triphenyl Phosphate



Specifications

Appearance	White flakes
Odor	Very faintly aromatic
Melting Point	48.5° C Min. start
Solution in Alcohol (10 gms. in 50 cc) Turbidity	Not more than faintly opalescent
Permanganate Test	Distinct purple color to be present after 30 minutes.
Assay	99% Min.
Free Phenol	0.1% Max.
Acidity (as H_3PO_4)	0.003% Max.

Containers

175-lb. barrels (incl.)

Description

Triphenyl Phosphate is a white crystalline compound melting at about 48.5° C and boiling at 245° C at 11 mm. pressure. Its evaporation rate is of the same order as Tricresyl Phosphate.

This product is miscible with the common solvents and thinners and with vegetable oils. Its solubility in water is 0.001% at 34° C and 0.002% at 54° C and it imparts some moisture resistance to cellulose acetate films. Its retentivity in cast cellulose acetate films is nearly 80%; that is—it can be incorporated in the proportion of 8 parts to 10 of acetate without causing separation and blooming. It imparts good flexibility and gives clear, tough compositions without tendency toward tackiness. Triphenyl Phosphate is toxic and should not be used in articles such as foil, which are to come in contact with foodstuffs. Its light stability is rather poor but the rate of discoloration of Triphenyl Phosphate-cellulose acetate compositions is much less than that of Tricresyl Phosphate-nitrocellulose mixtures.

One of the most valuable properties of Triphenyl Phosphate is that of fire retarding. When used alone in cellulose acetate films an amount of Triphenyl Phosphate equal to 20% of the cellulose acetate weight produces films which will not support combustion. When other plasticizers are used with it, a greater amount of Triphenyl Phosphate is necessary to retard the burning rate.

Triphenyl Phosphate mixed with Santicizer M-17 dissolves cellulose acetate when heated to temperatures above 120° C. Such mixtures, with or without the addition of pigments, may be used for making flexible sheets, either alone or on a fibre base. The pigmented sheets are especially fire resistant. The addition of a small amount of one of the Santolite resins is usually beneficial in aiding solution and increasing flexibility. As a suggestion for the relative amounts to be used, 10 parts by weight of cellulose acetate, 8 parts of Santicizer M-17, 8 parts of Triphenyl Phosphate and 1.5 parts of Santolite MHP gives a very flexible product.

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If a pigment or filler is to be used, it should first be ground with a portion of the plasticizer and may then be mixed directly into the hot solution.

The following table indicates the crystallizing point of solutions of Triphenyl Phosphate in Santicizers M-17, E-15 and B-16.

Crystallizing Points of Triphenyl Phosphate — Phthalyl Glycollate Mixtures

% Triphenyl Phosphate	% M-17	% E-15	% B-16	Crystallizing Point (° C.)
50	50	——	——	22
50	——	50	——	23
50	——	——	50	24
66⅔	33⅓	——	——	31
66⅔	——	33⅓	——	32.5
66⅔	——	——	33⅓	35
75	25	——	——	34
75	——	25	——	36
75	——	——	25	38
80	20	——	——	39
80	——	20	——	38
80	——	——	20	40
100				48.5

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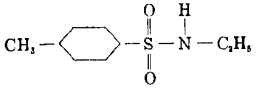
The Santicizers

(Sulfonamides, Sulfonates, Phthalyl Glycollates)

Santicizer 8

(Mixture of ortho and para toluene ethyl sulfonamides)



Specifications

Appearance	Light amber liquid (possibly partially crystallized)
Odor	Slight, characteristic
Free Amide	9% to 13%
Acidity (as acetic acid)	0.1% max.

Containers

475 lb. (approx.) drums (extra, but returnable)
45 lb. (approx.) tins (incl.)

Description

Santicizer 8 is a light amber colored liquid which will partially crystallize on long standing.

This product is readily miscible with all common organic solvents except the petroleum hydrocarbons in which it is only very slightly soluble. It is soluble in castor oil, slightly soluble in china wood oil and insoluble in linseed oil. In water it is soluble to the extent of about 0.13% at 23° C and 0.21% at 48° C. Its solubility in water is decreased by the presence of ammonia but is increased by other alkalies. Its retentivity in acetyl cellulose is about 90 parts by weight to 100 of acetate, and it imparts a high degree of plasticity. It is a solvent for both nitrocellulose and acetyl cellulose.

Santicizer 8 is an excellent plasticizer for cellulose acetate, giving a brilliance and polish not obtainable with other plasticizers. Although the light stability of Santicizer 8 in nitrocellulose is not of the highest order, this plasticizer does improve the workability and gloss. It may be used in such compositions either alone or mixed with other plasticizers, solid or liquid. In cellulose acetate, however, its light stability is sufficient to meet most of the ordinary requirements of moulding compositions.

This product, being practically insoluble in petroleum hydrocarbons is a valuable plasticizer for coatings designed to withstand gasoline and related products. It can be used with Santolite resins for that purpose; to illustrate, a lacquer made from 1 part Santicizer 8, 2 parts nitrocellulose and 6 parts of Santolite MHP was found to be unaffected by gasoline and, also, to prevent corrosion of iron panels exposed to a salt solution of from 3% to saturation over a period of ten weeks.

Santicizer 8 has some plasticizing action on such protein compounds as casein, glue, soybean protein and corn protein. It may be used alone or in conjunction with other materials such as glycerine or similar compounds. The use of from 10% to 40% on the protein weight is suggested.

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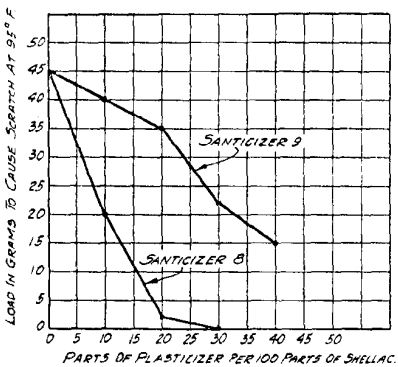
Santicizer 8 greatly increases the flexibility of shellac, having at the same time a considerable softening effect. An amount equal to 10% of the shellac weight produces very pronounced results. It may be incorporated either by direct fusion or by means of solvents. It does not destroy the adhesion of the shellac nor affect the heat curing qualities.

The accompanying graph shows the relative softening effect on shellac of Santicizers 8 and 9 when incorporated at the rate of 10, 20, 30 and 40 parts per 100 parts (by weight) of the resin. The softening effect was measured by the load (in grams) required to cause a steel point to scratch the surface of the composition at 95° F (35° C).

Santicizer 8 is also useful with vinyl resins especially polyvinyl acetate-formal resin.

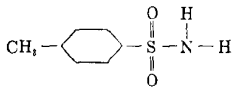
Fig. 2

SOFTENING EFFECT ON SHELLAC OF SANTICIZERS 8 AND 9



Santicizer 9

(Mixture of ortho and para toluene sulfonamides)



Specifications

Appearance	Fine granular particles
Melting Point	105° C min.
Melt	Liquid, clear and light yellow
Acidity	pH 4.6 min. in dilute acetone (2 gram sample in 15 cc A. R. Acetone and 35 cc of CO_2 free distilled water).

Containers

250-lb. barrels (incl.)

Description

Santicizer 9 is a white solid melting at about 105° C. Its solubility is quite low in coal-tar hydrocarbons and negligible in petroleum hydrocarbons. It is readily soluble in most other solvents, and in hot linseed, china wood, and castor oils. It is soluble in water to the extent of only about 1.0% at 34° C. Its solubility in

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water is increased by the presence of alkali, being about 5% at 20° C for a mixture of equal volumes of water and concentrated ammonia solution. It is the least soluble of our plasticizers in ethylene dichloride and in benzene, its solubility in ethylene dichloride being about 4% at 30° C and in benzene about 1.5% at 30° C.

Santicizer 9 has a retentivity in cellulose esters of only about 30 parts per 100 by weight and does not impart great flexibility.

Santicizer 9 differs greatly from other plasticizers in its action. Relatively small amounts impart a gloss to polished articles and gives smooth working and uniform curing of moulded products. It blends readily with most synthetic resins and does not impart the softening action of liquid plasticizers. Because of its adaptability to a wide variety of materials Santicizer 9 is particularly valuable to the makers of all sorts of moulding compositions.

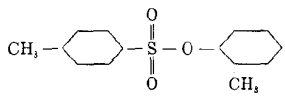
In some phenol-aldehyde resins Santicizer 9 appears to act not only as a lubricant but also as a promoter, giving more uniform and thorough curing.

Santicizer 9, in amounts of about 20 parts per 100, has a temporary plasticizing action on protein compounds such as corn protein and soybean protein. It may be mixed in either alone or in conjunction with some other material such as glycerine or a related product. Its increased solubility in slightly alkaline solutions may also be of use in incorporating it into certain compounds where such solutions are used as swelling agents or actual solvents for the plastic material.

Santicizer 9 is a plasticizer for shellac but its action is less pronounced than that of Santicizer 8. It does not have as great a softening effect, 30 parts of Santicizer 9 producing about the same degree of softening as 10 parts of Santicizer 8. See Figure 2 for comparative effects of Santicizers 8 and 9 on shellac.

Santicizer 10

(Ortho-cresyl para-toluene sulfonate)



Specifications

Appearance	White crystals
Melt	Practically colorless
Crystallizing Point	51° C min.
Acidity (as acetic acid)	0.03% max.

Containers

200-lb. barrels (incl.)

Description

Santicizer 10 is a solid plasticizer for cellulose esters and many resins. Its retentivity in nitrocellulose is about 50 and in cellulose acetate 30 parts per 100. From 15 to 20 parts are required to give added flexibility to cellulose acetate.

Santicizer 10 is quite stable toward heat and is resistant to hydrolysis. It is soluble in all the common organic solvents but insoluble in water. When used with cellulose esters, Santicizer 10 imparts gloss, hardness and moisture resistance. In such compositions it is best used with small amounts of liquid plasticizers. Santicizer 10 is suggested also as a plasticizer for phenolaldehyde, vinyl and polystyrene resins.

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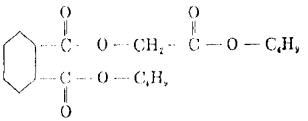
Santicizer B-16

(Butyl phthalyl butyl glycollate)



Specifications

Color (APHA)	45 max.
Specific Gravity at 25°/25° C.	1.097 ± 0.005
Refractive Index at 25° C.	1.490 ± 0.002
Acidity (as acetic acid)	0.02% max.
Odor	Slight fruity
Sulfur (copper strip test)	None

Containers

55-gallon tin lined drums (approx. 500 lbs.)
(drums extra, but returnable)
5-gallon cans (45 lbs.) (incl.)

Description

Santicizer B-16 is a practically colorless liquid which boils at 219° C at 5mm and does not crystallize at temperatures as low as - 35° C. Its water solubility is 0.0012% at 30° C. It is extremely light stable.

Santicizer B-16 is a solvent for nitrocellulose and is compatible with most resins, imparting a good flexibility. Its compatibility with cellulose acetate seems to depend greatly upon the acetyl content of the latter; the retentivity value for one sample of cellulose acetate of about 52% combined acetic acid content was around 40% while for another sample of 56% combined acetic acid content the retentivity was 100%. With nitrocellulose it gives clear, brilliant films which are flexible, tough, moisture resistant and have good weathering qualities. Santicizer B-16 probably embodies more desirable properties than any other single nitrocellulose plasticizer, fire retarding action being about the only property it does not have. It imparts about the same degree of flexibility as Dibutyl Phthalate but produces less softening of the film.

Santicizer B-16 is a solvent for and imparts plasticity to many synthetic resins. It has especially interesting properties when used with those resins of the glycerol-phthalate and phenol-aldehyde types in which it may be incorporated at various stages of resin formation. When added to a simple glycerine-phthalic anhydride resin at any stage before the final gel formation, it retards the rate of thickening and permits the acid number of the resin to be lowered without completely destroying solubility. If such a resin is heated beyond the gel stage, the product may still be thermoplastic although its solubility will be radically changed.

Santicizer B-16 has an unusually wide range of use, covering not only the synthetic plastic materials but also the natural resins. Its solvent properties, light stability, low volatility and low pour point are important factors to be considered.

Santicizer B-16 is miscible with castor, linseed and china wood oils and somewhat retards gel formation in the latter on heating.

Santicizer B-16 swells crepe rubber but appears to have no effect on vulcanized rubber. It is an excellent plasticizer for chlorinated rubber, from 10 to 25 parts per 100 usually being required.

Santicizer B-16 is an exceptionally good plasticizer for polystyrene, whether for moulding or coating uses. It maintains the excellent properties of the resins and in coatings greatly retards weathering failure.

Mixtures of Santicizer B-16 and Santolite resins (MS preferred) may be used to plasticize certain compounds such as casein and corn protein, being incorporated either as solutions in some organic solvent or in the form of emulsions. The proportions of the several

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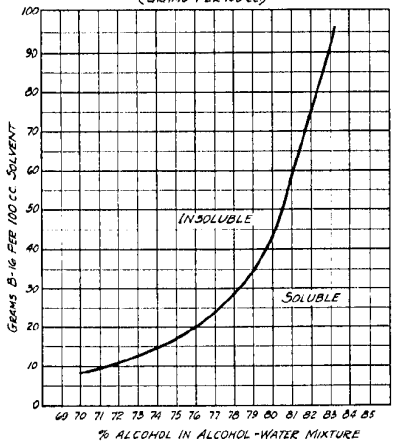
components can be varied between wide limits; 1 part of B-16 to from 2 to 10 parts of Santolite, and 1 part of such mixture added in amounts from 0.3 to 1.5 parts of the protein compound greatly increase water resistance. It should be noted that B-16 alone is not a plasticizer for protein compounds.

Santicizer B-16 darkens and then decomposes on heating to high temperatures at atmospheric pressure. The approximate temperatures and the effects obtained are given below:

Up to 290° C	Very slight color change
From 290° to 300° C	Darkens rapidly
From 340° to 350° C	Boils with decomposition. Phthalic Anhydride is given off and the product becomes very dark.

Fig. 3



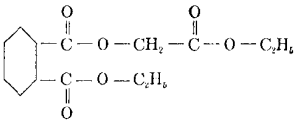
The addition of water causes Santicizer B-16 to be thrown out of solution from those organic solvents which are miscible with water.

The solubility of Santicizer B-16 in alcohol-water mixtures of various concentrations is shown in Figure 3.

Vapor pressures of Santicizer B-16 are shown in Figure 4.

Santicizer E-15

(Ethyl phthalyl ethyl glycollate)



Specifications

Color (APHA)	25 max.
Specific Gravity at 25°/25° C	1.180 ± 0.005
Refractive Index at 25° C	1.498 ± 0.002
Acidity (as acetic acid)	0.02% max.
Odor	Slight fruity
Sulfur (copper strip test)	None

Containers

55-gallon tin-lined drums, (approx. 500 lbs.),
(drums extra, but returnable)
5-gallon cans (approx. 50 lbs.) (incl.)

Description

Santicizer E-15 is a practically colorless liquid with a boiling point of 190° C at 5 mm and a crystallizing point of 20° C.

This product is miscible with the common organic solvents except the petroleum hydrocarbons. It is

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miscible with vegetable oils when heated but partially separates on cooling. Its solubility in water is 0.0175% at 30° C.

Santicizer E-15 is a solvent for both nitrocellulose and acetyl cellulose and for most resins. It is light-fast, and does not evaporate even from the thinnest films. With both acetyl and nitrocellulose it gives clear, tough, flexible films which have greatly increased resistance to moisture penetration. This is an efficient plasticizer which gives practically all the desirable qualities except fire resistance. It is an active solvent and the amount which may be incorporated in cellulose esters depends only upon the degree of plasticity desired.

Santicizer E-15 is highly recommended for use with cellulose acetate and with vinyl resins. It imparts slightly less flexibility than Santicizer M-17 but has less softening effect and produces somewhat tougher compositions.

Santicizer E-15 partakes of the properties of both B-16 and M-17 although mixtures of these probably cannot be relied upon to give results identical with those obtained by the use of E-15.

For vapor pressures of Santicizer E-15 see Figure 4.

The following table gives a few comparisons of the three phthalyl glycollate plasticizers:

		B-16	E-15	M-17
Viscosity in Centipoises at	0° C	295.3	611.1	1671.4
	10° C	136.5	215.7	454.8
	25° C	51.3	63.0	100.3
Flash Points (Degrees F)		380° F	380° F	375° F
*Tensile Strengths (in Kg/Cm_2) of Cellulose Acetate films	0% (Control)	528	528	528
	25%	420	472	468
	50%	315	256	266
	75%	243	136	144
*Elongation (in per cent) of cellulose Acetate films	0% (Control)	2.3	2.3	2.3
	25%	6.	5.7	10.
	50%	12.3	11.7	24.7
	75%	13.3	28.	35.3
Increase in color rating (APHA) due to heating at 100° C for four hours		5 max.	5 max.	5 max.
% of Plasticizer decomposed by 10% NaOH solution in 20 minutes at	32° C	0	0.93	7.09
	80° C	0	11.19	21.28

*The tensile strength and elongation values are for comparative purposes only. In no sense are they to be considered absolute values.

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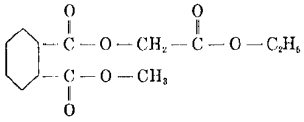
Santicizer M-17

(Methyl phthalyl ethyl glycollate)



Specifications

Color (APHA)	20 max.
Specific Gravity at 25°/25° C	1.220 ± 0.005
Refractive Index at 25° C	1.504 ± 0.002
Acidity (as acetic acid)	0.02% max.
Odor	Slight fruity
Sulfur (copper strip test)	None

Containers

55-gallon tin-lined drums, (approx. 500 lbs.),
(drums extra, but returnable)
5-gallon cans (approx. 50 lbs.) (incl.)

Description

Santicizer M-17 is a practically colorless liquid with a boiling point of 189° C at 5 mm. It remains liquid at temperatures as low as −35° C and is a solvent for both nitrocellulose and acetyl cellulose. It imparts a high degree of plasticity which is maintained undiminished even in extremely thin films exposed to air currents for a long time. It is very light stable and may be used in transparent or tinted articles without danger of yellowing.

This product is not miscible with castor, linseed, or china wood oil or with petroleum hydrocarbons but is readily miscible with other organic solvents. Its solubility in water is 0.09% at 30° C but it imparts a considerable degree of resistance to moisture penetration in both nitrocellulose and acetyl cellulose films. Santicizer M-17 is probably the best cellulose acetate plasticizer available.

Where it is desired to use a hot mix and avoid the use of volatile solvents, cellulose acetate may be dissolved directly in Santicizer M-17 by the aid of heat. By employing acetate of the proper acetyl content and viscosity, and amounts of M-17 equal to from 1 to 2 times the weight of acetate, it is possible to make solutions which will flow or be workable at temperatures of from 120° to 180° C and which will set to a tough, transparent product on cooling. The character of the product may be varied by additions of Triphenyl Phosphate and Santolite resins.

The retentivity of Santicizer M-17 like that of Santicizer B-16 varies with the acetyl content of cellulose acetate. Thus the use of 2 parts of Santicizer M-17 with 1 part of cellulose acetate having a combined acetic acid content of 52% produced marked exudation of the plasticizers whereas when the same proportions were used with an acetate of 56% combined acetic acid content there was no exudation. This phenomenon of exudation, caused by the use of too large a proportion of plasticizer, can frequently be overcome by the addition of small percentages of Santolite resins.

Santicizer M-17 affects synthetic resins in a manner similar to Santicizers B-16 and E-15 but usually it gives a greater degree of flexibility. Its action is pronounced with alkyd, vinyl, polystyrene and many phenolic resins and with chlorinated rubber. Often as little as 5 parts per 100 produces marked flexibility. It is not compatible with resins of the urea-formaldehyde type or with protein compounds such as corn protein, soybean protein or casein. It may be used with

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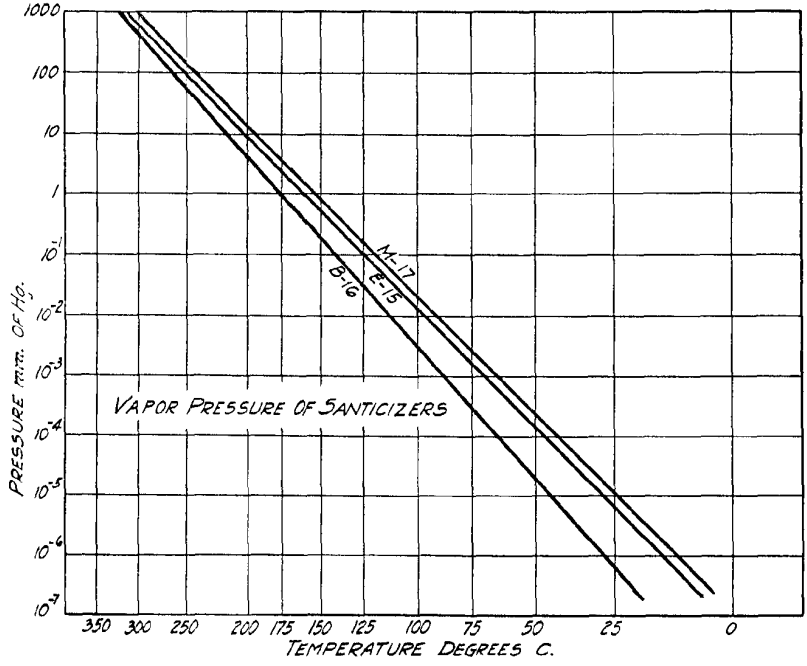
some of these compounds, however, when mixed with Santolite resins in the manner outlined under Santicizer B-16.

Santicizer M-17 dissolves Santolite resins, and as both are very resistant to petroleum products and, also, compatible with so many film-forming materials they make an excellent combination for producing naphtha-resistant coatings. By varying the proportions of each of the three components—Santicizer M-17, Santolite resin and film material, which is usually a cellulose ester—a practically complete range of properties can be obtained from hard to soft, from solid to liquid at slightly elevated temperatures, sticky or entirely non-tacky, brittle or flexible. Thus such compositions can be applied to a wide variety of uses.

Vapor pressures of Santicizer M-17 are given in Figure 4.

Fig. 4



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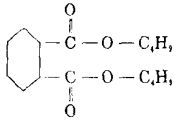
The Phthalates

Dibutyl Phthalate



Specifications

Appearance	Clear, oily liquid
Color (APHA)	10 max.
Odor	Slight
Acidity (as phthalic acid)	0.01% max.
Specific Gravity at 20°/20° C	1.0477 ± 0.001
Refractive Index at 25° C	1.4905 ± 0.001
Purity	Essentially 100%
Sulfur (copper strip test)	None

Containers

55-gal. one-time shippers (approx. 460 lbs.) (incl.)

Description

Dibutyl Phthalate, one of the most widely used plasticizers for nitrocellulose, is a practically colorless liquid which boils at 340° C at atmospheric pressure and 206° C at 20 mm and crystallizes at about —35° C. It has a weight of about 8.75 pounds per gallon.

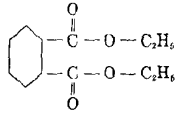
It is miscible with all the common organic solvents and with oils but is soluble in water only to the extent of 0.001% at 30° C. In spite of this low solubility, however, it adds practically nothing to the moisture resistance of nitrocellulose films. It is compatible with most lacquer resins.

Dibutyl Phthalate has excellent light stability which permits its use in colorless, white or delicately tinted products. Its retentivity in cellulose acetate is less than 20 parts per 100 and in that amount does not increase the plasticity, so it is restricted to use with nitrocellulose or other plastics. It is a solvent for nitrocellulose and gives a high degree of plasticity but greatly reduces the tensile strength and tends to produce softness.

The stability of Dibutyl Phthalate and its high solvent power for most plastic materials make it one of the most acceptable plasticizers for general use.

For vapor pressures of Dibutyl Phthalate see Figure 5.

Diethyl Phthalate



Specifications

Appearance	Clear, water-white oily liquid
Color (APHA)	Not darker than 10
Odor	Very slightly aromatic
Acidity (as phthalic acid)	0.01% max.
Specific Gravity at 20°/20° C	1.123 ± 0.005
Refractive Index at 20° C	1.5030 ± 0.001
Purity	Essentially 100%
Sulfur (copper strip test)	None

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Containers

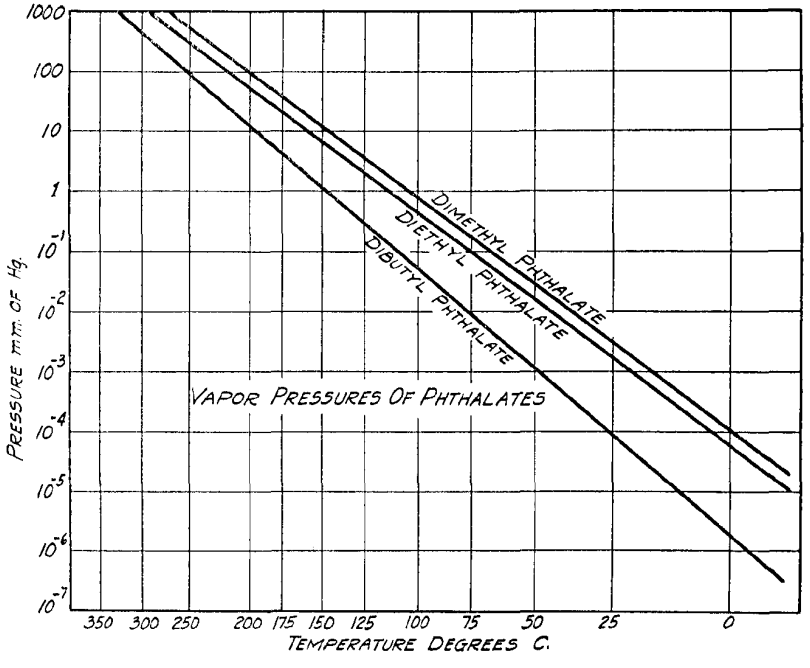
55-gal. drums (approx. 500 lbs.)
(drums extra, but returnable)

Description

Diethyl Phthalate is a colorless liquid plasticizer generally used in mixture with Dimethyl Phthalate as a plasticizer for cellulose acetate. Its boiling point is about 295° C and its weight about 9.35 lbs. per gallon. It is miscible with all the common organic solvents and diluents. Its chemical constitution places it between Dimethyl and Dibutyl Phthalates and its properties fall into that position, although it is more nearly like the former than the latter.

The evaporation rate of Diethyl Phthalate is too high for successful use as a regular nitrocellulose plasticizer

Fig. 5



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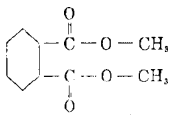
and it is not a solvent for cellulose acetate. Thus its range of usefulness is somewhat restricted.

Mixtures of Diethyl and Dimethyl Phthalates usually give better results than can be obtained by either one alone, the proportions generally used being approximately equal parts by weight.

Diethyl Phthalate imparts slightly less flexibility to cellulose acetate than does Dimethyl Phthalate and its effect on moisture penetration is about the same. Its viscosity is considerably less than that of Dibutyl Phthalate and varies at about the same rate for equal changes in temperatures.

For vapor pressures of Diethyl Phthalate see Figure 5.

Dimethyl Phthalate



Specifications

Appearance	Clear, practically water white oily liquid
Color (APHA)	Not darker than 10
Odor	Not more than slightly aromatic
Acidity (as phthalic acid)	0.01% max.
Specific Gravity at 15.6/15.6° C	1.196 ± 0.001
Refractive Index at 20° C	1.5155 ± 0.001
Purity	Essentially 100%
Sulfur (copper strip test)	None

Containers

55-gal. tin-lined drums (approx. 500 lbs.)
(extra, but returnable)

Description

Dimethyl Phthalate is a colorless, liquid, solvent plasticizer for cellulose acetate. It is completely compatible with nitrocellulose, also, but is seldom used with that material because it does not impart the required qualities. Its boiling point is 282° C, its crystallizing point 0° C, and its weight about 10 pounds per gallon. It is miscible with all common organic solvents and with oils (except petroleum oils) and has a solubility in water of 0.4% at 32° C. It has excellent light stability.

Dimethyl Phthalate, having a rather low boiling point and high evaporation rate is apt to be lost from plastic compositions, leaving them brittle. This is especially true in the case of thin films or those objects where the ratio of surface to volume is high. In certain cases too, where the finished article will be exposed to severe cold, there is danger of the Dimethyl Phthalate crystallizing, causing not only brittleness but also a whitening and lack of transparency which may be at least partly permanent.

Dimethyl Phthalate is much used but cannot be said to meet very rigid plasticizer requirements. Its use is restricted almost entirely to the cellulose acetate field, and, there, as a general rule, it is used in combination with Diethyl Phthalate or some other plasticizer. It should be noted however, that although Diethyl Phthalate has a slightly higher boiling point and lower volatility than Dimethyl Phthalate, its loss by evaporation from cellulose acetate compositions is equal to that of Dimethyl Phthalate.

For vapor pressures of Dimethyl Phthalate see Figure 5.

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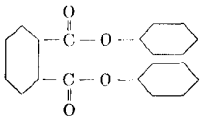
Diphenyl Phthalate



Specifications

Appearance	White powder
Melt	Clear and very light yellow color
Crystallizing point	69° C min.

100-lb. containers (incl.)

Description

Diphenyl Phthalate is a white powder, melting at about 69° C and readily soluble in ketones, esters and chlorinated hydrocarbons. Its solubility in alcohols, turpentine and linseed oil is rather low, being in the neighborhood of 5.0 grams per 100 c.c. of solvent at 25° C.

Diphenyl Phthalate is compatible with nitrocellulose and with the sulfonamide, phenolic, polystyrene and vinyl types of synthetic resins. In nitrocellulose lacquers it produces hard coatings that have excellent gloss retention and weather resistance. The addition of Diphenyl Phthalate to Santolite resins lowers their softening point, equal parts of Diphenyl Phthalate and Santolite MHP being practically liquid at normal temperatures. Such mixtures of Diphenyl Phthalate with either Santolite MS or Santolite MHP are excellent plasticizers for nitrocellulose, in odorless, flexible, adhesive coatings.

Diphenyl Phthalate is completely insoluble in water and gives increased water resistance to all compositions in which it is used.

Diphenyl Phthalate when used alone does not usually impart a high degree of flexibility but it blends well with other plasticizers and can be used in varied combinations. This plasticizer is especially recommended for vinyl resins, polystyrene, ethyl cellulose, and some of the natural resins such as Damar.

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General Data

Miscibility of Liquid Plasticizers With Organic Solvents

The liquid plasticizers, Tricresyl Phosphate, Santicizers 8, B-16, E-15 and M-17 and Dibutyl, Diethyl and Dimethyl Phthalates are miscible in all proportions with the following organic liquids—

Methyl Alcohol	Trichlorethylene
Ethyl Alcohol	Carbon Tetrachloride
Butyl Alcohol	Benzene
Acetone	Xylene
Methyl Ethyl Ketone	Monochlorbenzene
Ethyl Acetate	o-Dichlorbenzene
Amyl Acetate	Chlorinated Diphenyl (Aroclor 1242)
Ethylene Dichloride	Pine Oil

Flash Points*

Plasticizer	°F	Calculated °C
Tricresyl Phosphate	455	235
Diphenyl Phthalate	435	224
Triphenyl Phosphate	430	221
Santicizer B-16	380	193
Santicizer E-15	380	193
Santicizer M-17	375	190
Santicizer 9	370	188
Santicizer 10	360	182
Santicizer 8	345	174
Dibutyl Phthalate	340	170
Diethyl Phthalate	305	152
Dimethyl Phthalate	300	149

* Determined in Cleveland Open Cup.

Miscibilities with some other liquids are given in the chart below:

		Santicizers				Phthalates		
	Tricresyl Phosphate	8	B-16	E-15	M-17	Di-butyl	Di-ethyl	Di-methyl
Turpentine	M	PM	M	M	PM	M	M	PM
Linseed Oil (Raw)	M	I	M	PM	I	M	M	M
China Wood Oil	M	PM	M	PM	I	M	M	M
Soybean Oil	M	I	M	PM	I	M	M	PM
Perilla Oil	M	I	M	PM	I	M	M	M
Castor Oil	M	M	M	PM	I	M	M	M
Chlorinated Paraffin	M	I	M	M	I	M	M	M
Gasoline (Skelly E)	M	I	M	I	I	M	M	I

M = Completely miscible. PM = Partly miscible.
I = Not miscible.

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Solubilities of Solid Plasticizers in Organic Solvents

(Grams Plasticizer per 100 cc Solvent at 25°C.)

	Triphenyl Phosphate	Santicizer 9	Santicizer 10	Diphenyl Phthalate
Methyl Alcohol	335	37	20	12
Ethyl Alcohol	160	25	13	8
Butyl Alcohol	135	5	12	4
Acetone	340	50	225	215
Methyl Ethyl Ketone	350	45	250	140
Ethyl Acetate	270	20	200	95
Amyl Acetate	165	10	140	25
Ethylene Dichloride	400	3	340	180
Trichlor Ethylene	310	v. s. s.	250	120
Carbon Tetrachloride	240	v. s. s.	215	70
Benzene	330	v. s. s.	300	90
Xylene	230	v. s. s.	170	45
Monochlorbenzene	340	v. s. s.	250	110
o-Dichlorbenzene	320	v. s. s.	215	110
Turpentine	36	v. s. s.	35	10
Pine Oil	120	5	40	22
Linseed Oil (Raw)	13	v. s. s.	15	12
Tung Oil	22	v. s. s.	15	13
Soybean Oil	12	v. s. s.	12	10
Perilla Oil	12	v. s. s.	14	10
Castor Oil	27	v. s. s.	14	10
Mineral Oil	< 2	v. s. s.	v. s. s.	< 0.5
Chlorinated Diphenyl (Aroclor 1242)	114	v. s. s.	125	90
Chlorinated Paraffin	24	v. s. s.	25	25
Gasoline (Skelly E)	2.7	v. s. s.	4	0.5

v. s. s. means very slightly soluble.

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Solubilities of Some Resins and Waxes in Dibutyl Phthalate and Santicizers B-16, E-15, and M-17

Product	Dibutyl Phthalate	B-16	E-15	M-17
Alkyd Resins	SH	S	S	S
Phenolic Resins	SH	S	S	S
Vinyl Resins	S	S	S	SH
Polystyrol Resins	S	S	S	SH
Sulfonamide Resins	S	S	S	S
Urea Resins	I	I	I	I
Amberol	S	S	S	SH
Ester Gum	S	S	S	SH
Rosin	S	S	S	S
Shellac	SH	SH	SH	SH
Manilla Gum	SH	SH	SH	SH
Elemi Gum	S	S	S	SH
Gum Arabic	I	I	I	I
Gum Ghati	I	I	I	I
Paraffin Wax	SH	SH	SSH	SSH
Carnauba Wax	SH	SH	SSH	I

I—Indicates that the material is insoluble.
S—Indicates that the material is soluble. Where heating is necessary to obtain solution there is no separation on cooling.
SH—Indicates that the material is soluble when hot but separates on cooling.
SSH—Indicates slight solubility when hot.

Viscosities and Pour Points[1] of Liquid Plasticizers

Plasticizer	Pour Point[2] ° C	Viscosity In Centipoises 10° C	20° C
Tricresyl Phosphate	-26°	450.8	161.0
Dibutyl Phthalate	-40°	32.9	19.7
Diethyl Phthalate	Below -40°	19.6	12.7
Dimethyl Phthlate	-26°	30.1	17.1
Santicizer B-16	Below -40°	136.5	51.3
Santicizer E-15	-34.5°	215.7	63.0
Santicizer M-17	-26°	454.8	100.3

(1) Pour points were determined according to the method outlined in the ASTM Standards on Petroleum Products.
(2) The pour point temperatures are in some cases lower than the crystallizing points due to the phenomenon of "super-cooling."

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TABLE OF CHARACTERISTICS

	TRICRESYL PHOSPHATE	TRIPHENYL PHOSPHATE	SANTICIZER 8	SANTICIZER 9	SANTICIZER 10
Molecular Weight	368	326	199	171	262
Color and Form	Colorless liquid	White flakes	Light amber liquid	White granules	White crystals
Melting Point		48.5° C		105° C	
Boiling Point	295° C/13 mm	245° C/11 mm			
Crystallizing Point	Non-cryst., solid at —35° C				51° C
Specific Gravity	1.165/20° C	1.268/60° C	1.188/25° C	1.313/25° C	1.207/15° C
Pounds per Gallon	9.7	10.5	9.9	10.9	10.06
Refractive Index	1.556/20° C				
Evaporation Rate Gms/sq. cm/hr/ 100° C	0.00000708	0.00000028	0.0002659	0.000053 at 65° C	
Solubility in Water	Less than 0.002% at 85° C	0.001% at 34° C 0.002% at 54° C	0.13% at 23° C 0.213% at 48° C	1% at 34° C	0.0008% at 30° C
Retentivity in N/C[1]	100 plus	100	100	25—30	50
Retentivity in Ac/C[2]	0	80	90	25—30	30
Light Fastness in N/C[3]	Poor	Poor	Poor	Poor	Medium
Light Fastness in Ac/C		Fair	Good		
Fire Retardation	Excellent	Excellent	None	None	None
Toxicity[4]					
N/C Dilution Ratio (Toluene)[5]	5.0				
N/C Dilution Ratio (Naphtha)[6]	0.7				

(1) **RETENTIVITY IN NITROCELLULOSE.**
Retentivity in N/C was determined by dissolving weighed amounts of the plasticizer in a 15% solution of ½ second N/C in a solvent consisting of equal parts by volume of butyl acetate and toluene. From these N/C solutions, films of approximate 0.001" thickness were cast on glass plates, stripped off, dried at room temperature, then hung in a cabinet where the relative humidity was very nearly 100%. In those mixtures where the amount of plasticizer exceeded the retentivity a blushing or exudation developed in the films within a week. The retentivity is calculated from the formula:

$$\text{Retentivity} = \frac{100 \times \text{wt. of plasticizer}}{\text{Wt. of nitrocellulose}}$$

Measurements were not made beyond 100 parts of plasticizer per 100 parts nitrocellulose by weight.

(2) **RETENTIVITY IN CELLULOSE ACETATE.**
The retentivity in Ac/C was determined as for N/C except that the films were made from an 11.5% solution of lacquer viscosity Ac/C dissolved in acetone.

It should be noted that the retentivity may vary considerably with differences in the acetyl content of the cellulose acetate, so the values given in these tables must not be considered as absolute.

(3) **LIGHT FASTNESS IN NITROCELLULOSE.**
This was determined by casting uniform N/C films containing 50 parts of plasticizer per 100 parts of N/C upon white glass panels, drying, exposing in a "Uvisrc" and comparing the color intensities at regular intervals. Dibutyl Phthalate, which has a satisfactory light stability for most uses, will show a slight yellowing in 30 minutes, while Tricresyl Phosphate will exhibit a color of the same intensity in from 5 to 10 minutes. Much longer exposures are required to develop yellowing in cellulose acetate and since the requirements vary widely for different uses, no clear-cut comparisons are made as for N/C. All the Ac/C plasticizers may be considered as satisfactory until the tests for the particular application being considered prove them unsatisfactory. In general, Dimethyl Phthalate and Santicizers B-16, E-15 and M-17 may be considered as equal in stability, Santicizer 8 best, and Triphenyl Phosphate last.

(4) **TOXICITY.**
The terms "toxic" and "non-toxic" are, scientifically speaking, only relative. A product may be harmless if used under the conditions commonly

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OF MONSANTO PLASTICIZERS

SANTICIZER B-16	SANTICIZER E-15	SANTICIZER M-17	DIBUTYL PHTHALATE	DIETHYL PHTHALATE	DIMETHYL PHTHALATE	DIPHENYL PHTHALATE
336	280	266	278	222	194	318
Colorless liquid	Colorless liquid	Colorless liquid	Colorless liquid	Colorless liquid	Colorless liquid	White powder
219° C/5 mm	190° C/5 mm	189° C/5 mm	206° C/20 mm	295° C	282° C	
Below —35° C	20° C	Below —35° C	—35° C	—0.3° C	0° C	69° C
1.097/25° C	1.180/25° C	1.220/25° C	1.047/20° C	1.123/20° C	1.196/15.6° C	1.28/25° C
9.15	9.84	10.2	8.75	9.35	10.0	10.68
1.490/25° C	1.498/25° C	1.504/25° C	1.490/25° C	1.503/20° C	1.515/20° C	1.572/74° C
0.0000881	0.0001106	0.000221	0.000221	0.000617	0.001925	
0.0012% at 30° C	0.0175% at 30° C	0.09% at 30° C	0.001% at 30° C	0.058% at 30° C	0.4% at 32° C 0.6% at 63° C	Insol.
100	100	100	100	100	100	
20—30	100	100	Less than 20	100	100	20
Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Poor
Excellent	Excellent	Excellent		Excellent	Excellent	
None	None	None	None	None	None	None
4.0	3.9	2.9	3.75			
1.1	0.2	0	1.8			

prevailing in industrial practice but hazardous if applied to some unusual application. *In any proposed use where toxicity is considered to be a factor, we suggest that you write us for specific information* regarding the available toxicological data which may apply to your problem.

In general the possible toxic effects of the products discussed in this booklet may be described as follows:

The phthalate esters (Diphenyl, Dibutyl, Diethyl and Dimethyl Phthalates) seem safe for all normal requirements.

The phthalyl glycollates (Santicizers B-16, E-15 and M-17) seem to be the safest of any.

Triphenyl Phosphate is definitely a hazard in articles connected with the food industry but otherwise seems quite safe.

The toxicity of Tricresyl Phosphate depends upon the isomeric forms present. The ortho isomer is considered the most dangerous. The para and meta isomers appear to be much safer and the so-called "non-toxic" grade is composed of a mixture of these two. "Tricresyl Phosphate Monsanto" consists solely of this so-called "ortho free" or "non-toxic" grade.

Santicizers 8, 9 and 10 seem to have slight toxic properties and are not recommended for any use where they might be taken internally.

The Santolite resins appear to be safe for all normal requirements.

(The Aroclors—see pages 32-40—must be considered toxic under some conditions of use. They should not be used in connection with the food industry and continuous exposure in the liquid or vapor phase should be avoided.)

(†) **NITROCELLULOSE DILUTION RATIO:** (Toluene)
This determination was made by dissolving 2.0 grams of nitrocellulose in 20 cc of plasticiser, adding toluene slowly until the mixed liquids no longer had solvent power for N/C, which point was indicated by either the development of a turbidity in the solution, or failure of jell particles to re-dissolve.

$$\text{Dilution Ratio} = \frac{\text{cc. of toluene}}{\text{cc. of plasticiser}}$$

(*) **NITROCELLULOSE DILUTION RATIO:** (Naphtha)
Determined in the same way as for toluene (†) except that petroleum naphtha was used as the diluent.

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The Santolites

(Aryl Sulfonamide — Formaldehyde Resins)

General Properties

The Santolites increase the retentivity of cellulose acetate for plasticizers and tend to prevent separation and exudation. For example, in a mixture of 10 parts of cellulose acetate, 6 parts of Santicizer M-17 and 6 parts of Triphenyl Phosphate, the Triphenyl Phosphate would probably begin to separate out after a time. This could be prevented by adding to the composition, let us say, 3 parts of Santolite resin. Furthermore, the addition of the Santolite would increase the flexibility of the product and permit reduction of the plasticizer content. The figures given are only approximate but illustrate the point.

The Santolites make solutions of low viscosity. If one adds to a nitrocellulose solution of about spraying lacquer viscosity, a weight of Santolite MHP equal to 50% of the nitrocellulose present, there is essentially no increase in the viscosity of the solution. The addition of 100% of Santolite gives only a very slight increase in viscosity.

Films composed of 2 parts of nitrocellulose and 1 part of Santolite MHP are much harder than films made without the use of Santolite. Equal parts of nitrocellulose and Santolite produce films of about the same hardness as though no Santolite were present. The addition of a plasticizer reduces the hardness of such films but a mixture of 10 parts of nitrocellulose, 8 parts of Santolite MHP and 3 parts of Santicizer B-16 gives films of nearly the same hardness as though they were of nitrocellulose alone.

The Santolites increase the moisture resistance of nitrocellulose films. An amount equal to 50% of the nitrocellulose weight reduces the moisture penetration to about one-third of that of a straight nitrocellulose film of the same thickness.

The Santolites are soluble in and slowly decomposed by alkali solutions. They are not soluble in varnish and paint oils.

The Santolites are compatible with vegetable proteins (corn or soybean) but do not of themselves act as plasticizers. Mixtures of the Santolites with liquid plasticizers (for example Santolite MS with 50% of its weight of Santicizer B-16) do, however, impart excellent flexibility. The particular Santolite and the kind and amount of plasticizer will be governed by the degree of flexibility and other properties desired.

The Santolites increase the flexibility and toughness of ethyl cellulose. This is unusual in that they do not have a comparable effect on cellulose nitrate or acetate.

The Santolites are also compatible with polyvinyl acetate resins, increasing the flow at elevated temperatures and improving the workability. In this they are materially aided by the addition of plasticizers, the solid plasticizers giving especially interesting combinations. Such mixtures are conveniently made by simply heating and mixing, thereby avoiding the use of volatile solvents. Of the solid plasticizers, Santicizer 10 produces the greatest effect, Diphenyl Phthalate next and Santicizer 9 the least.

When heated, the Santolites give off a small amount of formaldehyde. They become harder, the melting point is raised slightly, and subsequent evolution of formaldehyde takes place only at higher temperatures. Nitrocellulose lacquers containing Santolite are not especially resistant to heat even though the Santolite may have previously been heated to a relatively high temperature.

Although the Santolite resins themselves may have a very slight odor of formaldehyde, that odor will not be present in compositions of Santolites with cellulose esters or ethers.

The Santolite resins are more light-stable than many of the natural resins such as rosin, ester gum, Elemi or Damar.

The Santolites are valuable as ingredients of heat-sealing lacquers. They should be used in conjunction with a plasticizer either liquid or solid and by varying the amounts of plasticizer and resin, the temperature at which heat-sealing is obtained can be raised or lowered as desired. As an example, a lacquer containing 100 parts (by weight) of nitrocellulose, 75 parts Santolite MHP and 75 parts Santicizer B-16 gives excellent sealing at 103° C. If the resin and plasticizer are each reduced to 50 parts, a temperature of about 113° C is required. When 100 parts of Santolite MHP and 50 parts of Santicizer B-16 to 100 parts of nitrocellulose are used, again the sealing is excellent at

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103° C, but if 100 parts of B-16 and 50 parts of MHP are used, the heat-sealing properties are poor even at 113° C.

Solid plasticizers usually necessitate the use of sealing temperatures about 10° C higher than are required by the same amounts of liquid plasticizers.

Santolite K requires a lower proportion of plasticizer than Santolites MS or MHP.

The solubility and miscibility of Santolites in various compounds are indicated below.

Santolite MS

Specifications

Color	Pale Yellow
Solution in benzene (1:5)	Clear, very slight turbidity max.
Solution in benzene (4:6)	No crystalline deposit in 24 hours.
Refractive Index at 50° C	1.5690 — 1.5720

Containers

250-lb. tins (incl.)
50-lb. tins (incl.)

Specifications

For Solution TB

Composition	85% Santolite MS, 15% solvent (95% toluene and 5% butyl acetate) Tolerance from 14% to 16% solvents.
Appearance	Light colored, viscous liquid, which is free flowing at temperatures above 20° C.
Refractive Index at 25° C	1.5630 ± 0.002

Containers

55-gal. drums (approx. 540 lbs.) (drums extra, but returnable) 5-gal. tins (approx. 45 lbs.) (incl.)

Description

Santolite MS is a soft, practically colorless resin made by the condensation of formaldehyde with aromatic sulfonamides. At temperatures above 50° C it is a viscous liquid.

This resin, like all the Santolites, is compatible with both nitrocellulose and acetyl cellulose and, being a solvent for both, it can be used in any proportion. It forms brittle compositions with both these esters but the addition of a plasticizer makes such combinations permanently flexible. It is easily miscible with all the common organic solvents and thinners except petroleum hydrocarbons. It is not miscible with varnish and paint oils. Santolite MS is excellent for water-white lacquers which will not be exposed to extreme weather conditions, its high gloss and lack of color being unusual in the resin field.

To facilitate handling, this resin is also supplied as a solution containing 85% Santolite MS and 15% of a solvent consisting of 95% toluene and 5% butyl acetate. This is known as "Santolite MS-TB Solution" and is a free flowing liquid at temperatures above 20° C. It weighs 10.3 lbs. per gallon.

Santolite MHP

Specifications

Color and Appearance	Clear, hard, nearly colorless, resinous lumps.

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Refractive Index in solution — 25 parts MHP to 75 parts toluene at 30° C ..... 1.5080 to 1.5110

Solubility in benzene (4:6) ... No crystalline ppt. in 24 hours.

Containers

200-lb. tins (incl.)
50-lb. tins (incl.)

Description

Santolite MHP is similar to MS in characteristics, except that it is a much harder resin, softening at about 62° C and being brittle at normal temperatures. It is nearly colorless and is well adapted to specialty lacquers, fabric coatings, moulding compositions and the like. Being incompatible with drying oils it cannot be used as a varnish material. Exceptional features of this resin are the ease with which it may be worked into practically any formula using a cellulose ester and the wide variation of properties obtained by its use. Its high degree of solubility makes very concentrated solutions possible and its extreme compatibility with plasticizers and cellulose esters removes much of the danger of blushing, sweating and separation.

Santolite MHP can be used in spraying, dipping or brushing lacquers to make clear, colorless, odorless coatings of good gloss and adhesion. It does not materially increase the viscosity of the solution and permits the building up of a high solids content in the lacquer. It is compatible with all the common plasticizers.

Although Santolite MHP, when used alone, does not plasticize cellulose esters, it does increase the flexibility of ethyl cellulose and produces very tough pliable compositions of great clarity and brilliance.

Santolite K

Specifications

Appearance ..... Soft sticky resin.

Color ..... Not more than No. 5 by Monsanto Santolite K Standard (comparable in depth of color but not in shade to No. 5 of the Gardner 1933 standard).

Acid Number ..... 10 Max.

Refractive Index at 50° C 1.5370 ± 0.003

Containers

55-gal. drums (approx. 500 lbs.) (drums extra, but returnable) 5-gal. tins (approx. 45 lbs.) (incl.)

Description

Santolite K is a soft sticky resin with the qualities of both the sulfonamide and alkyd types. It is compatible with cellulose esters and ethers. Santolite K has plasticizing properties of itself but for most purposes additional plasticizer is desirable and Santicizer M-17 is recommended, although others may be used advantageously.

Santolite K is soluble in practically all common organic solvents except the petroleum hydrocarbons. It is not compatible with drying oils so cannot be used in oil varnishes. Santolite K has a better light stability than the other Santolites and is of special value for increasing the resistance to moisture penetration of cellulose ester compositions.

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Solubility and Miscibility of Santolites

Alcohol	Soluble. Films from solutions in all alcohols except methyl are permanently wet or tacky. From methyl alcohol they harden slowly.
Esters	Soluble. Films from such solutions dry hard.
Ketones	Soluble. Films from such solutions dry hard.
Aromatic Hydrocarbons	Soluble. Films from such solutions dry hard.
Aliphatic Hydrocarbons	Insoluble. Santolites produce coatings which are not attacked by gasoline or related products.
Acetic Acid	Soluble if the acid is over 72% (by weight) concentration.
Glycerine	Soluble. Heat 1 part by weight of Santolite MHP in 2 parts of glycerine at 120°C. until dissolved. Then adjust the solution to the desired concentration by adding more glycerine or MHP.
Drying Oils	Not miscible.
Fatty Acids	Miscible.
Vinyl Resins	Miscible.
Shellac	Miscible.
Paraffin	Not miscible.
Carnauba Wax	Not miscible.
Aroclor Resins	Partially miscible. 100 grams of Aroclor 4465 will dissolve 4 grams of Santolite MS. 100 grams of Santolite MS will dissolve 30 grams of Aroclor 4465.

Table of Characteristics of Santolites

	MS	MHP	K
Color and Form	Soft, pale yellow resin	Hard, brittle, nearly colorless lumps	Soft, viscous resin: No. 5 max. color(1)
Flow Point*	——	——	Flows slowly at 30° C.
Flash Point	295° F.	310° F.	400° F.
Specific Gravity	1.355 at 25° C.	1.35 (approx.)	1.307 at 25° C.
Refractive Index	1.5690 to 1.5720 at 50° C.	1.5080 to 1.5110 (25% in toluene)	1.5370 ± 0.003 at 50° C. (approx.)
Solubility in Organic Solvents	Insol. Gasoline	Insol. Gasoline	Insol. Gasoline. Sol. in other organic solvents(2)
Solubility in Drying Oils	Insol.	Insol.	Insol.
Retentivity(3) in N/C	Over 100	Over 100	Over 100
Retentivity(3) in Ac/C	Over 100	Over 100	Over 100
Acid Number	Neutral	Neutral	10 Max.

(1) Monsanto Santolite K Color Standard. Comparable in depth of color but not in shade to the Gardner 1933 Standard.

(2) Soluble in aromatic hydrocarbons containing 5 to 15 per cent of an alcohol, ester, or chlorinated hydrocarbon.

(3) Retentivity is given in parts per 100 parts by weight of the N/C or AC/C.

* While Santolites MS and K can best be removed from containers by warming to the flow point, Santolite MHP is best removed by chilling and then breaking into lumps by striking the sides of the container.

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The Aroclors

(Chlorinated Diphenyls)

General Properties

The Aroclors range in form and appearance from mobile oily liquids to fine white crystals and hard transparent resins. They are non-oxidizing, permanently thermoplastic, of low volatility and non-corrosive to metals. They are not hydrolyzed by water or alkalies. The viscous liquids and the resins will not support combustion when heated alone.

The crystalline Aroclors are relatively insoluble, but the liquid and resinous products are soluble in most of the common organic solvents, thinners and oils. The main exceptions are that all the Aroclors are insoluble in water, glycerine or glycols and Aroclor 5460 is insoluble in the lower molecular weight alcohols. Aroclor 4465 is only partly soluble in the lower alcohols. The liquid and viscous resins are light in color while the hard resins are yellow. For almost every Aroclor described in this booklet there is a dark-colored grade

TABLE OF CHARACTERISTICS

	1242	1248	1254
Color and Form	Practically colorless	Yellow-tinted oily liquid	Yellow-tinted viscous liquid
Softening Point			
Pour Point (ASTM)	—17.7° to —20.7° C	—7.0° C	8.0° to 12.0° C
Distilling Range (ASTM)	322.0° to 365.0° C (Uncorrected)	330.0° to 370.0° C (Uncorrected)	365.0° to 390.0° C
Flash Point (Cleveland Open Cup)	176.0° to 180.0° C	193.0° C	None
Specific Gravity	1.338 to 1.348 at 65/15.5° C	1.404 to 1.414 at 65/15.5° C	1.495 to 1.505 at 65/15.5° C
Pounds per Gallon	11.50	12.06	12.86
Bulking Value (Gallons per pound)	0.0869	0.0829	0.0778
Refractive Index (20° C)	1.627 to 1.629	1.630 to 1.631	1.637 to 1.639 at 25° C
Evaporation Loss (5 Hours)	3.04 to 3.64% at 163° C	3.0 to 4.0% at 163° C	Less than 0.4% at 100° C
Viscosity (Saybolt Seconds)	50 to 53 at 54.4° C	73 to 80 at 54.4° C	42 to 45 at 98.9° C

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of otherwise approximately the same physical and chemical characteristics. These darker products carry a lower price and can frequently be used where color is not important.

The excellent electrical properties, fire resistance and inertness of the Aroclors make them useful in many applications not mentioned in this booklet. The information assembled here is restricted to that which is considered pertinent to the plastic and coating fields only.

The properties imparted by the Aroclors and their usefulness for particular applications vary in regular gradients over the series so the selection of the right Aroclor for a specific use can generally be made simply by a comparison of the physical properties of the several Aroclors.

OF SOME OF THE AROCLORS

1260	1270	4465	5442	5460
Light yellow sticky resin	White crystalline powder	Yellow transparent brittle resin	Yellow transparent sticky resin	Yellow transparent resin
	285.0° to 300.0° C (Hold point)	60.0° to 66.0° C	48.5° C	100.0 to 105.5° C
26.0° to 34.0° C				
385.0° to 420.0° C	450.0° to 460.0° C		Too high for ASTM. Requires vacuum	Too high for ASTM. Requires vacuum
None	None	None	247.0° C	None
1.550 to 1.560 at 90/15.5° C	1.950 at 25°/25° C	1.712 to 1.723	1.4548	1.740 to 1.745
13.39	16.25	14.28	12.10	14.50
0.0746	0.0615	0.0700	0.0626	0.0690
		1.664 to 1.667		
0.0% to 0.2% at 100° C	0.0% to 0.2% at 163° C	0.23 to 0.29% at 163° C	0.012% at 100° C	0.025%
69 to 74 at 98.9° C		100—165 at 54.4° C	313.5	

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Chlorine Content of Pure Chlorinated Diphenyls*

Chlorinated Diphenyl	% Chlorine
Monochlorodiphenyl	18.8
Dichlorodiphenyl	36.8
Trichlorodiphenyl	41.4
Tetrachlorodiphenyl	48.6
Pentachlorodiphenyl	54.4
Hexachlorodiphenyl	59.0
Heptachlorodiphenyl	62.8
Octachlorodiphenyl	65.9
Nonachlorodiphenyl	68.8
Decachlorodiphenyl	71.1

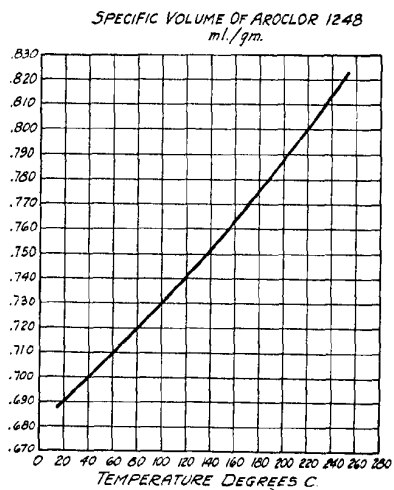
* The Aroclors are mixtures of two or more chlorodiphenyls and some contain chlorinated diphenyl benzenes.

The Aroclors are compatible with most of the common plastic materials (see compatibility table on this page). The degree of flexibility imparted by the Aroclors diminishes progressively in the order of liquid Aroclor—soft resin—hard resin. The hardness of the resulting compositions increases in the same order. Usually a satisfactory balance between flexibility and hardness can be obtained either by selecting the Aroclor of proper physical characteristics or by using a mixture of two or more Aroclors.

Compatibility With Various Materials

Nitrocellulose	C
Cellulose Acetate	I
Ethyl Cellulose	C
Benzyl Cellulose	C
Vinyl Resins	C
Coumarone and Idene Resins	C
Phenolic Resins	Varies.*
Ester Gum	C
Rosin	C
Chlorinated Rubber	C
Polystyrol Resins	C
Damar Resin	C
Manila Gum	I
Asphalt	C
Rubber	C
Paraffin	C
Sulfur	C

C—indicates compatibility to a degree sufficient to be of value.
I—indicates incompatibility.
*Not compatible in final stage.



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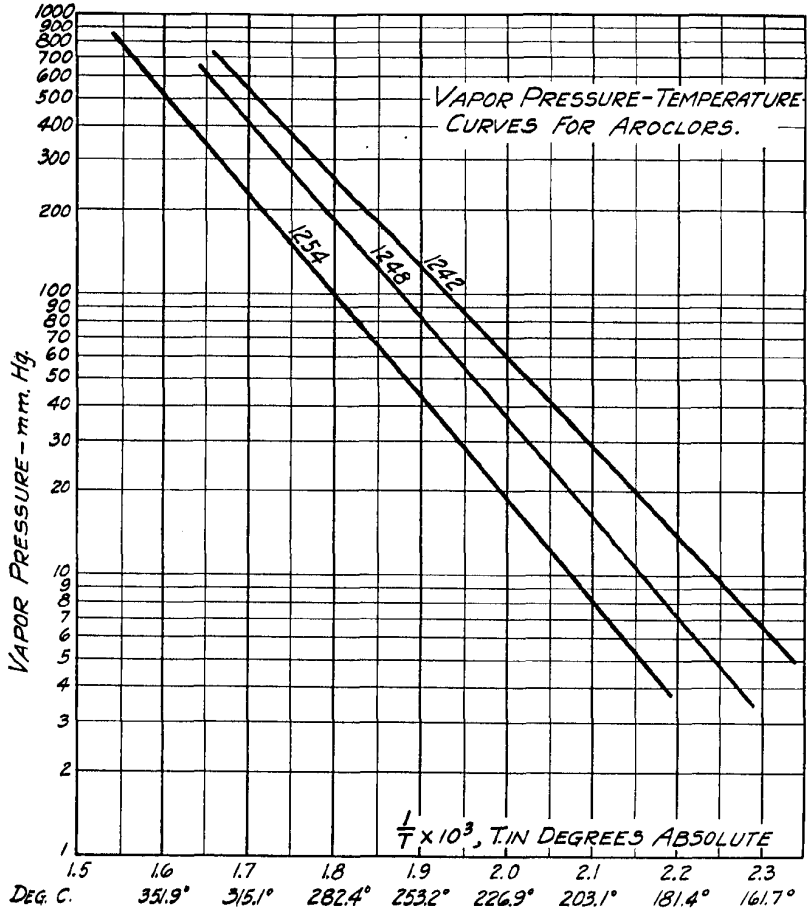

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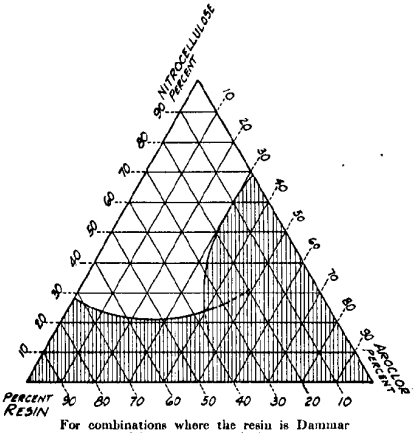
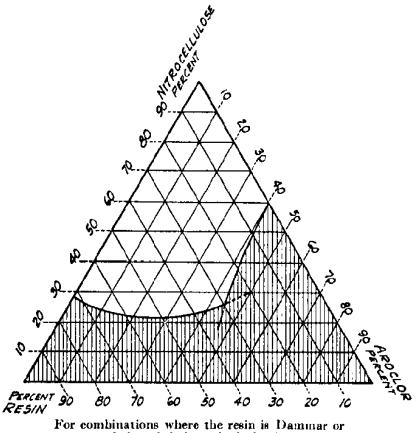
DIAGRAMS SHOWING PRACTICAL COMPOSITION

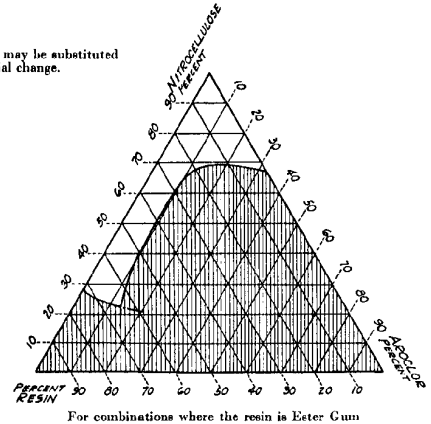


For combinations where the resin is Dammar or a resin of the phthalic anhydride-glycerol type and where the Aroclor is Aroclor 1262.*



For combinations where the resin is Dammar or a resin of the phthalic anhydride-glycerol type and where the Aroclor is Aroclor 1254.

*Aroclor 1260 may be substituted without material change.



For combinations where the resin is Ester Gum or Amberol and where the Aroclor is Aroclor 1254 or Aroclor 1262.

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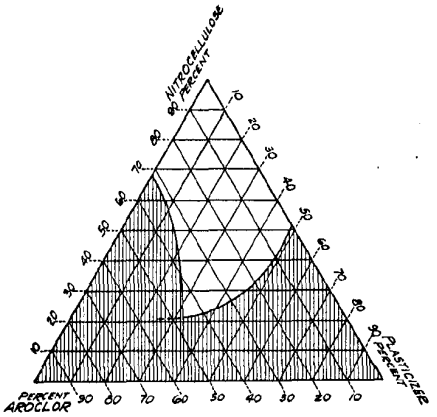
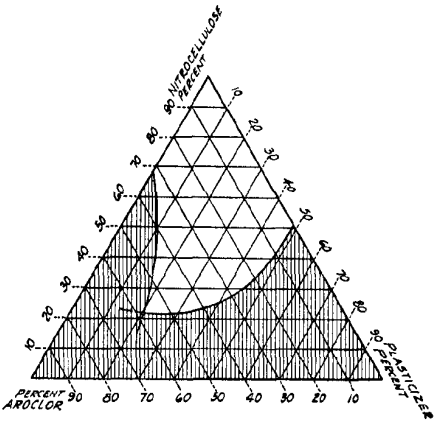
OF LACQUERS USING AROCLORS 1254 AND 1262



For combinations where the Aroclor resin is Aroclor 1262* and where the plasticizer is Dibutyl Phthalate.



For combinations where the Aroclor resin is Aroclor 1262* and where the plasticizer is Tricresyl Phosphate.

In the trilinear diagrams the compositions, represented by any point in the unshaded areas, are those which produce homogeneous lacquer films. On the other hand compositions represented by points in the shaded areas produce impractical, segregated, brittle or soft films. For detailed information as to the derivation and use of these diagrams reference is made to the following articles:

Jenkins & Foster, "Compatibility Relationships of the Aroclors in Nitrocellulose Lacquers," Ind. Eng. Chem. 23, 1362 (1931).

Hofmann & Reid, "Graphical Methods in Lacquer Technology," Ind. Eng. Chem. *20*, 431 (1928); "Formulation of Nitrocellulose Lacquers," Ind. Eng. Chem. *20*, 687 (1928).

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SUGGESTED USES FOR AROCLORS

Nitrocellulose Coatings

The Aroclors function both as plasticizers and resins and may be used alone with the nitrocellulose or in combinations with other plasticizers or resins. They impart weather resistance, luster, adhesion and decreased burning rate. Their excellent electrical characteristics (high dielectric constant and resistivity and low power factor) and their property of retarding the passage of moisture and gases through nitrocellulose films make the Aroclors of special value in coatings for electrical insulating materials.

The accompanying trilinear diagrams show the practical compatibility limits of Aroclors 1254 and 1262 when used in conjunction with some other resins and plasticizers. Aroclor 1260 gives values almost the same as those shown for 1262. The less viscous Aroclors have greater and the more resinous Aroclors less compatibility than for those shown. (See trilinear diagrams on pages 36 and 37.)

To illustrate the differences possible to obtain by changes in formulation, three formulas are given below. All have excellent durability but the third is much softer and more flexible than the other two. Only the solids contents are given. The amounts tabulated are parts by weight.

Aroclor Lacquers

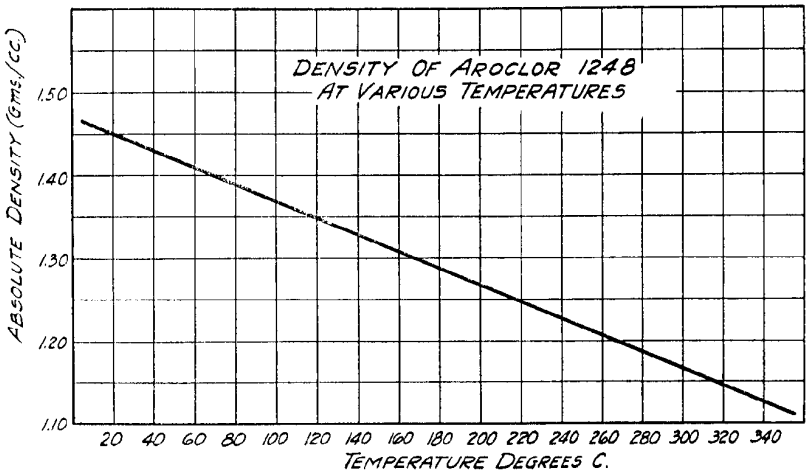
	No. 1	No. 2	No. 3
½ second Nitrocellulose (dry)	100	100	100
Damar resin	80	—	—
Ester Gum	—	80	—
Aroclor 1260	20-39	20	80-70
Dibutyl Phthalate	20- 0	20	—
Tricresyl Phosphate	—	—	39-70

No. 1 and No. 2 have excellent sanding and polishing qualities. No. 3 is very flexible but too soft for sanding.

Where extremely high flexibility is desired, as for example in lacquers for high tension automotive cables, the following composition is suggested:

15—20 sec. R. S.

Nitrocellulose	8 parts by weight
Tricresyl Phosphate	10 parts by weight
Aroclor 1242	7 parts by weight



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Chlorinated Rubber Finishes

Aroclors 1242, 1254 and 1260 are recommended as plasticizers for chlorinated rubber. They give tough flexible compositions and may be used alone or together with the resins and oils commonly employed in chlorinated rubber formulations. From 40 to 60 parts to each 100 parts by weight of chlorinated rubber is suggested. The Aroclors are especially valuable as finishes for alkaline surfaces such as concrete, brick, stucco, etc., and for acid and alkali resistant coatings.

Ethyl Cellulose

The Aroclors are very compatible with ethyl cellulose, the liquids imparting great flexibility and the resinous products great hardness. 75 parts by weight of Aroclor 1242 with 100 parts of ethyl cellulose produces great flexibility and just a slight tackiness. Aroclor 5460 in the same proportion produces a very hard and somewhat brittle composition. Aroclor 4465 produces hard films which are not brittle at ordinary temperature.

For coatings of high gloss and exceptional weathering qualities to be applied to rigid surfaces, compositions containing equal parts by weight of Aroclor 5460 and ethyl cellulose are suggested. If greater flexibility is required, one of the softer Aroclors should be used, either alone or as a replacement for part of the Aroclor 5460 and the proportion of Aroclor should be decreased.

Vinyl Resins

The Aroclors are compatible with all the vinyl resins. The properties imparted depend upon the particular Aroclor and the vinyl resin used. The selection of the correct Aroclor for a particular use can usually be made by consideration of the physical properties of the Aroclor series.

Impregnation

The Aroclors may be used to impregnate cloth, paper, wood or asbestos in order to impart moisture and gas resistance, adhesion, insulating properties, alkali or other chemical resistance, flame resistance, or lubricating qualities. For this type of work they are used in combinations with other materials such as waxes, inorganic pigments, asphalt, tars, aluminum stearate, sulphur, etc. in order to obtain exactly the physical characteristics desired for the specific purpose. Aroclors 1254, 4465 and 5460 or the corresponding dark-colored products are suggested as most applicable.

Moisture Proofing

For use as moisture proof coatings the Aroclors are best combined with waxes, such as paraffin or carnauba, oils such as mineral oil, and resins such as ester gum or other synthetic resins. The simplest compositions contain only Aroclor and paraffin. A moisture proofing compound composed of 96% (by weight) of Aroclor 5460 and 4% of paraffin (melting point 54° C) has an ASTM softening point of about 82° C and is very efficient. Substituting Aroclor 4465 for Aroclor 5460 produces a compound with a softening point of about 58° C.

Softening point and viscosity when melted may be further decreased by using mixtures of Aroclors. For example, a composition containing 40% of Aroclor 1260, 56% of Aroclor 5460 and 4% of paraffin will be very soft at ordinary temperatures. Increased proportions of paraffin will also produce softer compounds.

Inks

The Aroclors are used as vehicles for carrying pigments used in glass decoration. When the decorations have been applied and the glass is fired, the Aroclors volatilize without carbonization and thus avoid discoloration of the glass. Aroclors 1254 and 4465 are used.

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Rubber and Rubber Substitutes

The Aroclors when in a liquid condition have a solvent action on rubber. Aroclors 1254 and 1260 are milled into rubber in order to impart permanent tackiness and adhesion. A small amount of Aroclor 1260 added to hard rubber acts as a plasticizer and reduces the brittleness.

Aroclor 1270, being a hard crystalline material of high melting point, can be ground to a powder and then milled into rubber. The milling temperature being below the melting point of the Aroclor, the latter is dispersed through the mass of rubber and acts as an efficient flame reducer. This same procedure can be used with the so-called synthetic rubbers (such as neoprene) to impart fire-proofness. From 5% to 25% of Aroclor 1270 based on the weight of the plastic is required.

Pigment

Aroclor 1270 is a hard, white crystalline product of high melting point, insoluble in most solvents, resistant to chemicals and to oxidation. When ground to a fine powder it makes an excellent organic pigment for use with the various plastics. It may be used alone or with conventional pigments.

Mold Lubricants

Because of their inertness and low volatility, the Aroclors are excellent mold lubricants. As an example — the addition of 1% of Aroclor 1242 or 5460 to a vinyl formal resin produces great improvement in ease of molding operation as well as in the appearance of the molded pieces.

The Aroclors are equally applicable to other molding compositions, the particular one to be selected and the method of use being governed, of course, by the molding material and the conditions of operation.

Paints and Varnishes

The Aroclors are soluble in paint and varnish oils and impart properties corresponding to the physical character of the particular Aroclor. The hard resinous Aroclors tend to give increased hardness to the films while the viscous resins impart flexibility.

The Aroclors do not react chemically with oils, hence there is no advantage in heating together in making a varnish. They are best added as a "chill back" or as a cold cut in the thinning operation. As far as incorporation of the Aroclors is concerned, the only reason for heating is to make the Aroclors liquid so that they can be readily mixed with the oils.

Aroclors 4465 and 5460 will produce paints that are very quick drying and yet have excellent durability. The weight of Aroclor used should be from 30% to 50% of the weight of the oils.

Aroclor 1260 is best for short oil varnishes that are required at the same time to be flexible. The Aroclor may be considered to play the same role as oil, with the difference that it does not oxidize and lose its flexibility on exposure. Resins of the alkyd, phenolic or ester gum type or a harder Aroclor such as 5460 may be used in making varnish formulations. It is suggested that for two parts by weight of oil, one part of Aroclor 1260 and one part of other resin be used. These proportions can be varied as required. The Aroclors impart water and alkali resistance and in these qualities enhance the value of the other resins used in the varnish.

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