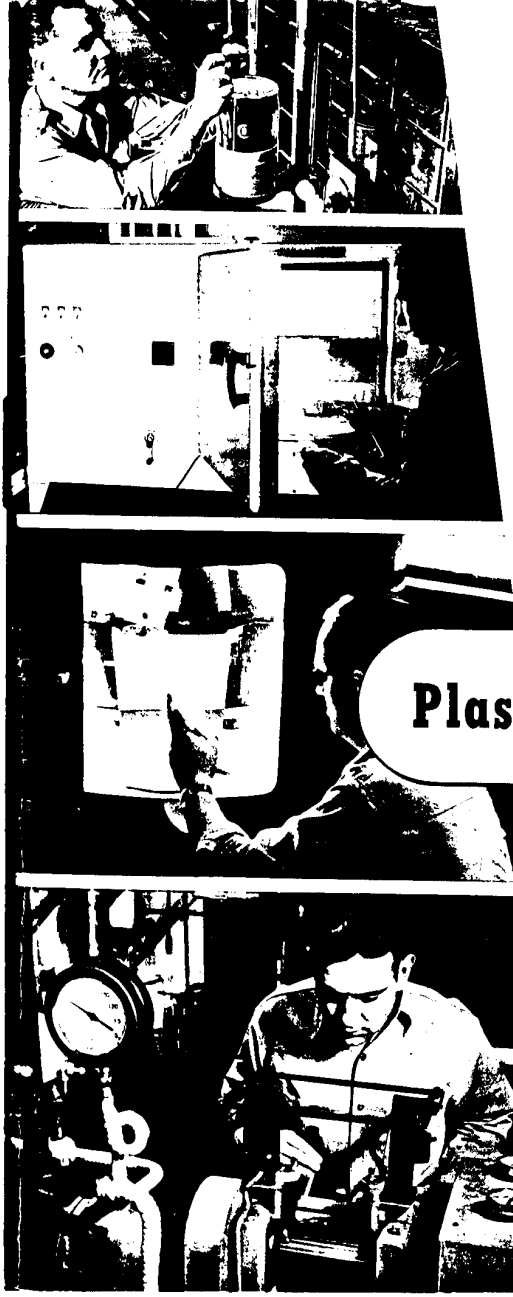

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Plasticizers and Resins

MONSANTO
CHEMICALS — PLASTICS

Eng. dev. booklet.

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PLASTICIZERS AND RESINS

Specifications and Application Data

Revised March, 1946

MONSANTO CHEMICAL COMPANY
ST. LOUIS, U. S. A.
NEW YORK • BOSTON • SPRINGFIELD, MASS. • WASHINGTON, D.C.
CHICAGO • DETROIT • AKRON • BIRMINGHAM • CHARLOTTE
SAN FRANCISCO • LOS ANGELES • SEATTLE • MONTREAL • TORONTO
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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 derivatives 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 to 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 molded synthetic products industries. Camphor was the first satisfactory plasticizer, and it was its use with nitrocellulose that made celluloid and molded 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 molding and coating materials, composed largely of synthetic resins, were developed and requirements became much more exacting. These compositions required new plasticizers, or to be more exact, properties not imparted by the older plasticizers. Extreme 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.

Plasticizers are required to impart such a multiplicity of properties that it is not reasonable to expect any one of them to do everything. We often recommend that mixtures of several plasticizers be used, selecting the components of the mixture on the basis of the physical and chemical properties of each plasticizer. But this means one can frequently make use of the excellent properties of a relatively incompatible plasticizer, which by itself would be unusable.

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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Suggested Uses for Plasticizers

Acrylic Type Resins

Dibutyl Phthalate and Santicizer B-16 are recommended. The solid plasticizers produce less softening effect but also less flexibility.

Alkyd Resins

Santicizers B-16, E-15 and M-17 are recommended as plasticizers in amounts of from 5% to 40% of the resin. Tricresyl Phosphate and Dibutyl Phthalate may also be used. Ortho-Nitrobiphenyl may be used in alkyd resin varnishes in amounts up to 10% without effect upon the drying time. 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.

Benzyl Cellulose

Diphenyl Phthalate is recommended. Santicizers B-16 and E-15 and Tricresyl Phosphate are also excellent for many purposes. 25 PHR* 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.

Cellulose Acetate

Dimethyl Phthalate, Diethyl Phthalate, Ortho-Nitrobiphenyl, Triphenyl Phosphate, Santicizers 3, 8, 10, M-17, E-15 and, for some types of acetate, B-16, are all of value.

Dimethyl Phthalate and Diethyl Phthalate produce great flexibility and are relatively cheap. A rather high evaporation rate and poor moisture resistance are the chief defects.

*PHR = parts per 100 parts resin.

Ortho-Nitrobiphenyl is very compatible and gives clear, workable compositions of good flexibility.

Triphenyl Phosphate provides non-flammability (film 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 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 most 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 and 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 of their low compatibility.

Cellulose Acetobutyrate

Dibutyl Phthalate, Tricresyl Phosphate and Santicizer 10, B-16, E-15 and M-17 and Ortho-Nitrobiphenyl 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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Cellulose Acetopropionate

Santicizers 8, E-15, and M-17 and Ortho-Nitrobiphenyl are recommended. Triphenyl and Tricresyl Phosphates, Dibutyl Phthalate and the Aroclors are also useful.

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 PHR are suggested although more can be used, the retentivity of Santicizer M-17 being almost 200 PHR in 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. The Aroclors are especially useful where alkali resistance is desired.

Ethyl Cellulose

Santicizer M-17 produces maximum flexibility. Amounts above 75 PHR produce tacky compositions. Santicizer E-15, B-16 and 8, Dibutyl Phthalate, Tricresyl and Triphenyl Phosphates, Ortho-Nitrobiphenyl, and HB-40 are all 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.

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.

Neoprene

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

Nitrocellulose

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

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 is a low-cost, general purpose plasticizer.

Santicizer 8 produces high flexibility, gloss, brilliance and smooth working qualities in lacquers. Its color

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stability is of the same order as that of Tricresyl Phosphate.

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

Ortho-Nitrobiphenyl produces results similar to camphor. In molded plastics it may be used alone, or with camphor or camphor oil. In lacquers it produces hard, tough, resistant compositions and seems to aid solvent release.

The Aroclors act both as 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 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.

The Santolite resins, like the sulfonamide plasticizers, tend to accelerate the decomposition of nitrocellulose at elevated temperatures and so should not be employed in nitrocellulose compositions that may be heated much over 80° C.

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% will improve the workability and curing of phenolic molding compositions. The Aroclors may be used in special cases as lubricants or in coating compositions.

Polystyrene

Santicizers B-16 and 10, Ortho-Nitrobiphenyl 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.

Polyvinyl Acetate

Mixtures of plasticizers usually give the best results. Santicizers M-17, E-15 and B-16 are recommended as liquid plasticizers. Ortho-Nitrobiphenyl, Dibutyl Phthalate and Tricresyl Phosphate are also useful. 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 Butyral

Dibutyl Phthalate and Ortho-Nitrobiphenyl are especially recommended, but Santicizers 8, B-16, E-15 and M-17, Tricresyl Phosphate and the Aroclors may also be used to obtain special properties.

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Polyvinyl Chloride

Santicizers M-17, E-15 and Ortho-Nitrobiphenyl are efficient plasticizers. Tricresyl Phosphate, Dibutyl Phthalate and Santicizer B-16 also have good compatibility. The Aroclors are compatible but do not produce great flexibility. Santicizer 140 produces compositions having fire resistant qualities similar to TCP but more flexible.

Polyvinyl Formal

Diethyl Phthalate, Ortho-Nitrobiphenyl and Santicizers 8, B-16, E-15 and M-17 are recommended. Santicizers 10 and Tricresyl and Triphenyl Phosphate are also useful.

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 improves the flexibility and water resistance.

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 lesser degree. Combinations of solid plasticizers and the Santolites make efficient plasticizers for cellulose esters and ethers and polyvinyl resins. 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 improves the uniformity and workability of resins of this class.

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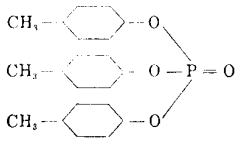
The Phosphates

Tricresyl Phosphate
Technical



(Para Isomer)

Specifications

Form	Clear, practically colorless, oily liquid.
Color	APHA 40 max.
Free Phenols (Permanganate Test)	A distinct purple color to be present after 30 minutes (10 gram sample — 40 cc. N/100 $KMnO_4$).
Acidity (as H_3PO_4)	0.01% max.
Specific Gravity at 25/25° C.	1.166 ± 0.007
Ester Value	Essentially 100%

Containers

55-gallon 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

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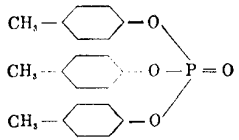
used effectively, however, in mixtures with more compatible plasticizers.

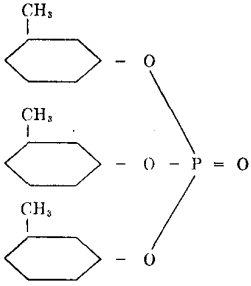
Tricresyl Phosphate has good lubricating properties which, in addition to its stability and fire resistance, make it valuable as a special lubricant, cutting oil component, and pump seal.

Three isomers of Tricresyl Phosphate are possible—the tri-ortho—, tri-meta—, and tri-para cresyl phosphates, and the technical grades usually contain all three isomers with the meta- and para-derivatives predominating. The structural formula for the para compound is



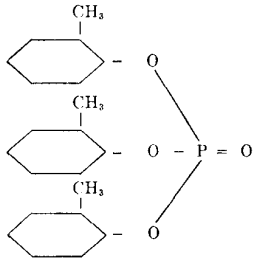
This isomer is a solid, melting point 77°-78° C., boiling point at 10 mm. 250°-255° C.

In the meta-compound the methyl group occupies the position:

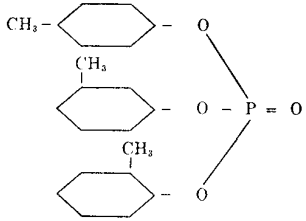


This isomer is a liquid at normal temperatures, with a boiling point at 10 mm. of 240°-243° C.

The ortho compound is also a liquid:



Obviously it is possible to have all three in a single molecule, thus—



This matter of isomers explains why there may be minor differences in physical constants, such as specific gravity, refractive index, etc., between various production lots of Tricresyl Phosphate. These variations do not, however, involve differences in plasticizing properties.

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.

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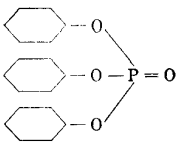
The following table of physical and chemical properties gives values that are accurate for the particular samples *upon which the tests were run*, or are averages of a great many samples, but are not intended to be considered as the arbitrary limits for all Tricresyl Phosphate.

Empirical Formula	$C_{21}H_{21}O_4P$
Molecular Weight	368.358
Specific Gravity	1.162 at 20°/20° C.
Refractive Index	1.556 at 25° C.
Boiling Point	235° C. at 4 mm. 295° C. at 13 mm. 420° C. at 760 mm.
Flash Point	235° C. (455° F.) Cleveland Open Cup
Crystallizing Point	Non-crystalline solid at −35° C.
Pour Point	−26° C.
Specific Heat	0.47—0.02
Solubility	0.002% at 85° C. in water. Miscible with all common organic solvents.
Viscosity—at 3.0° C.	1100. centipoises
6.5° C.	755. centipoises
10.0° C.	460. centipoises
20.0° C.	160. centipoises
25.0° C.	113. centipoises
30.0° C.	74.4 centipoises
40.0° C.	39.2 centipoises
50.0° C.	23.7 centipoises
Heat of Vaporization	21120 Cals./mol. 57 Cals./gm. 103 BTU./lb.

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.)	Not more than faintly opalescent
Permanganate Test	Distinct purple color to be present after 30 minutes.
Free Phenol	0.1% max.
Acidity (as H_3PO_4)	0.003% max.

Containers

225 lb. Leverpaks.

Description

Triphenyl Phosphate is a white crystalline solid 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.

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This product is soluble in 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 cellulose acetate varies between 40 and 80 PHR depending upon the type of acetate, the method of incorporation, the conditions under which the end product is used, and the age of the end product. In most formulations the amount of Triphenyl Phosphate used is less than 40 PHR. 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 valuable property of Triphenyl Phosphate is that of fire retarding. When used alone in cellulose acetate films an amount of Triphenyl Phosphate equal to 20 PHR 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 has fair softening action upon most synthetic rubbers and is essentially insoluble in gasoline and mineral oils, which combination of properties makes it a valuable ingredient of many synthetic rubber formulations. The amount used is generally in the range of 5% to 20% by weight.

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 fiber 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.

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.

Following are some of the chemical and physical properties of Triphenyl Phosphate—

Empirical Formula	$C_{18}H_{15}O_4P$
Molecular Weight	326.28
Specific Gravity	1.268 at 60° 20° C.
Refractive Index	1.550 at 60° C.
Melting Point	48.5° C.
Boiling Point	245° C. at 11 mm.
Flash Point	225° C.
Specific Heat	0.50 ± 0.02

Solubility in:

Water	0.001% at 34° C.
	0.002% at 54° C.
Gasoline	2.7 grams TPP/100 cc. solvent
Benzene	230. grams TPP/100 cc. solvent
Ethyl Alcohol	160. grams TPP/100 cc. solvent
Ethyl Acetate	270. grams TPP/100 cc. solvent
Acetone	340. grams TPP/100 cc. solvent
Ethylene Dichloride	400. grams TPP/100 cc. solvent
Linseed Oil (Raw)	13. grams TPP/100 cc. solvent
Turpentine	36. grams TPP/100 cc. solvent

Triphenyl Phosphate imparts excellent properties, but because of its rather low compatibility with many plastics its true value will appear when it is used as one component of a plasticizer mixture.

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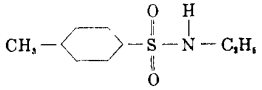
The Santicizers

(Sulfonamides, Sulfonates, Phthalyl Glycollates)

Santicizer 3

N-ethyl para toluene sulfonamide



Specifications

Appearance	White Solid
Odor	Slight, Characteristic
Color (Melt) APHA	50 max.
Melting Point	59.0° C. min.
Acidity (as H_2SO_4)	0.10% max.

Containers

Fiber Containers	Approx. 400 lbs. net

Description

Santicizer 3 is a white, solid sulfonamide plasticizer, melting at about 60° C. Its compatibility with the common plastics is limited and its greatest value is obtained in conjunction with other plasticizers. When used either in such combination or as the sole plasticizer Santicizer 3 imparts high gloss, toughness and hardness. It also seems to sharpen the softening point of some thermoplastic compositions, especially the cellulose esters.

Santicizer 3 imparts desirable properties to cellulose acetate although the compatibility is less than 50 PHR. In addition to gloss, toughness, and hardness, it improves the flow of molding compositions.

Its compatibility with nitrocellulose is low but it does improve the film properties of coating compositions, although not recommended for outdoor exposure or temperatures above 80° C.

Santicizer 3 has very limited compatibility with cellulose acetate-propionate and cellulose acetate-butyrate.

With ethyl cellulose, Santicizer 3 is compatible only in low concentrations but it improves the gloss, toughness and general film properties.

Santicizer 3 is not recommended for use with polyvinyl chloride or polyvinyl chloride-acetate.

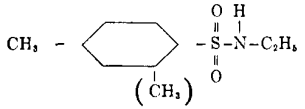
With polyvinyl formal, Santicizer 3 imparts good flow and excellent gloss although the compatibility is less than 50 PHR. For best results it should be used in combination with other plasticizers. This is a general characteristic of Santicizer 3. It maintains its good effects even when used in amounts of 5 to 20 PHR and in mixture with other plasticizers even though these are used in much higher proportions.

0614432

TOWOLDMON0038570

Santicizer 8

(Mixture of ortho and para N-ethyl toluene sulfonamides)



Specifications

Appearance	Light yellow, viscous liquid
Odor	Slight, characteristic
Free Amide	9% to 13%
Acidity (as acetic acid)	0.1% max.

Containers

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

Description

Santicizer 8 is a light yellow colored liquid that is readily soluble in 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 cellulose acetate is about 90 PHR and it imparts a high degree of plasticity. It is a solvent for both nitrocellulose and cellulose acetate.

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 preferably mixed with other plasticizers, solid or liquid. In cellulose acetate, however, its light stability is sufficient to meet most of the ordinary requirements of molding 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 in combination 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.

Some of the chemical and physical properties of Santicizer 8 are:—

Empirical Formula	$C_9H_{13}O_2NS$
Molecular Weight	199.262

0614433

TOWOLDMON0038571

Specific Gravity	1.190 at 25° 25° C.
Refractive Index	1.540 at 25° C.
Flash Point	174° C.
Solubility in	
water	0.13% at 23° C.
	0.213% at 48° C.
gasoline	insoluble cold
	very slightly soluble hot
turpentine	15 gms. per 100 cc. turps.
castor oil	soluble
tung oil	slightly soluble cold
	soluble hot
linseed oil	insoluble cold
	soluble hot
common organic solvents	soluble
Viscosity (approx.)	at 10° C.—3170 centipoises
	at 20° C.— 750 centipoises

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.

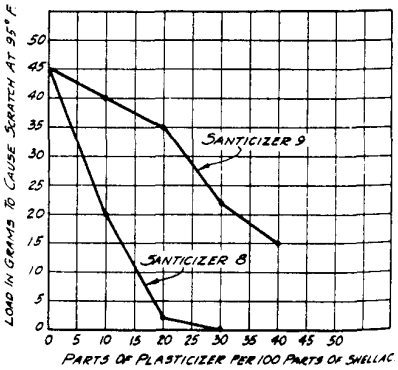
Santicizer 8 greatly increases the flexibility of shellac, having at the same time a considerable softening effect. An amount equal to 10% of the shellac produces very pronounced results. It may be incorporated either by direct fusion or by means of solvents. It does not destroy the adhesion of the shellac 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 and polyvinyl acetal.

Fig. 1

SOFTENING EFFECT ON SHELLAC OF SANTICIZERS 8 AND 9

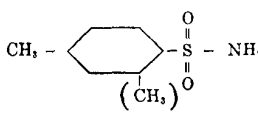


0614434

TOWOLDMON0038572

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

275 lbs. Leverpaks

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 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 PHR and does not impart great flexibility. Nitrocellulose compositions containing Santicizer 9 should not be subjected to prolonged heating above about 80° C. The sulfonamide may accelerate decomposition of the nitrocellulose and disintegration of the entire composition.

Santicizer 9 differs materially from other plasticizers in its action. Relatively small amounts impart a gloss to polished articles and gives smooth working and uniform curing of molded 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 molding 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 when from 2 to 5% is used.

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 1 for comparative effects of Santicizer 8 and 9 on shellac.

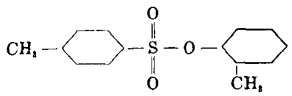
Empirical Formula	$C_7H_9O_2NS$
Molecular Weight	171.21
Specific Gravity	1.313 at 25° 25° C.
Melting Point	105° C. (approx.)
Solubility in:	
Water	1.0% at 34° C.
Benzene	1.5% at 30° C.
Ethylene Dichloride	4.0% at 30° C.
Turpentine	2.5% at 20° C.
Linseed Oil	Insoluble at 20° C.

0614435

TOWOLDMON0038573

Santicizer 10

(Ortho-cresyl para-toluene sulfonate)



Specifications

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

Containers

200-lb. barrels (incl.)

Description

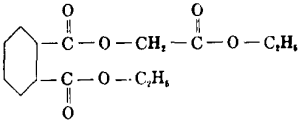
Santicizer 10 is a solid plasticizer for cellulose esters and many resins. Its retentivity in nitrocellulose is about 50 and in cellulose acetate 30 PHR. From 15 to 20 PHR are required to give added flexibility to cellulose acetate.

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 phenol-aldehyde, vinyl and polystyrene resins. It is compatible with shellac but produces less flexibility than either Santicizer 8 or Santicizer 9. Some of its physical and chemical properties are:

Empirical Formula	$C_{14}H_{14}O_3S$
Molecular Weight	262.312
Specific Gravity	1.207 at 15° C.
Crystallizing Point	51.0° C.
Flash Point	182° C.
Solubility in:	
Water	0.0008% at 30° C.
Organic Solvents	See Chart, Page 37

Santicizer E-15

(Ethyl phthalyl ethyl glycollate)



Specifications

Color (APHA)	20 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
Sulfur (copper strip test)	None

Containers

55-gallon drums (approx. 500 lbs.), (incl.)
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.

0614436

TOWOLDMON0038574

This product is miscible with the common organic solvents except the petroleum hydrocarbons. It is 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 cellulose acetate and for most resins. It is light-fast, and relatively non-volatile 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.

Some of its physical and chemical properties are:

Empirical Formula	$C_{14}H_{18}O_6$
Molecular Weight	280.304
Specific Gravity	1.180 at 25° C.
Refractive Index	1.498 at 25° C.
Boiling Point	190° C. at 5 mm. 320° C. at 760 mm. (approx.)
Crystallizing Point	20° C.
Flash Point	193° C.
Effect of heating at atmospheric pressures—	
Up to 300° C.	Slight color change
After boiling at 320° C.	Light yellow
Heat of Vaporization	37430 Cals. mol. 134 Cals. gm. 241 BTU. lb.

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		380° F.	380° F.	375° F.
*Tensile Strengths (in Kg/Cm_2) of cellulose acetate films	0 PHR (control)	528	528	528
	25 PHR (control)	420	472	468
	50 PHR (control)	315	256	266
	75 PHR (control)	243	136	144
*Elongation (in per cent) of cellulose acetate films	0 PHR (control)	2.3	2.3	2.3
	25 PHR (control)	6.	5.7	10.
	50 PHR (control)	12.3	14.7	24.7
	75 PHR (control)	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.
% Plasticizer decomposed by 10% NaOH solution in 20 minutes at	32° C.	0	0.93	7.09
	80° C.	0	11.19	21.28

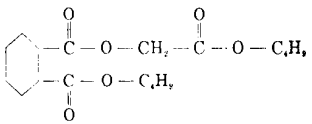
*Tensile strength and elongation values are for comparative purposes only. In no sense are they to be considered absolute values.

0614437

TOWOLDMON0038575

Santicizer B-16

(Butyl phthalyl butyl glycollate)



Specifications

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

Containers

55-gallon drums (approx. 500 lbs.), (incl.)
5-gallon cans (45 lbs.), (incl.)

Description

Santicizer B-16 is a practically colorless liquid which boils at 219° C. at 5 mm. 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.

Some of its physical and chemical properties are:

Empirical Formula	$C_{18}H_{24}O_6$
Molecular Weight	336.372
Specific Gravity	1.097 at 25° C.
Refractive Index	1.490 at 25° C.
Boiling Point	219° C. at 5 mm. 345° C. at 760 mm. (approx.)
Crystallizing Point	—35° C.
Heat of Vaporization	41570 Cals. mol. 124 Cals. gm. 223 BTU. lb.

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 PHR while for another sample of 56% combined acetic acid content the retentivity was 100 PHR. 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.

0614438

TOWOLDMON0038576

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 PHR usually being required.

Santicizer B-16 is an exceptionally good plasticizer for polystyrene, whether for molding or coating uses. It maintains the excellent properties of the resins and in coatings greatly retards weathering failure. 15-20 PHR is recommended.

Mixtures of Santicizer B-16 and Santolite resins (MS preferred) may be used to plasticize certain compounds such as casein and corn proteins, being incorporated either as solutions in some organic solvent or in the form of emulsions. The proportions of the several components can be varied between wide limits: 1 part of B-16 with 2 to 10 parts of Santolite and 1 part of such mixture added to 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.

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

Santicizer B-16 solubility in ethanol-water mixtures increases slowly to 10% in 72% ethanol; rapidly to 60% in 81% ethanol and 100% in 84% ethanol.

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

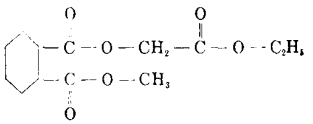
Santicizer B-16 is an excellent plasticizer for shellac when incorporated into solutions of that resin. From 5 to 30 PHR are suggested depending upon the degree of softness and flexibility desired. It is compatible with most natural resins. 25 PHR in rosin gives a combination that is flexible at 0° C. 30 PHR gives good plasticity to Kauri Gum.

Santicizer B-16 has a fair compatibility with paraffin — about 35 PHR at normal temperatures and a greater amount when warmed.

It is a good plasticizer for chlorinated rubber and appears to promote adhesion. It does not give as great flexibility as does Santicizer M-17 but produces more than Dibutyl Phthalate. About 40 PHR is recommended.

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, characteristic
Sulfur (copper strip test)	None

Containers

55-gallon drums (approx. 550 lbs.), (incl.)
5-gallon cans (approx. 50 lbs.), (incl.)

0614439

TOWOLDMON0038577

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 cellulose acetate. 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.

Some of the chemical and physical properties of Santicizer M-17 are:

Empirical Formula	$C_{13}H_{14}O_6$
Molecular Weight	266.262
Specific Gravity	1.220 at 25° C.
Refractive Index	1.504 at 25° C.
Boiling Point	189° C. at 5 mm. 310° C. at 760 mm. (approx.)
Crystallizing Point	Less than —35° C.
Flash Point	190° C.

Effect of heating at atmospheric pressures—

Up to 190° C.	Slight yellow color
250° C.	Light yellow
310° C.	Yellow

Heat of Vaporization	35170 Cals. mol. 133 Cals. gm. 239 BTU. lb.

Santicizer M-17 is not soluble in castor, linseed, or china wood oil or petroleum hydrocarbons, but is readily soluble in most 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 cellulose acetate 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 PHR 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 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 since 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. Such compositions can be applied to a wide variety of uses.

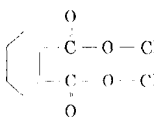
Vapor pressures of Santicizer M-17 are given in Figure 4.

0614440

TOWOLDMON0038578

The Phthalates

Dimethyl Phthalate



Specifications

Appearance	Clear, water-white, oily liquid
Color (APHA)	10 max.
Odor	Not more than slightly aromatic
Acidity (as phthalic acid)	0.01% max.
Specific Gravity at 25° 25° C.	1.190 ± 0.001
Refractive Index at 20° C.	1.5155 ± 0.001
Purity	Essentially 100%
Sulfur (Copper strip test)	None

Containers

55-gallon (approx. 500 lbs.). (incl.)

Description

Dimethyl Phthalate is a colorless, liquid solvent-plasticizer for cellulose acetate. It is completely compatible with nitrocellulose, but is seldom used with that material because it does not impart the desired qualities. Its boiling point is 282° C., its crystallizing point 0° C. and its weight about 10 pounds per gallon. It is soluble in 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 widely 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 vapor pressure than Dimethyl Phthalate, its loss by evaporation from cellulose acetate compositions is equal to that of Dimethyl Phthalate.

In addition to its use as a plasticizer, Dimethyl Phthalate is a very efficient insect repellent. It appears to be quite harmless when applied to the skin and maintains its effectiveness for several hours.

For vapor pressures of Dimethyl Phthalate see Figure 7.

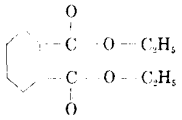
Some of its chemical and physical properties are:

Empirical Formula	$C_{10}H_{10}O_4$
Molecular Weight	194.18
Specific Gravity	1.190 at 25° 25° C.
Refractive Index	1.515 at 20° C.
Boiling Point	282° C.
Crystallizing Point	0° C.
Pour Point	26° C. (Super-cools)
Flash Point	149° C.
Flame Point	172° C.
Specific Heat	0.27
Heat of combustion	5,769 Cal. grams
Heat of Vaporization	27690 Cals. mol.
	139 Cals. gm.
	251 BTU. lb.

0614441

TOWOLDMON0038579

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 25°/25° C.	1.120 ± 0.005
Refractive Index at 20° C.	1.5030 ± 0.001
Assay (ester content)	99% min.
Sulfur (copper strip test)	None

Containers

55-gal. drums (approx. 500 lbs.), (incl.)

Description

Diethyl Phthalate is a colorless, liquid plasticizer generally used alone or 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.

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 7.

Some of the chemical and physical properties of Diethyl Phthalate are:

Empirical Formula	$C_{12}H_{14}O_4$
Molecular Weight	222.232
Specific Gravity	1.123 at 20° C.
Refractive Index	1.5030 at 20° C.
Boiling Point	295° C. at 760 mm.
Crystallizing Point	−0.3° C.
Flash Point	152° C.
Specific Heat	0.29
Heat of Vaporization	33350 Cals. mol. 151 Cals. gm. 272 BTU. lb.

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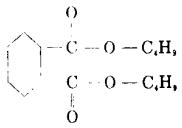
Dibutyl Phthalate



Specifications

Appearance	Clear, oily liquid
Color (APHA)	20 max.
Odor	Slight
Acidity (as phthalic acid)	0.01% max.
Specific Gravity at 25° 25° C.	1.045 ± 0.001
Refractive Index at 25° C.	1.4905 ± 0.001
Assay (ester content)	99% min.
Sulfur (copper strip test)	None

Containers

55-gal. one-time shippers (approx. 465 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 soluble in 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 PHR and in that amount does not increase the plasticity. It is a solvent for nitrocellulose and gives a high degree of plasticity but greatly reduces the tensile strength and tends to produce softness if used in large proportions.

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 7.

The viscosity of Dibutyl Phthalate (determined by the Hoeppler Viscosimeter) in centipoises through the range of 10° C. to 50° C. is shown in the following table:

Temperature Degrees C.	Viscosity Centipoises
9.9	31.9
11.0	29.6
15.2	25.5
19.4	21.4
30.0	13.1
40.0	8.9
50.0	6.5

Some of the chemical and physical properties of Dibutyl Phthalate are as follows:

Empirical Formula	$C_{16}H_{22}O_4$
Molecular Weight	278.336
Specific Gravity	1.048 at 20° 20° C.
Refractive Index	1.490 at 25° C.
Boiling Point	206° C. at 20 mm. 340° C. at 760 mm.
Crystallizing Point	—35° C.
Flash Point	170° C.
Specific Heat	0.34
Heat of Vaporization	30980 Cals. mol. 111 Cals. gm. 201 BTU. lb.

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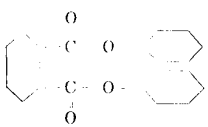
Diphenyl Phthalate



Specifications

Appearance	Coarse white powder or fused solid
Free Acid (as Phthalic)	0.20% max.
Free Phenol	0.20% max.
Ash	0.05% max.
Moisture	0.50% max.

Containers

Flake—150 lb. containers (incl.)
Fused—525 lb. Black iron drums (Extra, returnable)

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 cc. 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 and 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.

Some of its chemical and physical properties are:

Empirical Formula	$C_{20}H_{14}O_4$
Molecular Weight	318.312
Specific Gravity	1.28 at 20° C.
Refractive Index	1.572 at 71° C.
Boiling Point	405° C.
Crystallizing Point	69° C.
Flash Point	224° C.
Heat Stability	Discolors quite rapidly at 150° C.

HB-40

HB-40 is a high boiling liquid hydrocarbon that has considerable merit as a plasticizer for ethyl cellulose, polystyrene and benzyl cellulose.

HB-40 has the following physical and chemical properties:

Appearance	Mobile, oily liquid
Color	Less than 200 APHA

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Distillation Range	340°-396° C. (645°-745° F.)
Specific Gravity	1.004 ± 0.003 at 25° 15.6° C.
Refractive Index	1.5675 ± 0.0075 at 25° C.
Flash Point	345° F. (174° C.)
Flame Point	385° F. (196° C.)
Crystallizing Point	5° C. (approx.)
Pour Point	−28° C. (−18° F.) (Super-cools)
Light Stability	Darkens on exposure to sunlight
Heat Stability	Appears to be relatively stable at the boiling point in glass. Decomposes at 250° C. in iron. Does not readily oxidize.
Stability to Acids and Alkalies	Stable in boiling 10% NaOH or H_2SO_4
Solubility in	
Water	Insoluble
Ethyl Alcohol	6 cc. HB-40 in 100 cc. at 25° C.

Soluble in all proportions with

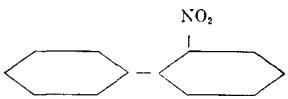
Acetone	Linseed Oil
Benzene	Mineral Oil
Carbon Tetrachloride	Skellysolve B
Castor Oil	Solvent Naphtha
Ether	Turpentine
Ethyl Acetate	

HB-40 is useful not only in straight polystyrene resins, where it may be added to the monomer before polymerization, but also in styrene copolymers and combinations with other resins where it acts as a blending agent as well as a plasticizer. The compatibility with straight polystyrene resin is about 50 PHR.

HB-40 is a solvent plasticizer for the asphaltic bases used in certain coatings and seems to aid brushability and gloss.

Although stable under normal conditions HB-40 is not highly resistant to oxidation when heated and is discolored by ultraviolet light.

Ortho-Nitrobiphenyl



Specifications

Appearance and Color	Light yellow to reddish crystalline solid
Crystallizing Point	34.5° C. min.
Distilling Range:	
95% (1-96 cc.)	5° C. max.
100% (between 320.0° C. and 330.0° C.)	7° C. max.

Description

Ortho-Nitrobiphenyl, also called Ortho-Nitrodiphenyl, is a light yellow to reddish colored liquid or solid of characteristic odor. It is compatible with the cellulose esters and ethers, polyvinyl chloride, polyvinyl butyral, polyvinyl acetate, polystyrene, rosin, rosin esters, modified rosin esters, modified phenolic resins, oil soluble phenolic resins, alkyd resins and vegetable oils. This wide compatibility, a low rate of hydrolysis, and resistance to acids, alkalies, and mineral oil, together with an unusually low price make ONB a very attractive plasticizer.

Some of the physical and chemical properties of Ortho-Nitrobiphenyl are:

Empirical Formula	$C_{12}H_9O_2N$
Molecular Weight	199.20
Melting Point	Approx. 35° C. (Super-cools readily)
Boiling Point at 10 mm.	Approx. 172° C.
Boiling Point at 760 mm.	Approx. 330° C.
Refractive Index at 25° C.*	Approx. 1.613

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Specific Gravity at 40° 15.5° C.	Approx. 1.189
Viscosity at 25° C.*	38 centipoises
Viscosity at 45° C.	12 centipoises
Weight gallon	Approx. 9.9 lbs.
Flash Point	143° C. (289.5° F.)
Fire Point	179° C. (354.5° C.)

*Obtained on supercooled material.

Solubility:

Practically insoluble in water (either hot or cold). Readily soluble in:

Benzene	Carbon Tetrachloride
Ethyl Alcohol	Perchlorethylene
Methyl Alcohol	Glacial Acetic Acid
Ether	Mineral Spirits
Acetone	Pine Oil
Methyl Ethyl Ketone	Turpentine
Ethyl Acetate	Linseed Oil
Amyl Acetate	Soya Bean Oil
Ortho-Dichlorobenzene	Corn Oil

Ortho-Nitrobiphenyl (ONB) plasticizes most resins, both synthetic and natural, the amount required varying with the resin and the intended use. It may be used as the sole plasticizer or, preferably, in conjunction with one or more other plasticizers. The volatility of ONB is less than Diethyl Phthalate but greater than Dibutyl Phthalate.

In nitrocellulose, the plasticizing action of Ortho-Nitrobiphenyl is similar to and in some cases superior to that of camphor. The two plasticizers work well together, or camphor oil may be substituted for all or part of the camphor in the formula. In lacquers ONB aids solvent release.

With cellulose acetate and cellulose aceto-propionate ONB is highly compatible, 50 PHR giving clear, transparent compositions of good molding properties and medium flexibility.

Ortho-Nitrobiphenyl is compatible with cellulose acetate-butyrate and produces hard, tough compositions suitable for either molding compounds or lacquers.

ONB is very compatible with ethyl celluose and produces compositions of good weather resistance.

Compatibility with the several vinyl resins varies considerably. It is highly compatible with polyvinyl acetate, 50 PHR giving very flexible, tacky compositions. In polyvinyl formal the plasticizing effect is greater than in cellulose acetate, 50 PHR producing good flexibility but no tackiness. Temperatures of 150°-160° C. are required for good flow in molding.

With polyvinyl butyral 50 PHR of Ortho-Nitrobiphenyl produces very flexible but slightly tacky compositions which have good weather resistance. This is about the compatibility limit. Temperatures of 120°-130° C. are sufficient for good flow.

Ortho-Nitrobiphenyl is quite satisfactory with polyvinyl chloride but requires a working temperature of more than 150° C. and the use of some stabilizer such as lead carbonate. The compatibility limit lies somewhere between 40 and 50 PHR. 40 PHR produces hard, tough, flexible, transparent compositions.

The compatibility of Ortho-Nitrobiphenyl with polyvinyl chloride-acetate copolymers increases and the working temperature decreases with increased acetate contents. Vinylite VYNW, with a 95 5 chloride - acetate ratio, requires a temperature of over 150° C. for good flow, while VYHH with an 85 15 ratio flows well at 110°-120° C. With both however, 40 PHR gives very flexible compositions.

With polystyrene, Ortho-Nitrobiphenyl is highly compatible and imparts flexibility without causing the undue softening and tackiness which result from the use of the usual types of plasticizers.

Ortho-Nitrobiphenyl has good fungicidal properties when incorporated in plastic compositions.

Coated textiles, where Ortho-Nitrobiphenyl was the plasticizer and the base plastic of the coating was polyvinyl acetate, polyvinyl formal, polyvinyl butyral, cellulose acetate, Vinylite VYHH, or polystyrene, did not support growth of Aspergillus niger, Penicillium, Chaetomium globosum or Metarrhizium, even after the coated textiles have been leached in running water for 48 hours.

Heating the coated textiles for 5 days at 105° C. resulted in some loss in fungus resistance.

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Fig. 2

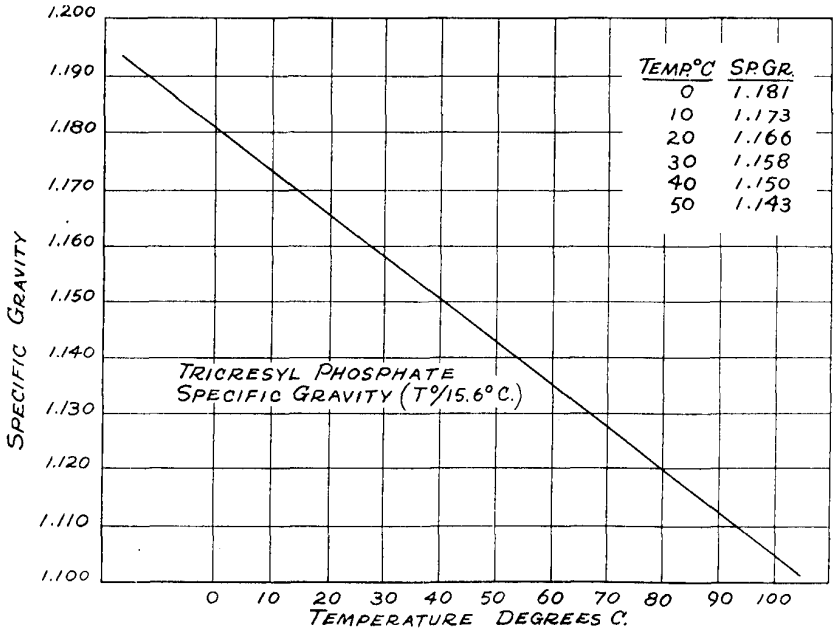

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Fig. 3

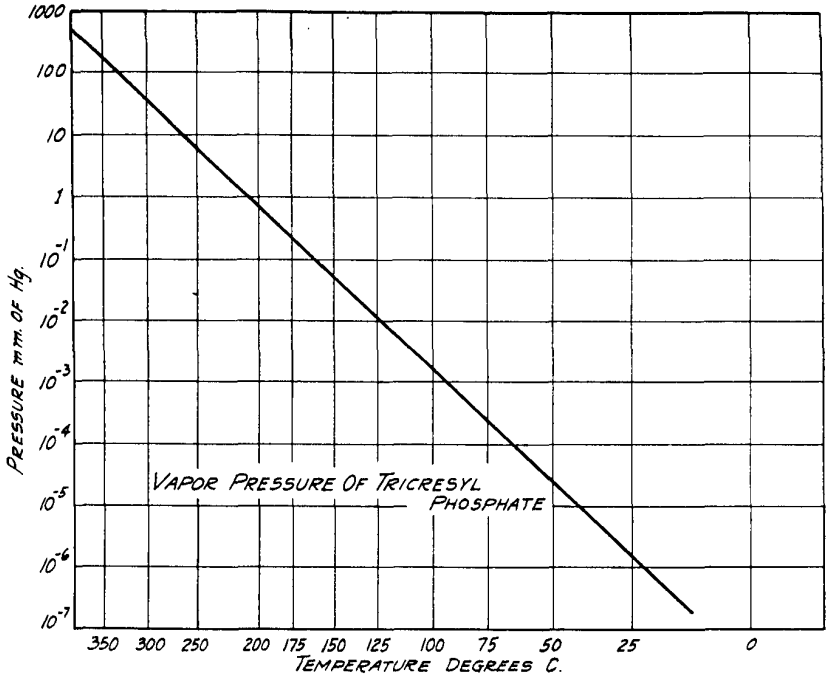

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Fig. 4

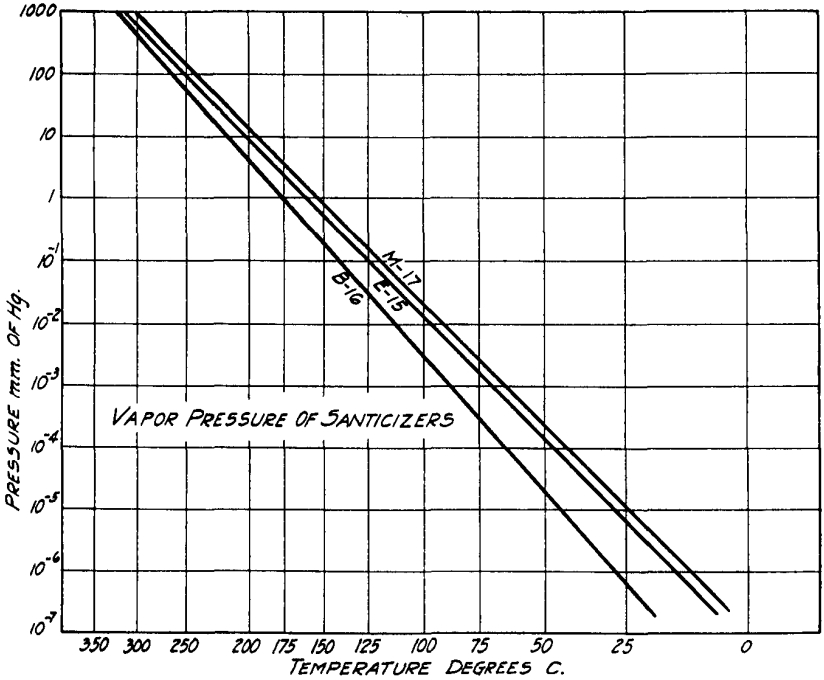

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Fig. 5

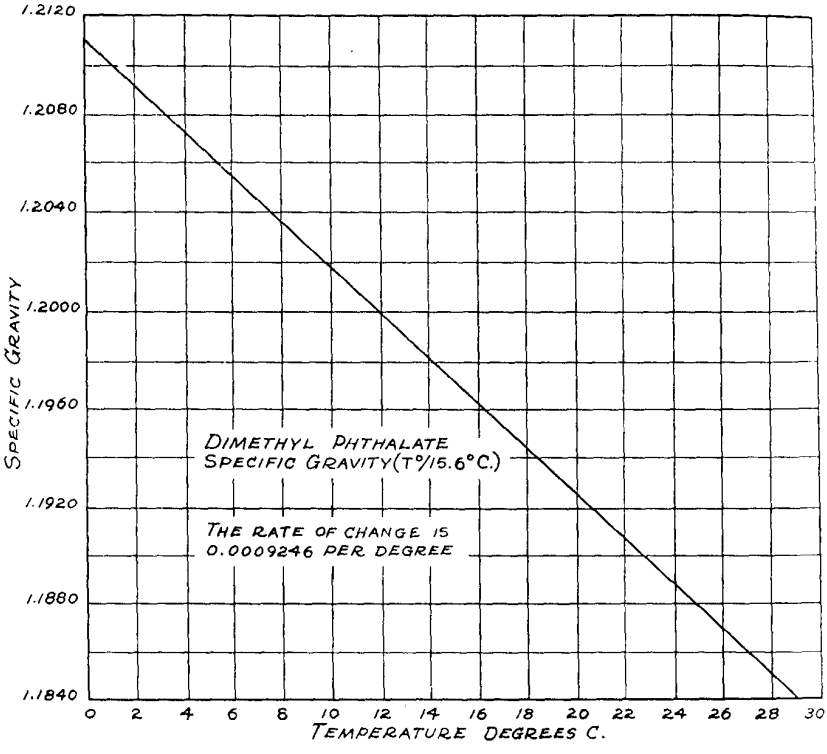

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Fig. 6

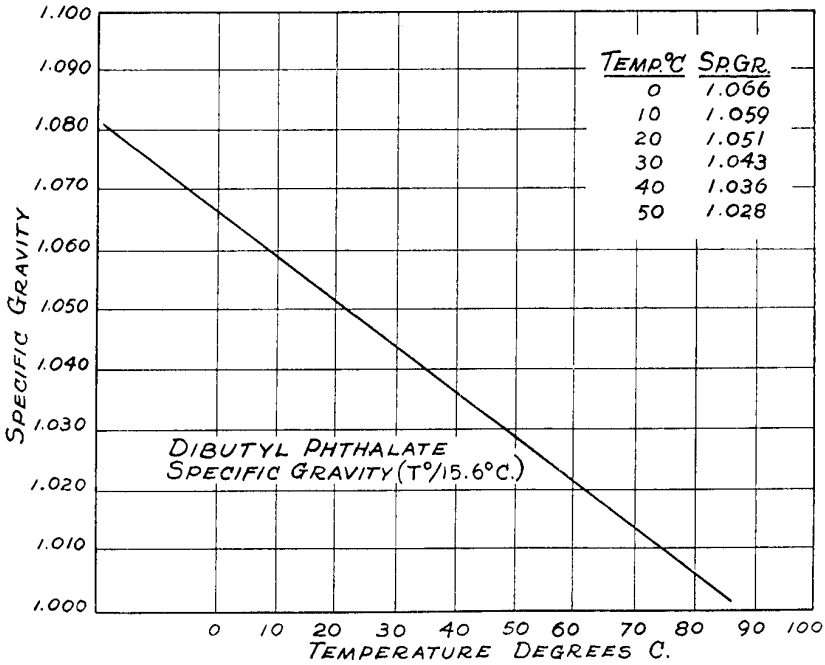

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Fig. 7

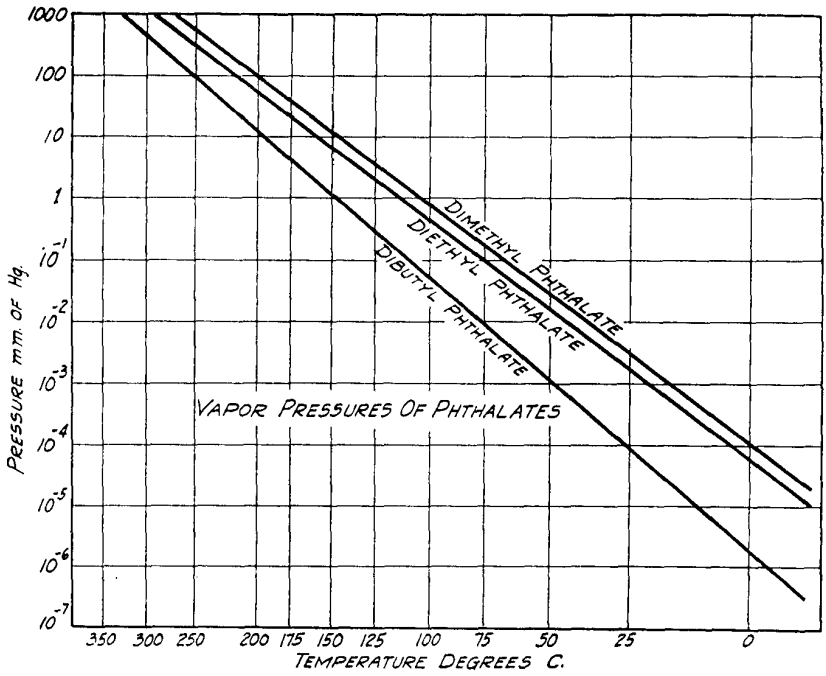

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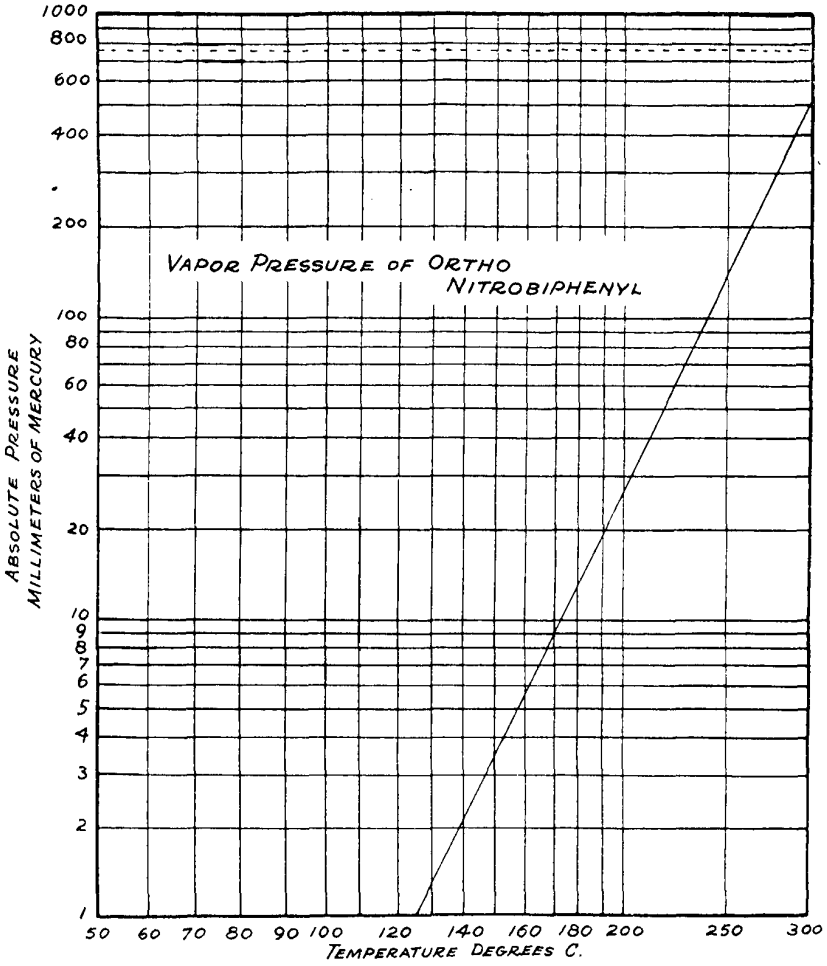
Fig. 8



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TOWOLDMON0038591

General Data

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
HB-40	345	174
Dibutyl Phthalate	340	170
Diethyl Phthalate	305	152
Dimethyl Phthalate	300	149

*Determined in Cleveland Open Cup.

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 Phthalate	-26°	30.1	17.1
Santicizer B-16	Below -40°	136.5	68.2
Santicizer E-15	-34.5°	215.7	92.3
Santicizer M-17	-26°	454.8	169.0

(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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Solubility of Liquid Plasticizers in Organic Solvents and Oils

		Santicizers				Phthalates			
	Tricresyl Phosphate	8	B-16	E-15	M-17	Di-Butyl	Di-Ethyl	Di-Methyl	HB-40
Methyl Alcohol	M	M	M	M	M	M	M	M	S
Ethyl Alcohol	M	M	M	M	M	M	M	M	S
Butyl Alcohol	M	M	M	M	M	M	M	M	M
Acetone	M	M	M	M	M	M	M	M	M
Methyl Ethyl Ketone	M	M	M	M	M	M	M	M	M
Ethyl Acetate	M	M	M	M	M	M	M	M	M
Amyl Acetate	M	M	M	M	M	M	M	M	M
Ethylene Dichloride	M	M	M	M	M	M	M	M	M
Trichlorethylene	M	M	M	M	M	M	M	M	M
Carbon Tetrachloride	M	M	M	M	M	M	M	M	M
Chlorinated Paraffin	M	I	M	M	I	M	M	M	M
Gasoline (Skellysolve E)	M	I	M	I	I	M	M	I	M
Benzene	M	M	M	M	M	M	M	M	M
Xylene	M	M	M	M	M	M	M	M	M
Monochlorobenzene	M	M	M	M	M	M	M	M	M
o-Dichlorobenzene	M	M	M	M	M	M	M	M	M
Chlorinated Biphenyl (Aroclor 1242)	M	M	M	M	M	M	M	M	M
Pine Oil	M	M	M	M	M	M	M	M	M
Turpentine	M	S	M	M	S	M	M	S	M
Linseed Oil (Raw)	M	I	M	S	I	M	M	M	M
Tung Oil	M	S	M	S	I	M	M	M	M
Soybean Oil	M	I	M	S	I	M	M	S	M
Perilla Oil	M	I	M	S	I	M	M	M	M
Castor Oil	M	M	M	S	I	M	M	M	M

M = Miscible S = Soluble

I = Insoluble

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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	15
Monochlorobenzene	340	v. s. s.	250	110
o-Dichlorobenzene	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 Biphenyl (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
Polystyrene	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	SH
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.

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SUGGESTED PLASTI

● Denotes: of use
X Denotes: of special value

	Alkyds	Benzyl Cellulose	Buna N	Cellulose Acetate	Cellulose Acetobutyrate	Cellulose Acetopropionate	Cellulose Nitrate	Chlorinated Rubber	
Aroclors	X	●	X		X	X	●	●	
Dibutyl Phthalate	X		X		●	X	●	●	X
Diethyl Phthalate				●					
Dimethyl Phthalate				●					
Diphenyl Phthalate		●					●		●
HB-40		●							
Ortho-Nitrobiphenyl			●	●	●	●	●	●	X
Santicizer 3				●	●	●			
Santicizer 8				●	●	●	X		
Santicizer 9					X		X		
Santicizer 10				●	X	X	●		
Santicizer B-16	●	X	●		●	X	●	●	●
Santicizer E-15	●	X	X	●	●	●	X	●	X
Santicizer M-17	X		X	●	●	●	X	●	X
Triphenyl Phosphate				●	●	X	X		
Tricresyl Phosphate	X		X		●	X	●	●	X

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TOWOLDMON0038596

'ICIZER APPLICATIONS

Cellulose	Kauri Gum	Manila Gum	Melamine-Formaldehyde	Phenol-Formaldehyde	Polyamide	Polyvinyl Acetate	Polyvinyl Butyral	Polyvinyl Chloride	Polyvinyl Chloride-Acetate	Polyvinyl Formal	Polystyrene	Rosin	Santolites	Shellac	Urea-Formaldehyde	Zein
•						•	X	X	•		•	•	X			
•	•	X				•	•	X	X		•		•	X		
		X								X			X	X		
•						•					X					
•											•					
		X				•	•	•	•	•	•		X	X		
•					•	X				X	X		•	•		•
•					•	•	X			•	X		•	•		•
			•	X	X	X							X	X	•	X
						X				X	•		X			
•	•	•	X			•	X	•	•		•	•	•	•	X	X
•		X				•	X	X	X	•	X		•	X		
•		X		X		•	X	X	X	•	X		•	X		
						X				X						
•				X		•	X	•	•	X	•		X			

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TABLE OF CHARACTERISTIC(

	TRICRESYL PHOSPHATE	TRIPHENYL PHOSPHATE	SANTICIZER 3	SANTICIZER 8	SANTICIZER 9	SANTICIZ 10
Molecular Weight	368	326	199	199	171	262
Color and Form	Colorless liquid	White flakes	White solid	Light amber liquid	Granules	White cryst
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.		58° C.			51° C.
Specific Gravity	1.165/20° C.	1.268/60° C.	1.171 at 65°/65° C.	1.188/25° C.	1.313/25° C.	1.207 15° C
Pounds per Gallon	9.7	10.5	9.76	9.9	10.9	10.06
Refractive Index	1.556/20° C.		1.522/65° C.			
Evaporation Rate Gms/sq. cm/hr/100° C	0.00000708	0.00000028		0.0002659	0.000053 at 56° C.	
Solubility in Water	Less than 0.002% at 85° C.	0.001% at 34° C. 0.002% at 54° C.	0.6% at 34° 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	40-30	50	90	25-30	30
Light Fastness in N/C[3]	Poor	Poor	Poor	Poor	Poor	Medium
Light Fastness in Ac/C		Fair	Good	Good		
Fire Retardation	Excellent	Excellent	None	None	None	None
Toxicity[4]	See footnote					

(1) **RETENTIVITY IN NITROCELLULOSE**

Retentivity in N/C was determined by dissolving weighed amounts of the plasticizer in a 15% solution of R.S. 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 film within a week. The retentivity is expressed in parts of plasticizer per 100 parts of resin by weight. Measurements were not made beyond 100PHR.

(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 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 "Uviare" 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 next, and Triphenyl Phosphate last.

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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.	405° 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.
9.17	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	165
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

TOXICITY

The terms "toxic" and "non-toxic" are, scientifically speaking, only relative. A product may be harmless if used under the conditions commonly 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 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 49-59) 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.

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The Santolites

(Aryl Sulfonamide — Formaldehyde Resins)

The Santolites are condensation products of aryl sulfonamides and formaldehyde. They vary from hard brittle resins to soft sticky resins, which for ease of handling are cut with a sufficient amount of solvent to make them flow readily. They are exceptionally compatible with other resins and perform many functions of an unusual nature.

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, 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 MHP 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 but with increased flexibility.

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. Compositions containing both nitrocellulose and Santolite resins should not be subjected to temperatures much above 80° C. or rapid decomposition of the nitrocellulose may occur.

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.

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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 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 of Santolites in various compounds is given on page 48.

Santolite MS

Specifications

Appearance and Color	Pale yellow viscous resin
Color of Benzene Solution (25 gms. in 50 cc.)	APHA 70 max.
Solution in benzene (1:5)	Clear
Solution in benzene (1:6)	No crystalline deposit in 24 hours.
Refractive Index at 50° C.	1.5690 — 1.5720

Containers

60 lbs. cans (incl.)

Santolite MS
80% Solution

Specifications

Appearance and Color	Light colored viscous liquid. Free flowing above 20° C. Color not darker than APHA 70 when 25 cc. of sample is dissolved in 35 cc. of normal butyl acetate.
Butyl Acetate (by weight)	19.0 to 21.0%
Composition (by weight)	80% Santolite MS 20% Butyl Acetate
	(Tolerances — 19-21% solvent)
Sp. Gr. @ 25° 25° C.	1.2098
Ref. Ind. @ 25° C.	1.5448 (approx.)

Containers

540 lbs. net. Non-returnable galvanized drums.

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 cellulose acetate and, being a

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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 soluble in the common organic solvents and thinners except petroleum hydrocarbons. It is insoluble in 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 80% Santolite MS and 20% butyl acetate. This is known as "Santolite MS-80% solution" and is a free flowing liquid at temperatures above 20° C. It weighs about 10.1 lbs. per gallon.

Santolite MHP

Specifications

Appearance	Hard, practically colorless resin
Color of Solution (25 gms. in 75 gms. of 26 butyl acetate)	APHA 80 max.
Refractive Index at 25° C. (25 gms. in 75 gms. of 20 butyl acetate)	1.4280-1.4310
Penetration (200 gm. load for 5 seconds at 25° C.)	2.0 mm. max.

Containers

60 lbs. cans (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, molding 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	Clear, light yellow, sticky resin
Color	Santolite K Color Standard* 2.5 max.

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Refractive Index at 50° C.	1.5330-1.5390
Acid Number	10 max.

*Comparable in depth of color but not in shade to the Gardner 1933 Standard.

Containers

55-gal. drums (approx. 500 lb.) (one time shippers.)
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.

Santolite K-5

Specifications

Appearance	Clear, light yellow, sticky resin
Color	Santolite K Color Standard 2.5 max.
Refractive Index at 50° C.	1.5420-1.5520
Acid Number	10 max.

Containers

500 lbs. net. Non-returnable galvanized drums.

Description

Santolite K-5 differs from Santolite K chiefly in being somewhat harder at normal temperatures, and having less plasticizing action. The addition to Santolite K-5 of 25% to 30% by weight of a liquid plasticizer such as Santicizer M-17 will give a product almost identical in characteristics to Santicizer K.

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Solubility 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	Insoluble.
Fatty Acids	Miscible.
Vinyl Resins	Miscible.
Shellac	Miscible.
Paraffin	Insoluble.
Carnauba Wax	Insoluble.
Aroclor Resins	Partially soluble. 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 Biphenyls)

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.

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 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.

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GENERAL PHYSICAL PROPERTIES

	Aroclor 1221	Aroclor 1232	Aroclor 1242	Aroclor 1248	Aroclor 125
Form	Colorless mobile oil	Practically colorless mobile oil	Practically colorless mobile oil	Yellow tinted oily liquid	Light yellow viscous oil
Color—NPA	0.5 max.	0.5 max.	0.5 max.	0.5 max.	1.0 max.
Acidity—Maximum (Mgm. KOH per Gm.)	0.01	0.01	0.01	0.01	0.01
Coefficient of Expansion cc/cc °C.	0.000707 (15°–40°C.)	0.000725 (25°–100°C.)	0.000678 (25°–65°C.)	0.000702 (25°–65°C.)	0.000661 (25°–65°C.
cc cc °F.	0.000392 (50°–104°F.)	0.000402 (77°–212°F.)	0.000377 (77°–149°F.)	0.000389 (77°–149°F.)	0.000367 (77°–149°F.
Density—					
Specific Gravity 25° 25°C. (77° 77°F.)	1.177 to 1.187	1.262 to 1.272	1.378 to 1.388	1.447 to 1.457	1.538 to 1.54
Pounds per Gallon—25°C. (77°F.)	9.82	10.51	11.50	12.08	12.83
Distillation Range—ASTM D-20 Mod. °C.	275°–330°C. Corr.	290°–325°C. Corr.	322°–365°C. Uncorr.	330°–370°C. Uncorr.	365°–390°C.
°F.	527°–626°F. Corr.	554°–617°F. Corr.	612°–689°F. Uncorr.	626°–698°F. Uncorr.	689°–734°F.
Evaporation Loss—ASTM D-6 Mod.					
163°C. 5 hrs.	—	—	3.04 to 3.64	3.0 to 4.0	1.06 to 1.28
100°C. 6 hrs.	1.0 to 1.5	1.0 to 1.5	—	—	0.4
Flash Point—Cleveland Open Cup °C.	140.6°C.	152°–154°C.	176°–180°C.	193°–196°C.	None
°F.	285.0°F.	305°–310°F.	348°–356°F.	379°–384°F.	
Fire Point—Cleveland Open Cup °C.	176.7°C.	238°C.	334°C.	None	None
°F.	350.0°F.	460°F.	633°F.		
Pour Point—ASTM °C.	Crystals at 1°C.	—35.5°C.	—17.7° to —20.7°C.	—7°C.	8° to 12°C.
°F.	Crystals at 34°F.	—32°F.	—0.2° to —5.2°F.	19.4°F.	46° to 54°F.
Softening Point—ASTM °C.	—	—	—	—	—
°F.	—	—	—	—	—
Refractive Index—D-line—20°C.	1.617–1.618	1.620–1.622	1.627–1.629	1.630–1.631	1.637–1.639 at 25°C.
Viscosity—Saybolt Universal 210°F. (98.9°C.) Sec. (ASTM—D-88)	30.5	31.0–32.0	34.0–34.6	36.0–37.0	43.5–48.5
130°F. (54.4°C.)	35.4	39.0–41.0	49–56	69–78	260–440
100°F. (37.8°C.)	40.2	47.6–50.0	80–93	185–240	1800–3800

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OF SOME OF THE AROCLORS

Aroclor 1260	Aroclor 1262	Aroclor 1268	Aroclor 1270	Aroclor 4465	Aroclor 5442	Aroclor 5460	Aroclor 2565
Light yellow soft sticky resin	Light yellow sticky clear resin	Pale yellow opaque brittle resin	White crystaline powder	Yellow transparent brittle resin	Yellow transparent sticky resin	Yellow transparent resin	Brown-black opaque resin
1.0 max.	1.2 max.	—	—	1.5 max.	—	2.0 max.	—
0.015	0.02	—	0.175	0.05	0.028	0.07	1.26
	0.000640 (25°–90°C.) 0.000355 (77°–194°F.)	—	—	0.000611 (25°–65°C.) 0.000339 (77°–149°F.)	0.00123 (25°–99°C.) 0.000683 (77°–210°F.)	0.00179 (25°–124°C.) 0.000994 (77°–255°F.)	0.000656 (25°–65°C.) 0.000364 (77°–149°F.)
1.618 to 1.629 13.50	1.646 to 1.653 13.72	1.804 to 1.811 15.13	1.914 to 1.960 16.24	1.712 to 1.723 14.28	1.432 to 1.447 11.96	1.740 to 1.745 14.50	1.724 to 1.740 14.41
385°–420°C. 725°–788°F.	373°–404°C. Uncorr. 703°–759°F. Uncorr.	— —	450°–460°C. 842°–860°F.	Requires vacuum Requires vacuum	— —	Requires vacuum Requires vacuum	— —
0.6 to 0.2	0.48 to 0.56 —	0.15 to 0.24 —	0.0 to 0.1 —	0.23 to 0.29 —	2.0 0.012	0.025 1.51 to 1.71 (at 260°—5 hrs.)	0.21 to 0.24 —
None	None	None	None	None	247°C. 477°F.	None	None
None	None	None	None	None	>350°C. >662°F.	None	None
36° to 36°C.	34.9° to 38.0°C.	—	—	—	46°C.	—	—
96° to 97°F.	95° to 100.4°F.	—	—	—	115°F.	—	—
	—	135° to 160°C. (hold pt.)	294° to 300° C. (hold pt.)	60° to 66° C.	48.5° to 53°C.	100° to 105.5°C.	66° to 72C.
	—	275° to 320°F. (hold pt.)	561° to 572°F. (hold pt.)	140° to 151°F.	119° to 127°F.	212° to 222° F.	149° to 162°F.
	1.6501–1.6517	—	—	1.664–1.667	—	1.660–1.665	—
30–32	90–103	—	—	92–156 (200°F. or 130°C.)	313.5	—	—
2000–4500	600-850 at 160°F.	—	—	—	—	—	—
—	—	—	—	—	—	—	—

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Chlorine Content of Pure Chlorinated Biphenyls*

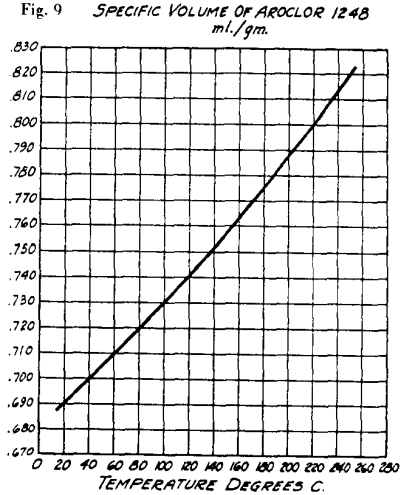
Chlorinated Biphenyl	% Chlorine
Monochlorbiphenyl	18.8
Dichlorobiphenyl	36.8
Trichlorobiphenyl	41.4
Tetrachlorobiphenyl	48.6
Pentachlorobiphenyl	54.4
Hexachlorobiphenyl	59.0
Heptachlorobiphenyl	62.8
Octachlorobiphenyl	65.9
Nonachlorobiphenyl	68.8
Decachlorobiphenyl	71.1

*The Aroclors are mixtures of two or more chlorobiphenyls and some contain chlorinated terphenyls.

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.

The following compatibility chart will give a fairly good idea of what may be expected from any one of the Aroclors. Although every Aroclor is not included, the chart covers a sufficient range and displayed such definite trends as to permit assumptions to be made regarding others of the series.

Fig. 9 SPECIFIC VOLUME OF AROCLOR 1248



Compatibility Table

	1242	1254	1262	4465	5460
Nitrocellulose	100 PHR	100 PHR	50 PHR	I	I
Cellulose Acetate	I	I	I	I	I
Cellulose Acetopropionate	C	C	I	I	I
Cellulose Acetobutyrate	C	C	50 PHR	I	I
Ethyl Cellulose	C	C	C	C	C
Benzyl Cellulose	C	C	C	C	C
Polyvinyl Acetate	C	100 PHR	I	I	I
Polyvinyl Formal	C	C	100 PHR	50 PHR	50 PHR
Polyvinyl Acetal	C	C	C	100 PHR	100 PHR
Polyvinyl Butyral	C	C	100	100 PHR	100 PHR
Polystyrene	C	C	C	C	C
Chlorinated Rubber	C	C	C	C	C

C—Compatible in all proportions
I—Incompatible
PHR—Parts of Aroclor by weight per 100 parts plastic base.

The Aroclors are compatible also with coumarone-indene resins, ester gum, rosin, damar, rubber, asphalt, paraffin and sulfur. They are compatible with "A" and "B" stage phenolics but not with the completely cured resin. Aroclors are incompatible with manilla gum.

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Solubility of Aroclors in 100 Milliliters of Various Solvents

Type of Solvent	Aroclor 1242 Cold	1242 Hot	1248 Cold	1248 Hot	1251 Cold	1251 Hot	1270 Cold	1270 Hot	1265 Cold	1265 Hot
Acid										
Acetic Acid	S	S	--	--	S	S	--	--	SS	S
Oleic Acid	S	S	--	--	S	S	--	--	S	VS
Benzoic Acid	10.0 31°C.	--	10.0 32°C.	--	--	--	--	--	--	--
Aldehyde										
40% Formaldehyde	I	I	I	I	I	I	I	I	I	I
Furfural	VS	VS	VS	VS	VS	VS	SS	SS	VS	VS
Amine										
Aniline	S	S	--	--	S	S	--	--	VS	VS
Pyridine	132.5 30°C.	440 99°C.	--	--	114 31°C.	425 100°C.	--	--	VS	VS
Chloro — derivative										
Amyl chlorides — mixed	S	S	S	S	S	S	--	--	VS	VS
Carbon Tetrachloride	S	S	S	S	S	S	3.65	--	VS	VS
Chloroform	S	S	S	S	S	S	--	--	VS	VS
Dichlorethylene	--	--	--	--	--	--	3.06	--	VS	VS
Ethylene Dichloride	S	S	S	S	S	S	--	--	VS	VS
Monochlorobenzene	S	S	S	S	S	S	2.89	--	VS	VS
Orthodichlorobenzene	--	--	--	--	--	--	--	--	VS	VS
Tetrachlorethane	S	S	S	S	S	S	--	--	VS	VS
Trichlorethane	S	S	S	S	S	S	3.31	--	VS	VS
Trichlorethylene	S	S	S	S	S	S	--	--	VS	VS
Drying Oil										
Tung Oil	S	S	S	S	S	S	--	--	VS	VS
Linseed Oil	S	S	S	S	S	S	--	--	VS	VS
Ester										
Amyl Acetate	S	S	S	S	S	S	--	--	VS	VS
Butyl Acetate	S	S	S	S	S	S	--	--	VS	VS
Cellosolve Acetate	S	S	S	S	S	S	--	--	VS	VS
Cottonseed Oil	S	S	S	S	S	S	--	--	S	VS
Dibutyl Phthalate	S	S	S	S	S	S	--	--	S	VS
Diethyl Phthalate	S	S	S	S	S	S	--	--	S	VS
Ethyl Acetate	S	S	S	S	S	S	--	--	S	VS
Ethyl Lactate	S	S	S	S	S	S	--	--	VS	VS
Ethylene Glycol Diacetate	S	S	S	S	S	S	--	--	VS	VS
Methyl Acetate	S	S	S	S	S	S	--	--	S	S
Tricresyl Phosphate	S	S	S	S	S	S	--	--	SS	S
Ether: Ethyl Ether	S	S	S	S	S	S	S	S	S	--
Ether Alcohol										
Carbitol	224 31°C.	307 99°C.	VS	VS	173 26°C.	259 98°C.	--	--	SS	--
Cellosolve	S	S	S	S	S	S	--	--	S	--
Diethylene Glycol	--	--	--	--	--	--	--	--	S	--
p-p' Dihydroxy Ethyl Ether	16.9 23°C.	19 99°C.	SS	SS	8 30°C.	10 100°C.	--	--	SS	--
Hydrocarbon										
Benzene	VS	VS	VS	VS	VS	VS	3.5	--	VS	VS
Gasoline	VS	VS	VS	VS	VS	VS	--	--	VS	VS
Kerosene	VS	VS	VS	VS	VS	VS	--	--	VS	VS
Mineral Spirits	VS	VS	VS	VS	VS	VS	--	--	VS	VS
Paraffin	2.0 27.5°C.	S	2.0 28°C.	S	--	S	--	--	< 5.0	S
Pine Oil	S	S	VS	VS	S	S	--	--	S	S
Toluene	VS	VS	VS	VS	VS	VS	--	--	VS	VS
Turpentine	VS	VS	VS	VS	VS	VS	--	--	VS	VS
Xylene	VS	VS	VS	VS	VS	VS	--	--	VS	VS
Hydroxy — derivative										
Amyl Alcohol	S	S	--	--	S	S	--	--	S	S
n-Butyl Alcohol	S	S	--	--	S	S	--	--	SS	S
Ethyl Alcohol (3-A)	23.3 20°C.	80.0 70°C.	--	--	10 27°C.	28 75°C.	--	--	SS	--
Glycerin	I	I	I	I	I	I	I	I	I	I
Methyl Alcohol	42.5 20°C.	88.5 60°C.	--	--	15 20°C.	22.2 65°C.	--	--	SS	--
Phenol — 90%	194 30°C.	S	--	--	SS	S	--	--	S	S
Ketone										
Acetone	S	S	--	--	S	S	--	--	S	S
Miscellaneous										
Carbon Disulfide	S	S	--	--	S	S	--	--	VS	VS
Nitrobenzene	S	S	--	--	S	S	--	--	VS	--
Water	I	I	I	I	I	I	I	I	I	I

I — Insoluble S — Soluble SS — Slightly Soluble VS — Very Soluble

Figures show grams of Aroclor per 100 milliliters of solvent at 25°C. unless otherwise indicated.

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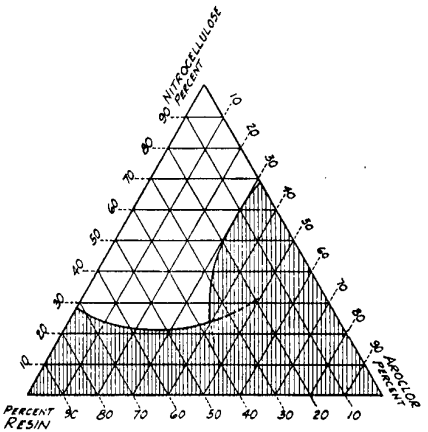
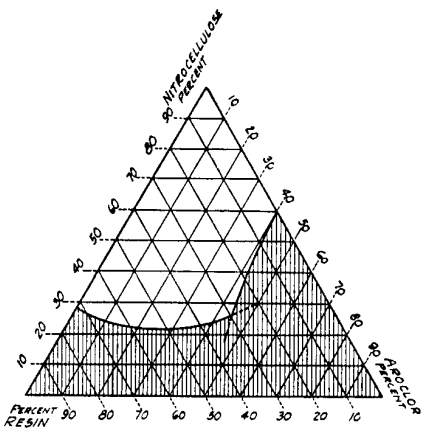
DIAGRAMS SHOWING PRACTICAL COMPOSITION

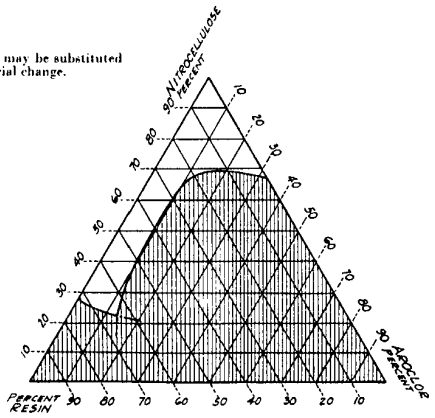


For combinations where the resin is damar or a resin of the phthalic anhydride-glycerol type and where the Aroclor is Aroclor 1262.*



For combinations where the resin is damar 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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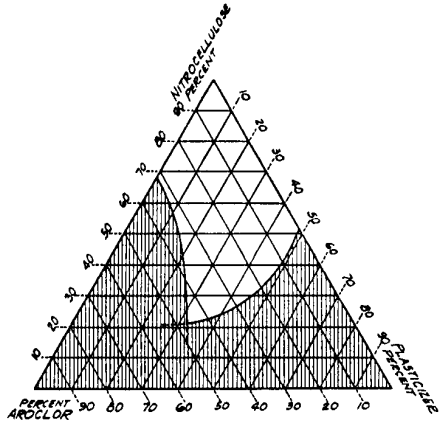
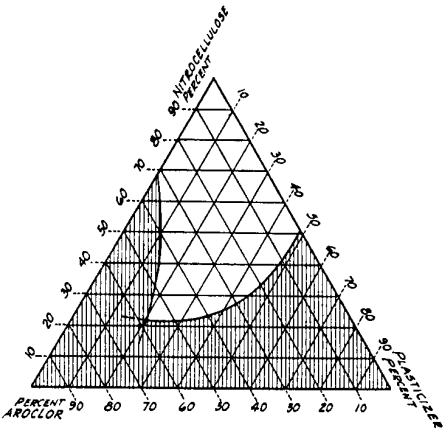
N OF LACQUERS USING AROCLORS 1254 AND 1262



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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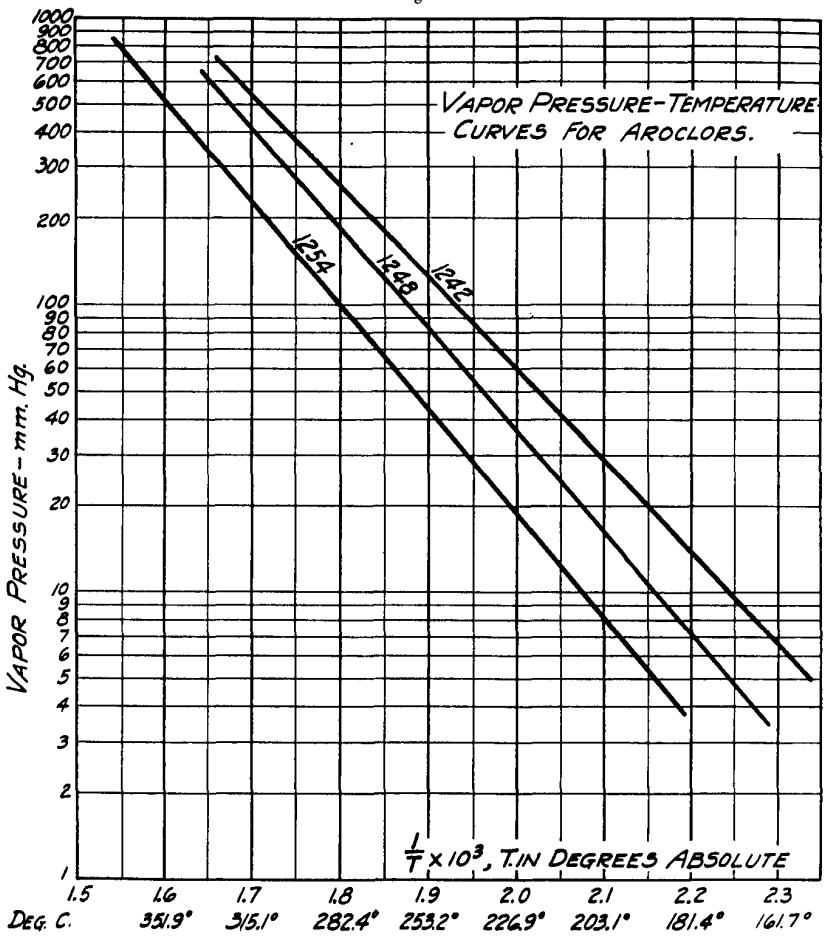
Fig. 10



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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 54 and 55.)

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

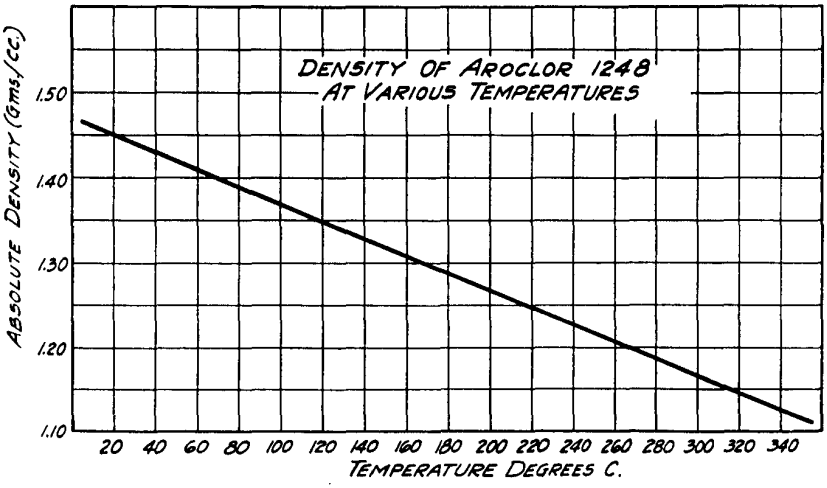
No. 1 and No. 2 have excellent sanding and polishing qualities. No. 3 is very flexible but too soft for sanding.

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

Fig. 11



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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 PHR are 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 flexibility and the resinous products, hardness. 75 PHR of Aroclor 1242 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 temperatures.

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.

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.

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.

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.

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 polyvinyl formal resin increases the ease of molding operation as well as improves 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.

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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 varnish 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.

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.

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 PHR of Aroclor 1270 are required.

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.

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