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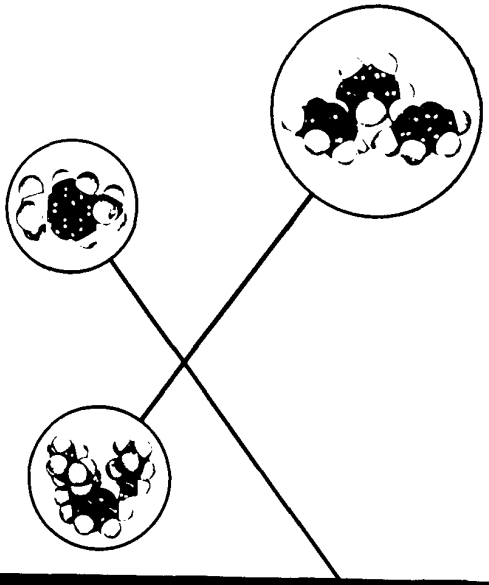
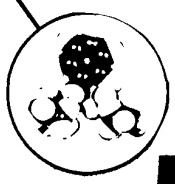


MONSANTO PLASTICIZERS

MONSANTO
CHEMICALS – PLASTICS



CHOOSING PLASTICIZERS

MONSANTO PLASTICIZERS

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FOR OPTIMUM QUALITY...

Molding Compounds

Plastic Free Films

Textile and Paper Coatings

Adhesives

Wood Bonding Agents

Surface Coatings

Synthetic Rubber

For Every Formula Using Plastics—

CHOOSE THE BEST . . . Plasticizers

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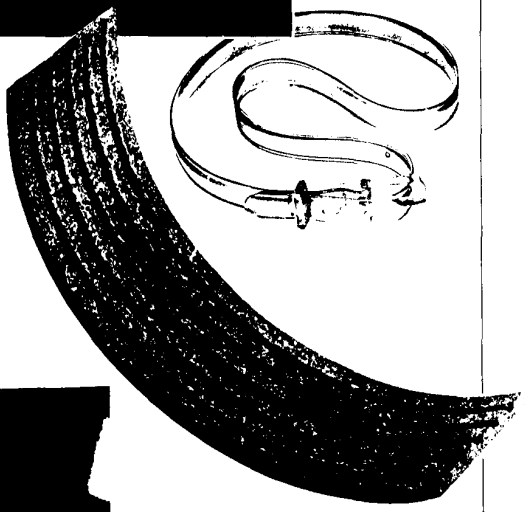



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INTRODUCTION

Plasticizers are low melting solids or high boiling organic liquids. They are added to plastic compositions and surface coatings to extend or modify the natural properties of the resins and to develop new, improved properties not present in the resins themselves.

Plasticizers have grown in importance with the growth of the plastics and surface coating industry. New basic resins have required new plasticizing agents; older materials have found wider application because of improved properties developed through the use of unique plasticizers or plasticizer combinations.

As one of the major producers of chemicals for industry, Monsanto offers manufacturers of resin-based products a complete line of plasticizing agents. These plasticizers range from "standard" products to new, specialty plasticizers formulated to create improved properties in plastics and surface coatings. These properties range from flame retardency to improved low temperature flexibility. Monsanto plasticizers can impart such properties as improved flexibility, higher gloss, better weather resistance, good electrical properties, solvent and abrasion resistance, and many others.

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HOW A PLASTICIZER WORKS

The entire plastics industry is based upon the art of obtaining plasticity of one kind or another in *high molecular weight resins.* Aside from possible modifications of the molecule itself, base resins may be plasticized by heat, solvents, or plasticizers.

Heat contributes plasticity at some stage of practically all plastics processing. However, once a thermoplastic is cooled—this plasticizing effect disappears. Solvents, too, are employed during the initial compounding of some thermoplastic molding materials and in the manufacture of lacquers and surface coatings. But like heat, the effect of the solvents is temporary—once they have evaporated, the resin is left in its original state.

Plasticizers impart relatively permanent flexibility, toughness, and improved flow. They are *chemically related to solvents—the usual basis* for classification is the degree of volatility; plasticizers being relatively non-volatile compounds solvents possessing much higher volatility.

Thermosetting resins in their final infusible, in*soluble state are held together in a three* dimensional network by primary chemical bonds. This structure strongly resists outside forces, whether these forces be heat or the "separating" action of a solvent or plasticizer.

Thermoplastic resins, on the other hand, are held together by primary chemical bonds in a longitudinal direction only. These chemical bonds operate only along the length of the polymer chain The binding forces between chains are the Van der Waal forces or secondary bonds. These between-chain bonds are of a *physical rather than* chemical nature and thus are susceptible to modification by external forces more readily than primary chemical bonds. Consequently, plasticizing a thermoplastic resin consists basically of a controlled modification of the attractive forces between molecular chains. The extent of plasticizing action depends in part upon the molecular structure of the polymer and in part on the molecular structure of the plasticizer.

The attractive forces or bonds between the chains vary in magnitude and number with the resin The polymer chains of some resins are strongly bonded together by many cross-tying attractive forces, others are more loosely knit. The stronger the bonding forces between the polymer, the *more highly polar must be* the plasticizer. Rubber and neoprene, for example, are less strongly

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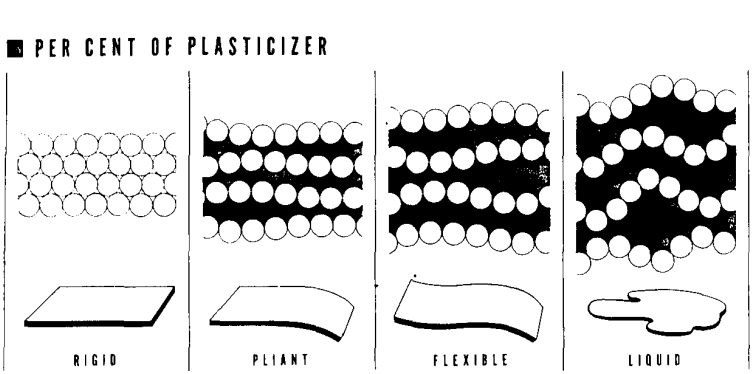

bonded than cellulose acetate or polyamide resins. Compounds such as hydrocarbons can be used to plasticize the more weakly bonded resins, but polyvinyl chloride or cellulose acetate require polar plasticizers plus heat and sometimes solvents to aid in compounding.

Plasticizers, like solvents, are attracted by the polar groups on the polymer chain and replace polymer-polymer bonds with polymer-plasticizer bonds. In addition, the sheer bulk of a plasticizer molecule and the configuration of its grouping disrupts the forces between chains. At high concentrations the plasticizer forms a continuous phase in which the separated chains can move. In such concentrations, the state of the plasticized mass is apt to be a soft gel.

Because of the relatively large size of most plasticizer molecules, it is frequently necessary to use heat, solvents, or a combination of both to aid in "loosening up" the resin structure to incorporate the plasticizer. Polyvinyl chloride, for example, is compounded with plasticizers at elevated temperatures. At room temperatures, the plasticizer does not separate adequately the polymer chains because of the strong secondary linkages or Van der Waal forces. The incorporation of camphor in cellulose nitrate is also aided by the action of heat and, in addition, solvents. Plasticizers are an essential aid in processing most resins. Without the softening action of the plasticizer, many resins could not be fabricated into films, sheets or useful molded articles. Plasticizers are used to improve the flow of resins into a mold and to impart flexibility and added toughness to the finished product. This has made possible many uses of resins to make intricate molded products. By improving adhesion, flexibility, and outdoor durability plasticizers made possible the development of lacquers for automobile and household uses.

Mechanically, a plasticizer reduces somewhat the tensile strength and increases the elongation and elasticity of a resin. To possess really high elasticity, the polymer chain must be able to kink readily. In cellulose derivatives, the chains are themselves relatively bulky and no amount of plasticization can ever produce the flexible elastomers that can be obtained with the more extensible molecules such as polyvinyl chloride.

By decreasing the forces holding the chains together, the plasticizer also lowers the vitrification point, sometimes called the "flex temperature," or brittle point.

Although in practice, all efficient plasticizers are polar compounds, the polarity characteristics are not a complete guide to the evaluation of a plasticizer. Other considerations such as compatibility, permanence, and the efficiency of the compound determine its suitability. In addition, certain plasticizers are used to impart special properties.

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EVALUATING PLASTICIZERS

Because of the wide variety of resins it is improbable that such a thing as a universal plasticizer will ever be found. Paper or textile coaters and manufacturers of molded products, surface coatings, or free film have specific performance specifications for their products and some of these requirements depend as much on the plasticizer as on the resin.

In judging the value of a plasticizer, the following characteristics must be evaluated:

COMPATIBILITY

The compatibility of a plasticizer with a resin is a function of its polarity, molecular size, and structural configuration. Slightly incompatible plasticizers may often be made compatible through the use of mutual solvents or other plasticizers.

PERFORMANCE

Permanence is the cumulative effects of low volatility, solvent resistance, good heat and light stability, and resistance to migration. As a general rule, the higher the molecular weight of a plasticizer, the lower the volatility. Heat and light stability and odor of the plasticizer depend upon the purity of the plasticizer and on the compound type. Color and taste are primarily a characteristic of the purity of the plasticizer. Optimum qualities in plasticizers can be obtained by the use of suitable raw materials and modern methods of manufacture.

EFFICIENCY

Efficiency is judged best on the basis of performance response. The efficiency of the plasticizer is determined by the extent of plasticizing action measured against the quantity of plasticizer required. Depending upon the property desired, the efficiency might be judged on the basis of elongation, flex temperature, tensile strength, modulus, hardness, or even weather or solvent resistance.

SPECIAL PROPERTIES

Flame resistance
Toxicity
Gloss
Adhesion
Abrasion resistance
Resistance to specific solvents
Electrical properties

Beyond meeting basic requirements, a number of Monsanto plasticizers are designed to add specific properties to the end product. Wider application of resin materials and more merchandisable finished products are possible through special properties created in the finished article. Selected Monsanto Santicizers offer flame resistance, improved electrical properties, higher gloss, greater low temperature flexibility, non-toxicity or greater solvent and abrasion resistance.

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For free film, lacquers, paper and textile coatings, rubber, and molded products — Monsanto supplies plasticizers that will extend or modify the properties of substantially any resin or combination of resins, natural or synthetic. Special properties not present in base resins can be added, processing expedited, and the performance of the finished product vastly improved when plastics are compounded with plasticizers exactly suited to the need.

Monsanto offers the trade a complete line of quality plasticizers. Raw materials, processing, and control—the three factors most important to purity and stability — are designed to assure optimum, dependable performance in Monsanto plasticizers serving the diverse requirements of the plastics industry.

Forty-eight years' experience in the manufacture of organic chemicals enables Monsanto to produce the finest quality plasticizers for natural or synthetic resin applications. Both liquid and solid plasticizers are available. These efficient plasticizers are of four general types:

Phthalates • Phthalyl Glycollates • Phosphates • Sulfonamides

In addition, Monsanto supplies a number of specialty plasticizers with outstanding performance characteristics in specific applications.

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MONSANTO PLASTICIZERS



TOWOLDMON0006245



Phthalate plasticizers, efficient processing components for plastics, particularly cellulosics, improve the properties of finished articles.









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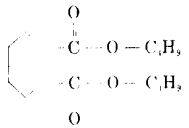
PHTHALATE PLASTICIZERS

Dibutyl Phthalate

Physical Constants



Molecular weight	278.3
Specific gravity at 25/25° C.	1.045
Lbs./gallon	8.75
Flash point	340° F. (170° C.)
Crystallizing point	Less than −35° C.
Viscosity (in centistokes) at 0° C.	54.91
Viscosity (in centistokes) at 25° C.	15.60
Refractive index at 25° C.	1.4915
Boiling point (760 mm.)	340° C.
Physical form	Clear, mobile liquid
Sulfur (copper strip test)	Negative

Specifications

Appearance	Clear, oily liquid
Maximum color	APHA 20
Odor	Slight
Acidity (as phthalic acid)	0.01% Max.
Assay (ester content)	99% Min.
Specific gravity 25/25° C.	1.045 ± 0.001
Refractive index at 25° C.	1.4905 ± 0.001

Dibutyl phthalate is a colorless liquid, soluble in all common organic solvents and oils, but practically insoluble in water (0.001% at 30° C.). It is one of the widest used chemical plasticizers for nitrocellulose. Dibutyl phthalate is compatible with most resins which are used to modify lacquer formulations. Its excellent light stability makes it suitable for use in colorless, white, or delicately tinted products.

Dibutyl phthalate is a strong solvent for nitrocellulose and capable of imparting good gloss and a high degree of plasticity. Only relatively small quantities are required as large proportions tend toward a reduction of tensile strength and softness.

Dibutyl phthalate makes possible the compounding of economical lacquer formulations. It has a high dilution ratio with petroleum naphtha and therefore is an excellent plasticizer for cellulose nitrate lacquers formulated with low-cost petroleum solvents. Pyroxylin textile coatings may obtain improved low temperature flexibility when dibutyl phthalate is mixed with castor oil and the combination used as the plasticizer.

In cellulose acetate, dibutyl phthalate has limited compatibility (less than 20 PHR) and when used with this resin, it is generally combined with other plasticizers such as dimethyl phthalate and triphenyl phosphate.

Dibutyl phthlate is used in relatively low percentages for plasticizing phenolic resin laminating varnish resins. In this application, dibutyl phthalate permits the post-forming of cured laminated sheets into various shapes suitable for luggage containers and decorative panels.

Because of its low toxicity and faint odor, dibutyl phthalate may be used for paper coatings to be used on food products.

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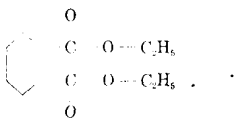
Diethyl Phthalate

Physical Constants



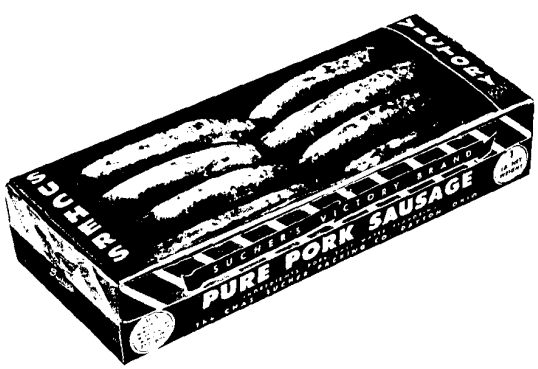
Molecular weight	222.2
Specific gravity at 25/25° C.	1.120
Lbs./gallon	9.35
Flash point	305° F. (152° C.)
Crystallizing point	−0.3° C.
Viscosity (in centistokes) at 0° C.	31.31
Viscosity (in centistokes) at 25° C.	9.79
Refractive index at 25° C.	1.5002
Boiling point (760 mm.)	298° C.
Physical form	Clear, mobile liquid
Sulfur (copper strip test)	Negative

Specifications

Appearance	Clear, water-white, oily liquid
Maximum color	APHA 10
Odor	Not more than slightly aromatic
Acidity (as phthalic acid)	0.01% Max.
Assay (ester content)	99% Min.
Specific gravity at 25/25° C.	1.120 ± 0.005
Refractive index at 20° C.	1.5030 ± 0.001

Diethyl phthalate is a colorless, liquid plasticizer, miscible with all the common organic solvents and diluents. It is one of the most widely used plasticizers for cellulose acetate, especially for molded products. It is easily compatible, stable, and imparts excellent molding qualities.

Although it may be used as the sole plasticizer, it is more frequently used in mixture with dimethyl phthalate. The proportions used are generally mixtures of equal parts by weight. Diethyl phthalate imparts slightly less flexibility to cellulose acetate plastic sheets than dimethyl phthalate. Its effect on moisture penetration is about the same. 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 approximately equal to that of dimethyl phthalate.



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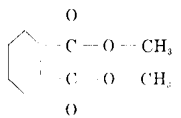
Dimethyl Phthalate

Physical Constants



Molecular weight	194.2
Specific gravity at 25/25° C.	1.189
Lbs./gallon	10
Flash point	300° F. (149° C.)
Crystallizing point	0° C.
Viscosity (in centistokes) at 0° C.	54.34
Viscosity (in centistokes) at 25° C.	11.42
Refractive index at 25° C.	1.5138
Boiling point (760 mm.)	282° C.
Physical form	Clear, mobile liquid
Sulfur (copper strip test)	Negative

Specifications

Appearance	Clear, water-white, oily liquid
Maximum color	APHA 10
Odor	Not more than slightly aromatic
Acidity (as phthalic acid)	0.01% Max.
Assay (ester content)	99% Min.
Specific gravity at 25/25° C.	1.190 ± 0.001
Refractive index at 20° C.	1.5155 ± 0.001

Dimethyl phthalate is a colorless, liquid, solvent-plasticizer for cellulose acetate. Dimethyl phthalate is soluble in all common organic solvents and oils (except petroleum oils) and it has excellent light stability. It is soluble in water to the extent of 0.4% at 32° C.

Dimethyl phthalate is widely used in the cellulose acetate field. It is frequently combined with diethyl phthalate or Santicizer M-17. Its widest use is in plasticizing cellulose acetate sheeting and film, molding powders, and insulating lacquers.

Since dimethyl phthalate has a relatively high vapor pressure, it is apt to be less permanent in compositions having high surface area in relation to the mass, such as films and coatings. Where finished articles may be exposed to low temperatures, there is a possibility of dimethyl phthalate crystallizing, causing not only brittleness, but loss of transparency and whitening which may be partially permanent. Combining dimethyl phthalate with diethyl phthalate or Santicizer M-17 prevents this.





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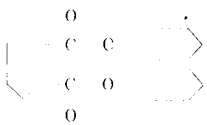
Diphenyl Phthalate



Physical Constants



Molecular weight	318.3
Refractive index at 74° C.	1.572
Specific gravity at 20° C.	1.28
Flash point	435° F. (224° C.)
Boiling point (760 mm.)	405° C.
Physical form	White powder
Melting point	Approx. 69° C.

Specifications

Appearance	Coarse white powder or fused solid having a slight yellowish cast
Acidity (as phthalic)	0.20% Max.
Free phenol	0.20% Max.
Ash	0.05% Max.
Moisture	0.50% Max.

Diphenyl phthalate is a white powder readily soluble in ketones, esters, and chlorinated hydrocarbons. The solubility in alcohols, turpentine, and linseed oil is rather low, about 5 gm. per 100 cc. of solvent at 25° C. Diphenyl phthalate is completely insoluble in water and gives increased moisture resistance and outdoor durability to compositions in which it is used.

Diphenyl phthalate is compatible with nitrocellulose and with the sulfonamide, phenolic, polystyrene, and vinyl type resins. In nitrocellulose lacquers, it produces hard coatings that have excellent gloss retention and weather resistance.

In ethyl cellulose, diphenyl phthalate is non-volatile and produces hard, tough films with good flexibility and weathering properties. In high concentrations there is a tendency for it to crystallize from the film, consequently it is generally used in fairly low percentages and mixed with other plasticizers.

Diphenyl phthalate is compatible with polyvinyl chloride resins and serves as a processing aid in the calendering or extruding of rigid products. At the elevated temperatures (150° C.–170° C.) employed in calendering or extruding, diphenyl phthalate becomes liquid and is an effective solvent plasticizer and increases ease of processing. After the article has been processed and is allowed to cool, the plasticizing action is slight and the article is hard and rigid.

The addition of diphenyl phthalate to Santolite MHP lowers its softening point and forms a liquid eutectic composition at approximately equal parts by weight. Such mixtures are excellent plasticizers for cellulose and vinyl lacquers and adhesives.

Diphenyl phthalate is also compatible with polystyrene and some of the natural resins such as dammar.

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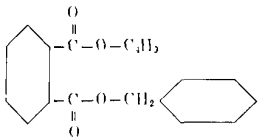
Santicizer 160 (Butyl benzyl phthalate)

Physical Constants



Molecular weight	312.4
Specific gravity at 25 25° C.	1.116
Lbs. gallon	9.3
Flash point	390° F. (199° C.)
Crystallizing point	Less than −35° C.
Viscosity (in centistokes) at 0° C.	206.83
Viscosity (in centistokes) at 25° C.	35.22
Refractive index at 25° C.	1.5356
Boiling point (760 mm.)	370° C. (approx.)
Physical form	Clear, mobile liquid
Sulfur (copper strip test)	Negative

Specifications

Appearance	Clear, oily liquid
Maximum color	APHA 75
Odor	Slight, characteristic
Acidity (as phthalic acid)	0.02% Max.
Assay (ester content)	98% Min.
Specific gravity at 25/ 25° C.	1.111 to 1.119
Refractive index at 25° C.	1.5336 to 1.5376

Santicizer 160 is a practically colorless liquid with a slight aromatic odor. It is a phthalate type plasticizer specially developed for wide general compatibility.

Santicizer 160 is particularly effective for plasticizing vinyl resins which are used for films, coatings, flexible molded products and extrusians. Its outstanding properties are excellent processing characteristics at calender or extruder temperatures, excellent heat and light stability, low flammability and oil extraction. Volatility and low temperature flexibility are sufficiently adequate for most applications. All these properties combine to establish Santicizer 160 as an outstanding plasticizer for thick sections such as floor tile, upholstery sections and shoe welting to which this plasticizer is especially adapted.

When it is desired to utilize the advantages of this plasticizer in thinner vinyl films, it is generally desirable to combine it in either a two or three component plasticizer blend, consisting of Santicizer 141 and, where desired, with a fatty acid-type ester or dioctyl adipate.

In extruding or calendering vinyl compositions, Santicizer 160 significantly reduces the viscosity of the composition at the elevated temperatures used. This reduced viscosity permits increased production or enables the manufacturer to lower calender or extruder temperatures and still maintain the same production rate.

Santicizer 160 is heat and light stable. It may be processed at elevated temperatures for long periods of time without discoloration. Films and sheeting containing this plasticizer exhibit resistance to embrittlement on Florida exposure.

Vinyl films plasticized with Santicizer 160 possess exceedingly low rates of flammability. At 33% plasticizer concentration, Santicizer 160 produces 3 and 6 mil films of very low burning rate and 12, 25, and 40 mil films which are non-flammable. With Santicizer 141 a synergistic effect occurs and clear, transparent, non-flammable films down to 3 mils may be produced with 35% plasticizer consisting of equal parts of Santicizer 160 and Santicizer 141.

Santicizer 160 imparts excellent oil and abrasion resistance to vinyl compositions. These properties are important in such applications as wire jacketing compositions, floor tile, and gaskets.

In cellulose nitrate films, Santicizer 160 produces clear coatings superior to dibutyl phthalate in hardness, permanence, flexibility, toughness, and water permeability. It is an excellent plasticizer for producing weather resistant and furniture lacquers.

With ethyl cellulose, clear rigid sheets, moldings, films, and hot melt (dip) compositions may be produced with Santicizer 160 which are valuable for use in the packaging and protective coatings field.

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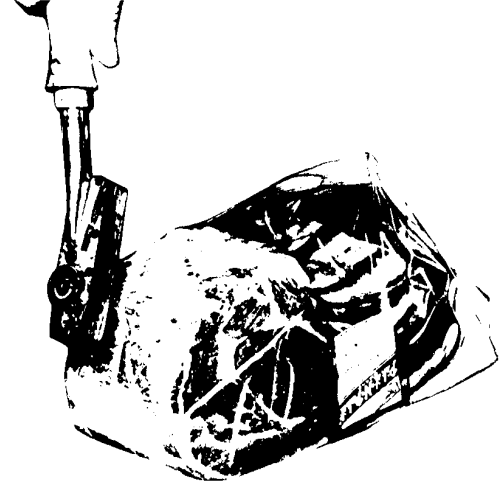

Phthalyl glycollates are the safest plasticizers for transparent food wrapping and heat sealing lacquer coatings. Santicizers E-15, B-16, and M-17 may be used even in meat wrappings that are to be used by individual, local retailers who package food products for display.

For information on approved specific application or additional toxicity data, write your nearest Monsanto office.



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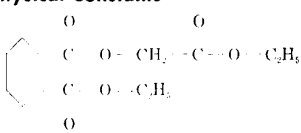
PHTHALYL GLYCOLLATE PLASTICIZERS

Santicizer E-15 (Ethyl phthalyl ethyl glycollate)

Physical Constants



Molecular weight	280.3
Specific gravity at 25/25° C.	1.180
Lbs./gallon	9.85
Flash point	386° F. (190° C.)
Crystallizing point	20° C.
Viscosity (in centistokes) at 0° C.	616.48
Viscosity (in centistokes) at 25° C.	57.67
Refractive index at 25° C.	1.498
Boiling point (760 mm.)	320° C.
Sulfur (copper strip test)	Negative

Specifications

Appearance	Clear, water-white, oily liquid
Maximum color	APHA 20
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

Santicizer E-15 is highly recommended for use with cellulose acetate. It is a practically colorless liquid with a high boiling point and low water solubility (0.0175% at 30° C.). Santicizer E-15 is light fast and relatively non-volatile even from thin films. It is miscible with the common organic solvents except the petroleum hydrocarbons. It is also miscible with vegetable oils when hot but partially separates on cooling.

Santicizer E-15 is an active solvent for cellulose acetate and nitrate and for most other resins as well. The amount that can be incorporated with cellulose esters depends only on the degree of plasticity desired. With both cellulose acetate and cellulose nitrate it produces tough, flexible films which have great resistance to moisture penetration.

In cellulose acetate plastic sheeting, for a given tensile strength, Santicizer E-15 imparts greater elongation than M-17, although the latter shows a somewhat better fold resistance and resistance to tearing. Light stability and dimensional stability of plastic sheets containing Santicizer E-15 are excellent.

Santicizer E-15 is non-toxic. It may be used in cellulose-based lacquers for paper or in foils to be used for food wrapping and packaging.

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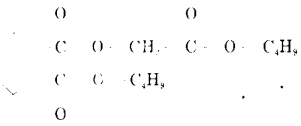
Santicizer B-16 (Butyl phthalyl butyl glycollate)

Physical Constants



Molecular weight	336.4
Specific gravity at 25/25° C.	1.097
Lbs. gallon	9.15
Flash point	390° F. (199° C.)
Crystallizing point	Less than −35° C.
Viscosity (in centistokes) at 0° C.	279.50
Viscosity (in centistokes) at 25° C.	46.14
Refractive index at 25° C.	1.490
Boiling point (760 mm.)	345° C.
Sulfur (copper strip test)	Negative

Specifications

Appearance	Clear, practically white, oily liquid
Maximum color	APHA 45
Acidity (as acetic acid)	0.02% Max.
Odor	Characteristic, slight odor
Specific gravity at 25/25° C.	1.097 ± 0.005
Refractive index at 25° C.	1.490 ± 0.002

Santicizer B-16 is an extremely light stable plasticizer, colorless, odorless, and tasteless. It is practically insoluble in water (0.0012% at 30° C.).

Santicizer B-16 probably offers more desirable properties as a plasticizer for nitrocellulose than any other single plasticizer. Santicizer B-16 gives clear, brilliant films that are flexible, tough, moisture resistant, and have good weathering properties. In general, it produces the same degree of flexibility as dibutyl phthalate but with less softening action.

Used in polyvinyl chloride, Santicizer B-16 imparts good heat and light stability and is especially useful for clear, colorless films. Since Santicizer B-16 is tasteless and non-toxic, such plasticized vinyls are safe for beverage tubing, certain food packaging, hospital sheeting, anatomical restorations, and dress shields.

Santicizer B-16 is miscible with castor, linseed, and china wood oils, retarding gel formation somewhat when the latter is heated.

Santicizer B-16 is especially desirable for use with alkyds and phenol-aldehyde resins. Incorporated at various stages of resin formation in alkyds, Santicizer B-16 retards thickening rate and permits the acid number of the resin to be lowered without effecting solubility. The plasticizer may be added at any stage prior to final gel formation. If such resins are heated beyond the gel stage, the product may still be thermoplastic, but solubility will be effected.

Santicizer B-16 is an exceptionally good plasticizer for polystyrene, particularly for molding or coating applications. 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 MS may be used to plasticize casein and corn proteins. They should be 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. One part of B-16 with two to ten parts of Santolite and one part of such mixture may be added to from 0.3 to 1.5 parts of the protein compound. The combination greatly increases water resistance. It should be noted that B-16 alone is not a plasticizer for protein compounds.

Santicizer B-16 is a good plasticizer for chlorinated rubber and its presence appears to promote adhesion. It imparts greater flexibility than dibutyl phthalate. About 40 PHR is recommended.

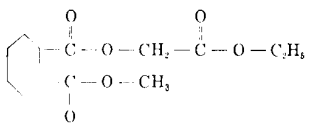
Santicizer B-16 is an excellent plasticizer for shellac when incorporated into shellac solutions. 30 PHR imparts good plasticity to Kauri gum; 25 PHR in rosin produces flexibility at 0° C. Santicizer B-16 also has a fair compatibility with paraffin—approximately 35 PHR at normal temperatures, higher when warmed.

0614812

TOWOLDMON0006254

Santicizer M-17 (Methyl phthalyl ethyl glycollate)

Physical Constants



Molecular weight	266.3
Specific gravity at 25 25° C.	1.220
Lbs. gallon	10.20
Flash point	380° F. (193° C.)
Crystallizing point	Less than −35° C.
Viscosity (in centistokes) at 0° C.	1476.21
Viscosity (in centistokes) at 25° C.	82.42
Refractive index at 25° C.	1.504
Boiling point (760 mm.)	310° C.
Physical form	Clear, mobile liquid
Sulfur (copper strip test)	Negative

Specifications

Maximum color	APHA 20
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

Santicizer M-17 is a practically colorless liquid which is a solvent for both nitrocellulose and cellulose acetate. It is stable, imparts a high degree of plasticity, and has only a faint odor. Santicizer M-17 is light stable and may be used in light tinted or transparent products without danger of yellowing on exposure.

Santicizer M-17 is probably one of the best single plasticizers for cellulose acetate available. It combines high solvency, low volatility, and dimensional stability along with its other good general properties. Santicizer M-17 is an excellent plasticizer for cellulose acetate molding compositions as well as for coatings.

In compounding cellulose molding and sheeting compositions, Santicizer M-17 lowers processing costs since it may be hot-mixed directly with the resin flake and does not require the use of volatile solvents. The retentitivity of Santicizer M-17 like that of Santicizer B-16, varies with the acetyl content of cellulose acetate. Santicizer M-17 is compatible at 66% plasticizer content with an acetate of 56% combined acetic acid but is incompatible at 52% acetic acid content. Exudation caused by excessive use of plasticizer can frequently be overcome by the addition of small percentages of Santolite MHP.

Santicizer M-17 is non-toxic and imparts a high degree of resistance to moisture penetration. Santicizer M-17 is recommended for use in cellulose acetate sheets to be used for food packaging, for acetate lacquers on paper for food, and for grease resistant acetate coatings.

Santicizer M-17 is not soluble in vegetable oils such as castor, linseed, or china wood oil or petroleum hydrocarbons, although it is readily soluble in most other organic solvents. It is soluble in water only to the extent of 0.09% at 30° C. Santicizer M-17 dissolves Santolite resins. Since both are very resistant to petroleum products and also compatible with so many film-forming materials, they make an excellent combination for producing gasoline, oil, or grease resistant coatings.

Santicizer M-17 is compatible with alkyd, vinyl, polystyrene, many phenolic resins, and chlorinated rubber. Frequently as little as 5 PHR produces a marked flexibility.

0614813

TOWOLDMON0006255



Low temperature flexibility and flame resistance properties can be added during the milling operation.

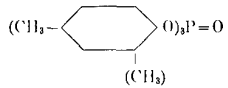
0614814

TOWOLDMON0006256

PHOSPHATE PLASTICIZERS

Tricresyl Phosphate

Physical Constants



Molecular weight	368.4
Specific gravity at 25 25° C.	1.162
Lbs./gallon	9.7
Flash point	470° F. (243° C.)
Crystallizing point	Less than −35° C.
Viscosity (in centistokes) at 0° C.	1256.14
Viscosity (in centistokes) at 25° C.	88.6
Refractive index at 25° C.	1.556
Boiling point (760 mm.)	420° C.
Physical form	Clear, mobile liquid

Specifications

Appearance	Clear, practically colorless, oily liquid
Maximum color	APHA 40
Permanganate test	No change within ½ hour
Acidity (as H_3PO_4)	0.01 % Max.
Specific gravity at 25/25° C.	1.166 ± 0.007

Tricresyl phosphate is a practically colorless and odorless liquid. It is the standard fire retarding plasticizer for nitrocellulose and vinyls. 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 compatible with most lacquer resins and produces firm, tough, flexible films with excellent weathering properties.

Tricresyl phosphate is widely used in vinyl resins, particularly in electrical applications. It has good electrical properties and imparts flame resistance to the composition. Tricresyl phosphate has extremely low volatility and possesses a high order of permanency.

Tricresyl phosphate is miscible with all common solvents and thinners. Although tricresyl phosphate has a low compatibility with cellulose acetate, fire resistance can be imparted to cellulose acetate compositions by blending tricresyl phosphate with more compatible plasticizers such as triphenyl phosphate and dimethyl phthalate.

Tricresyl phosphate has good lubricating properties. Coupled with fire resistance and good stability, this property makes the compound valuable as a special lubricant, cutting oil additive, and pump seal.

The ortho isomer of tricresyl phosphate is believed to be the toxic element in normal tricresyl phosphate. This isomer has been virtually eliminated from Monsanto tricresyl phosphate. Consequently, toxicity danger is reduced to a minimum and the plasticizer is more suitable for wider application.

0614815

TOWOLDMON0006257

Triphenyl Phosphate

Physical Constants



Molecular weight	326.4
Specific gravity at 60 20° C.	1.268
Flash point	437° F. (225° C.)
Crystallizing point	49° C.
Boiling point (760 mm.)	370° C. (approx.)
Physical form	White flakes
Refractive index at 60° C.	1.550

Specifications

Appearance	White flakes
Odor	Very faintly aromatic
Melting point	48.5° C. Min. to start
Solution in alcohol (10 gms. in 50 cc.)	Not more than faintly opalescent
Maximum color	APHA 20 (molten)
Permanganate test	No change within ½ hour
Acidity (as H_3PO_4)	0.003% Max.

Triphenyl phosphate is a white, crystalline, solid plasticizer. It is fire retarding and is compatible with cellulose acetate, vinyl resins, and synthetic rubbers.

Triphenyl phosphate is soluble in all the common solvents and thinners and in vegetable oils. Its solubility in water is 0.001% at 34° C. and 0.002% at 54° C. The compound imparts some resistance to moisture penetration in cellulosic films.

When used alone in cellulose acetate, 20 PHR of triphenyl phosphate yields films that will not support combustion. Its retentivity in the resin varies between 40 and 80 PHR depending upon the type of acetate, method of incorporation, conditions of use, and 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 mixed with Santicizer M-17 dissolves cellulose acetate at 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.

Triphenyl phosphate should not be used in articles such as foils 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.

Triphenyl phosphate may be used to plasticize vinyl resins. Because of its crystalline nature, it is apt to crystallize if used alone, causing some blooming. The presence of a solvent type plasticizer will prevent this tendency.

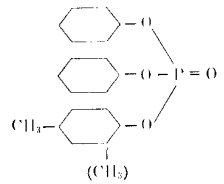
Triphenyl phosphate, when heated above its melting point, softens Santolite MHP resin. Equal weights of Santolite MHP and triphenyl phosphate form a eutectic composition which is a liquid at room temperature. This mixture is particularly effective for plasticizing polyvinyl chloride, polyvinyl acetate, and cellulose resins. It imparts gloss and excellent resistance to aliphatic hydrocarbons; in films it promotes adhesion. Flame resistance and low volatility are added features.

Triphenyl phosphate has fair softening action upon most synthetic rubbers. It is essentially insoluble in gasoline and mineral oils. This combination of properties makes it a valuable ingredient for many synthetic rubber formulations. The amount used is generally in the range of 5% to 20% by weight.

TOWOLDMON0006258

Santicizer 140 (Cresyl diphenyl phosphate)

Physical Constants



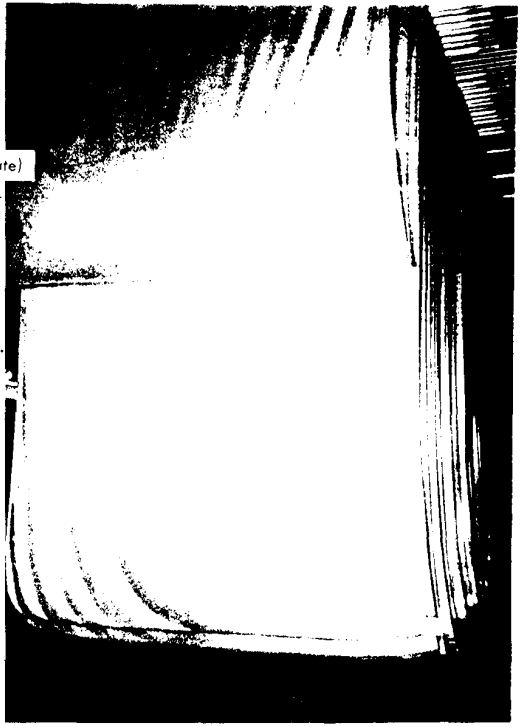
Molecular weight	340.3
Specific gravity at 25° 25° C.	1.208
Weight gallon	Approx. 10 lbs.
Flash point	450° F. (232° C.)
Crystallizing point	Less than −35° C.
Viscosity (in centistokes) at 0° C.	208.45
Viscosity (in centistokes) at 25° C.	32.99
Refractive index at 25° C.	1.560
Boiling point (760 mm.)	Approx. 390° C.
Physical form	Clear, mobile liquid

Specifications

Appearance	Clear, mobile liquid
Acidity (as H_3PO_4)	Not over 0.01%
Maximum color	APHA 40
Refractive index at 25° C.	1.560 ± 0.010
Specific gravity at 25° 25° C.	1.208 ± 0.005
Odor	Essentially odorless

Santicizer 140 is a liquid plasticizer with sufficient compatibility with cellulose acetate to serve as an alternate plasticizer for solid triphenyl phosphate. It imparts flame resistance and has approximately the same order of permanence as tricresyl phosphate.

Santicizer 140 is readily compatible with polyvinyl chloride. It imparts flame resistance equal to tricresyl phosphate in polyvinyl chloride films and coatings. Other advantages over tricresyl phosphate include greater chemical stability and improved flex temperature. Santicizer 140 is more efficient in its plasticizing action than tricresyl phosphate. A film plasticized with Santicizer 140 to the same Shore Durometer hardness as a film containing tricresyl phosphate will show better low temperature flexibility than the tricresyl phosphate-plasticized film.



Soft, flexible, and long wearing — because the right plasticizer was used.

Santicizer 140 has good solvent action and is heat and light stable. After 15 minutes heating at 200° C., the color of Santicizer 140 darkens only slightly; tricresyl phosphate darkens from APHA 40 to APHA 140. The abrasion resistance of films and coatings is markedly improved when Santicizer 140 is used.

Santicizer 140 is compatible with ethyl cellulose. Ethyl cellulose forms a flexible, tough composition with 50 PHR of Santicizer 140. This composition is also flame retardant

Santicizer 140 is also compatible with cellulose acetate-propionate, cellulose acetate-butyrate and polyvinyl formal and butyral in amounts up to 50 parts of plasticizer to 100 parts of resin.



0614817

TOWOLDMON0006259

Santicizer 141 (an alkyl-aryl phosphate)

Physical Constants

Molecular weight	362.4
Specific gravity at 25, 25° C.	1.090
Lbs., gallon	9.1
Flash point	435° F. (224° C.)
Viscosity (in centistokes) at 0° C.	61.49
Viscosity (in centistokes) at 25° C.	16.37
Refractive index at 25° C.	1.508
Boiling point (760 mm.)	375° C. (approx.)
Physical form	Clear, mobile liquid

Specifications

Maximum color	APHA 100
Odor	Slight, sweet
Specific gravity at 25/25° C.	1.089 – 1.093
Refractive index at 25° C.	1.507 – 1.510
Acidity (as phosphoric)	Less than 0.01%

Santicizer 141 is a nearly colorless liquid plasticizer compatible with almost all the common base resins. It is an outstandingly effective plasticizer for polyvinyl chloride, polyvinyl copolymers, and Buna N type synthetic rubbers. Santicizer 141 not only obtains excellent low-temperature flexibility at low volatile loss, but imparts flame resistance as well. This latter property makes it possible for manufacturers to produce colorless, transparent vinyl films which are flame retardant. Free film plasticized with Santicizer 141 will not support combustion after the flame source is removed. Compositions with even higher flame resistance can be obtained with a plasticizer combination (50–50) of Santicizer 160 and 141.

An outstanding characteristic of Santicizer 141 is its effect on vinyl compositions when it is used in combination with a phthalate type plasticizer.

Santicizer 141 in combination with a phthalate plasticizer significantly increases resistance to embrittlement and improves weather resistance of vinyl film over the amount obtainable with a phthalate-type plasticizer alone.

Santicizer 141 combines most of the desirable properties of earlier polyvinyl chloride plasticizers into a single compound. It is an extremely efficient plasticizer and imparts improved low-temperature flexibility to films and coatings. Compositions plasticized with Santicizer 141 are tough, flexible, and flame resistant. In vinyl compositions, the abrasion resistance is increased by using increased amounts of the plasticizer. The films have satisfactory moisture resistance and tensile strength.

Santicizer 141 incorporated in polyvinyl chloride shows good oil resistance, and better heat and light stability than compositions plasticized with tricresyl phosphate.

Santicizer 141 is compatible with cellulose nitrate, cellulose acetate-butyrate, ethyl cellulose, polymethyl methacrylate, polystyrene, and polyvinyl butyral.

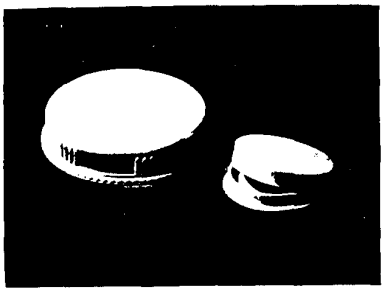
The percentage compression set of Hycar rubber when plasticized with Santicizer 141 is less than with tricresyl phosphate or dibutyl sebacate. The low temperature flexibility and solvent resistance are good.

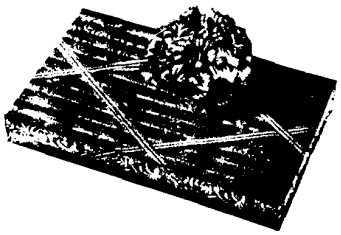
Santicizer 141 may be considered a non-toxic plasticizer. This property makes it suitable for use in dentures, anatomical restorations, dispensing tubing, syringes, hospital bed sheeting, and certain food wrapping. Santicizer 141 is completely safe for use in products that will come in intimate contact with the human body. However, like other manufacturing chemicals, it is not designed to be taken internally.

0614818

TOWOLDMON0006260

SULFONAMIDE PLASTICIZERS





Molded products gain improved flow and decorative lacquers acquire high gloss and toughness with proper plasticizers.

Santicizer 3 (N-ethyl para toluene sulfonamide)

Physical Constants



Molecular weight	199.3
Density (solids)	1.253 gm. ml.
Flash point	371° F. (188° C.)
Melting point	59.0° C.
Physical form	Practically white solid
Boiling point (760 mm.)	340° C. (approx.)

Specifications

Appearance	Practically white solid
Maximum color	APHA 60 (molten)
Melting point	58.0° C. Min.
Acidity (as acetic)	0.10% Max.
Refractive index at 65° C.	1.512 – 1.532
Specific gravity at 65/ 65° C.	1.166 – 1.176

Santicizer 3 is a solid, sulfonamide type plasticizer. Its compatibility with commonly used resins is limited but it is widely used in combination with other plasticizers. Either in combination or alone, Santicizer 3 imparts high gloss, toughness, and hardness.

Santicizer 3 sharpens the softening point of some thermoplastics, especially the cellulose esters. Its use makes possible such products as heat sealing lacquer coatings and adhesives.

Santicizer 3 is compatible with cellulose acetate to the extent of 50 PHR. In addition to its effect on toughness and gloss, it improves the flow of molding compositions and lowers moisture permeability. Its compatibility with polyvinyl formal is approximately the same as with cellulose acetate, and its use improves flow and imparts excellent gloss.

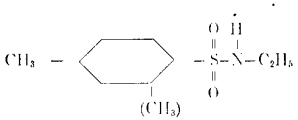
Santicizer 3 is commonly used in combination with other plasticizers. It imparts its property improvements when used in amounts as low as 5–20 PHR even though additional plasticizers of another type are used in much greater amounts.

0614819

TOWOLDMON0006261

Santicizer 8 (Mixture of N-ethyl ortho and para toluene sulfonamides)

Physical Constants



Molecular weight	199.3
Specific gravity at 25/25° C.	1.190
Lbs. gallon	9.92
Flash point	345° F. (174° C.)
Viscosity (in centistokes) at 0° C.	10,000
Viscosity (in centistokes) at 25° C.	358.4
Refractive index at 25° C.	1.540
Physical form	Clear, viscous liquid
Crystallizing point	Less than 0° C.
Boiling point (760 mm.)	340° C. (approx.)

Specifications

Appearance	Light yellow, viscous liquid
Odor	Slight, characteristic
Free amide	9% to 13%
Acidity (as acetic acid)	0.1% Max.
Color	APHA 200 Max.

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.

Since Santicizer 8 is practically insoluble in hydrocarbons, it is a valuable plasticizer in compositions required to withstand gasoline, greases, and related products. Monsanto Santolite resins combined with Santicizer 8 and nitrocellulose produce lacquers which are unaffected by gasoline and oils.

Santicizer 8 is an excellent plasticizer for cellulose acetate, giving a brilliance and polish not obtainable with other plasticizers. In cellulose acetate, the plasticizer's light stability is sufficient to meet most of the ordinary requirements of molding compositions. Santicizer 8 imparts high tensile strength, elongation, and flexibility to cellulose acetate sheeting and films.

Santicizer 8 is highly compatible with nitrocellulose lacquers imparting excellent flexibility, moisture resistance, and adhesion. In combination with Santolite MHP it is especially adapted for producing lacquers resistant to aliphatic hydrocarbons.

Santicizer 8 is highly compatible with proteins. It is compatible to the extent of at least 50% by weight in zein and casein coatings, improving flexibility, water resistance, gloss, and adhesion. Santicizer 8 is one of the best plasticizers known for synthetic polyamides such as nylon and related resins. Santicizer 8 lowers the melting point and aids in processing. Its presence improves flexibility and toughness without adversely affecting other properties.

Santicizer 8 greatly increases the flexibility of shellac and at the same time has pronounced softening effect. The presence of Santicizer 8 does not impair the adhesion of the shellac. 10% Santicizer 8 on the weight of the resin produces pronounced results.

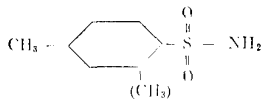
In polyvinyl acetate, Santicizer 8 produces stable adhesives with good adhesion and flexibility.

0614820

TOWOLDMON0006262

Santicizer 9 (Mixture of ortho and para toluene sulfonamides)

Physical Constants



Molecular weight	171.2
Density (solids)	1.353 gm. ml.
Flash point	420° F. (206° C.)
Melting point	105° C.
Maximum color (molten)	Barrett 3.5
Physical form	Fine granular particles
Boiling point (760 mm.)	360° C. (approx.)

Specifications

Appearance	Fine white to light cream granular particles
Melting point	105° C. Min.
Melt	Liquid, clear and light yellow
Maximum acidity	pH 4.6, minimum in dilute acetone (2 gram sample in 15 cc. A.R. acetone and 35 cc. of CO_2 free distilled water)

Santicizer 9 differs materially from other plasticizers in its action. Relatively small amounts impart gloss, improve abrasion resistance and promote smooth working and uniform curing of molded products. It blends readily with most synthetic resins but does not have the softening action of liquid plasticizers.

In thermosetting resins, Santicizer 9 lowers the viscosity of the resin at molding temperatures and improves the flow of molding powder or impregnating resin and aids in wetting filler materials. Through this action, Santicizer 9 promotes more uniformity in the physical properties of filled materials. The amount usually used is 2–5%. In phenolics used for the manufacture of brake bands, surface coatings and composition wallboard, this action is of great value.

In melamine coating and laminating resins, Santicizer 9 promotes solution stability and compatibility, improves flow-out during baking or curing, and increases impact strength and abrasion resistance. Pigment discoloration during baking is lessened when Santicizer 9 is used.

In urea molding compositions, Santicizer 9 serves as a hardener and a flow aid.

Santicizer 9 has a retentivity in cellulose esters of about 30 PHR and tends to harden and toughen the compositions. The effect is to improve abrasion resistance and reduce the tendency to scuff and haze through surface marring.

Santicizer 9 in amounts of approximately 20 PHR has a temporary plasticizing effect on corn and soybean protein. It may be used alone or in combination with some other material, such as glycerine. The increased solubility of Santicizer 9 in alkaline solution can be used to incorporate the plasticizer in solutions to be used as a swelling agent or an actual solvent for plastics materials.

Santicizer 9 is a plasticizer for shellac but its action is less pronounced than Santicizer 8.

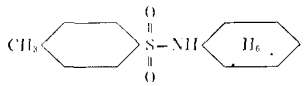
The solubility of Santicizer 9 is low in coal-tar hydrocarbons and neglible in petroleum hydrocarbons. It is readily soluble in most other solvents, and in hot linseed, china wood, and castor oils. In water, Santicizer 9 dissolves to the extent of 1% at 34° C. The solubility is increased to 5% at 20° C. in a mixture of equal parts of water and concentrated ammonia solution.

0614821

TOWOLDMON0006263

Santicizer 1-H (N-cyclohexyl para-toluene sulfonamide)

Physical Constants



Molecular weight	253
Density (solids)	1.125
Crystallizing point	86°-87° C.
Physical form	White crystals
Boiling point	350° C. (approx.)

Specifications

Appearance	Fine, white crystals
Melting point	86° C. Min.

Santicizer 1-H is a white, solid plasticizer which is relatively light stable and of a low order of toxicity. It is used in special crystallizing finishes, paper coatings, textile coatings and adhesives.

Santicizer 1-H is soluble in alcohols, esters, ketones, aromatic hydrocarbons, and vegetable oils. It is only slightly soluble in gasoline hydrocarbons and insoluble in water. It is heat stable up to at least 150° C.

Santicizer 1-H is a useful plasticizer in nitrocellulose heat-sealing lacquers, imparting a relatively sharp softening point. It is also used to incorporate incompatible components such as paraffin wax, for producing special coating effects such as crystallizing lacquers, and for improved adhesion. Santicizer 1-H is compatible with nitrocellulose up to 75 PHR. It does not give high flexibility by itself but auxiliary plasticizers such as dibutyl phthalate or Santicizer 160 may be added if more flexibility is desired.

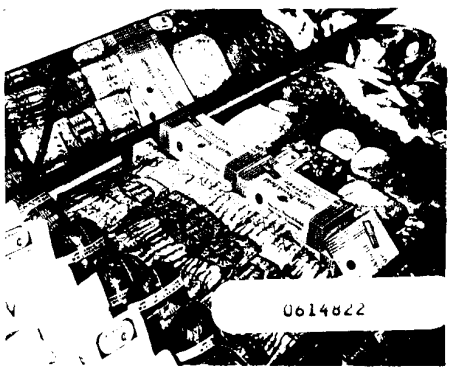
Santicizer 1-H improves the moisture resistance of cellulose acetate, although the retentivity in this resin is less than 25 PHR.

In ethyl cellulose, the retentivity is slightly below 50 PHR but the flexibility, hardness and light stability are good.

As little as 5% Santicizer 1-H in cyclicized rubber gives excellent flexibility but the plasticity rapidly disappears when the rubber becomes oxidized.

In shellac, Santicizer 1-H imparts good flexibility and has less softening effect than Santicizer 8. With Kauri resin, Santicizer 1-H produces a flexible, non-tacky composition.



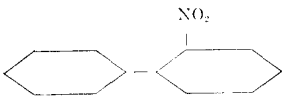


TOWOLDMON0006264

SPECIALTY PLASTICIZERS

Ortho-nitrobiphenyl (ONB)

Physical Constants



Molecular weight	199.2
Specific gravity at 25° 25° C.	1.203
Lbs. gallon	10.0
Flash point	289.5° F. (143° C.)
Crystalling point	34.5° C. Min.
Viscosity (in centistokes) 25° C.*	31.65
Refractive index at 25° C.*	Approx. 1.613
Boiling point (760 mm.)	Approx. 330° C.
Physical form	Light yellow to reddish crystalline solid or liquid

*Super cooled

Specifications

Crystallizing point	34.5° C. Min.

Distilling Range

95% (1%–96%)	5.0° C. Max.
100% (between 320.0° C. and 330.0° C.)	7.0° C. Max.

Ortho-nitrobiphenyl is compatible with the cellulose esters and ethers, polyvinyl chloride, polyvinyl butyral, polyvinyl acetate, polystyrene, rosin and rosin esters, modified phenolic resins, oil-soluble phenolics, alkyd resins and vegetable oils. Wide compatibility, a low rate of hydrolysis and low price make ONB an attractive plasticizer.

Ortho-nitrobiphenyl plasticizes most resins, both synthetic and natural. The amount required varies with the resins and the intended use. The volatility is less than diethyl phthalate but greater than dibutyl phthalate.

Ortho-nitrobiphenyl imparts fungicidal properties to textiles coated with ONB-plasticized nitrocellulose, polyvinyl acetate, polyvinyl formal, polyvinyl butyral, cellulose acetate, Vinylite VYHH, or polystyrene. ONB-plasticized coatings do not support growth of Aspergillus Niger, Penicillium, Chaetomium Globosum, or Metarrhizium even after leaching for 48 hours in running water.

Ortho-nitrobiphenyl is readily soluble in carbon tetrachloride, mineral spirits, pine oil, turpentine, benzene, acetone, glacial acetic acid, and perchlorethylene. It is a good solvent in its own right. With polystyrene, ONB is highly compatible and imparts good flexibility without causing undue softening and tackiness which occur from the use of the usual types of plasticizers.

The compatibility with vinyl resins varies. Ortho-nitrobiphenyl is highly compatible with polyvinyl acetate, 50 PHR giving very flexible, tacky compositions. In polyvinyl formal, 50 PHR produces good flexibility but no tackiness. Temperatures of 150–160° C. are required for good flow. The compatibility limit is about 50 PHR with polyvinyl butyral and the compositions are slightly tacky, very flexible, and possess good weather resistance. ONB is a satisfactory plasticizer for polyvinyl chloride especially where cost is a factor. 40 PHR in polyvinyl chloride produces tough, flexible, transparent compositions. In addition, ONB materially improves the compatibility of normally incompatible plasticizers such as oils and diluents.

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 ONB may be substituted for all or part of the camphor in the formula. In lacquers, ONB aids solvent release.

The Aroclors*

Monsanto Aroclors are a series of low cost, chlorinated poly-phenyls ranging from mobile oily liquids to fine white crystals and hard transparent resins. They are non-oxidizing, permanently thermoplastic, and of low volatility. The viscous liquids and resins will not support combustion when heated alone.

* Trade-mark registered.

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The crystalline Aroclors are relatively insoluble, but the liquid and resinous compounds are soluble in most of the common organic solvents, thinners, and oils.

Aroclors are attractive plasticizers in certain applications. They are compatible with most of the common plastics materials. 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 by selecting the Aroclor of proper physical characteristics or by using a mixture of two or more.

There are thirteen Aroclors, numerically coded, from colorless, mobile Aroclor 1221 to solid, dark brown Aroclor 2565. Each of the thirteen types are representative of a series.

The Aroclors are efficient and highly economical when used to extend other primary plasticizers.

The Aroclors are compatible with ethylcellulose, nitrocellulose, polystyrene, styrene-butadiene copolymers, vinyls, rubber, benzyl cellulose, and various waxes. The Aroclors are incompatible with cellulose acetate but may be used as a non-plasticizing lubricant in cellulose acetate processing. The compatibility of the Aroclors varies in phenolics, becoming incompatible in the final stage.

The Aroclors are highly compatible with ethylcellulose, the liquids imparting great flexibility and the resinous Aroclors imparting great hardness.

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.

The liquid Aroclors, 1221, 1232, 1242 and 1248 have a strong plasticizing action on rubber, both natural and synthetic. 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 retardant. This same procedure can be used with synthetic rubbers to impart fireproofness. From 5% to 25% of Aroclor 1270 based on the weight of the resin is required.

Aroclor 1262 is recommended as a plasticizer for crepe rubber resin in paint compositions. Used in concentrations of 5% to 50% based on the weight of the rubber resin, it increases the gloss and alkali resistance of the film and increases its adhesiveness toward steel.

Aroclor 1268 used at a level of about three pounds per 200 pounds of Neoprene has excellent working qualities as a plasticizer at 225–325° F. in injection moldings.

The Aroclors are compatible with all the vinyl resins and are used mainly as co-plasticizers with tricresyl phosphate, dioctyl phthalate, Santicizer 160 and other plasticizers for vinyls to impart not only plasticizing action, but chemical and corrosion resistance, and excellent electrical properties at a substantial reduction in cost.

Aroclor plasticizers are very attractive for use with dioctyl phthalate and Santicizer 141 in preparing organosols, plastisols or pastes of vinyl plastics used for making free films, textile coatings and coatings for paper. In these applications the fire resistant quality of Aroclors is valuable. Also, the Aroclors serve as excellent media for grinding and dispersing the pigments used.

Another excellent use for Aroclors in vinyl plastics is in the preparation of adhesives. The Aroclors impart outstanding adhesive qualities and give good resistance against water and chemical action. Moreover, the Aroclors are resistant to organism attack, and impart that resistance to vinyl adhesives especially when used in conjunction with Monsanto's fungicides—Santobrite, Santophen 20, or Milmer.

The Aroclors function both as plasticizers and resins and may be used alone with 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 strength and resistivity and low power factor) and their prop-

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erty of retarding the passage of moisture and gases through nitrocellulose, chlorinated rubber, and other film formers make the Aroclors of special value in coatings for electrical insulating materials.

For further information on the use of Aroclors in lacquers, adhesives, printing inks, modified rubber coatings, waxes, paints, and varnishes, write for Monsanto's 28-page booklet entitled, *The Aroclors* (P-115). Sent on request.

HB-40

Physical Constants

Specific gravity at 25° 25° C.	1.002
Weight per gallon	8.37 lbs.
Flash point	345° F (174° C.
Pour point	—25° C.
Viscosity 25° C. (in centistokes)	70
Refractive index at 25° C.	1.5675
Boiling point at 760 mm.	362° C.
Evaporation loss at 100° C. for 6 hrs.	0.033%

Specifications

Appearance	Practically colorless oily liquid.
Color	Less than 200 APHA (darkens on exposure to sunlight)
Odor	Faint and pleasant

Distillation Range

Start	340–349° C.
10%	345–358° C.
50%	353–360° C.
90%	362–389° C.
95%	371–396° C.

HB-40 is an exceptionally low cost, practically colorless liquid plasticizer, possessing non-migrating characteristics. Chemically it is a partially hydrogenated mixture of isomeric terphenyls.

It is compatible with polystyrene, vinyl resins, ethyl cellulose, and asphaltic compounds. HB-40 is also a "softener" and a swelling agent for rubber type compounds. It imparts good tensile strength, good elongation, and good moisture resistance to these types of plastics. Moreover, HB-40 possesses good electrical properties making it valuable in electrical applications.

HB-40 is especially suitable for use in polystyrene casting resins, polystyrene emulsion adhesives, and polystyrene adhesive formulations.

HB-40 is especially recommended for polyvinyl chloride plastic extrusions. For extruding, the amounts used are about 25% based on the total weight of the plasticizers. The finished extrusions possess good light stability and have a dry rather than a greasy feel. In vinyl base adhesives, HB-40 produces properties similar to those obtained with tricresyl phosphate and dibutyl phthalate but with important savings in cost.

HB-40 is a satisfactory plasticizer for injection molding ethylcellulose. It is used in amounts approximating 15% on the weight of the ethylcellulose molding powder.

HB-40 is practically non-toxic. Rats and rabbits survive acute doses of 25 grams per kilo. Chronic experiments with six grams per kilo. ingested daily for four months produced no toxicity.

The low temperature characteristics of HB-40 are about average. Its volatility is somewhat higher than average, but it is substantially lower than that of a number of widely used plasticizers. HB-40 does not have the outstanding resistance to discoloration possessed by several other commercial plasticizers when exposed to elevated temperatures and ultraviolet rays. However, in certain plastics where HB-40 is used in combination with other plasticizers, the plastics possess good light stability. HB-40 may be used as a co-plasticizer or as an extender for primary plasticizers selected to give outstanding low temperature and low volatility characteristics.

For further information on HB-40's applications in surface coatings, adhesives, asphalt base and Gilsonite paints, alkyd enamels, and other uses, request Monsanto Technical Bulletin No. P-104, titled HB-40.

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TABLE OF COMPARATIVE PROPERTIES



FLASH POINTS

470°F (243°C)	TRICRESYL PHOSPHATE
450°F (232°C)	SANTICIZER 140
437°F (225°C)	TRIPHENYL PHOSPHATE
435°F (224°C)	DIPHENYL PHTHALATE SANTICIZER 141
420 F (215 C)	SANTICIZER 9
405 F (207 C)	SANTICIZER 141
390°F (199°C)	SANTICIZER 160 SANTICIZER B-16
388°F (198°C)	SANTICIZER E-15
380°F (193°C)	SANTICIZER M-17
371°F (188°C)	SANTICIZER 3
345°F (174°C)	SANTICIZER 8
340°F (170°C)	DIBUTYL PHTHALATE
305°F (152°C)	DIETHYL PHTHALATE
300°F (149°C)	DIMETHYL PHTHALATE
288.5°F (143°C)	ORTHO-NITROBIPHENYL

BOILING POINTS at 760 mm*

420°C	TRICRESYL PHOSPHATE
405°C	DIPHENYL PHTHALATE
390°C (approx.)	SANTICIZER 140
375°C (approx.)	SANTICIZER 141
370°C	SANTICIZER 160
370°C (approx.)	TRIPHENYL PHOSPHATE
360°C	SANTICIZER 9
350°C	SANTICIZER 1-H
345°C	SANTICIZER B-16
340°C	DIBUTYL PHTHALATE SANTICIZER 3 SANTICIZER 8
330°C (approx.)	ORTHO-NITROBIPHENYL
320°C	SANTICIZER E-15
310°C	SANTICIZER M-17
298°C	DIETHYL PHTHALATE
282°C	DIMETHYL PHTHALATE

*From vapor pressure curves.

MOLECULAR WEIGHTS

368.4	TRICRESYL PHOSPHATE
362.4	SANTICIZER 141
340.3	SANTICIZER 140
336.4	SANTICIZER B-16
326.3	TRIPHENYL PHOSPHATE
318.3	DIPHENYL PHTHALATE
312.4	SANTICIZER 160
280.3	SANTICIZER E-15
278.3	DIBUTYL PHTHALATE
266.3	SANTICIZER M-17
253.0	SANTICIZER 1-H
222.2	DIETHYL PHTHALATE
199.3	SANTICIZER 3 SANTICIZER 8
199.2	ORTHO-NITROBIPHENYL
194.2	DIMETHYL PHTHALATE
171.2	SANTICIZER 9

CRYSTALLIZING POINTS

105°C	SANTICIZER 9
86-87°C	SANTICIZER 1-H
69°C	DIPHENYL PHTHALATE
59.0°C	SANTICIZER 3
49°C	TRIPHENYL PHOSPHATE
34.5°C* Minimum	ORTHO-NITROBIPHENYL
20°C*	SANTICIZER E-15
0°C	DIMETHYL PHTHALATE
Less than 0°C	SANTICIZER 8
Less than −0.3°C*	DIETHYL PHTHALATE
Less than −35°C	DIBUTYL PHTHALATE SANTICIZER 160 SANTICIZER B-16 SANTICIZER M-17 TRICRESYL PHOSPHATE SANTICIZER 140

*Supercools readily.

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REFRACTIVE INDEX at 25°C	SPECIFIC GRAVITY at 25°C	WEIGHT PER GALLON at 25°C	COLOR (APHA* MAX. SPECIFICATION)
1.613 (approx.) — ORTHO-NITROBIPHENYL	1.220 — SANTICIZER M-17	10.18 — SANTICIZER M-17	APHA 200 — SANTICIZER 8
	1.208 — SANTICIZER 140	10.08 — SANTICIZER 140	
	1.203 — ORTHO-NITROBIPHENYL	10.04 — ORTHO-NITROBIPHENYL	
	1.190 — SANTICIZER 8	9.93 — SANTICIZER 8	
	1.189 — DIMETHYL PHTHALATE	9.92 — DIMETHYL PHTHALATE	
	1.180 — SANTICIZER E-15	9.85 — SANTICIZER E-15	APHA 100 — SANTICIZER 141
1.560 — SANTICIZER 140			
1.556 — TRICRESYL PHOSPHATE			
			APHA 75 — SANTICIZER 160
	1.162 — TRICRESYL PHOSPHATE	9.70 — TRICRESYL PHOSPHATE	APHA 60 (molten) — SANTICIZER 3
1.540 — SANTICIZER 8			
1.535 — SANTICIZER 160			
			APHA 45 — SANTICIZER 6-16
	1.125 — SANTICIZER 1-H		APHA 40 — TRICRESYL PHOSPHATE
	1.120 — DIETHYL PHTHALATE	9.35 — DIETHYL PHTHALATE	SANTICIZER 140
	1.116 — SANTICIZER 160	9.31 — SANTICIZER 160	
1.513 — DIMETHYL PHTHALATE	1.097 — SANTICIZER B-16	9.15 — SANTICIZER B-16	
1.508 — SANTICIZER 141	1.090 — SANTICIZER 141	9.10 — SANTICIZER 141	
1.504 — SANTICIZER M-17			DIBUTYL PHTHALATE
1.500 — DIETHYL PHTHALATE			APHA 20 — SANTICIZER E-15
1.498 — SANTICIZER E-15			SANTICIZER M-17
1.492 — DIBUTYL PHTHALATE			APHA 20 (molten) — TRIPHENYL PHOSPHATE
1.490 — SANTICIZER B-16	1.045 — DIBUTYL PHTHALATE	8.72 — DIBUTYL PHTHALATE	APHA 10 — DIETHYL PHTHALATE
			APHA 10 — DIMETHYL PHTHALATE

*Distilled Water APHA 0
"Listerine" APHA 550

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BUILDING QUALITY

The quality of the final product is largely dependent upon the plasticizer milled into the resin.



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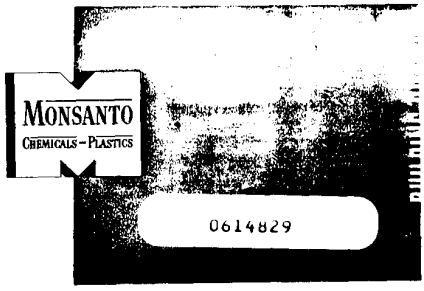
WITH PLASTICIZERS

The quality of the plasticizer is as important to the final product as the resin itself. Frequently (unless the plasticizer is carefully selected) a desired modification may be obtained at the expense of other properties inherent in the base resins. Compounding ingredients, such as fillers, colors, lubricants, and stabilizers, are of secondary importance. If the plasticizer is not perfectly suited to a specific commercial application, the other modifying agents are of little use.

COMPATABILITY

The most important factor in the choice of plasticizers is their compatibility with the resins they are intended to modify. Compatibility may be determined by solution casting a film and examining the film for clouding, streaking, exudation, or crystallization. Compatibility can also be determined by milling the resin with increasing amounts of plasticizer and visually examining the milled sheet for exudation, stickiness, or oiliness. The time and temperature required for milling is often an indication of compatibility. Generally speaking, a highly compatible plasticizer will form a clear homogenous sheet in a shorter space of time than a less compatible compound.

Monsanto's plasticizers have been developed with the purpose of providing either wide general compatibility or high compatibility with a given group of resins for specific application. The following charts suggest the wide compatibility of Monsanto plasticizers.



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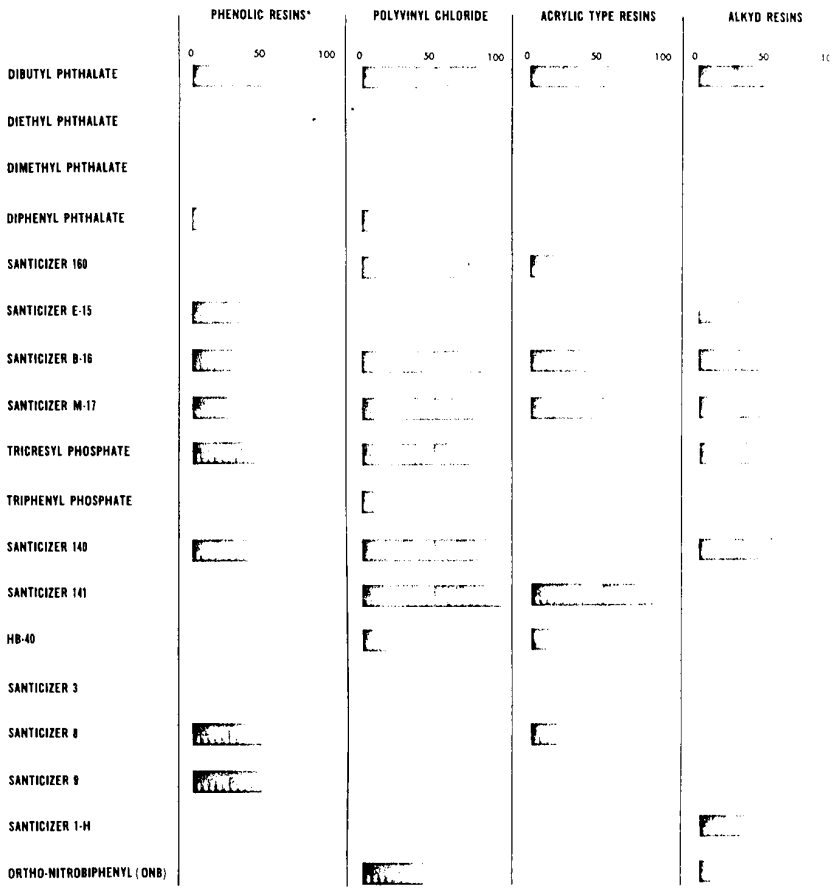
COMPATIBILITY in Parts per Hundred Parts of Resin



*Compatibility of most ester type plasticizers is limited and compatibility depends upon type of resin used. Santicizer 9 however has good compatibility, apparently through reaction with resin.

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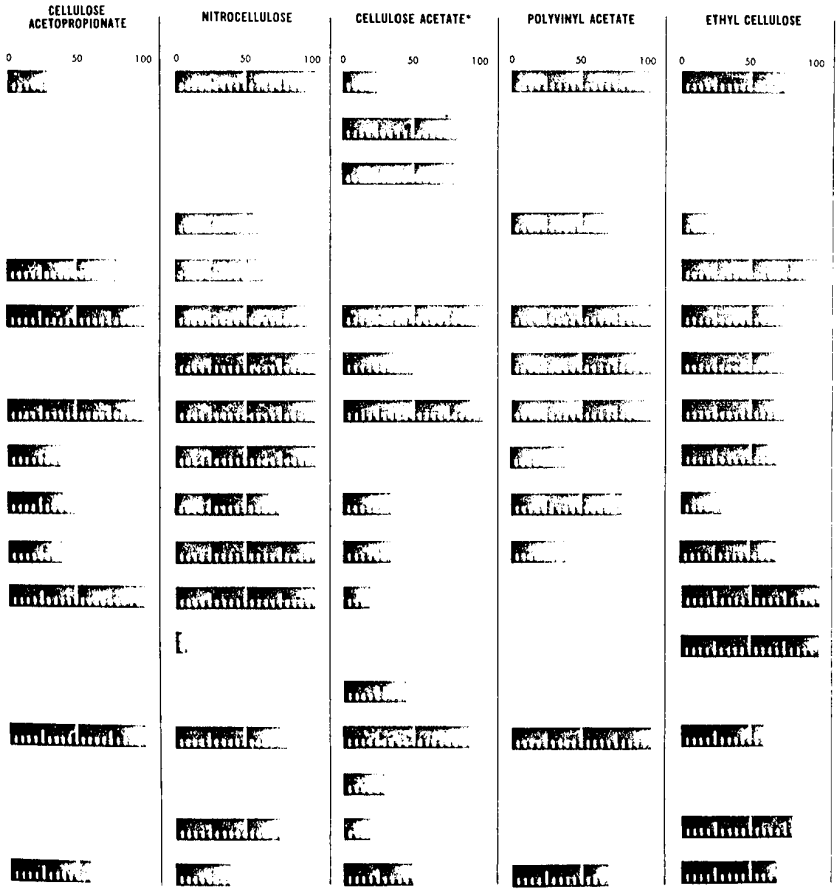

*Typical values may differ for different type of acetate.

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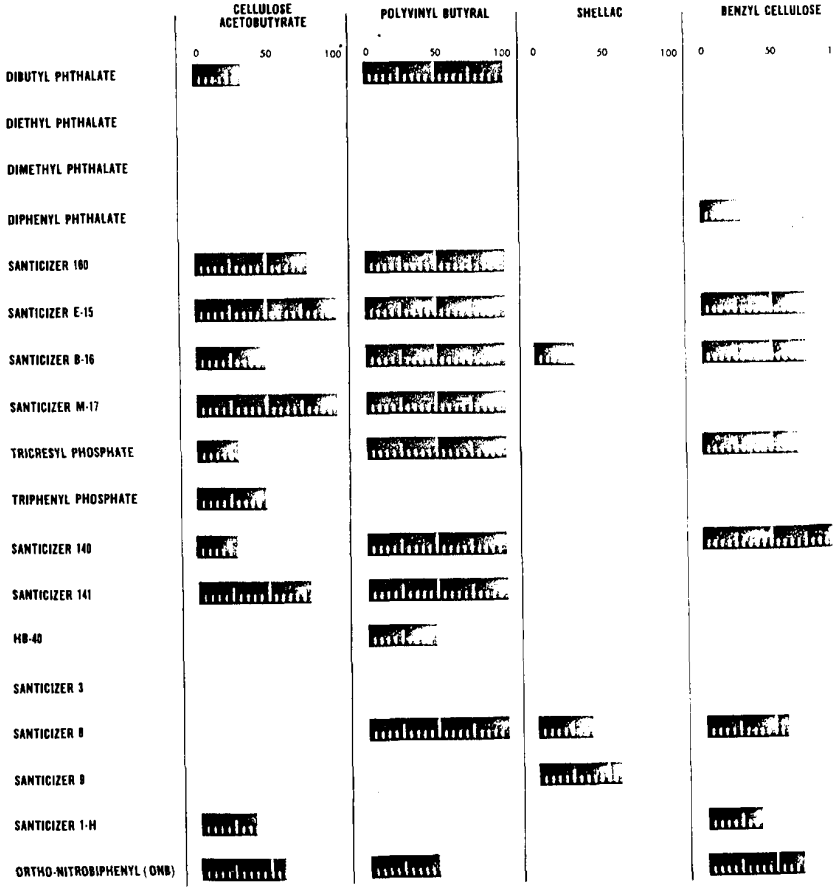
COMPATIBILITY in Parts per Hundred Parts of Resin



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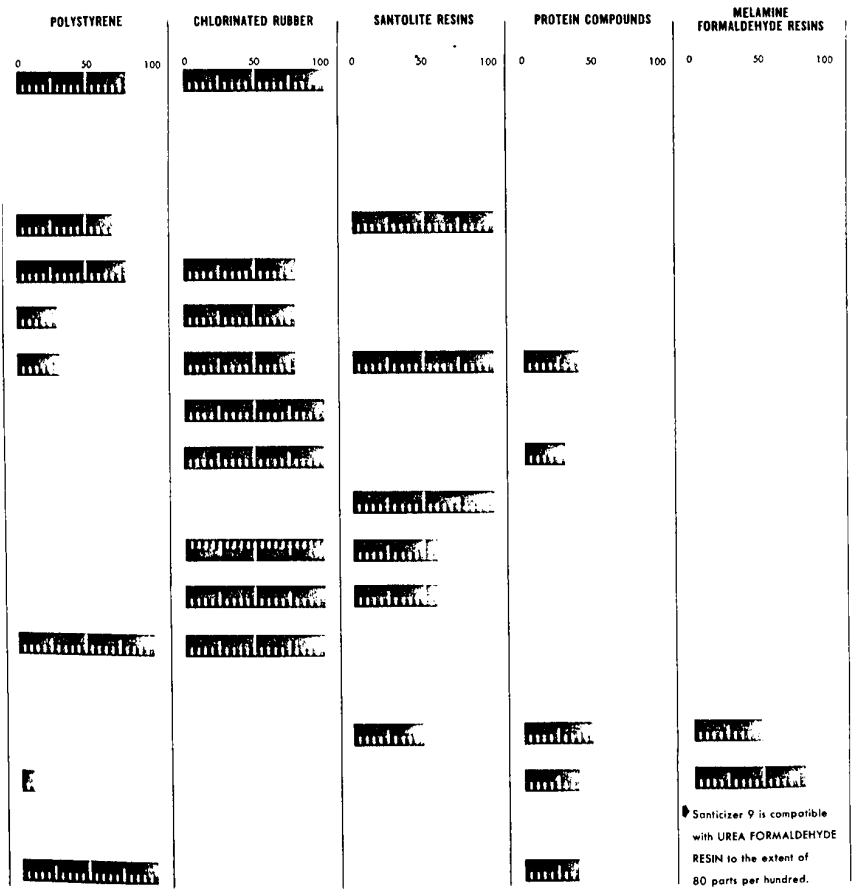

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PERFORMANCE



Once compatible, the plasticizer must be evaluated on the basis of its performance. The *efficiency* of a plasticizer is the performance of the finished product measured against the concentration of the plasticizer required to obtain the desired properties. Performance characteristics vary in importance in various end products. In most cases, performance is related to one or more of the physical and chemical properties of the plasticizer.

Low-Temperature Flexibility

Low-temperature flexibility, important in free film and paper and textile coatings, can usually be related to the viscosity-temperature relationships of a plasticizer and its freezing point. In general, the more fluid a plasticizer at reduced temperatures, the greater is its likelihood of imparting good low-temperature flexibility.

While practically all plasticizers will produce flexible compositions at room temperature, the flexibility — depending upon type and amount of plasticizer—will vary considerably at low temperatures. In many vinyl applications, low-temperature flexibility is essential to the usefulness of the product. Rainwear, shoe soles, and apparel accessories — particularly in cold climates— must retain their flexibility at low temperatures. The low-temperature flexibility performance of vinyls plasticized with Monsanto plasticizers are determined in the laboratory by the method of Clash and Berg.* This method determines the torsional flexibility of a plastic at various temperatures. An arbitrary minimum flexibility has been established and the temperature at which the vinyl under test exhibits this minimum flexibility is defined as its low-temperature flexibility. This "flex" temperature may also be defined as the lower temperature limit of the composition's usefulness as an elastomer.

The graphs that follow indicate the excellent low-temperature flexibility of several of Monsanto's plasticizers.

*Ind. Eng. Chem. 34, 1218 (1942)

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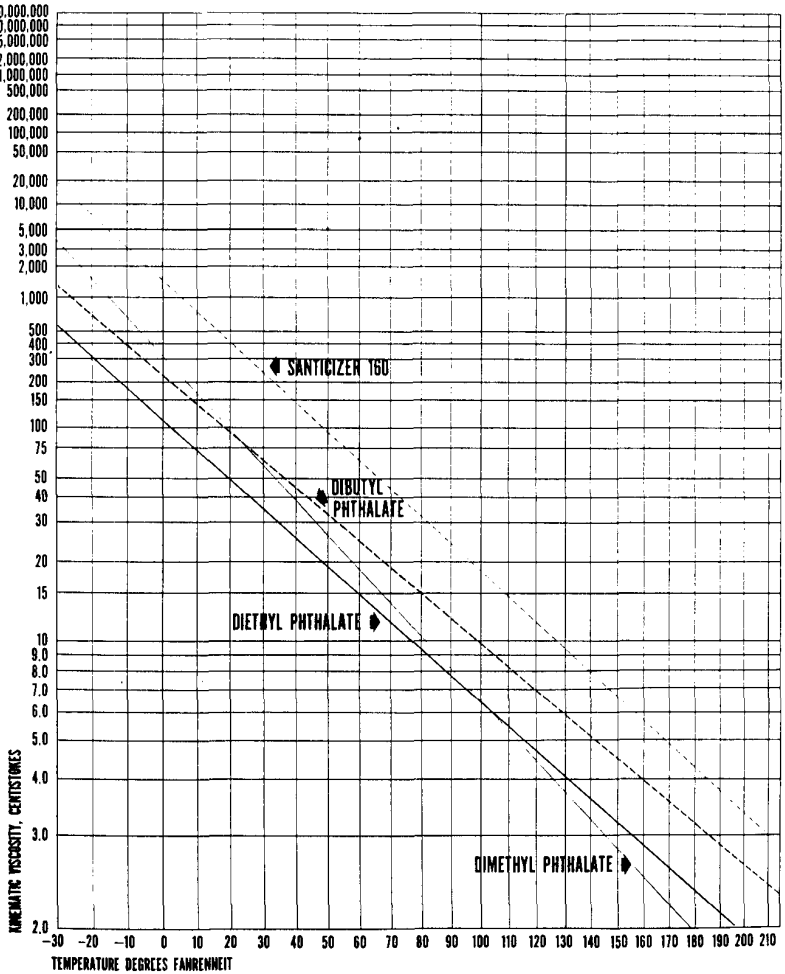
VISCOSITY CURVES PHTHALATE PLASTICIZERS

ASTM STANDARD VISCOSITY-TEMPERATURE CHART (D 341-39) MODIFIED



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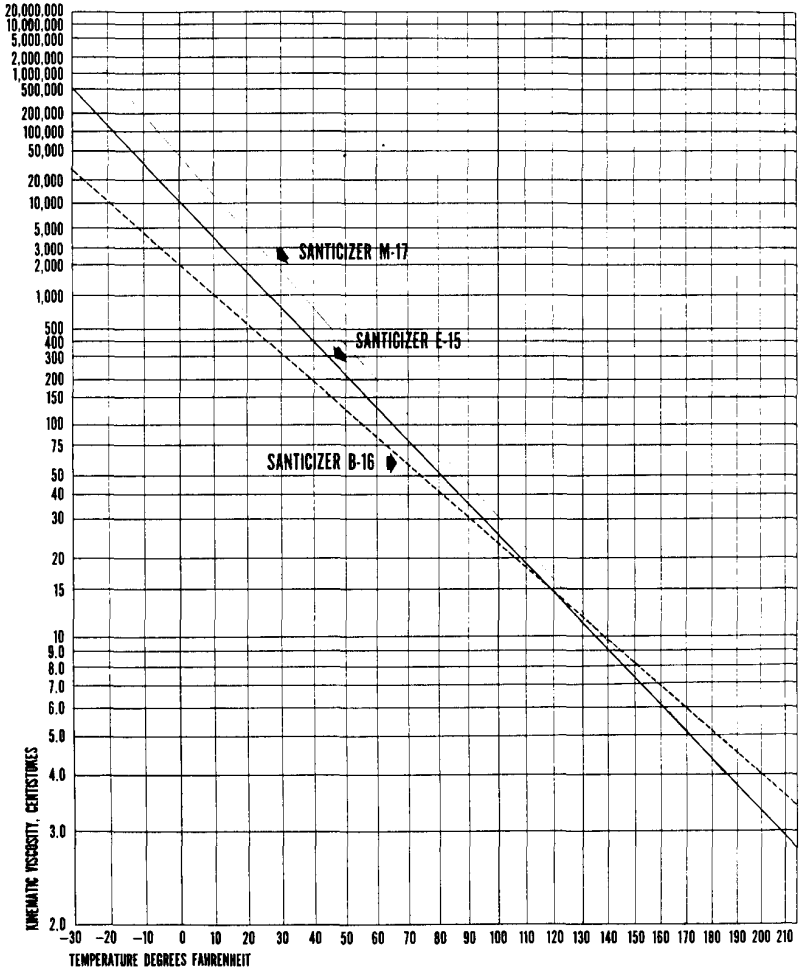
TOWOLDMON0006277

VISCOSITY CURVES PHTHALYL GLYCOLLATE PLASTICIZERS

ASTM STANDARD VISCOSITY-TEMPERATURE CHART (D 341-39) MODIFIED



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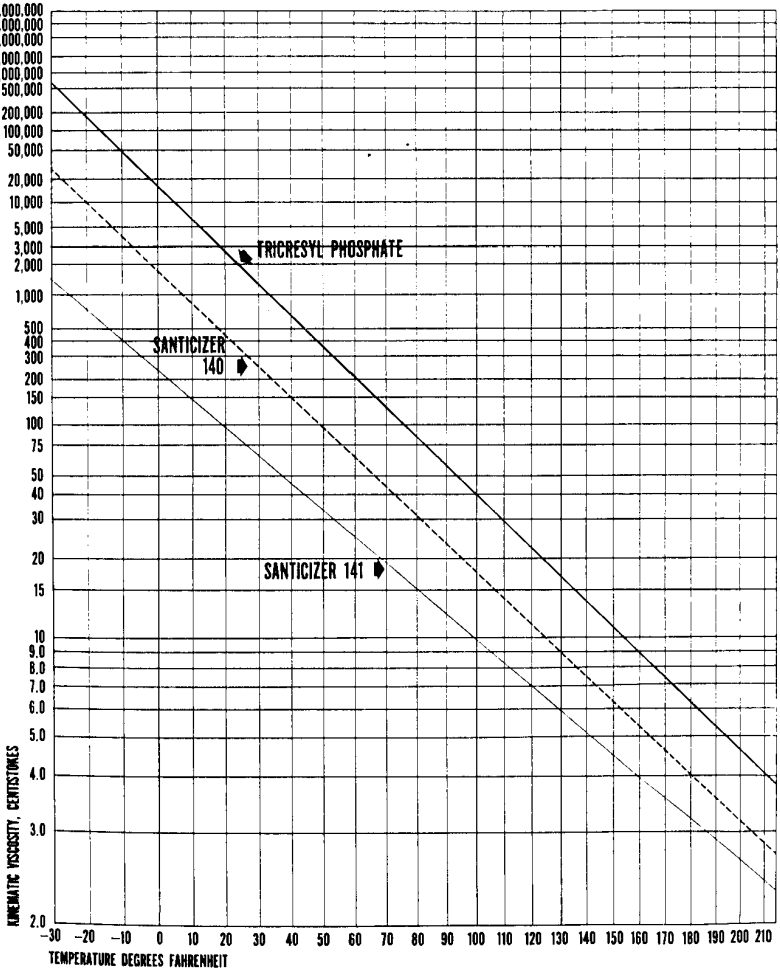
TOWOLDMON0006278

VISCOSITY CURVES PHOSPHATE PLASTICIZERS

ASTM STANDARD VISCOSITY-TEMPERATURE CHART (D 341-39) MODIFIED



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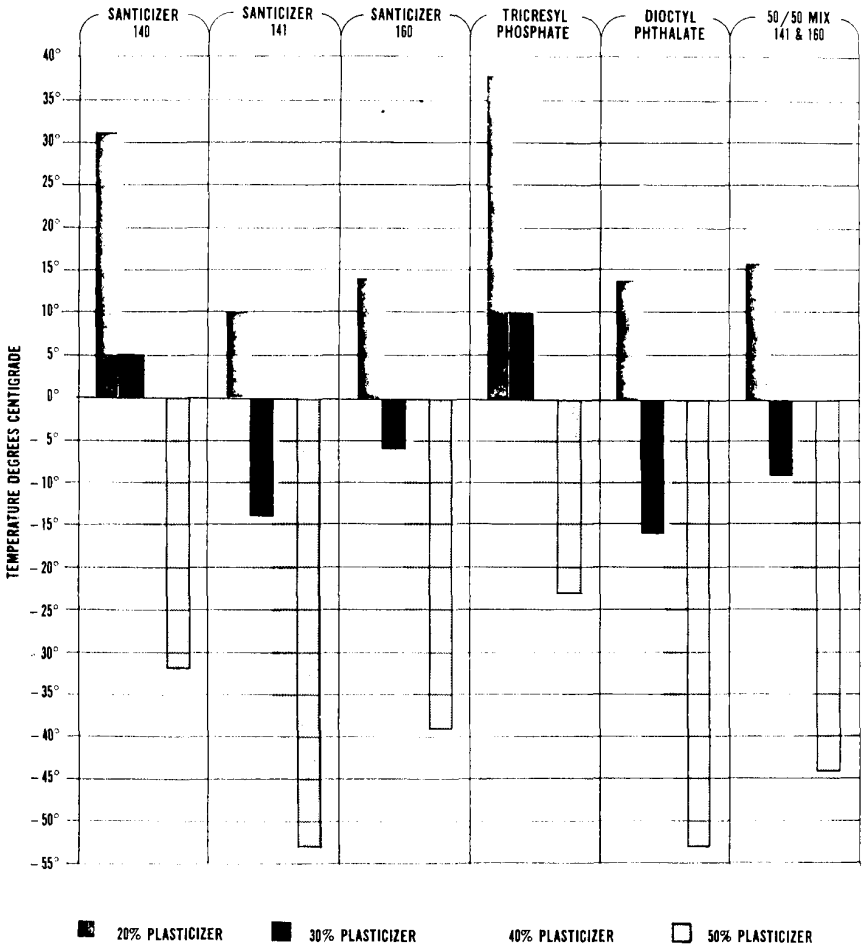
TOWOLDMON0006279

LOW TEMPERATURE FLEXIBILITY of Polyvinyl Chloride Film

(End of each bar indicates LOWEST LIMIT of flexibility)



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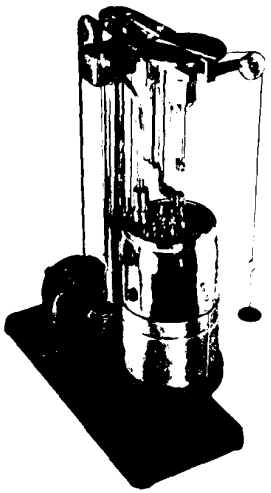
Flexibility

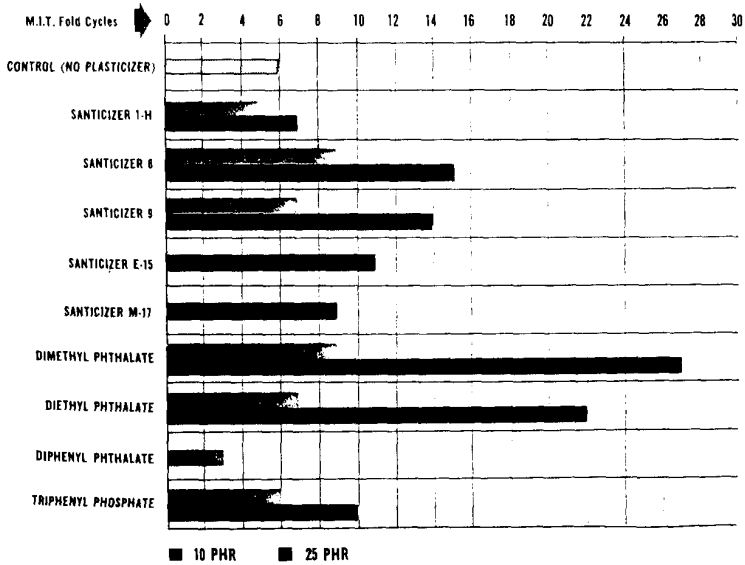
The efficiency of a plasticizer may also be judged by the amount of flexibility imparted to thin films and sheets. A high degree of flexibility is required in food wrappings, paper coatings, and cable and leather lacquers.

Flexibility is determined in the laboratory by using a Schopper Fold Tester for thin films and a M.I.T. Fold Endurance Tester for plastic sheeting. Films and sheeting are flexed under a constant load until breakage occurs and the number of cycles recorded.



FLEXIBILITY of Plasticized Cellulose Acetate Sheets

M. I. T. Fold Endurance Test (Sheet 0.010" Thick)



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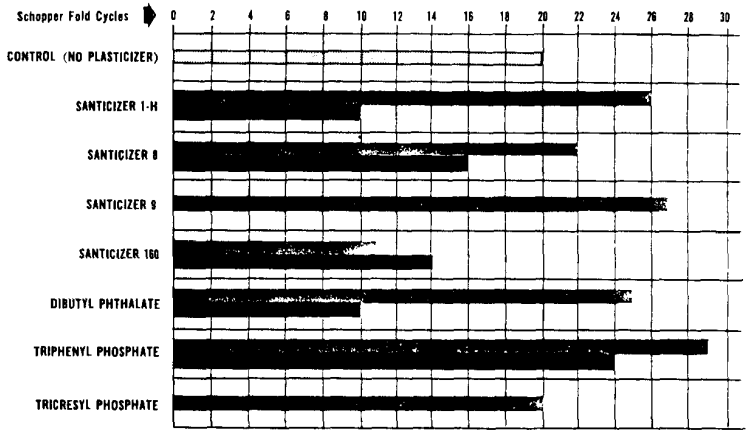
TOWOLDMON0006281

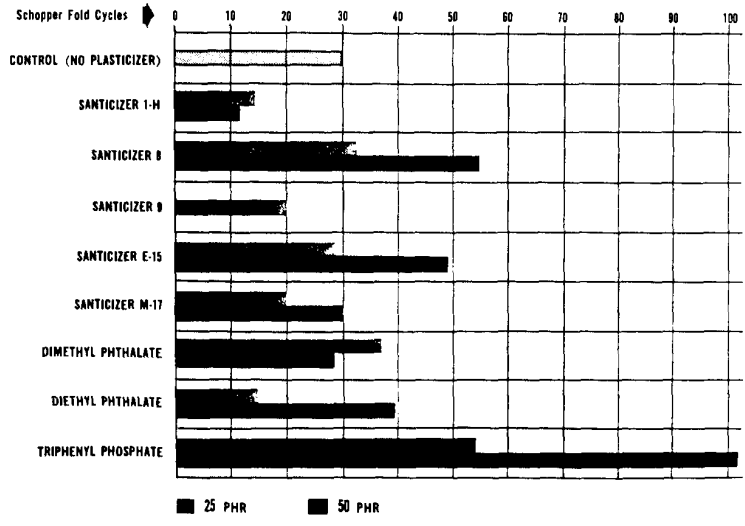
SCHOPPER FOLD FLEXIBILITY

TENSILE LOAD OF 1 KG. APPLIED DURING TEST

Plasticized Nitrocellulose Films (0.0010"—0.0015" Thick)



Plasticized Cellulose Acetate Films (0.0010"—0.0015" Thick)



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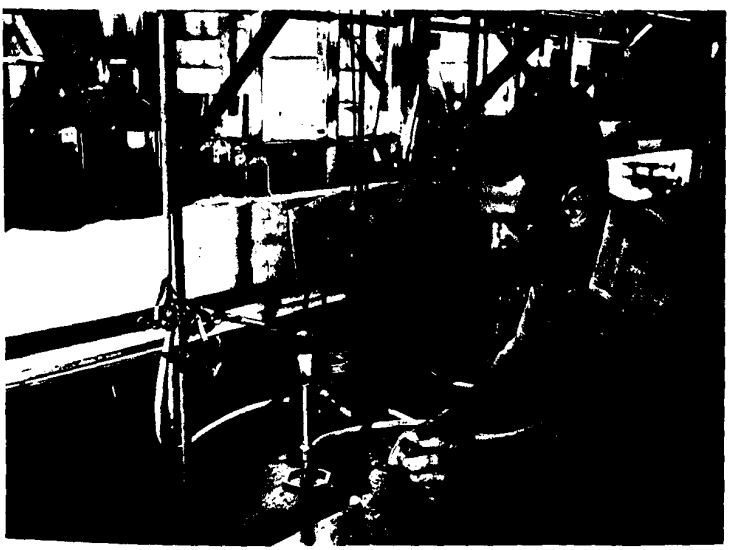
Flame Resistance

Monsanto plasticizers are outstanding in their ability to impart flame resistance to moldings, films and coatings. For example, while polyvinyl chloride itself does not burn, many ordinary plasticizers do. Consequently, the flammability of a vinyl composition is governed by the type and the amount of the plasticizer.

The flame resistance of a plasticizer is related to its chemical composition. Most phosphate type plasticizers are particularly good for developing flame resistance in plastics compositions.

Flame resistance is extremely important in free films, coated fabrics, lacquers, and textile coatings. In non-flammable resins, "threshold" concentrations exist for most plasticizers. Below this point, the compositions are no more flammable than the resin itself; above it, the flammability rapidly increases with the concentration of the plasticizer. Monsanto flame retardant plasticizers raise this threshold point and assure manufacturers of textile coatings and film that their plastics compositions will not continue to burn after the igniting source is removed.

In evaluating the flame resistance of a plasticized film, Monsanto laboratories use a test that not only shows the relationship between the flammability characteristics of various plasticizers but also permits an accurate prediction of the flammability of the finished article. Briefly, the flammability test consists of igniting a standard size sample (2 grams, ¼" x ¼" x .040" squares) of the vinyl composition for 30 seconds with specified size Bunsen Burners. The burners are extinguished and the time the sample continues to burn after flame is removed is recorded. The number of seconds the sample burns after ignition is called the Flame Out Time; it is a direct measure of the material's flammability. The following graph shows the flame out time for several of Monsanto's flame retarding plasticizers.



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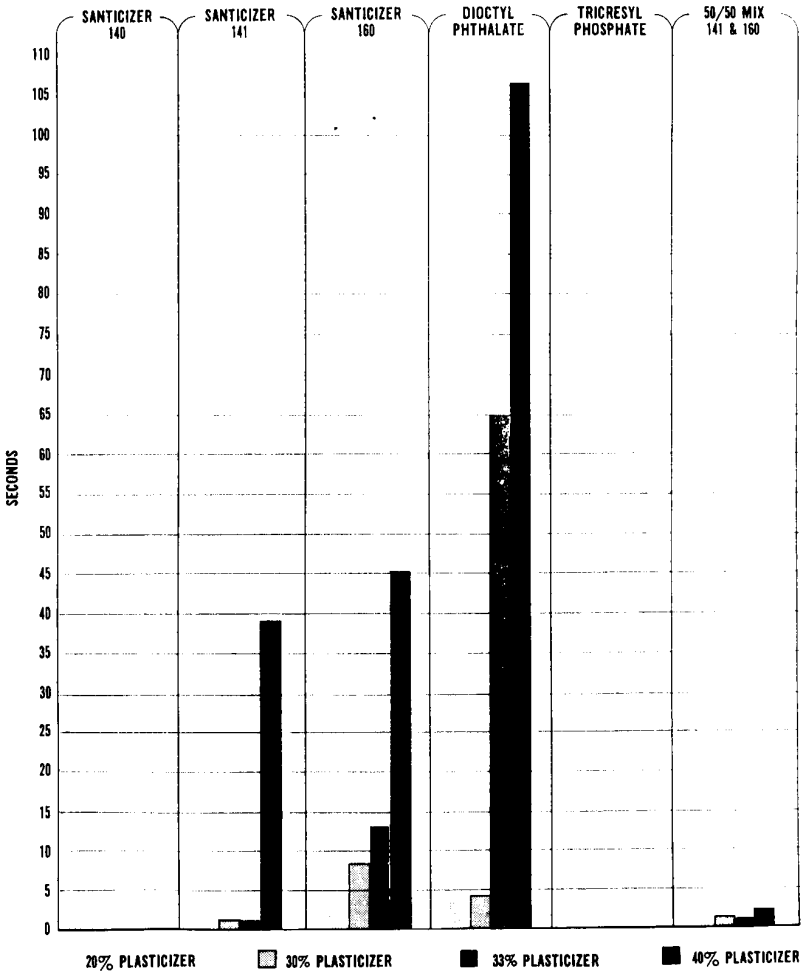
FLAME OUT TIME Polyvinyl Chloride Film



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TOWOLDMON0006284

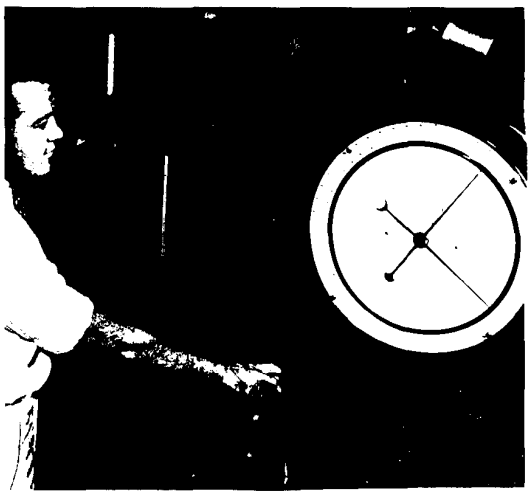


Elongation and Tensile Strength

The elongation and tensile strength directly affects the toughness of a plasticized composition. An efficient plasticizer can be used in low enough concentration so that the composition's elongation is increased but the tensile strength is not degraded past the point of usefulness.

The elongation is tested by applying a variable load at a constant rate of elongation to a plasticized film. Down to a certain thickness, film elongation is tested on a Scott L-6 Tensile Tester. Thin films are evaluated on a Gardner-Parks Tensilometer.

Elastomeric vinyl compositions to be used for shoe soles, sheeting, wire covering must be able to withstand severe pulling and stretching. Consequently compositions of high tensile strength coupled with high elongation are necessary in many applications.



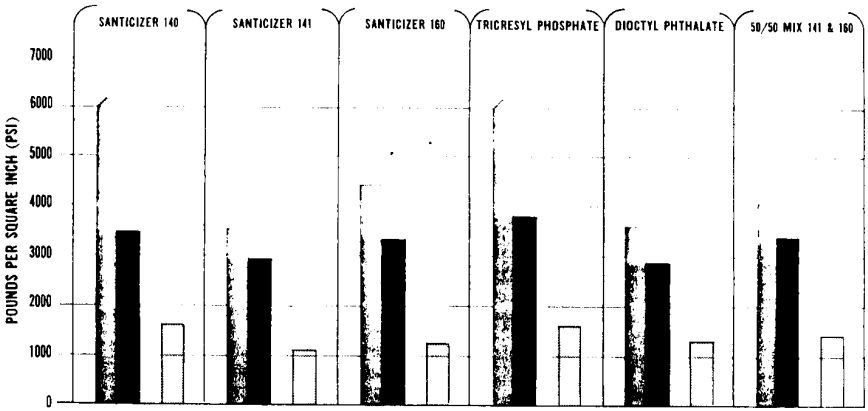
0614843

TOWOLDMON0006285

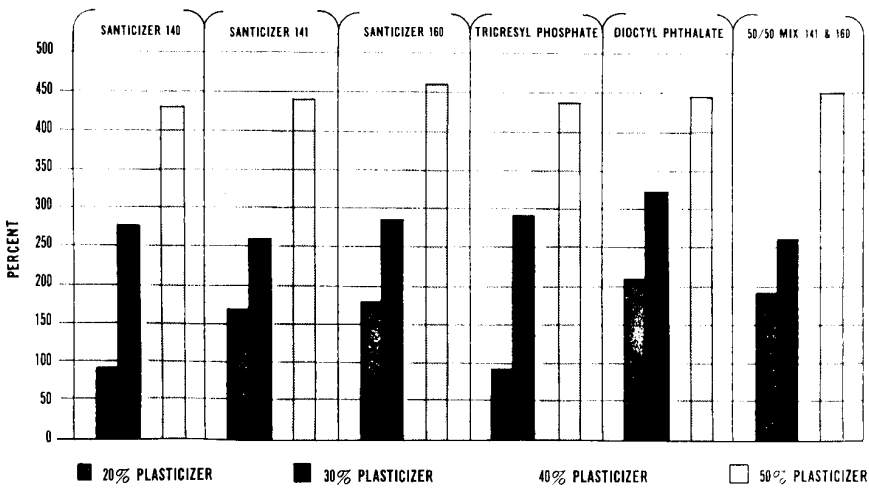
TENSILE STRENGTH AND ELONGATION of Polyvinyl Chloride Film

FILM THICKNESS 0.040"

TENSILE STRENGTH



ELONGATION



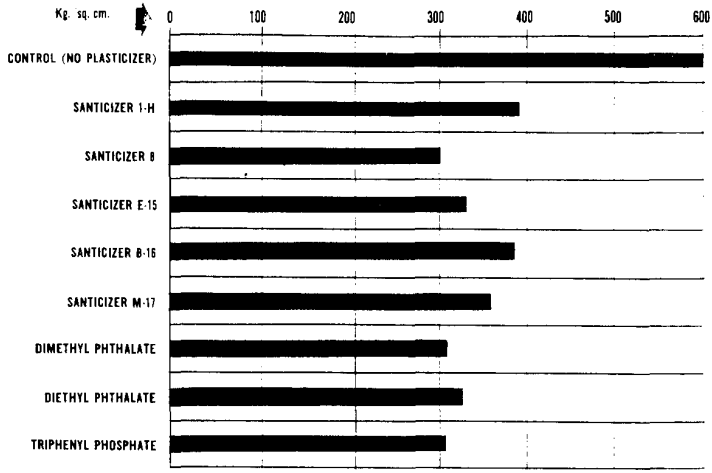
0614844

TOWOLDMON0006286

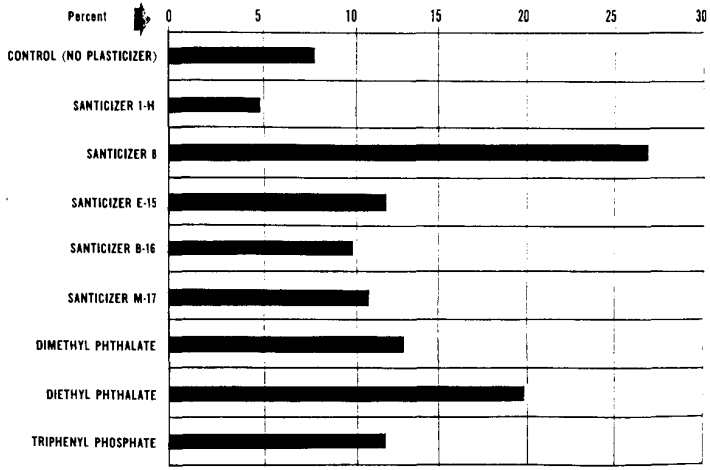
TENSILE STRENGTH AND ELONGATION of Cellulose Acetate Film

FILM THICKNESS 0.0010" — 0.0015"

TENSILE STRENGTH (50 Parts / 100 Parts Resin)



ELONGATION (50 Parts 100 Parts Resin)



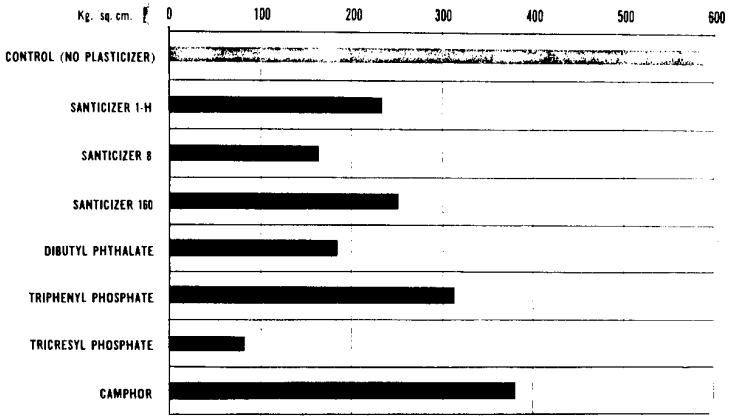
0014845

TOWOLDMON0006287

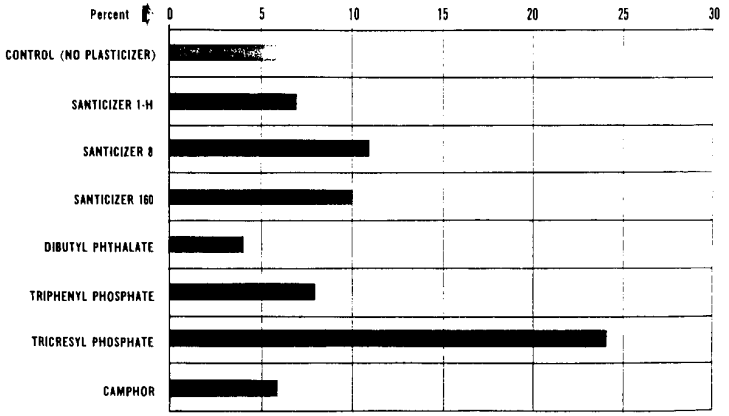
TENSILE STRENGTH AND ELONGATION of Nitrocellulose Films

FILM THICKNESS 0.0010" — 0.0015"

TENSILE STRENGTH (50 Parts/100 Resin)



ELONGATION (50 Parts/100 Parts Resin)



0614846

TOWOLDMON0006288

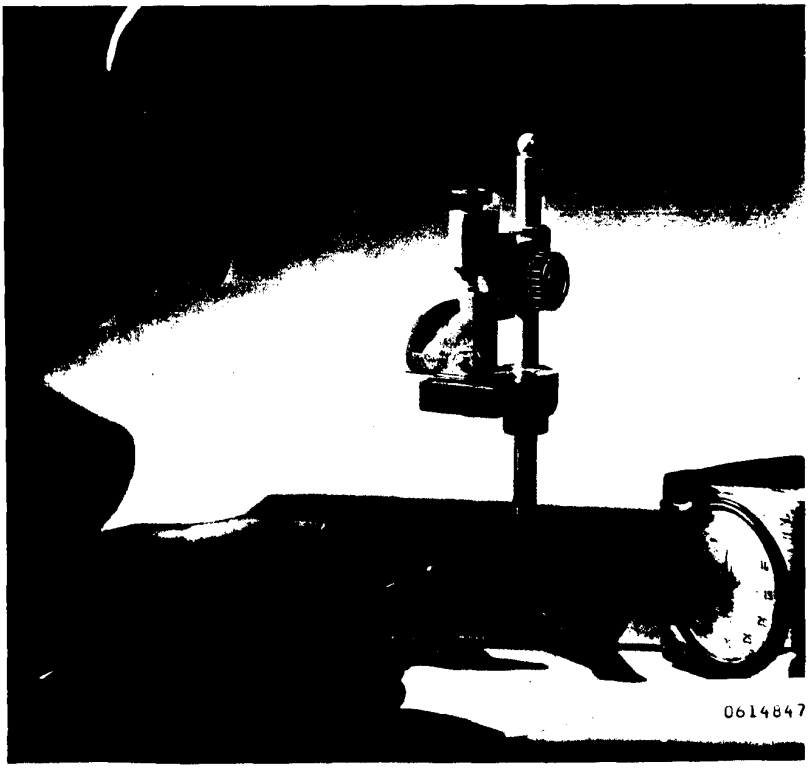
Hardness

Various applications of resins require compositions with different degrees of hardness. The hardness of elastomeric films is measured on a Shore Durometer. Hardness is measured in terms of the composition's resistance to the penetration of a standard needle under a standard load for a specified period of time. Increasing Shore Durometer Hardness units indicate increasing hardness or resistance to penetration.

For plastic molding or sheeting, a Rockwell Hardness tester is used. Again, the surface hardness is measured in terms of the composition's resistance to penetration. The Rockwell machine forces a standard ball against the plastic surface and resistance is expressed in terms of relative impenetrability. The higher the Rockwell reading, the harder the composition.

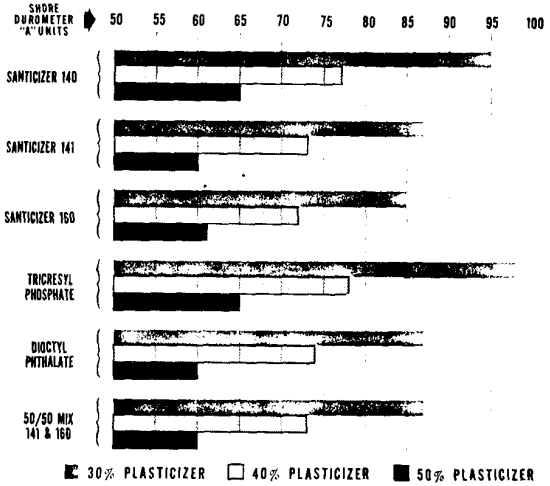
As the plasticizer content is increased, the hardness of the plasticized composition usually decreases. Variations in hardness may be obtained by varying both the amount and type of *plasticizer.*

The variation in hardness with increasing amounts of a plasticizer is frequently used in the industry as a measure of a plasticizer's efficiency. Plasticizers which show a greater softening effect at a given concentration are considered to be the more efficient. The effect of the plasticizer on hardness is highly important in extruded tubing, sheeting, wire coating, floor tile, and shoe soles.

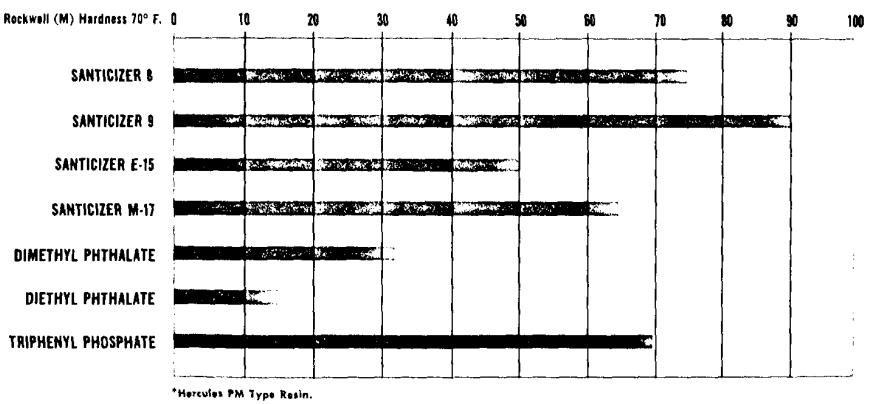


TOWOLDMON0006289

SHORE DUROMETER HARDNESS
Polyvinyl Chloride Film



PLASTICIZER EFFECT ON HARDNESS
of Cellulose Acetate Compositions* 34% Plasticizer



*Hercules PM Type Resin.

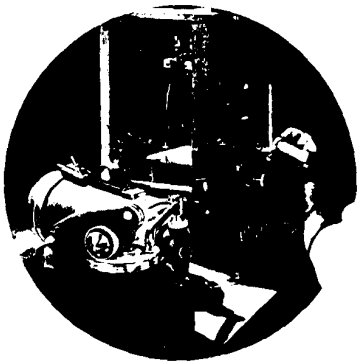
0614848

TOWOLDMON0006290

Abrasion Resistance

Abrasion resistance is a measure of a plasticized composition's resistance to scuffing, scarring, and surface damage. This property is highly important in luggage covering, shoe soles, wire jacketing, cable coating, floor covering and upholstery. The resistance to abrasion is governed by the type and amount of plasticizer used in a specified resin composition.

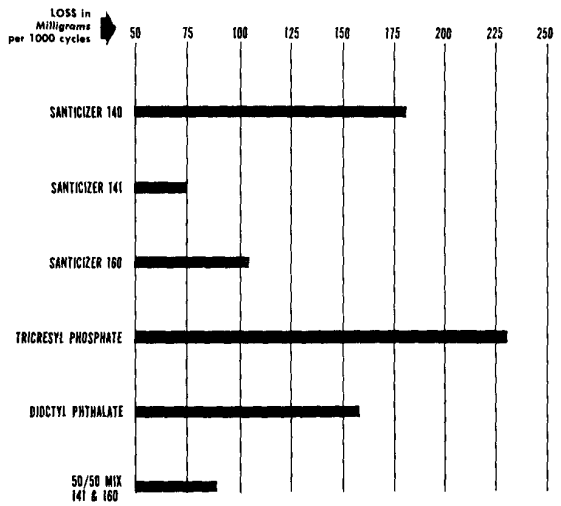
Tests on plasticized vinyl film show that the finished compositions possess varying degrees of resistance to abrasion depending on the plasticizer used. Evaluations of the various plasticizers were made using a standard Taber Abraser loaded as specified in each of the following tests. Low weight losses indicate the superior abrasion resistance of a number of Monsanto's plasticizers, notably Santicizers 141 and 160 and also the 50/50 mixture.



ABRASION RESISTANCE Polyvinyl Chloride Film

Taber Abraser

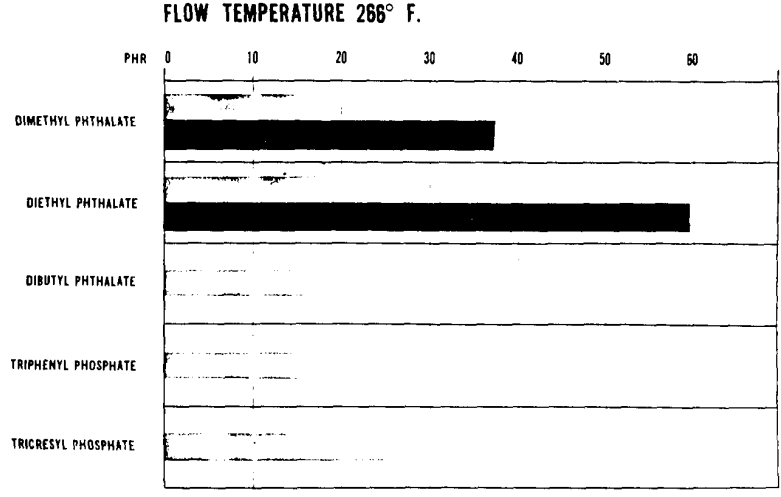
1000 GRAM LOAD, H-22 WHEELS, 40% PLASTICIZER



0614849

TOWOLDMON0006291

AMOUNT OF PLASTICIZER REQUIRED to Meet Specified Flow Conditions





CELLULOSE ACETATE-BUTYRATE (37% Butyryl, 13% Acetyl)

CELLULOSE ACETATE (38.5% Acetyl)

Flow Properties of Molding Compounds

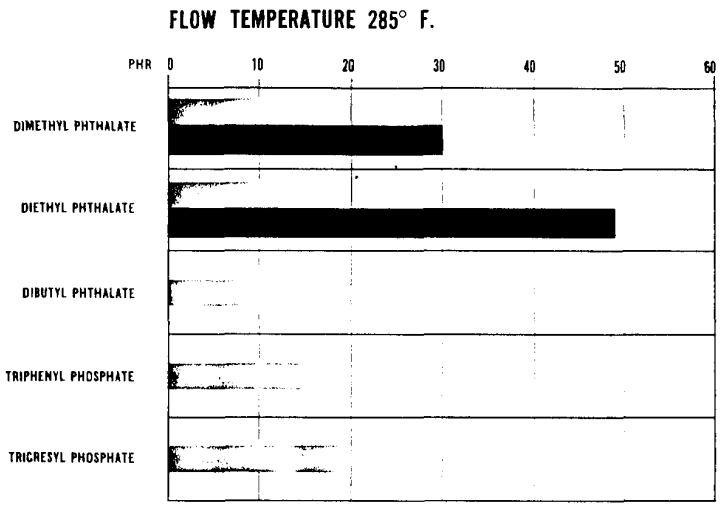
The performance efficiency of a plasticizer is frequently measured in terms of its improvement of the flow of molding compositions at elevated temperatures. This efficiency is generally expressed as the amount of plasticizer required to obtain a given rate of flow under specific conditions of temperature and pressure.

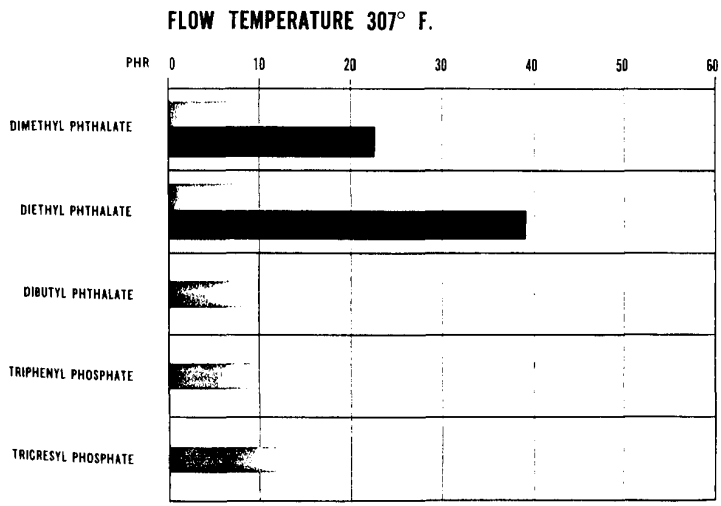
Plasticizers which impart the desired fluidity at lower concentrations are consequently the more efficient compounds for use in molding compounds.

0614850

TOWOLDMON0006292

IN CELLULOSIC MOLDING COMPOUNDS





0614651

TOWOLDMON0006293

Toxicity

The question of toxicity of plasticizers is one that is of extreme importance to the manufacturer of plastics products. In some applications such as beverage tubing, food packaging, dentures etc., no plasticizer can be used which can be extracted by the food and induce a possible deleterious action.

Several Monsanto plasticizers such as E-15, B-16, and M-17, have been used for years in applications where they come in intimate contact with the human body, or with foodstuffs. They have proved themselves to be non-toxic and satisfactory for such applications. This record of freedom from ill effects in actual use has been checked by animal experimentation.

New plasticizers, such as Santicizer 141, have been and are under active animal experimentation. The results show that Santicizer 141 can be considered non-toxic for the above uses.

In certain applications, such as in meat packing houses, government regulations require submission of the finished product to a designated agency for approval before it can be used.

Information on plasticizers for food wrapping, and all other questions concerning toxicity will be answered specifically by the Organic Development Department, Monsanto, St. Louis.

Electrical Properties

One of the major uses of plastics compositions is for electrical insulation and wire jacketing. For such applications, plasticizers must be selected which are best suited to the conditions of the application—both from a standpoint of electrical properties and for other properties, such as resistance to migration, good flexibility, tensile strength, and long life in the composition.

The electrical properties of the plasticizer per se are not always a complete guide to the electrical properties of the plasticized composition. The specific resistance of compositions will vary with the temperature; the loss factor will vary with the frequency and the temperature. In evaluating a plasticizer's electrical properties, the variables should be limited to specific resins in a particular application.

Since most plasticizers are polar compounds,



increasing concentrations tend to decrease the insulating properties of the plasticized compositions. For this reason, highly efficient plasticizers which impart the desired properties in low concentrations can, in general, be expected to retain good electrical properties in the plasticized compositions. A number of Monsanto plasticizers have a negligible effect on the electrical properties of base resins. As a rough basis of evaluation, efficient plasticizers with good heat stability, a high degree of permanence, and which are supplied free of impurities can be depended on to retain good electrical properties in the plasticized resin.

For insulation uses, particularly low frequency applications, **Specific Resistivity** is usually the most important electrical property considered and should be as high as possible. Low resistivity means greater losses of electrical energy due to ionic and electronic conduction.

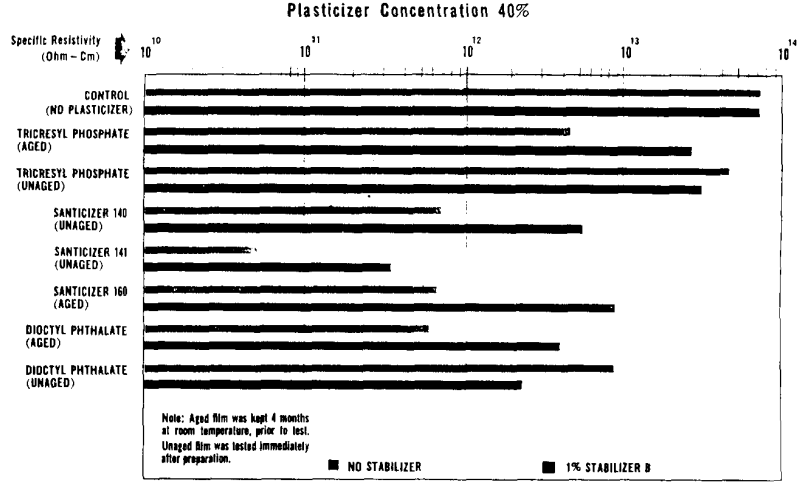
The **Loss Factor** may be defined as the product of the dielectric constant and the dissipation factor and should be as low as possible. The Loss Factor is the most significant of the two factors—Dissipation Factor and Dielectric Constant—since it represents the total loss.

Dielectric Constant is perhaps the least important constant determined for application such as wire insulation for 60 cycle current. For high frequency insulation it is more important than resistivity and equally as important as the Dissipation Factor.

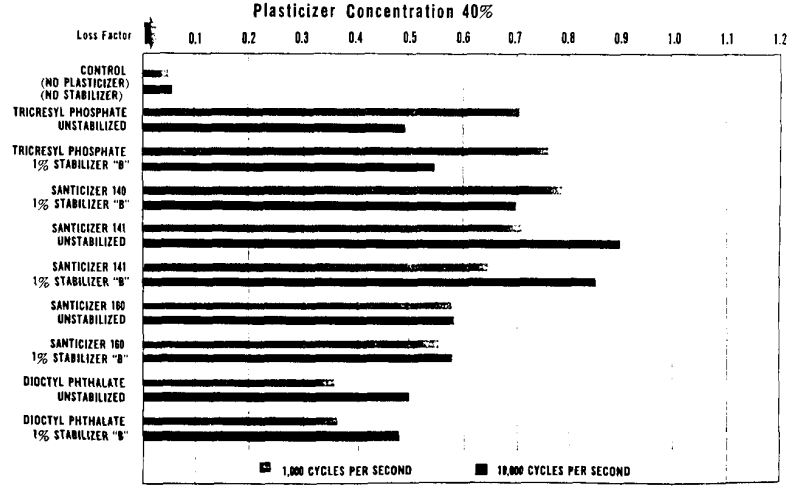
0614852

TOWOLDMON0006294

SPECIFIC RESISTIVITIES of Plasticized Vinyl Compositions at 25° C.



LOSS FACTOR of Plasticized Vinyl Compositions at 25° C.

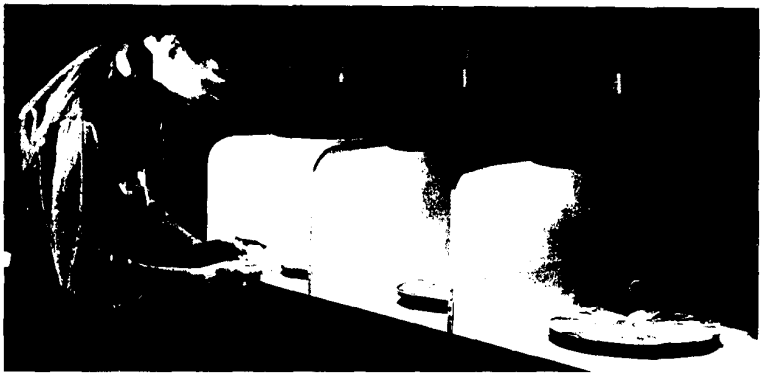


0614853

TOWOLDMON0006295

PERMANENCE

Since plasticized compositions depend upon the plasticizer for flexibility, dimensional stability, resistance to moisture penetration, and many other properties, it is essential that the plasticizer be permanent for the service life of the product. The permanence of a plasticizer is a combination of its volatility, oil and water resistance, resistance to migration and heat and light stability.



Stabilizers

Many resin-plasticizer formulations require heat or light stabilizers. This is particularly true where vinyl compounds are involved. Although Monsanto does not manufacture stabilizers, considerable research has been done on the problem of the proper selection and use of stabilizers as they pertain to Monsanto's plasticizers. The technique of stabilizing resin mixtures is advancing rapidly with the appearance of new stabilizers, resins, and plasticizers. Since each manufacturing problem differs as to resins, fillers, and plasticizers, it is most expedient to work out each stabilizing problem individually. The services of Monsanto's Research and Development Department are available to resin processors who have specific stabilization problems involving the use of Monsanto plasticizers.

0614854

TOWOLDMON0006296

Volatility

In general, plasticizers of high molecular weight and low vapor pressures may be depended upon to show a high degree of permanence. Low vapor pressure over an ascending scale of temperatures is an assurance to the manufacturer that the plasticizer will not evaporate from the plasticized composition. This is particularly important in films and coatings in which a large surface area is present in relation to the mass of the composition. In general, a solid plasticizer frequently has a lower vapor pressure than some of the liquid compounds. Frequently a combination of a solid and a liquid plasticizer will be a highly permanent plasticizing mixture with extremely low volatility in the molded, calendered, or cast composition.

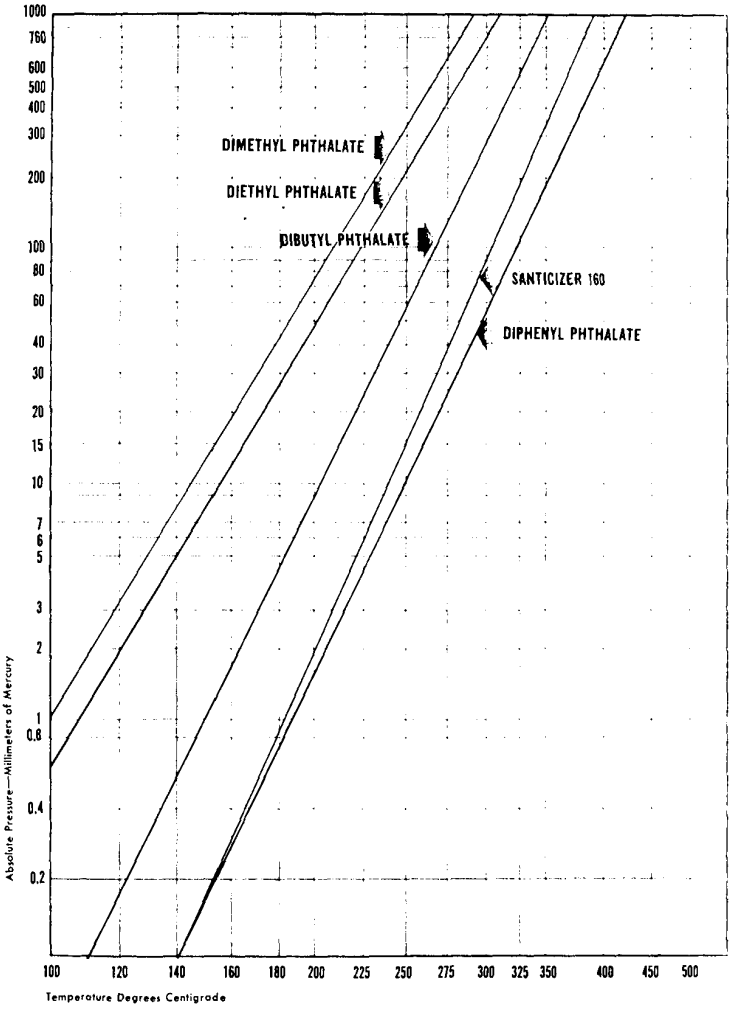
Monsanto diphenyl phthalate, triphenyl phosphate, tricresyl phosphate and Santicizers B-16, 140, 141 and 160 have high molecular weights and low volatility. They show low losses from compositions even when heated to higher-than-service temperatures.



0614855

TOWOLDMON0006297

VAPOR PRESSURES



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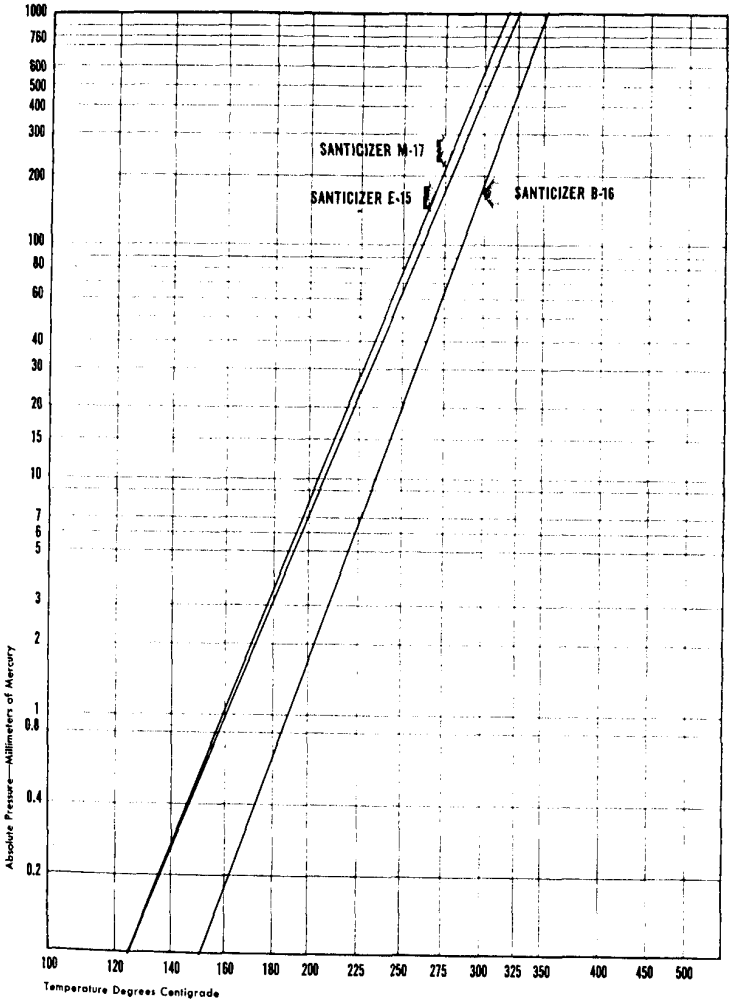
TOWOLDMON0006298

VAPOR PRESSURES



0614857

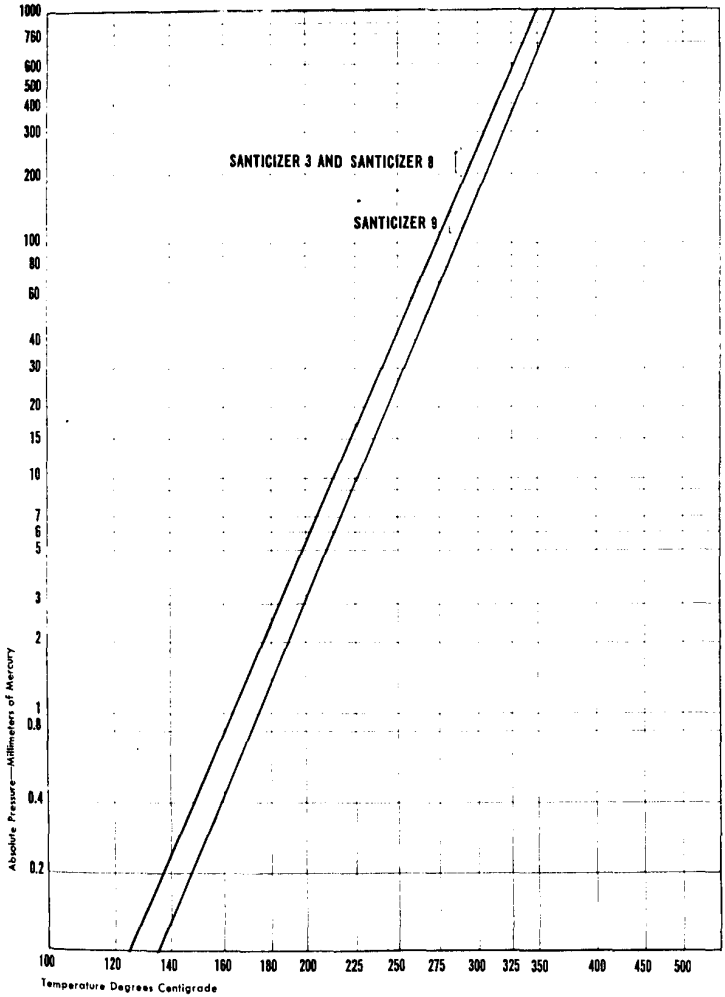
TOWOLDMON0006299

VAPOR PRESSURES

0614858

TOWOLDMON0006300

VAPOR PRESSURES

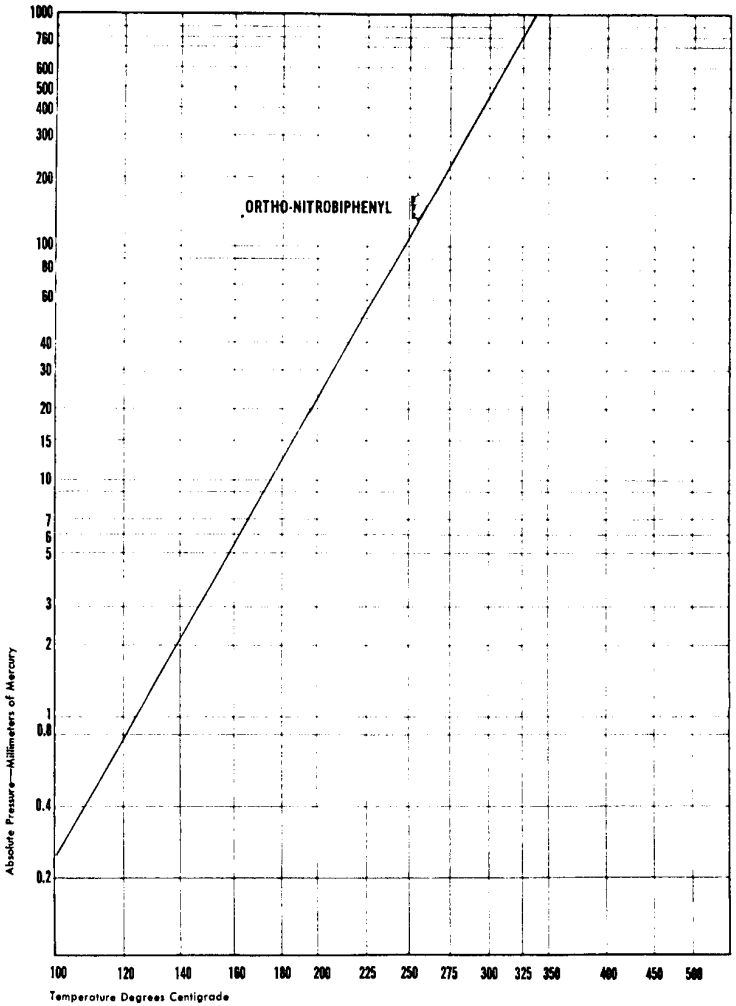


The vapor pressure data for the sulfonamide plasticizers are representative of commercial products and not necessarily those of pure compounds. The commercial sulfonamide plasticizers are generally mixtures of isomers.

0614859

TOWOLDMON0006301

VAPOR PRESSURES

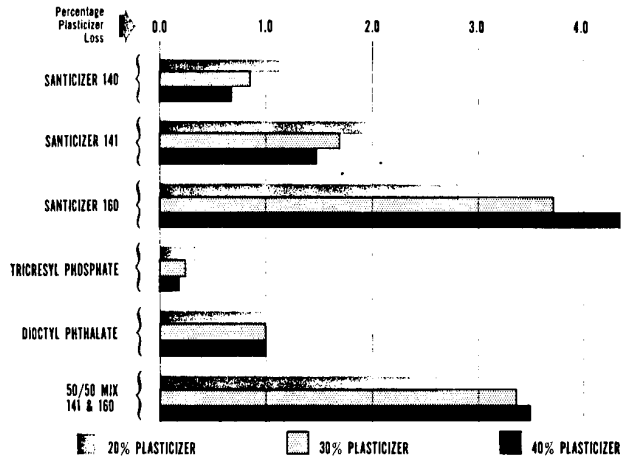


0614860

TOWOLDMON0006302

VOLATILITY from Polyvinyl Chloride Film

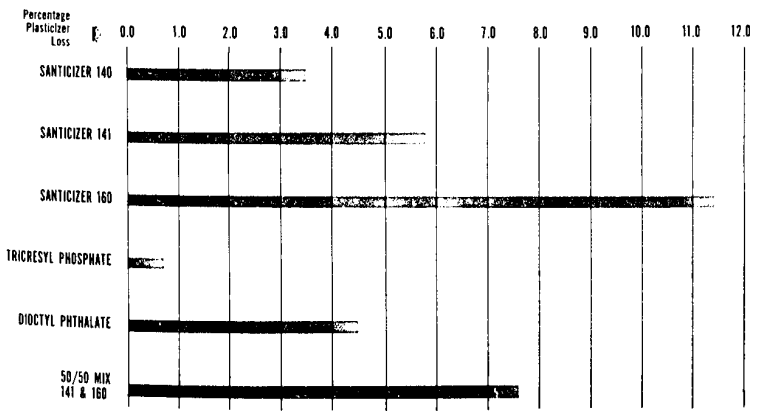
72 HRS. AT 82°C — ASTM D744-44T



VOLATILITY from Polyvinyl Chloride Film

24 HRS. AT 105° CENTIGRADE SAMPLE SIZE: 1"x3"x.040"

PLASTICIZER CONCENTRATION 40%

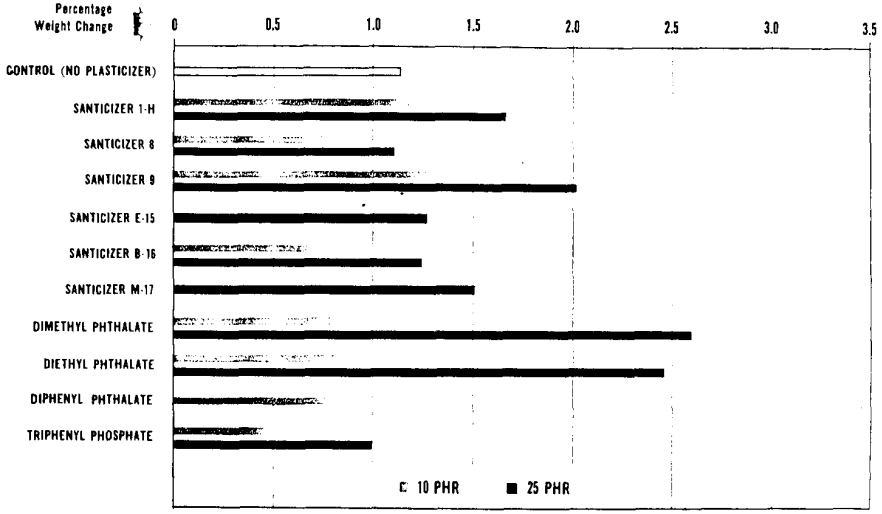


0614861

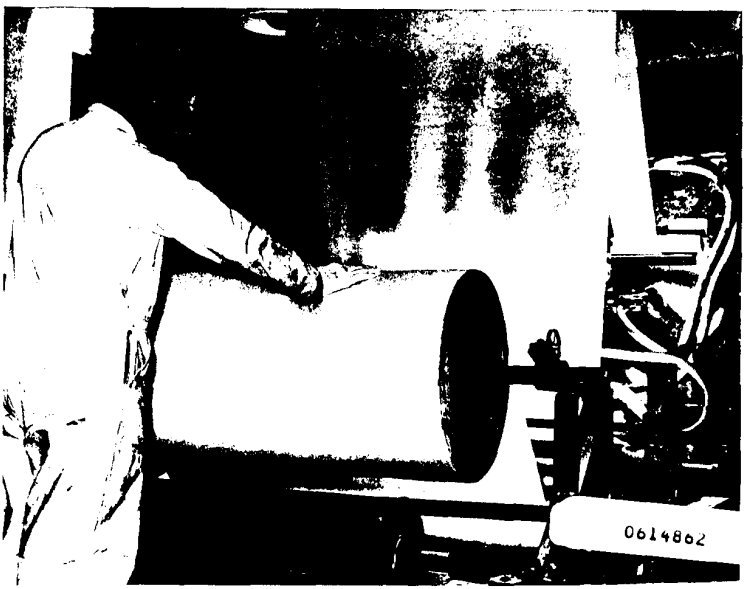
TOWOLDMON0006303

VOLATILITY from Cellulose Acetate Film

12 DAYS AT 60° CENTIGRADE SAMPLE SIZE: 1"x4"x.020"



Non-volatile plasticizers retain flow properties during production and preserve flexibility in end use.



TOWOLDMON0006304

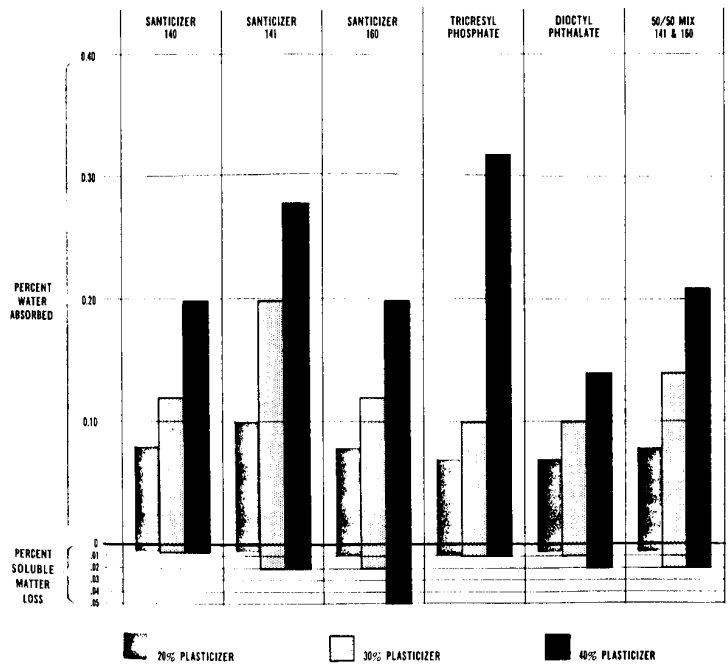
Water Resistance

In many applications, plastics products come in contact with water. Unless the plasticizer has extremely low solubility, it will be leached out causing loss of flexibility, swelling or shrinkage, and possibly clouding and crystallizing.

The behavior of plasticizers in water is studied in the laboratory under accelerated conditions. The amount of water absorbed and the loss by leaching is determined after soaking the plasticized compositions in distilled water for 24 hours. The permeability of thin films to moisture penetration is determined by sealing plastics film 0.0010"—0.0015" thick over glass bottles containing 10-15 gm of anhydrous calcium chloride. The area of film exposed is 10.5 sq. cm. The bottles are then exposed to an atmosphere of 100% relative humidity for 48 hours and the percentage increase in weight is measured. Plasticized films are compared with a control containing no plasticizer. The gain in weight of the control is taken as 100% permeability and the percentage permeability of the plasticized films computed in relation to the control.

WATER ABSORPTION and LOSS by LEACHING

Polyvinyl Chloride Film ASTM Test D-570-42 Sample Film .075" Thick



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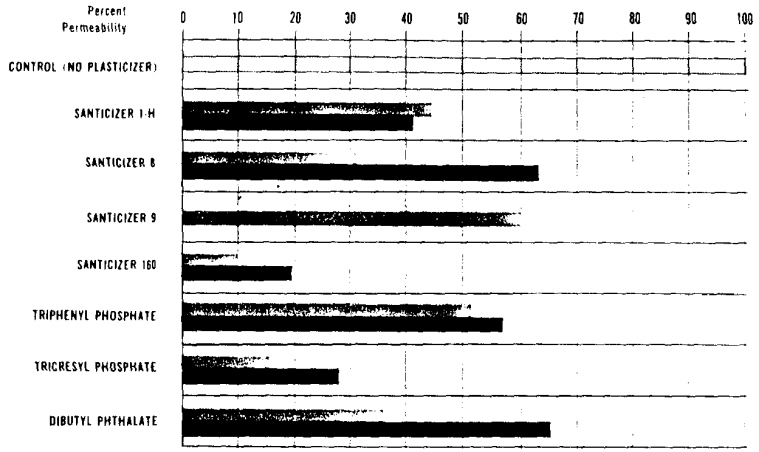
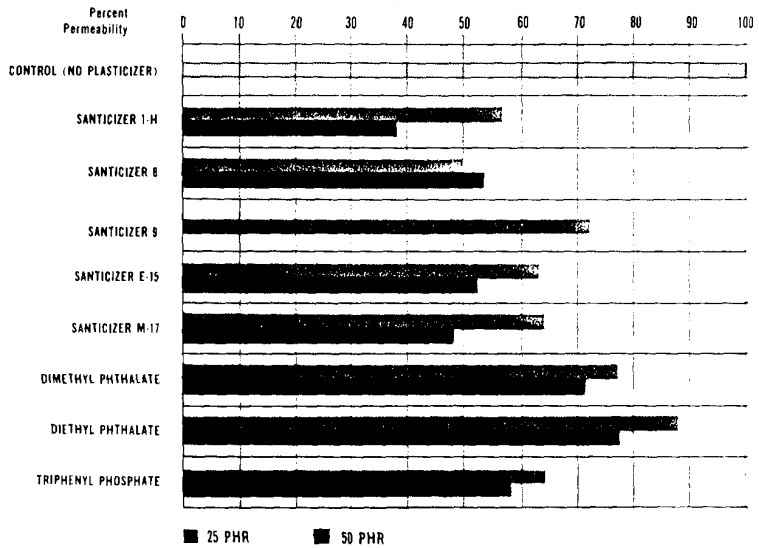
TOWOLDMON0006305

RESISTANCE TO MOISTURE PENETRATION

Plasticized Nitrocellulose Film (Film thickness 0.0010"–0.0015")



Plasticized Cellulose Acetate Film (Film thickness 0.0010"–0.0015")



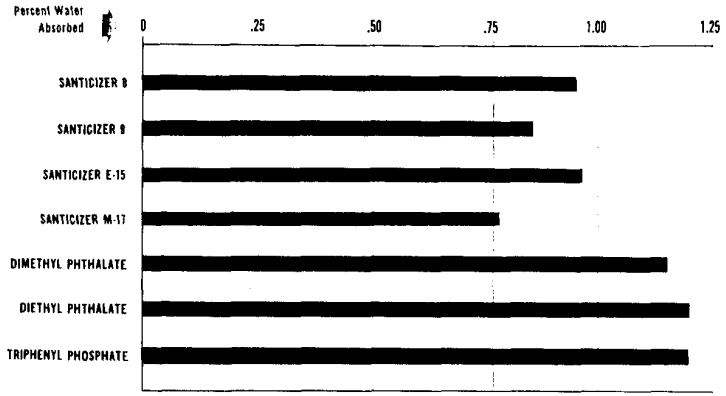
0614864

TOWOLDMON0006306

PERCENT WATER ABSORBED
in Cellulose Acetate Molding Compositions

34% PLASTICIZER CONTENT

2" DISK ¼" THICK IMMERSED 48 HOURS IN WATER AT 70° F.



Low water absorption and resistance to leaching is a prime requirement for many end uses of plastics film.



0614865

TOWOLDMON0006307

Oil Resistance

Lacquers and surface coatings, as well as extruded tubing and wire insulation frequently must be used in contact with oil and hydrocarbon solvents. Grommets, shoe soles, and floor covering must be oil resistant for long service life. This requirement demands that the plasticizer used in the materials of manufacture resists being solubilized in oil or the organic solvents likely to be encountered in service.

Tested according to A.S.T.M. methods, Monsanto plasticizers show good resistance to oil. After seven days immersion in No. 3 oil, vinyl compositions plasticized with Santicizer 160, 140, 141 and tricresyl phosphate suffered only negligible weight loss from contact with the oil.

SOLUBILITY OF PLASTICIZERS IN OILS

	OILS						
	HYDRO-CARBON	CASTOR	LINSEED	SOYBEAN	TUNG	PINE	PERILLA
TRIPHENYL PHOSPHATE	I	S	S	S	S	M	S
TRICRESYL PHOSPHATE	M	M	M	M	M	M	M
SANTICIZER 8	I	M	I	I	S	M	I
SANTICIZER 9	I	S (Hot)	S (Hot)	S (Hot)	S (Hot)	M	S (Hot)
SANTICIZER E-15	I	S (Hot)	S (Hot)	S (Hot)	S (Hot)	M	S (Hot)
SANTICIZER B-16	M	M	M	M	M	M	M
SANTICIZER M-17	I	I	I	I	I	M	I
DIBUTYL PHTHALATE	M	M	M	M	M	M	M
DIETHYL PHTHALATE	I	M	M	M	M	M	M
DIMETHYL PHTHALATE	I	M	M	S	M	M	M

S = SOLUBLE
I = INSOLUBLE
M = MISCIBLE

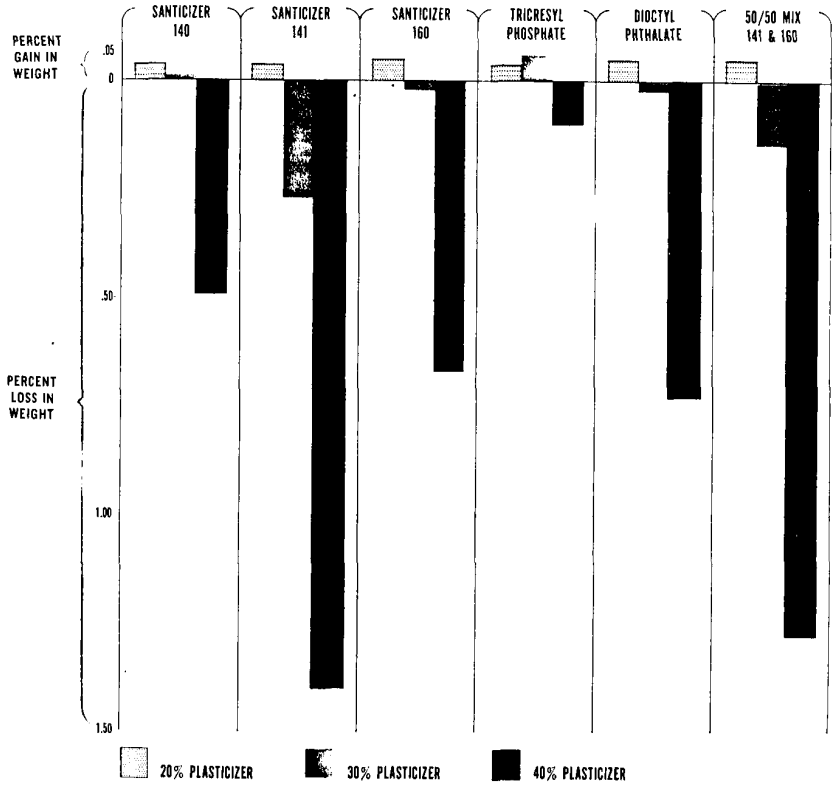
0614866

TOWOLDMON0006308

OIL RESISTANCE of Polyvinyl Chloride Film

ASTM Test D543-43*

Sample Film .075" Thick



*ASTM OIL #3, SUN OIL CO.

0614867

TOWOLDMON0006309

Migration

When two plastics surfaces are in contact with one another, plasticizer migration is the tendency of the plasticizer in one to leave the composition and enter the other. In cases of severe lifting migration, both surfaces are damaged by becoming marked, soft, or tacky. The amount of plasticizer migration is directly related to the temperature, pressure, and the time of contact between the two surfaces.

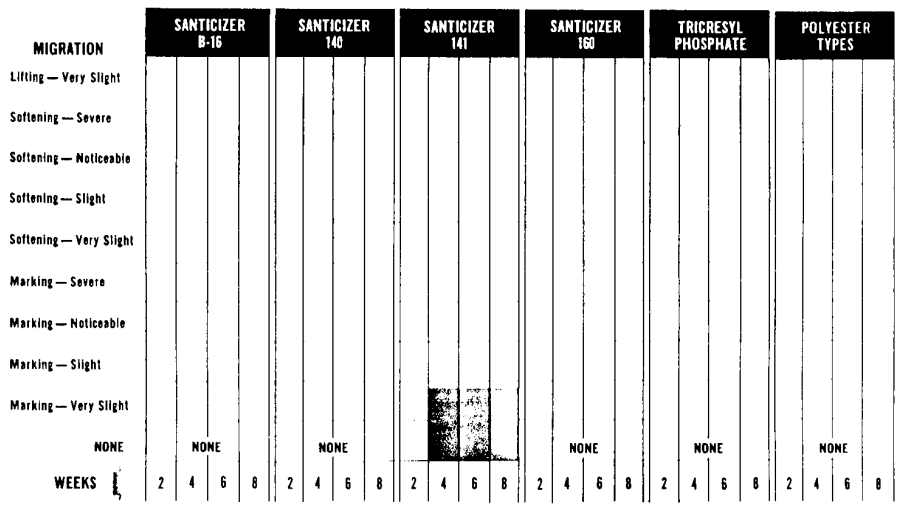
It is desirable that vinyl compositions used for apparel or accessories such as handbags that may contact varnished or lacquered surfaces be plasticized with compounds that exhibit migration tendencies not greater than *slight softening*. In electrical applications, also, non-migratory plasticizers are important. Polyethylene, widely used for insulation, is frequently jacketed with a plasticized vinyl resin.

In evaluating the migratory characteristics of a plasticizer in the laboratory, plasticized samples are placed in contact with a cellulose nitrate lacquered surface at a constant pressure and examined weekly for surface damage. They are rated visually from *no marking* to *severe lifting*.

POLYVINYL CHLORIDE PLASTICIZER MIGRATION

(26° C., ¼ pound per square inch pressure)

PLASTICIZER CONCENTRATION 20%



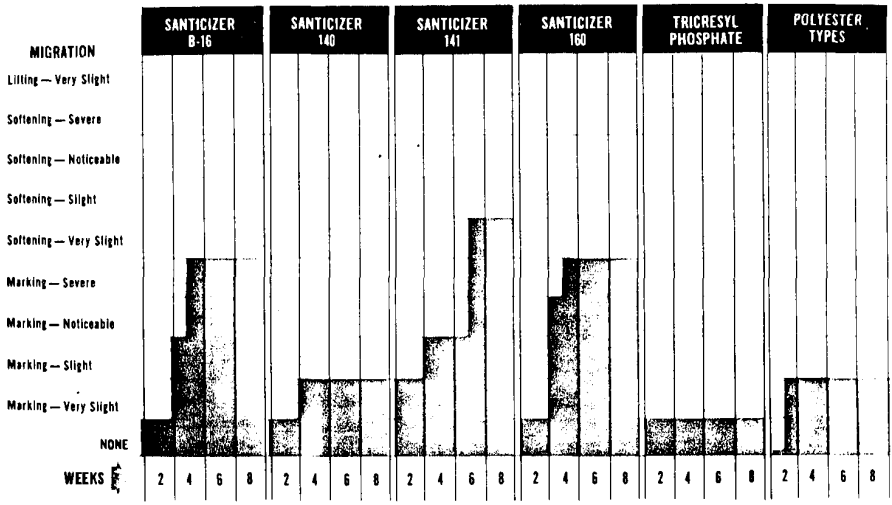
0614868

TOWOLDMON0006310

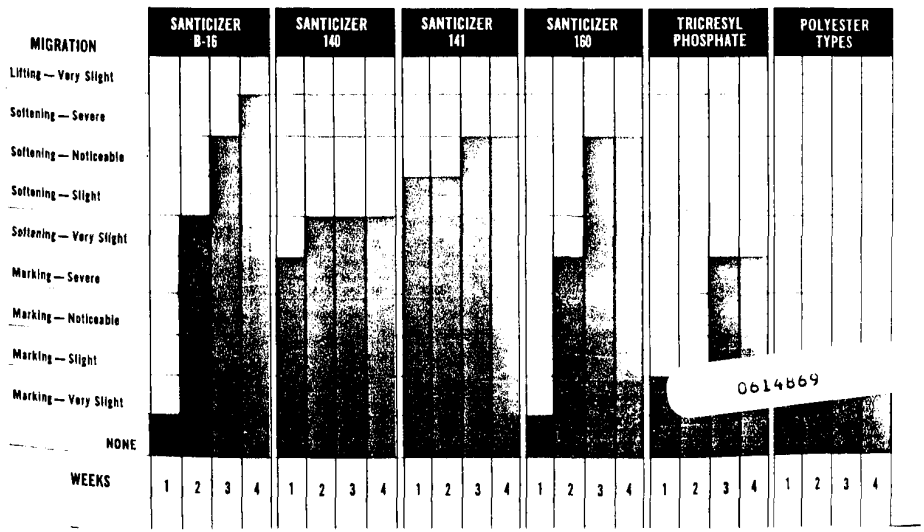
POLYVINYL CHLORIDE PLASTICIZER MIGRATION

(26° C., ¼ pound per square inch pressure)

PLASTICIZER CONCENTRATION 30%



PLASTICIZER CONCENTRATION 40%



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SOLUBILITY OF LIQUID PLASTICIZERS
in Organic Solvents and Oils

	TRICRESYL PHOSPHATE	SANTICIZER 8	SANTICIZER B-16	SANTICIZER E-15	SANTICIZER M-17	DIBUTYL PHTHALATE	DIETHYL PHTHLATE	DIMETHYL PHTHALATE
METHYL ALCOHOL	M	M	M	M	M	M	M	M
ETHYL ALCOHOL	M	M	M	M	M	M	M	M
BUTYL ALCOHOL	M	M	M	M	M	M	M	M
ACETONE	M	M	M	M	M	M	M	M
METHYL ETHYL KETONE	M	M	M	M	M	M	M	M
ETHYL ACETATE	M	M	M	M	M	M	M	M
AMYL ACETATE	M	M	M	M	M	M	M	M
ETHYLENE DICHLORIDE	M	M	M	M	M	M	M	M
TRICHLORETHYLENE	M	M	M	M	M	M	M	M
CARBON TETRACHLORIDE	M	M	M	M	M	M	M	M
CHLORINATED PARAFFIN	M	I	M	M	I	M	M	M
GASOLINE (SKELLYSOLVE E)	M	I	M	I	I	M	M	I
BENZENE	M	M	M	M	M	M	M	M
XYLENE	M	M	M	M	M	M	M	M
MONOCHLOROBENZENE	M	M	M	M	M	M	M	M
o-DICHLOROBENZENE	M	M	M	M	M	M	M	M

S = SOLUBLE
I = INSOLUBLE
M = MISCIBLE

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SOLUBILITIES OF SOLID PLASTICIZERS
in Organic Solvents

(GRAMS PLASTICIZER PER 100 CC. SOLVENT AT 25° C.)

	TRIPHENYL PHOSPHATE	SANTICIZER 9	SANTICIZER 10	DIPHENYL PHTHALATE
METHYL ALCOHOL	335	37	20	12
ETHYL ALCOHOL	160	25	13	8
BUTYL ALCOHOL	135	5	12	4
ACETONE	340	50	225	215
METHYL ETHYL KETONE	350	45	250	140
ETHYL ACETATE	270	20	200	95
AMYL ACETATE	165	10	140	25
ETHYLENE DICHLORIDE	400	3	340	180
TRICHLORETHYLENE	310	VSS	250	120
CARBON TETRACHLORIDE	240	VSS	215	70
BENZENE	330	VSS	300	90
XYLENE	230	VSS	170	45
MONOCHLOROBENZENE	340	VSS	250	110
o-DICHLOROBENZENE	320	VSS	215	110
TURPENTINE	36	VSS	35	10

VSS = VERY SLIGHTLY SOLUBLE

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RECOMMENDED PLASTICIZERS FOR SPECIFIC RESINS in Particular Applications

MOLDED PRODUCTS

RESIN	PERFORMANCE: Tensile Strength	Elongation	Hardness	Flexibility	Low Water Absorption	Flow Characteristics	Flame Resistance	Non-Toxic	PERMANENCE: Solvent Resistance	Low Volatility	Heat Stability	Light Stability
CELLULOSE ACETATE	S 8 S 1-H TPP DPP	DMP DEP SE-15 S 8 TPP	S 9 S 1-H TPP	S M-17 DMP S 8	S E-15 S M-17 DEP S 1-H	DMP S M-17	TPP S 140 S 141	S E-15 S M-17	S 8 S M-17 S 1-H	S E-15 S 8 S 9	S M-17 S E-15 DEP DMP	S M-17 S E-15
CELLULOSE ACETATE-BUTYRATE	S 8 TPP DPP	DBP TCP S 140	S 9 S 1-H TPP	S 140 S 8 TCP S E-15	S E-15 S M-17 S 8	DMP DEP	S 140 S 141 TPP	S 141 S E-15 S M-17	S 8 S M-17 S 1-H	S 140 S 141 S E-15	S M-17 S E-15 DMP	S M-17 S E-15
CELLULOSE PROPIONATE	S 8 TPP DPP	DBP TCP S 140	S 9 S 1-H TPP	S 140 S 8 TCP S E-15	S E-15 S M-17 S 8	DMP DEP	S 140 S 141 TPP TCP	S 141 S E-15 S M-17	S 8 S M-17 S 1-H	S 140 S 141 S E-15	S M-17 S E-15 DMP	S M-17 S E-15
ETHYL CELLULOSE	S 1-H DPP	S 9 DPP S 8 S M-17	S 1-H DPP	DPP S 160 S M-17 S 8	S M-17 S 1-H DPP	DBP S M-17 TPP	S 140 TCP TPP	S M-17 S E-15 S B-16	S 8 S M-17 TPP	TPP DPP S 1-H	S B-16 S M-17 TPP DPP	TPP DBP S 1-H S 8
POLYSTYRENE						S B-16 S 160 S M-17		S B-16	S M-17 S E-15	S B-16 S 160	S B-16 S 160	S B-16
POLYVINYL CHLORIDE	DPP TCP S 140	S 160 S 141	DPP TPP TCP	S 141 S 160 S B-16	S 141 S B-16 S 140	S 160 S 141	TCP S 140 S 141	S B-16 S 141	S M-17 S 140 S 160	TCP S 140 S 141	S 160 S 141 S B-16	S 160 S B-16 S 141
POLYVINYL ALCOHOL	S 9 S 8 S M-17	S 8 S M-17	S 9 TPP	S M-17 S E-15	S 8 S M-17	S M-17	TPP TCP	S M-17 S E-15	S 8 S M-17 TPP	TPP S E-15 S B-16	S M-17 S E-15 S B-16	S M-17 S E-15 S B-16
PHENOL-FORMALDEHYDE	Santicizer 9 used for improving flow characteristics of highly filled molding compositions. In laminating resins, DBP, Santicizer 160 and TCP are used for imparting flow in hot-punch and post-forming stock.											
MELAMINE FORMALDEHYDE	Santicizer 9 used for improving flow characteristics and impact resistance.											
UREA FORMALDEHYDE	Santicizer 9 used for improving flow characteristics and as a hardener.											
CELLULOSE NITRATE	Camphor is best general purpose plasticizer. DBP and ortho Nitrobiphenyl are used to modify camphor in various formulations.											

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ACRYLIC	Dibutyl phthalate, Santicizer 160, Santicizer 141 and Santicizer B-16 improve workability and flow characteristics. Hardness is decreased slightly. Santicizer 141 and B-16 recommended for non-toxic applications.
POLYAMIDES (Nylon, etc.)	Santicizer 8 is the most efficient plasticizer. Imparts additional flexibility without adversely affecting tensile strength, abrasion resistance and oil resistance. Santicizer 9 useful but less heat stable.
CASEIN	Santicizer 9 improves flow and clarity of moldings. Decreases water absorption.

SYNTHETIC ELASTOMERIC FREE FILMS

RESIN	PERFORMANCE: Tensile Strength	Elongation	Low Temperature Flexibility	Flame Resistance	Water Resistance	Abrasion Resistance	Low Compression Set	Non-Toxic	PERMANENCE: Low Volatility	Solvent Resistance	Heat Stability	Light Stability
POLYVINYL CHLORIDE	DPP TCP S 140	S 160 S 141	S 141 S 160 S B-16	TCP S 140 S 141	TCP S 140 S 141	S 141 S 160	S 141 S 160	S 141 S B-16	TCP S 140 S 141	S 160 TCP S 140	S 160 S B-16 S 141	S 160 S B-16 S 141
POLYVINYLIDENE-CHLORIDE			S M-17 DBP S B-16					S B-16 S M-17	S B-16	S M-17 DBP	S M-17 S B-16	S M-17 S B-16
POLYVINYL BUTYRAL	TPP S 140 TCP	S 141 S 160 S B-16	S 141 S 160 S B-16	TCP S 140 S 141	S 160 S 141 TCP	S 141 S 160	S 141 S 160	S 141 S B-16	S 141 S 160 TCP	S M-17 S 160	S 160 S B-16 S 141	S B-16 S 160 S 141
BUNA N	TCP DBP TPP	S 160 S 141 S B-16	S 141 S 160	TCP S 140 S 141 TPP	TCP S 140 S 141	S 141 S 160 S B-16	S 141 S 160	S B-16 S 141	TCP S 140 S 141	S M-17 S 140 TCP S 141	S B-16 S 160 S 141 DBP	S B-16 S 160 S 141 DBP
BUNA S	TCP DBP	S 160 S 141	S 141	TCP TPP S 140 S 141	TCP S 140 S 141	S 141 S 160 S 140	S 141 S 160	S B-16 S 141	TCP S 140 S 141	S M-17 S 140 TCP S 141	S B-16 S 160 S 141 DBP	S B-16 S 160 S 141 DBP

DPP—DIPHENYL PHTHALATE TCP—TRICRESYL PHOSPHATE S—SANTICIZER TPP—TRIPHENYL PHOSPHATE DBP—DIBUTYL PHTHALATE

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RECOMMENDED PLASTICIZERS FOR SPECIFIC RESINS in Particular Applications

LACQUERS — SURFACE COATINGS and ADHESIVES

RESIN	PERFORMANCE: Tensile Strength	Elongation	Adhesion	Resistance to Cold Checking	Hardness	Flexibility	Luster	Low Water Permeability	Flame Resistance	Non-Toxic	PERMANENCE: Solvent Resistance	Low Volatility	Heat Stability	Light Stability
CELLULOSE NITRATE	TPP S 160 S 1-H	TCP S 8 S 160	S 8 DBP TCP	S 141 S 160 DBP	TCP S 140	S 8 DBP TPP	S B-16 S 8 DPP	S 160 TCP S 8	TCP S 140 S 141	S B-16	S M-17	TCP S 140 S 141 S 160	S B-16 DBP S 160	DBP S 160 DPP
CELLULOSE ACETATE	S 1-H S 8 S M-17	S 8 DEP S E-15	S 8 S M-17 S 3	S 141 S 160	S 1-H S 9 S 8	TPP S 8 S E-15	S 8 S M-17 S E-15 S 3	S 8 S M-17	TPP S 140 S 9	S M-17 SE-15*	S M-17 SE-15 S 8	S 8 S M-17 S E-15	S M-17 S E-15	S E-15 S M-17
CELLULOSE ACETATE-BUTYRATE	S 1-H S 8 S M-17	S 8 DEP S E-15	S 8 S M-17 S 3	S 141 S 160	S 1-H S 9 S 8	TPP S 140 S 8	S 8 S M-17 S E-15	S 140 S 8 S M-17	S 140 TPP S 9	S M-17 S E-15	S M-17 S 8 TPP	S 140 S M-17 S 8	S M-17 S E-15	S M-17 SE-15
CELLULOSE PROPIONATE	S 1-H S 8 S M-17	S 8 DEP S E-15	S 8 S M-17 S 3	S 141 S 160	S 1-H S 9 S 8	TPP S 140 S 8	S 8 S M-17 S E-15	S 140 S 8 S M-17	S 140 TPP S 9	S M-17 S E-15	S M-17 S 8 TPP	S 140 S M-17 S 8	S M-17 S E-15	S M-17 S E-15
ETHYL CELLULOSE	S 1-H DPP	S 9 DPP S 8 S M-17	S 8 S 9	S 141 S 160	S 1-H DPP	S M-17 DPP S 8 S 9	S 8 DPP	DPP S 1-H S M-17	S 141 TCP TPP	S B-16 S E-15 S M-17	S M-17 S E-15 TPP	TPP DPP S 1-H	S B-16 S M-17 DPP	TPP S 1-H S 8
ACRYLIC	S 1-H DPP	S 160 S 141	S 8	S 141	DBP S 9 S 1-H	S B-16 S 160	S 8 S B-16	S 160 S 141	S 141	S 141 S B-16	S M-17 S 8	S 141 S 160	DBP S 160 S B-16	S B-16 S 160 DBP
POLYSTYRENE	DPP S 9	S B-16 S 160	S 8 S 9	S 141	DPP S 9	S 141 ONB S 160	S 8 S 9 S B-16	DPP S 160	S 141	S B-16 S 141	S 9 S 160	DPP S 141	S 160 S B-16	S 160 S B-16
POLYVINYL CHLORIDE	DPP TCP S 149	S 160 S 141	S 141 S 160	S 141 S 160	DPP TCP S 140	S 141 S 160 S B-16	S B-16 S 141 S 160	S 141 TCP S 140	TCP S 140 S 141	S 141 S B-16	TCP S M-17 S 140 S 141	TCP S 140 S 141	S 160 S 141 S B-16	S 160 S 141 S B-16

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POLYVINYL BUTYRAL	DPP TCP S 140	S 160 S 141	S 160 S B-16	S 141 S 160	DPP TCP S 140	S 141 S 160 S B-16	S B-16 S 160	S 141 S 160 TCP	TCP S 140 S 141	S B-16 S 141	TCP S M-17 S 140 S 141	S 160 S 141 TCP S 140	S 160 S 141 S B-16	S 160 S 141 S B-16
POLYVINYL ACETATE	DBP TCP S B-16 S 8	TCP S 8 S B-16	S 8 TPP ONB DBP	S 141 S B-16	DMP S 1-H S M-17 DPP	S 8 TPP S B-16 DBP	S 8 DBP	S 8 S B-16 TPP	TPP TCP S 140 S 141	S 141 S B-16	S 8 S M-17 TPP	TPP S 141 TCP DPP	DBP S B-16 S 141	DBP S B-16 S 141
POLYVINYL ALCOHOL	S 9 S 8 S M-17	S 8 S M-17	S 9	S B-16	S 9 TPP	S M-17 S E-15	S 8 S 9	S 8 S M-17	TPP TCP	S M-17	S 8 S M-17	S B-16 TPP TCP	S B-16 S M-17	S B-16 S M-17
POLYVINYLIDENE-CHLORIDE					S M-17 DBP S B-16					S M-17 S B-16				
CHLORINATED RUBBER (Parlon)	TPP S 140	DBP S 141 S 160	S B-16 S 160 TPP TCP	DBP TCP S 141	TPP TCP S 140	DBP TCP S B-16 S 141	DBP S B-16 S M-17	TCP S 140 S 141 S B-16	TCP S 140 S 141 TPP	S B-16 S 141	S M-17 S 140 TCP S 141	TCP S 140 S 141 S B-16	S B-16 S 160 S 141 DBP	S B-16 S 160 S 141 DBP
CYCLIZED RUBBER (Pliolite)	TCP DBP	S M-17 S B-16 S 160 S 141	DBP TCP S B-16 TPP	S 160 S 141 S B-16	TCP S 140 TPP	S 160 S 141 S B-16 TCP	S 160 S B-16 S 141	TCP S 140 S 141	TCP S 140 TPP S 141	S B-16 S 141 S M-17	S M-17 S 140 TCP	TCP S 141 S B-16 S 160	S B-16 S 160 S 141 DBP	S B-16 S 160 S 140 DBP
CASEIN, ZEIN	S 9	S 8	S 8 S 9		S 9	S 8	S 8 S 9	S 8 S 9			S 8	S 8 S 9	S 8 S 9	S 8
POLYAMIDES (Nylon, etc.)	Santicizer 8 imparts additional flexibility. High tensile strength, abrasion resistance and oil resistance are not adversely affected. Santicizer 9 also useful—but less heat stable.													
PHENOL-FORMALDEHYDE	Santicizers 8 and 9 improve flow and adhesion.													
MELAMINE-FORMALDEHYDE	Santicizer 9 improves solution and color stability, flow, adhesion, and impact resistance of melamine coatings.													
UREA-FORMALDEHYDE	Santicizer 9 improves flow and acts as a hardening agent.													

DPP—DIPHENYL PHTHALATE TCP—TRICRESYL PHOSPHATE S—SANTICIZER TPP—TRIPHENYL PHOSPHATE DBP—DIBUTYL PHTHALATE

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TECHNICAL SERVICE

Monsanto's Organic Divisional Development Department is organized to furnish you technical assistance on plasticizing problems. Staffed by men chosen for their knowledge and practical experience with plasticizers, the Organic Development Department studies your problem thoroughly and advises you fully on specific plasticizers for your particular product. From such practical information, you may discover that new plasticizers lately developed enable you to build additional properties into your current base resins, improving your product's quality and performance. For efficient processing, a more suitable plasticizer or plasticizer combination may speed up your output or make it possible for you to simplify your operation.

This advisory service is offered by Monsanto to all who use plasticizers in their processing or product manufacture. For prompt, technical assistance, simply write or call the Development Department, Organic Chemicals Division, Monsanto Chemical Company, St. Louis, Mo.

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