Monsanto

plasticizers

uses

properties

specifications

in

- extrusions
- plastic free films
- molding compounds
- surface coatings
- adhesives
- synthetic rubber
- textile and paper coati

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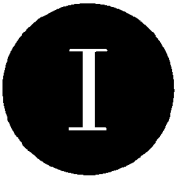
background information on plasticizers



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I

a introduction

b the Monsanto line of plasticizers

c how a plasticizer works

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introduction

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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 industries. 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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the Monsanto line of plasticizers

SANTICIZER®, HB-20: Trade Marks for Monsanto resin plasticizers.

AROCLOR®: Trade Mark for Monsanto chlorinated polyphenyls.

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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 quality control — the three factors most important to purity and stability — are closely supervised to assure optimum, dependable performance of Monsanto plasticizers serving the diverse requirements of the plastics industry.

More than half a century of 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 compounds are of five chemical types:

Adipates

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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how a plasticizer works

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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 processing stage for practically all thermoplastic resins. 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 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 nonvolatile compounds, solvents possessing much higher volatility.

Thermosetting resins in their final infusible, insoluble 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.

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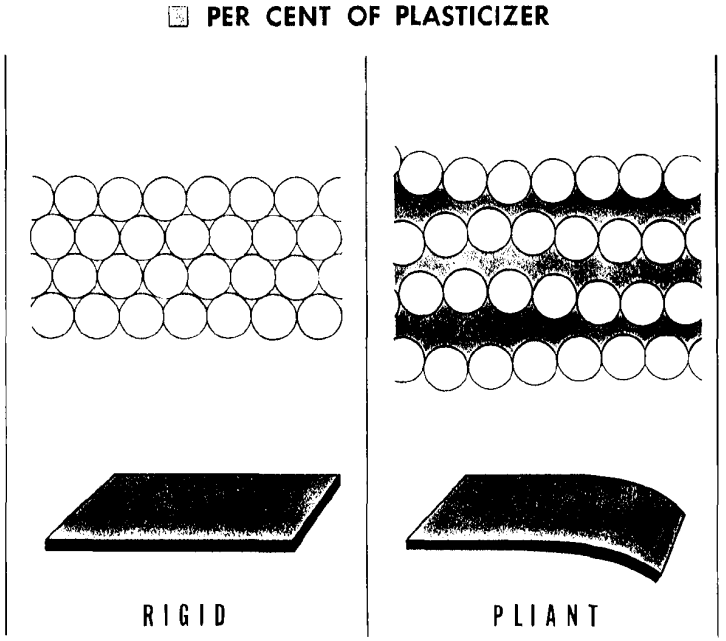
Thermoplastic resins, on the other hand, are held together by primary chemical bonds in a longitudinal direction only. These chemical bonds operate only along the length of the polymer chain. The binding forces between chains are the Van der Waal forces or secondary bonds. These between-chain bonds are of a physical rather than chemical nature and thus are more susceptible to modification by external



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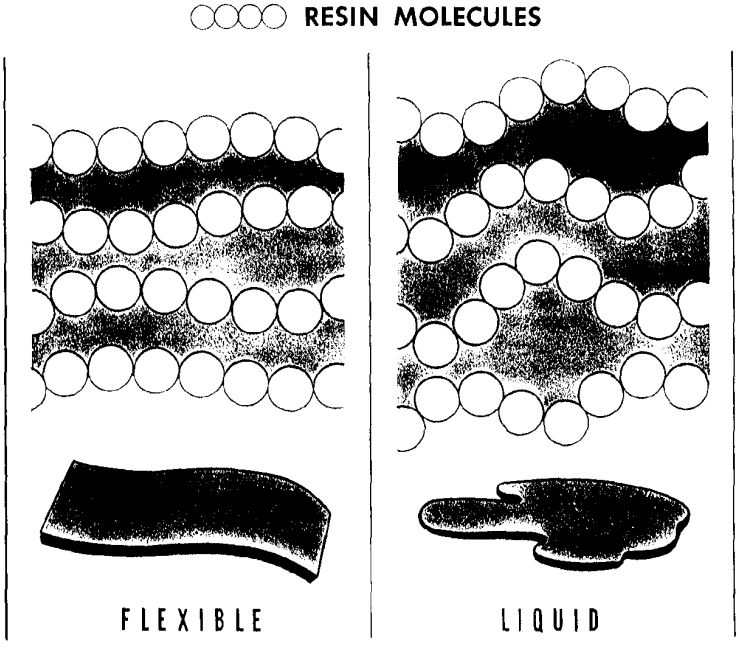
forces than primary chemical bonds. Consequently, plasticizing a thermoplastic resin consists basically of a controlled modification of the attractive forces between molecular chains. The extent of plasticizing action depends in part upon the molecular structure of the polymer and in part on the molecular structure of the plasticizer.



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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 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 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 adequately separate the polymer chains because of the strong secondary linkages or Van der Waal forces. Thus the incorporation of camphor in cellulose nitrate is aided by the action of heat and, in addition, solvents.

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Plasticizers are an essential aid in processing most resins and to impart flexibility and added toughness to the finished product. 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 through a die or into a mold. Plasticizers have made possible many uses of resins in the molding of intricate forms. By improving resin adhesion, flexibility, and outdoor durability, plasticizers also 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 stiff and no amount of plasticizing 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, efficiency and economy determine its suitability. In addition, certain plasticizers are used to impart special properties not inherent in the resin — flame retardence, for example.

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selecting the right plasticizer



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a CHOOSE THE RIGHT PLASTICIZER—TO BUILD QUALITY

1. Compatibility
2. Processing ease
3. Performance
4. Permanence
5. Special properties
   - Flame Resistance
   - Nontoxicity
   - Better Gloss
   - Good Adhesion
   - Solvent Resistance
   - Electrical Properties

b MONSANTO PLASTICIZERS FOR VINYL RESINS

1. Extrusions
2. Milled and calendered stocks
3. Plastisols and organosols
4. Polyvinyl acetate

c MONSANTO PLASTICIZERS FOR THERMOSETTING RESINS

1. Phenolics
2. Melamines
3. Ureas
4. Polyesters

d MONSANTO PLASTICIZERS FOR CELLULOSICS

1. Cellulose nitrate
2. Cellulose acetate and acetate-butyrate
3. Ethyl cellulose

e MONSANTO PLASTICIZERS FOR OTHER RESINS

1. Polystyrene latex
2. Chlorinated rubber
3. Polyamides and nylon
4. Casein and zein

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choose

the right plasticizer –

to build quality

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

1. 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.

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2. processing ease

Plasticizers differ in their solvating effects on a given resin. Those which have a strong solvating effect speed up the rates of calendering, banbury mixing, extrusion, plastisol fusion and other processing. Choosing a plasticizer which will give increased processing efficiency is an important means of reducing manufacturing costs, or of increasing production with existing equipment.

3. performance

Plasticizer choice has a profound effect on such performance characteristics of a plastic as the following: Hardness, flexibility, tensile and tear strength, abrasion resistance, flame resistance, odor, and color. The expected end-use of a plasticized resin determines the relative importance of the above factors.

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4. permanence

The "in service" performance of a plasticizer involves the factors which affect permanence; namely, low volatility, solvent resistance, good heat and light stability and resistance to migration. Generally, volatility decreases as plasticizer molecular weight increases. Heat and light stability and odor of a plasticizer depend upon its chemical type and its purity. Purity also determines plasticizer color and taste. Optimum performance qualities can be obtained by proper selection of raw materials, modern methods of manufacture and close quality control. These practices characterize Monsanto plasticizer production.

5. special properties

flame resistance
nontoxicity
better gloss
good adhesion
solvent resistance
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 imparted to end products by proper selection of plasticizers. Monsanto plasticizers may be chosen to impart flame resistance, improved electrical properties, greater low temperature flexibility, nontoxicity, improved solvent and abrasion resistance, etc. The information which follows will aid in the selection of Monsanto plasticizers for given applications and resins.

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Monsanto plasticizers

for

vinyl resins

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1. extrusions

wire and cable coatings

Monsanto's *Dioctyl Phthalate* possesses excellent electrical properties in vinyl wire and cable insulations. It is the major plasticizer for formulating Underwriter's type T and type TW 60° C. wire compound. Extender plasticizers are used to reduce cost in these formulations. *Tricresyl Phosphate* is recommended for flame retardant jacket stock and for 80° C. wire compounds. *Santicizer 160* is of value in type SPT wire insulation where advantage can be taken of its excellent processing characteristics and low cost. *HB-20* can also be used as an extender type plasticizer in these formulations. *Diisodecyl Phthalate* and *Di(n-Octyl, n-Decyl) Phthalate* are of value for compounds requiring good electrical and heat-aging properties.

hose and tubing

For garden hose a plasticizer combination of *Dioctyl Phthalate (DOP), Santicizer 160* and *Dioctyl Adipate* gives top quality. Similar quality at less cost can be obtained with *Di(n-Octyl, n-Decyl) Phthalate* and *Santicizer 160*. For beverage and hospital tubing, *Santicizer B-16* and *Santicizer 141* are completely nontoxic and most useful. *Monsanto DOP* is nontoxic and acceptable for all food applications excepting those foods which have a high fat content.

welting, gasket stocks and miscellaneous extrusions

Plasticizer combinations of *Dioctyl Phthalate, Santicizer 141* and a polymeric type plasticizer offer top quality, good processing formulations. For lower cost, quality formulations *Dioctyl Phthalate-Santicizer 160* plasticizer blends with high filler content and extended with secondary type plasticizers such as *HB-20* are useful. *Santicizer 160* is extremely useful in highly filled stocks because of its good filler-wetting and resin solvation characteristics.

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2. milled and calendered stocks

film and sheeting

For quality film a plasticizer blend of *Di(n-Octyl, n-Decyl) Phthalate* and *Santicizer 141*, stabilized with polymeric type plasticizers, offer maximum light-, flame- and extraction-resistance and ease of processing. *Santicizer 160* is used to reduce cost and improve resistance to extraction by oil and kerosene, as well as to speed up processing. *HB-20* is useful for reducing cost. A low cost flame resistant film of good quality can be made with a blend of *Dioctyl Phthalate* or *Diisodecyl Phthalate* with *Santicizer 141* or *140*, plus *Santicizer 160* and *Dioctyl Adipate*.

nontoxic films

Santicizers 141, B-16 and *E-15* are fully approved by the U. S. Bureau of Animal Industry and the U. S. Food and Drug Administration as being nontoxic for use in packaging for all types of meat and food products. Monsanto *Dioctyl Phthalate* is approved for contact with all foods except those which are fatty in nature.

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II

b

CONTINUED

sheeting

In sheeting, *Di(n-Octyl, n-Decyl) Phthalate* is a superior plasticizer for imparting permanence and excellent flexibility at a moderate cost. *Diisodecyl Phthalate* or *Dioctyl Phthalate* combined with *Santicizer 160* and either *Santicizer 140* or *141* all permit good quality medium-cost formulations. (See Monsanto Technical Bulletin 0-70: "MONSANTO PLASTICIZERS in Polyvinyl Chloride Film and Sheeting.")

floor coverings

Santicizer 160 and *140* and *Tricresyl Phosphate* are most useful in all types of vinyl flooring. These plasticizers and combinations of them tolerate large amounts of filler, process well, impart excellent permanence characteristics such as low volatility, good heat and light stability and resistance to extraction by oils, water and soaps. *Santicizer 160* and the *Phosphate Plasticizers* do not have a bluing effect during heat degradation with asbestos fillers. These plasticizers resist staining by asphalt and common food staining agents.

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3. plastisols and organosols

Di(n-Octyl, n-Decyl) Phthalate imparts to vinyl plastisols and organosols low initial viscosity and slow viscosity build-up on aging. *Diisodecyl Phthalate*, *Diisooctyl Phthalate* and *Dioctyl Phthalate* follow in this order of viscosity build-up. *Dioctyl Adipate* and *Diisodecyl Adipate*, while higher priced, are superior for low viscosity. *Santicizer 141* and *Santicizer 160* are useful in blends with *Dioctyl Phthalate* or *Di(n-Octyl, n-Decyl) Phthalate* for improving fusion characteristics and speeding up production cycles. *HB-20* is useful as an extender type plasticizer. *Ortho-Nitrobiphenyl (ONB)* finds a specialized use in plastisols for glove dipping because of its low cost and good fusion characteristics.

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4. polyvinyl acetate

coatings

For latex paint applications, *Dibutyl Phthalate* and *Santicizer 160* are recommended because of their good film formation characteristics, permanence and pigment stability. For paper coatings, *Santicizer B-16* and *Santicizer 141* are particularly recommended because of their grease resistance and nontoxicity.

adhesives

Dimethyl Phthalate, *Diethyl Phthalate*, *Dibutyl Phthalate*, *Santicizer 160*, *Tricresyl Phosphate*, *Triphenyl Phosphate*, *Santolite MHP* and *Santolite MS* all find utility in various adhesive formulations. (For details, see Monsanto Technical Bulletin No. 0-99: "MONSANTO PLASTICIZERS in Synthetic Resin Adhesives.")

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Monsanto plasticizers

for

thermosetting resins

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1. phenolics

Dibutyl Phthalate and *Santicizer 160* are recommended for plasticizing phenolics where good cold- and hot-punch characteristics are desired. *Tricresyl Phosphate* is useful for making flame-retardant laminates.

2. melamines

Santicizer 9 may be reacted with the Melamines directly, or added after their condensation to impart better flow characteristics, stability and shock resistance. Normally, from 15% to 25% of *Santicizer 9* is used.

3. ureas

Santicizer 9 is used as flow aid in the molding of urea plastics (improvement results from as little as ½% to 1%). *Santicizer 9* can also be used with ureas to improve flow characteristics and solution stability in coatings.

4. polyesters

Tricresyl Phosphate, *Santicizer 160* and *Santicizer M-17* can be used with Polyester laminating resins to improve flexibility and to lessen cracking around metallic inserts.

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Monsanto plasticizers

for

cellulosics

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1. cellulose nitrate

lacquers

Dibutyl Phthalate is the standard plasticizer for nitrocellulose lacquers. It possesses good solvent characteristics, good solvent release and satisfactory properties from the standpoint of volatility and cold check. Where lower volatility and better cold check characteristics are required, *Santicizer 160* and *Dioctyl Phthalate* are recommended. *Santicizer 160* combines low cost, excellent resistance to water and hydrocarbons, low volatility and good cold check properties. *Ortho-Nitrobiphenyl* is useful in low cost industrial coatings where good color and low odor are not prime requisites. *Santolite MHP* and *Santolite MS-80* are particularly useful because of their clarity, adhesive qualities and heat-sealing characteristics in such applications as fingernail lacquers, and heat-sealing adhesives. (See Monsanto Technical Bulletin 0-94: "SANTOLITE MHP AND SANTOLITE MS-80 Industrial Resins.")

moldings and sheeting

Camphor is the traditional plasticizer, although it has been partly replaced or extended in some instances by *Ortho-Nitrobiphenyl*.

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2. cellulose acetate and acetate-butyrate

moldings

A plasticizer blend of *Dimethyl Phthalate, Diethyl Phthalate* and *Triphenyl Phosphate* in approximately equal proportions offers optimum molding characteristics and physical properties as well as economy for cellulose acetate moldings. *Ortho-Nitrobiphenyl* is useful for reducing costs while imparting good properties.

sheeting

Santicizer M-17 yields a top quality cellulose acetate sheeting with excellent resistance to outdoor aging and good flexibility.
A plasticizer blend of *Diethyl Phthalate* and *Triphenyl Phosphate* in the ratio of 2 to 1 is also useful for good quality sheeting.

coatings

Santicizer 8 and *Santicizer M-17* are useful for coatings which are resistant to grease and aliphatic hydrocarbons.

Plasticizers of good efficiency such as *Dioctyl Phthalate* and *Dioctyl Adipate* are useful in cellulose acetate-butyrate sheeting and coatings.

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3. ethyl cellulose

moldings and sheeting

Dibutyl Phthalate and *Triphenyl Phosphate* are most useful as primary plasticizers. Low cost oils and petroleum products are used as extenders.

coatings

The phthalyl glycollates and the sulfonamide plasticizers are useful for coatings where advantage can be taken of their low toxicity and extraction resistance characteristics. Solid plasticizers such as *Diphenyl Phthalate* and *Santicizer 1-H* are useful with ethyl cellulose for making delayed-tack heat sensitive adhesives.

hot melts

Dioctyl Phthalate, Di(n-Octyl, n-Decyl) Phthalate and *Santicizer 160* are useful in ethyl cellulose hot melts for paper coatings, shoe adhesives, bookbinding adhesives, etc.

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Monsanto plasticizers

for

other resins

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1. polystyrene latex

Santicizer 160 is most useful as a plasticizer for polystyrene latices because of its good solvation characteristics, low volatility and excellent weathering properties. Plasticizer combinations of *Diethyl Phthalate* and *Aroclor 1248* are also useful as a reduced cost system with good properties.

2. chlorinated rubber

Dibutyl Phthalate and *Santicizer B-16* are useful for imparting flexibility, Monsanto Aroclors are useful for their chemical resistance, flexibilizing properties and low cost. (See Monsanto Technical Bulletin No. P-126: "Aroclors in—Pliolite S-5 Resins")

3. polyamides and nylon

The sulfonamide plasticizers (particularly *Santicizer 8*) are most useful as plasticizers which impart additional flexibility. *Santicizer 9*, a high melting point sulfonamide, is of interest in hot melt type adhesives.

4. casein and zein

Santicizer 8 is a solvent type primary plasticizer for these resins. *Santicizer B-16* and *Santicizer 141* are useful in combination with oleic acid in zein paper coatings.

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application data on various plasticizers



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III



a **Table I**

Comparative Performance, Permanence and Cost of Various Plasticizers in Polyvinyl Chloride

b **Table II**

Plasticizer Properties Imparted to Various Compatible Resins

c **Table III**

Plasticizers Most Useful With Various Compatible Resins

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comparative performance, permanence and cost of Monsanto plasticizers in polyvinyl chloride*

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III

a

TABLE I

PLASTICIZER	PHTHALATES					PHOSPHATES			ADIPATES		PHTHALYL GLYCOLLATES	
PROPERTY AND METHOD	DIBUTYL	DIOCTYL	BUTYL BENZYL (SANTICIZER 160)	DI (n-OCTYL, n-DECYL)	DIISODECYL	TRICRESYL	CRESYL DIPHENYL (SANTICIZER 140)	ALKYL DIARYL (SANTICIZER 141)	DIOCTYL	DIISODECYL	SANTICIZER 8-16	SANTICIZER M-17
LOW TEMPERATURE FLEXIBILITY, °C. (Method of Clash and Berg *Ind. & Eng. Chem.* 34, 1218)	−39°	−37°	−23°	−46	−35	−10°	−16°	−37	−65	−61	−26.5	−18
SHORE HARDNESS, "A" SCALE	72	73	72	75	75	78	77	73	70	73	76	76
FLAME-OUT TIME, SECONDS (After Heating 30 Secs. with Bunsen Burner)	—	100	45	—	—	0	0	38	100	—	—	—
VOLATILITY, % PLASTICIZER LOST (Heated 24 Hrs. at 105° C. in Freas Circulating Air Oven)	60.5	4.5	12.0	1.8	1.6	1.0	3.4	6.0	13.0	3.4	12.0	30.3
WATER EXTRACTION, % PLASTICIZER LOST (ASTM D57C-42)	0.11	0.02	0.05	0.03	0.02	0.01	0.01	0.02	0.10	0.07	0.13	0.52
KEROSENE EXTRACTION, % PLASTICIZER LOST (Extracted 96 Hrs. at 27° C.)	25.1	80.0	6.1	85.6	87.0	3.0	8.0	20.6	91.0	92.0	—	—
PLASTICIZER MIGRATION, % ABSORBED (Linde Silica Test, 1 Day at 25° C. J. R. Geenty in *Third Annual Proceedings SPI*, 1951)	—	2.0	1.6	5.1	2.0	0.4	1.5	4.0	9.5	—	2.0	
COST	MEDIUM	MEDIUM	LOW	MEDIUM	MEDIUM	MEDIUM	MEDIUM	MEDIUM	HIGH	HIGH	HIGH	HIGH

*Material Tested was 40 Mil Sheet at 40% Plasticizer Concentration.

SANTICIZER: Reg. U. S. Pat. Off.

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	PLASTICIZER	PHTHALATES								PHTHALYL GLYCOLLATES		
	PROPERTIES	DIMETHYL	DIETHYL	DIBUTYL	DIPHENYL *	BUTYL BENZYL (S. 160)	DIOCTYL & DI-ISOOCTYL	DI (n-OCTYL, n-DECYL)	DIISO-DECYL	S. S-15	S. B-16	S. M-17
PERFORMANCE	LIGHT COLOR	X	X	X	X	X	X	X	X	X	X	X
	LOW ODOR			X			X		X	X	X	X
	NONTOXICITY			**	**		**			X	X	**
	SOFTENING EFFICIENCY	X	X	X		X	X	E	X	X	X	X
	FILM FORMATION OR PROCESSING EASE	X	X	X		E	X	X	X	X	X	X
	TENSILE AND TEAR STRENGTH	X	X	X	E	E	X	X	X	X	X	X
	LOW TEMP. FLEXIBILITY	X	X	X		X	X	E	X	X	X	X
	HEAT SEALABILITY OR SENSITIVITY	X	X	X	E	X	X	X	X	X	X	X
	ELECTRICAL PROPERTIES			X		X	X	X	X			
	FLAME RESISTANCE											
PERMANENCE	LOW VOLATILITY		X	X	X	X	X	E	E		X	
	LIGHT AND HEAT STABILITY	X	X	X	X	X	X	X	X	X	X	X
	WATER OR MOISTURE RESISTANCE			X	X	X	X	X	X	X	X	X
	GREASE RESISTANCE					X				X	X	X
	NONMIGRATION	X	X	X	X	X	X	X	X	X	X	X
	NONNUTRIENT FOR FUNGI	X	X	X	X	X	X	X	X	X	X	X
	COST	LOW	LOW	MEDIUM	HIGH	LOW	MEDIUM	MEDIUM	MEDIUM	HIGH	HIGH	HIGH

*Properties considered for those resins most commonly used with the given plasticizer.

**Toxicity work indicates these compounds have a low order of toxicity. They have not yet been approved by the BAI or FDA, however.

X Denotes special value.

E Denotes exceptional value.

S. SANTICIZER: Reg. U. S. Pat. Off

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TOWOLDMON0006110
WATER_PCB-00002620

plasticizer properties imparted to various compatible resins*

PHOSPHATES				SULFONAMIDES				ADIPATES		MISCELLANEOUS	
TRIPHENYL	TRICRESYL	S. 140	S. 141	S. 1-H	S. 3	S. 8	S. 9	DIOCTYL	DI-ISODECYL	HB-20	ORTHO-NITRO-BIPHENYL (ONB)
X	X	X	X	X	X	X	X	X	X	X	
X			X	X	X		X	X	X		
			X	**							
			X			X		E	E	X	X
X	E	E	E			X				X	X
E	X	E	E	E	E	X	E	X	X	X	X
	X	X	X			X		E	E	X	
X	X	X	X	E	E	X	E	X	X	X	X
	X									X	
X	X	X	X								
E	E	E	X	X	X	X	E	X	E		
X		X	X				X	X	X		
X	X	X	X					X	X	X	X
X	X	X	X	X	X	X	X				
X	X	X		X	X	X	X			X	X
X	X	X		X	X	X	X	X	X	X	X
MEDIUM	MEDIUM	MEDIUM	MEDIUM	HIGH	MEDIUM	MEDIUM	MEDIUM	HIGH	HIGH	LOW	LOW

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WATER_PCB-00002621

		PLASTICIZER	PHTHALATES								PHTHALYL GLYCOLLATES		
		RESIN	DIMETHYL	DIETHYL	DIBUTYL	DIPHENYL	BUTYL BENZYL	DIOCTYL & DI-ISOOCTYL	DI (n-OCTYL n-DECYL)	DIISO DECYL	S. B-15	S. B-16	S. M-17
THERMOPLASTIC	VINYLS	POLYVINYL CHLORIDE AND COPOLYMERS				X	X	X	X	X		X	X
		POLYVINYL ACETATE	X	X	X	X	X					X	X
		POLYVINYL BUTYRAL					X					X	
		POLYVINYLIDENE CHLORIDE AND COPOLYMERS									X	X	
	CELLULOSICS	NITROCELLULOSE			X		X	X				X	
		CELLULOSE ACETATE	X	X							X		X
		CELLULOSE ACETATE-BUTYRATE			X			X	X				
		ETHYL CELLULOSE			X	X		X	X	X	X	X	X
	OTHER	ACRYLICS			X		X					X	X
		POLYSTYRENE				X	X	X					
		CHLORINATED RUBBER										X	
		POLYAMIDES AND NYLON										X	
		ZEIN AND CASEIN										X	
THERMOSETTING		PHENOLICS			X		X						
		MELAMINES											
		UREAS											
		POLYESTERS					X						

X Denotes special value.
S. Denotes SANTICIZER® Reg. U. S. Pat. Off.

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TOWOLDMON0006112
WATER_PCB-00002622

plasticizers most useful with various compatible resins

III

C

TABLE III

PHOSPHATES				SULFONAMIDES				ADIPATES		MISCELLANEOUS	
TRIPHENYL	TRICRESYL	S. 140	S. 141	S. 1-H	S. 3	S. 8	S. 9	DIOCTYL	DIISO-DECYL	HB-20	ORTHO-NITRO-BIPHENYL (ONB)
	X	X	X					X	X	X	X
X	X	X	X	X	X	X	X				X
			X					X	X		
X	X	X	X		X	X					X
X						X					X
X	X	X						X	X		
X	X	X	X	X	X	X	X	X	X	X	X
			X								X
						X					
			X			X					
	X	X				X	X				
							X				
		X	X								

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TOWOLDMON0006113
WATER_PCB-00002623

data on individual Monsanto plasticizers



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TOWOLDMON0006114
WATER_PCB-00002624

a **Table IV**

Chemical and Physical Properties and Specifications of Monsanto Plasticizers

b **Graph I**

Viscosity Curves for Phosphate Plasticizers: Tricresyl Phosphate, Santicizer 140 and Santicizer 141

c **Graph II**

Viscosity Curves for Phthalyl Glycollates: Santicizer B-16, Santicizer E-15 and Santicizer M-17

d **Graph III**

Viscosity Curves for Phthalate Plasticizers: Di(n-Octyl, n-Decyl) Phthalate, Diisooctyl Phthalate, Dioctyl Phthalate and Diisodecyl Phthalate

e **Graph IV**

Viscosity Curves for Phthalate Plasticizers: Dibutyl Phthalate, Diethyl Phthalate, Dimethyl Phthalate and Santicizer 160

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WATER_PCB-00002625

	PLASTICIZER	PHTHALATES					
	PROPERTY	DIOCTYL PHTHALATE	DIBUTYL PHTHALATE	DIETHYL PHTHALATE	DIMETHYL PHTHALATE	DIPHENYL PHTHALATE	SANTICIZER 160
PHYSICAL PROPERTIES	PHYSICAL FORM	CLEAR, OILY LIQUID	CLEAR, OILY LIQUID	CLEAR, MOBILE LIQUID	CLEAR, MOBILE LIQUID	WHITE POWDER	CLEAR, MOBILE LIQUID
	MOLECULAR WEIGHT	390.5	278.3	222.2	194.2	318.3	312.4
	SPECIFIC GRAVITY 25°/25° C.	0.982	1.045	1.120	1.189	1.28 DENSITY	1.116
	POUNDS PER GALLON	8.2	8.75	9.35	10	....	9.3
	CRYSTALLIZING POINT	−55° C. (GEL)	LESS THAN −35° C.	−0.3° C.	0° C.	69 C.	LESS THAN −35° C.
	BOILING POINT (760 MM)	386° C. (APP.) 230° C. 5MM	340° C.	298° C.	282° C.	405° C.	370° C. (APPROX.)
	FLASH POINT, CLEVELAND OPEN CUP	425° F.	340° F.	305° F.	300° F.	435° F.	390° F.
	REFRACTIVE INDEX, 25° C.	1.4840	1.4915	1.5002	1.5138	1.572	1.5356
SPECIFICATIONS	APPEARANCE	CLEAR, OILY LIQUID	CLEAR, OILY LIQUID	CLEAR, WATER-WHITE OILY LIQUID	CLEAR, WATER-WHITE OILY LIQUID	ESSENTIALLY WHITE FUSED SOLID	CLEAR, OILY LIQUID
	COLOR, APHA	25 MAX.	20 MAX.	10 MAX.	10 MAX.	....	40 MAX.
	ODOR	CHARACTERISTIC	SLIGHT	SLIGHTLY AROMATIC	SLIGHTLY AROMATIC	....	SLIGHT, CHARACTERISTIC
	REFRACTIVE INDEX, 25° C.	1.4810-1.4880	1.4905 ±0.001	1.5000 ±0.0001	1.5133 ±0.001	....	1.534 TO 1.538
	SPECIFIC GRAVITY 25°/25° C.	0.980-0.985	1.045 ±0.001	1.117 ±0.005	1.189 ±0.001	....	1.113 TO 1.120
	ACIDITY	AS PHTHALIC ACID, 0.01% MAX.	0.01% MAX. AS PHTHALIC ACID	0.01% MAX. AS PHTHALIC ACID	0.01% MAX. AS PHTHALIC ACID	0.20% MAX. AS PHTHALIC ACID	0.02% MAX. AS PHTHALIC ACID
	OTHER		ESTER ASSAY 99% MIN.	ESTER ASSAY, 99% MIN.	ESTER ASSAY 99% MIN.	FREE PHENOL 0.20% MAX. ASH 0.05% MAX. MOISTURE 0.50% MAX.	ESTER ASSAY 98% MIN.

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WATER_PCB-00002626

			PHOSPHATES				SULFONAM		
DIISOOCTYL PHTHALATE	DIISODECYL PHTHALATE	DI(n-OCTYL, n-DECYL) PHTHALATE	TRICRESYL PHOSPHATE	TRIPHENYL PHOSPHATE	SANTICIZER* 140	SANTICIZER 141	SANTICIZER 3	SANTICIZER 8	SANTIC 9
OILY LIQUID	CLEAR, OILY LIQUID	CLEAR, OILY LIQUID	CLEAR, MOBILE LIQUID	WHITE FLAKES	CLEAR, MOBILE LIQUID	CLEAR, MOBILE LIQUID	PRACTICALLY WHITE SOLID	CLEAR, VISCOUS LIQUID	FINE GRANU PARTICL
390.5	446.3	418.3	368.4	326.4	340.3	362.4	199.3	199.3	171.
0.982	0.9650	0.9730	1.162	1.268 (AT 60/20° C.)	1.208	1.090	1.253 DENSITY	1.190	1.35 DENSI
8.2	8.05	8.1	9.7	....	10 (APPROX.)	9.1	....	9.92	....
−45° C.	−53° C.	−30° C.	LESS THAN −35° C.	49° C.	LESS THAN −35° C.		59.0° C. (MELTING POINT)	LESS THAN 0° C.	105° (MELTING
233° C. AT 5 MM	249°-256° C. AT 4 MM	232°-267° C. AT 5 MM	420° C.	370° C.	390° C.	375° C.	340° C.	340° C.	360°
430° F.	450° F.	426° F.	470° F.	437° F.	450° F.	435° F.	371° F.	345° F.	420°
1.4840	1.4844	1.4820	1.556	1.550 (AT 60° C.)	1.560	1.508	1.522 (AT 65° C.)	1.540	
CLEAR, OILY LIQUID	CLEAR, OILY LIQUID	CLEAR, OILY LIQUID	CLEAR, OILY LIQUID	WHITE FLAKES	CLEAR, MOBILE LIQUID	CLEAR, MOBILE LIQUID	PRACTICALLY WHITE SOLID	LIGHT YELLOW, VISCOUS LIQUID	
35 MAX.	100 MAX.	50 MAX.	40 MAX.	20 MAX. (MOLTEN)	40 MAX.	100 MAX	60 MAX. (MOLTEN)	200 MAX.	
CHARACTERISTIC	SLIGHT, CHARACTERISTIC	SLIGHT, CHARACTERISTIC	SLIGHT CHARACTERISTIC	VERY FAINTLY AROMATIC	ESSENTIALLY ODORLESS	SLIGHT, SWEET		SLIGHT, CHARACTERISTIC	
1.4810-1.4880	1.4794-1.4864	1.4785-1.4855			1.560 ±0.010	1.507-1.510	1.512-1.532 (AT 65° C.)		
0.980 TO 0.985	0.9645-0.9665	0.968 TO 0.977	1.157 TO 1.173		1.208 ±0.005	1.089-1.093	1.166-1.176 (AT 65/65° C.)		
0.01% MAX. AS PHTHALIC ACID	0.01% MAX. AS PHTHALIC ACID	0.01% MAX. AS PHTHALIC ACID	0.01% MAX. AS H_3PO_4	0.003% MAX. AS H_3PO_4	0.01% MAX. AS H_3PO_4	0.01% MAX. (AS PHOSPHORIC)	0.1% MAX. (AS ACETIC)	0.1% MAX AS ACETIC	
			PERMANGANATE TEST NO CHANGE WITHIN ½ HOUR	PERMANGANATE TEST NO CHANGE WITHIN ½ HOUR					

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*REG. U. S. PAT. OFF.

TOWOLDMON0006117
WATER_PCB-00002627

chemical and physical properties and specifications of Monsanto plasticizers

IV a

TABLE I

I D E S	PHTHALYL GLYCOLLATES			SPECIALTY PLASTICIZERS		ADIPATES	
SANTICIZER 1-H	SANTICIZER E-15	SANTICIZER 8-16	SANTICIZER M-17	ORTHO-NITROBIPHENYL (ONB)	HB-20	DI(2-ETHYL-HEXYL) ADIPATE	DIISODECYL ADIPATE
WHITE CRYSTALS	CLEAR, OILY LIQUID	CLEAR, OILY LIQUID	CLEAR, MOBILE LIQUID	LIGHT YELLOW TO REDDISH CRYSTALLINE SOLID, OR LIQUID	PRACTICALLY COLORLESS, OILY LIQUID	CLEAR, OILY LIQUID	CLEAR, OILY LIQUID
253	280.3	336.4	266.3	199.2		370.6	426.6
1.125 DENSITY	1.180	1.097	1.220	1.203		0.927	0.919
....	9.85	9.15	10.2	10.0	8.1	7.7	7.6
86°-87° C.	20° C.	LESS THAN −35° C.	LESS THAN −35° C.	34.5° C. MIN.			
350° C.	320° C.	345° C.	310° C.	330° C. (APPROX.)	BOILING RANGE 320-360° C.	214° C. AT 5 MM.	240° C. AT 5 MM.
	386° F.	390° F.	380° F.	289.5° F.	160° C.	377° F.	425° F.
	1.498	1.490	1.504	1.613 (APPROX.)	1.5470	1.446	1.450
YELLOWISH-BROWN FUSED MASS	CLEAR, WATER-WHITE, OILY LIQUID	CLEAR, PRACTICALLY WHITE, OILY LIQUID	CLEAR, MOBILE LIQUID	LIGHT YELLOW TO DARK BROWN SOLID OR LIQUID	PRACTICALLY COLORLESS OILY LIQUID	CLEAR LIQUID	CLEAR LIQUID
250 MAX. (MOLTEN)	20 MAX.	45 MAX.	20 MAX.		110 MAX.**	100 MAX.	100 MAX.
	SLIGHT	CHARAC-TERISTIC, SLIGHT ODOR	SLIGHT CHARAC-TERISTIC		FAINT AND PLEASANT	MILD	MILD
	1.498 ±0.002	1.490 ±0.002	1.504 ±0.002		0.968 0.974 (25°/15.5° C.)	1.444—1.448	1.4503—1.4507
	1.182 ±0.003	1.098 ±0.005	1.220 ±0.005		1.5475 ±0.0005	0.927 ±0.003 (20°/20° C.)	0.919 ±0.003 (20°/20°C.)
	0.02% MAX. AS ACETIC	0.02% MAX. AS ACETIC	0.02% MAX. AS ACETIC			0.5 MEQ. PER 100 GM. MAX.	0.5 MEQ. PER 100 GM. MAX.
CRYSTALLIZING POINT 83.5° C. MIN.				CRYSTALLIZING POINT 34.5° C. MIN.			

**DARKENS ON EXPOSURE TO SUNLIGHT

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TOWOLDMON0006118
WATER_PCB-00002628

chemical and physical properties and specifications of Monsanto plasticizers

IV a TABLE IV

PLEASE TURN PAGE

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viscosity curves for PHOSPHATE PLASTICIZERS:

Tricresyl Phosphate

Santicizer 140

and Santicizer 141

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TOWOLDMON0006120
WATER_PCB-00002630

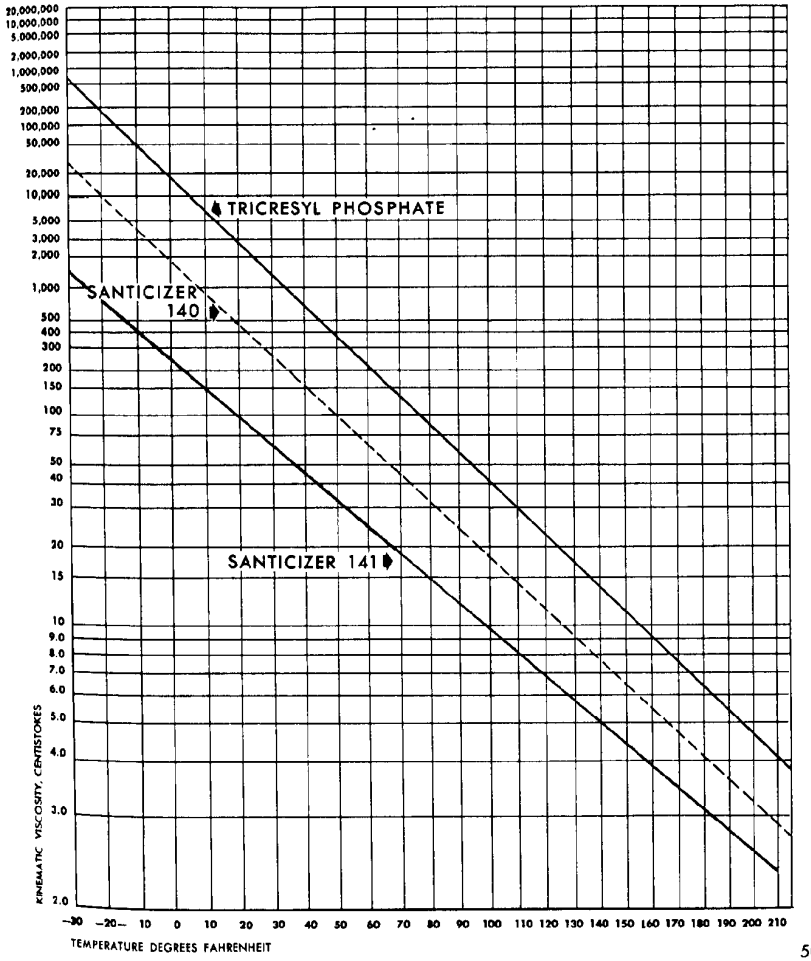
IV

b

GRAPH I

VISCOSITY CURVES FOR PHOSPHATE PLASTICIZERS

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



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viscosity curves for PHTHALYL GLYCOLLATES:

Santicizer B-16

Santicizer E-15

and Santicizer M-17

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TOWOLDMON0006122
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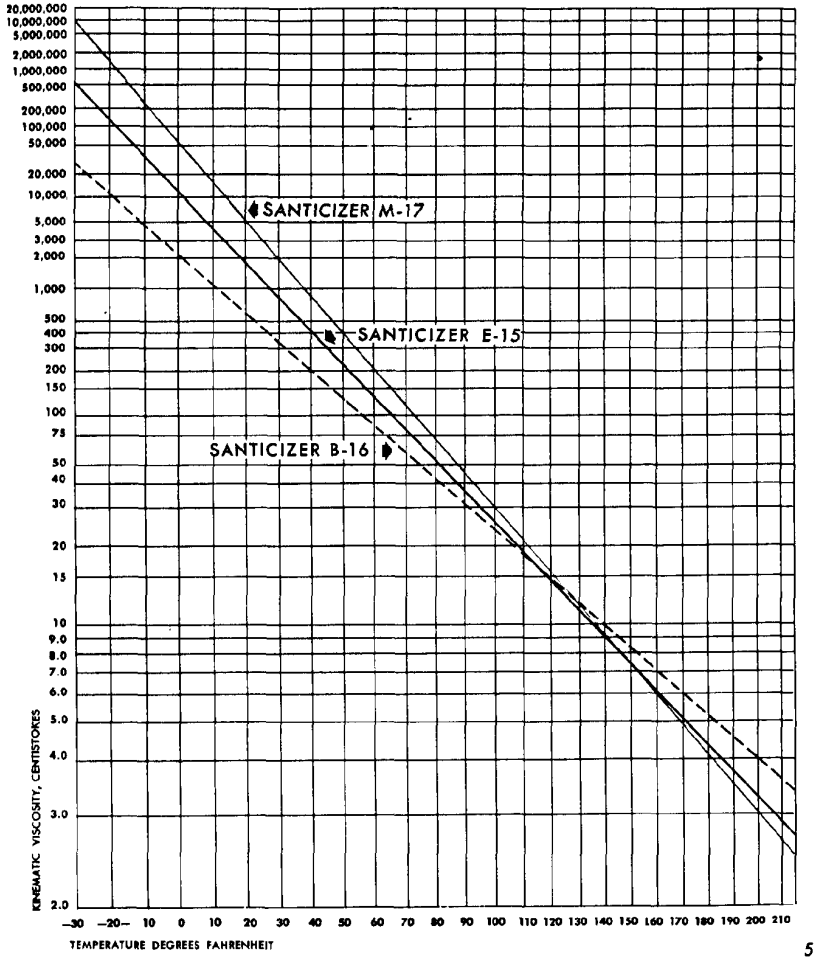
IV

C

GRAPH II

VISCOSITY CURVES FOR PHTHALYL GLYCOLLATES

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



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viscosity curves for PHTHALATE PLASTICIZERS:

Di(n-Octyl, n-Decyl) Phthalate

Diisooctyl Phthalate

Dioctyl Phthalate

and Diisodecyl Phthalate

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TOWOLDMON0006124
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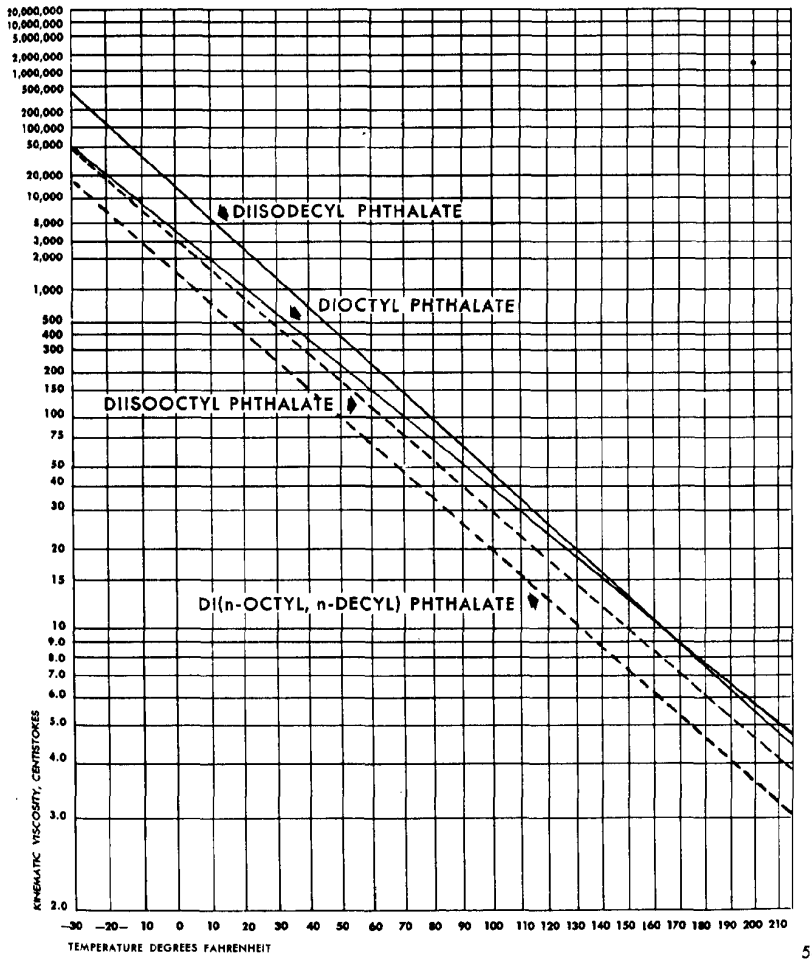
VISCOSITY CURVES FOR PHTHALATE PLASTICIZERS

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



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TOWOLDMON0006125
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viscosity curves for PHTHALATE PLASTICIZERS:

Dibutyl Phthalate

Diethyl Phthalate

Dimethyl Phthalate

and Santicizer 160

0614676

TOWOLDMON0006126
WATER_PCB-00002636

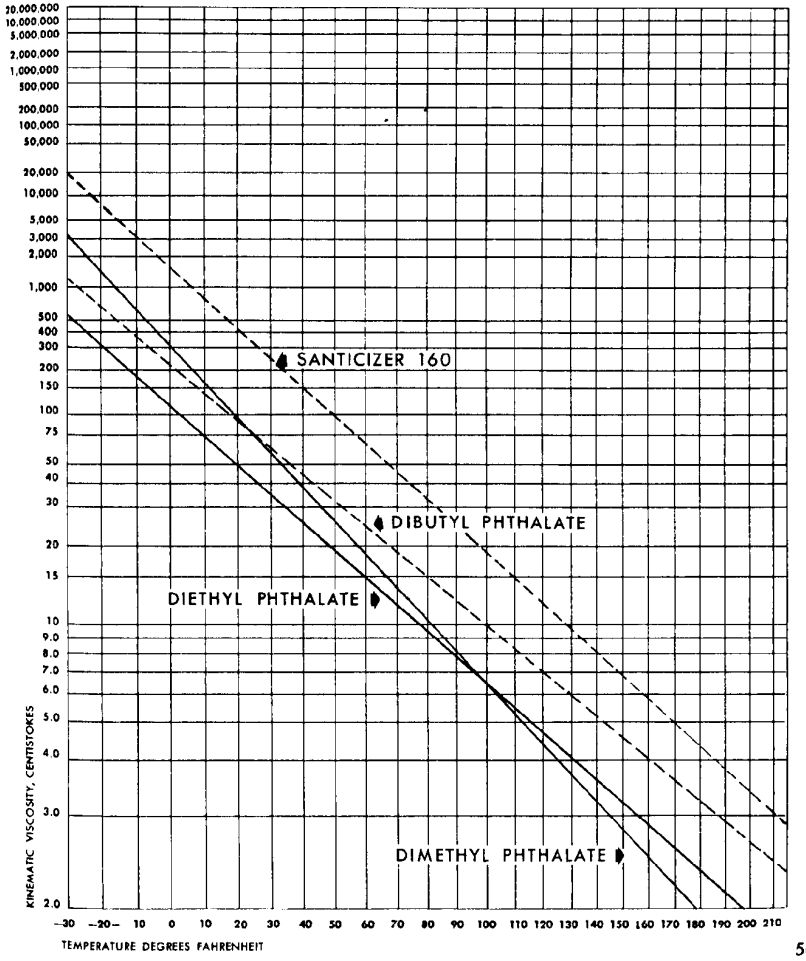
IV

e

GRAPH IV

VISCOSITY CURVES FOR PHTHALATE PLASTICIZERS

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



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supplementary information



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TOWOLDMON0006128
WATER_PCB-00002638



a Literature Available on Monsanto Plasticizers

b Technical Service Available

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TOWOLDMON0006129
WATER_PCB-00002639

literature available on Monsanto plasticizers

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TOWOLDMON0006130
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The following technical bulletins, data sheets and booklets give technical information on the properties and applications of various Monsanto plasticizers and resins. Literature items are available upon request.

ADIPATE PLASTICIZERS

Technical Bulletin O-106:	DIOCTYL ADIPATE (DOA)
Technical Bulletin O-113:	DIISODECYL ADIPATE

PHTHALATE PLASTICIZERS

Technical Bulletin O-82:	DIOCTYL PHTHALATE (DOP)
Technical Bulletin O-108:	DIISODECYL PHTHALATE (DIDP)
Technical Bulletin O-109:	DI(n-OCTYL, n-DECYL) PHTHALATE (DNODP)
Technical Bulletin O-92:	SANTICIZER 160 (Butyl Benzyl Phthalate)

PHOSPHATE PLASTICIZERS

Technical Bulletin O-88:	SANTICIZER 140
Technical Bulletin O-89:	SANTICIZER 141—The Nontoxic Plasticizer

SULFONAMIDE PLASTICIZERS

Technical Bulletin O-81:	SANTICIZER 3
Technical Data Sheet:	SANTICIZER 8—Use in Adhesives
Technical Data Sheet:	SANTICIZER 8—Use in Coatings
Technical Data Sheet:	SANTICIZER 8—Use in Moldings

Other Plasticizers

Technical Bulletin O-78:	Ortho-NITROBIPHENYL Plasticizer and Chemical Intermediate
Technical Bulletin OD-700:	Ortho-NITROBIPHENYL Toxicity Data
Bulletin O-P-115:	AROCLORS
Bulletin O-P-153:	HB-20, EXTENDER TYPE VINYL PLASTICIZER

Application Literature

Technical Bulletin O-69:	BULK TANK STORAGE OF PLASTICIZERS (Describes mechanical and safe handling procedures)
Technical Bulletin O-70:	MONSANTO PLASTICIZERS in Polyvinyl Chloride Film and Sheeting
Technical Bulletin O-99:	MONSANTO PLASTICIZERS in Synthetic Resin Adhesives
Booklet:	Faster Processing of Polyvinyl Chloride With Monsanto Plasticizers
Technical Bulletin O-94:	SANTOLITE MHP and SANTOLITE MS-80% (Monsanto Industrial Resins)
Technical Bulletin O-16:	SANTOMASK II (odor masking agent)

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technical service available

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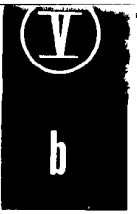

The Plasticizer Sales Department of Monsanto's Organic Chemicals Division is organized to furnish you technical assistance with plasticizing and processing problems. Staffed by men chosen for their knowledge and practical experience with plasticizers, the Plasticizer Sales Department is equipped to study your problem thoroughly and to give advice based on the latest developments in the plasticizer field. From such practical advice you may discover that newly developed plasticizers may enable you to build into your product the exact qualities desired, or they may permit you to boost production with the same equipment you are using. The right combination of plasticizers may allow important processing simplifications.

Augmenting this technical assistance on a personal basis is an increasing amount of technical literature which brings to you the latest developments from Monsanto's plasticizer research laboratories.

Technical assistance is offered to all who use plasticizers in their manufacturing processes. For prompt technical assistance, simply write or call MONSANTO CHEMICAL COMPANY, Plasticizer Sales Department, 800 North Twelfth Boulevard, St. Louis 1, Missouri.

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WATER_PCB-00002643



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

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