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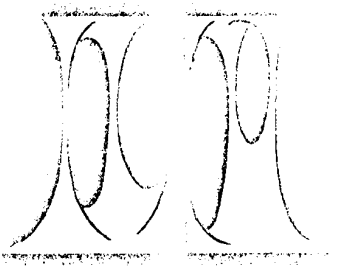
PLASTICIZERS IN SYNTHETIC RESIN ADHESIVES



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SYNTHETIC-RESIN ADHESIVES—A GROWING MARKET

Consumption of synthetic-resin adhesives is rapidly expanding both because of continuing displacement of older gluing materials in steadily-growing uses and because of the introduction of many new applications for which conventional adhesives are unsuitable. Superior performance of the synthetic-resin adhesives has enabled them to supplant conventional adhesives based on natural products in many large-volume applications. Wide-spread and increasing usage of synthetic-resin adhesives is foreseen in such diverse industries as the following:

Shoe manufacturing

Book binding

Paper-bag and folding-box-carton manufacturing

Food-container production

Food packaging (labeling, sealing, wrapping, etc.)

Tobacco packaging

Specialty product packaging

Automobile production

Building construction

Use of the proper plasticizer in synthetic-resin adhesives — to best accomplish the desired purpose of the adhesive for its intended application — is extremely important. The plasticizer in an adhesive formulation improves film formation; imparts tack, flexibility, and gloss; decreases drying time; and lowers production costs.

More synthetic-resin adhesives are used today than ever before because:

- Synthetic-resin adhesives adapt well to high-speed sealing and labeling machines, thereby increasing production rates.
- Synthetic-resin adhesives are cleaner, easier to use. They keep maintenance costs down.
- Synthetic-resin adhesives resist deterioration caused by water, light, and fungus much better than the usual adhesives based on natural proteinaceous materials.
- Adhesive emulsions require no volatile, toxic, or flammable solvents. Emulsion properties are easily adjusted and controlled.

Monsanto Chemical Company, a major supplier of plasticizers for synthetic-resin adhesives, offers plasticizers that are efficient, heat and light stable, and non-toxic. Lack of toxicity is especially important now in food applications because of the 1958 amendment to the Federal Pure Food, Drug, and Cosmetic Act. Monsanto plasticizers impart excellent grease resistance and heat

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sealability to the adhesive. Because of the great variety of Monsanto plasticizers, customers can realize lower costs by taking advantage of mixed shipments.

This bulletin suggests typical formulations for various adhesive applications and describes the benefits to be derived from the use of plasticizers in synthetic-resin adhesives. If you need additional assistance, experienced Monsanto technical representatives are always ready to help you with your special formulation problems. Since Monsanto does not have a vested interest in any particular plasticizer, you are assured of advice directed toward achievement of the best possible performance of your product.

DEVELOPMENT OF SYNTHETIC-RESIN ADHESIVES

Not long ago industrial users or consumers could choose among only a few naturally derived materials for their adhesive applications. Constant industrial demand for adhesives with greater strength, faster tack, and greater versatility for bonding many types of surfaces forced the development of synthetic-resin adhesives. With the great number of excellent adhesives now available, both industry and consumers have a much wider choice and are more likely to obtain suitable adhesives to fill specialized needs.

Only synthetic-resin adhesives are able to tolerate extreme exposure conditions. They withstand temperatures that quickly destroy natural materials, and they bond surfaces — such as rubber and metal — that normally defy bonding. From 1946 to 1956, synthetic-resin adhesives gained dominance among adhesives in major construction. For nearly any fastening job, a good synthetic-resin adhesive is now available.

Synthetic-resin adhesives commonly used are based on vinyl polymers (polyviny acetate, polyvinyl alcohol, and polyvinyl chloride); on condensation resins (urea-formaldehyde, melamine-formaldehyde, phenol-formaldehyde, resorcinol-formaldehyde); on cellulose derivatives; polyesters; elastomers; and epoxies. Addition of plasticizers generally modifies an adhesive to suit a particular need.

TYPES OF RESIN-ADHESIVE FORMULATIONS

The major types of plasticized synthetic-resin-adhesive formulations are emulsion, hot-melt, delayed-tack, solution, pressure-sensitive, and adhesive primers or coatings. These types will be discussed in order. Suppliers of special ingredients are listed at the end of this bulletin.

EMULSION ADHESIVES

Resin-emulsion adhesives are emulsions of plasticized or unplasticized resins dispersed in a water base. They offer the advantages of reduced fire and toxicity hazard because of the elimination of volatile, flammable, and possibly toxic solvents.

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POLYVINYL ACETATE ADHESIVES

The widely-used polyvinyl acetate-emulsion adhesives possess quick tack, good adhesion to many surfaces, grease resistance, non-toxicity, and many other desirable features.

Monsanto Plasticizers for polyvinyl acetate-emulsion adhesives

Monsanto liquid plasticizers most commonly used in the polyvinyl acetate-emulsion adhesives are *Santicizer** 160, dibutyl phthalate, *Aroclor** *1221*, *Aroclor 1232*, *Aroclor 1242*, dimethyl phthalate, diethyl phthalate, tricresyl phosphate, *Santicizer* 140, *Santicizer* 141, *Santicizer* M-17, *Santicizer* B-16, *Santicizer* E-15, and *Santicizer* 8.

Dibutyl phthalate imparts good flexibility and softening action with relatively low volatility.

Santicizer 160 is considered better than dibutyl phthalate in most applications because of lower volatility, improved moisture resistance, and film toughness.

Diethyl phthalate is used for fast-tack, non-toxic applications.

The *Aroclor* plasticizers impart quick tack, good adhesion to many surfaces, and are widely used in commercial adhesives either as extender plasticizers or alone to make versatile, low-cost adhesives.

Dimethyl phthalate is preferred in polyvinyl acetate adhesives for bonding cellulose acetate film or sheeting because of its better solvency action on the cellulose acetate. Uses for this type of adhesive include covering cut-out windows in cartons or for laminating paper.

Santicizer 140, *Santicizer* 141, and tricresyl phosphate are used when flame resistance, oil resistance, and low volatility are desired. *Santicizer* 141 is most efficient in polyvinyl acetate adhesives, followed by *Santicizer* 140 and tricresyl phosphate.

For bonding overlays of paper, *Santicizer* M-17 is frequently used for its superior light stability, quick tack, and solvency on cellulose acetate.

Santicizer 8 imparts excellent grease resistance, good flow and wetting action, and improves the bonding of rubber to metal.

Monsanto's solid plasticizers, *Santicizer* 1-H, *Santicizer* 9, diphenyl phthalate, dicyclohexyl phthalate, and *Aroclor* 5460, are frequently used in polyvinyl acetate-emulsion adhesives to impart better heat-sealing characteristics. They also improve moisture and solvent resistance.

For nontoxic adhesives, *Santicizer* B-16, *Santicizer* E-15, *Santicizer* 141, and diethyl phthalate have been accepted by the U. S. Bureau of Animal Industry and the Food and Drug Administration. Typical illustrations of the use of these products include adhesives for food-wrapping films, boxboard manufacture, and envelope adhesives.

Table 1 on page 5 lists performance data of Monsanto plasticizers in polyvinyl acetate.

*Aroclor, Santicizer: Monsanto Chemical Company trademarks. Registered in U.S. Patent Office.

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Table I. PERFORMANCE OF MONSANTO PLASTICIZERS IN POLYVINYL ACETATE-EMULSION ADHESIVES

Plasticizer[a]	Volatility 20 Hours at 87° C (Activated Carbon) (per cent)	Low-Temp. Flexibility (Modified Clash & Berg Test) (° C)	Oil Extraction—Weight Loss After 24 Hours at Room Temperature (per cent)		
			Kerosene	Peanut Oil	Cotton-Seed Oil
Aroclor 1221	5.2	—5.0	0.63	—	—
Aroclor 1232	4.8	4.0	0.54	—	—
Aroclor 1242	4.4	5.3	0.57	—	—
Triphenyl Phosphate	2.0	5.7	0.02	0.37	0.38
Tricresyl Phosphate	0.75	3.6	0.16	0.38	0.46
Dimethyl Phthalate	5.6	—1.6	0.92	0.75	0.93
Diethyl Phthalate	4.8	—5.0	0.85	0.63	0.82
Dibutyl Phthalate	4.4	—6.1	0.59	0.51	0.59
Diphenyl Phthalate	5.9	—	1.31	0.90	0.98
Santicizer B-16	2.2	—3.9	0.08	0.46	0.36
Santicizer M-17	3.6	1.5	0.19	0.50	0.48
Santicizer 1-H	1.5	—	0.96	0.36	0.53
Santicizer 8	3.6	6.4	0.43	0.60	0.64
Santicizer 9	3.1	—	1.13	0.57	0.63
Santicizer 140	1.2	5.0	0.15	0.34	0.36
Santicizer 141	1.8	—3.3	0.17	0.42	0.31
Santicizer 160	2.1	1.9	0.20	0.39	0.34

[a] Formulation: 11 parts plasticizer in 100 parts Gelva S-55 (polyvinyl acetate) emulsion. Film thickness 0.040 inch.

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Monsanto Rosin Additives for Polyvinly Acetate Adhesives

Monsanto industrial resins, *Santolite** MHP and *Santolite* MS-80%, when used to modify polyvinyl acetate adhesives, give a very tough but flexible product. They impart quick tack and adhesion to a wide variety of surfaces. Normally, they are compounded with a liquid plasticizer, such as dibutyl phthalate or *Santicizer* 160, or with an eutectic mixture (1:1) of dibutyl phthalate and triphenyl phosphate.

The *Santolite* resins are especially useful to bond cellophane or aluminum foil to paper.

Monsanto Preservatives and Odor-Masking Agents for Polyvinyl Acetate Adhesives

Monsanto supplies a complete line of industrial preservatives including *Santobrite**, Monsanto's Penta (pentachlorophenol), and technical sodium benzoate. These materials are useful in preventing fungus attack on the adhesive if natural materials, subject to fungus attack, are incorporated in the formulation.

Monsanto odor-masking agents for polyvinyl acetate include *Santomask** II, methyl salicylate, coumarin, and vanillin.

Literature on these products is available on request.

Polyvinyl Acetate-Adhesive Formulations

Polyvinyl acetate-emulsion adhesives range in complexity from simple blends of polyvinyl acetate and plasticizer to more complex formulations involving many ingredients.

Formula No. 1, presented as a guide to general polyvinyl acetate-emulsion adhesives, illustrates the types and range of concentrations of ingredients that may be incorporated for various adhesive applications. (An index of formulation ingredients and their suppliers begins on page 24.)

Formula 1—General Polyvinyl Acetate-Emulsion Adhesive

Ingredient	Parts by Weight
Polyvinyl acetate emulsion (55% solids)	100
Plasticizer	10 - 50
Clay filler	0 - 30
Cooked starch or dextrine	0 - 1000
Preservative	0 - 2
Stabilizer	0 - 2
Wetting Agent	0 - 0.2
Secondary Water	0 - 100
Defoamer	0 - 2
Odorant (masking agent)	0 - 1

*Santolite; Santobrite; Santomask: Monsanto Chemical Company trademarks. Registered in U.S. Patent Office.

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Formulas 2 through 6 illustrate five of the most widely used applications for polyvinyl acetate adhesives.

Formula 2—Quick-Tack Polyvinyl Acetate-Emulsion Adhesive

Ingredient	Parts by Weight
Gelva S-55 polyvinyl acetate emulsion	100
Santicizer 160	12
Santicizer 8	12
Water	9.0

Formula 3—Polyvinyl Acetate Adhesive or Glue for Wood

Ingredient	Parts by Weight
Gelva S-55 polyvinyl acetate emulsion	95
Santicizer 160 or dibutyl phthalate	3
Water	2

Formula 4—Low-Cost, Quick-Tack Polyvinyl Acetate Adhesive

Ingredient	Parts by Weight
Gelva S-55 polyvinyl acetate emulsion	100
Aroclor 1232	11

Formula 5—Typical Polyvinyl Acetate Combining Adhesive

Ingredient		Parts by Weight
Polyco 117 H		64.9
Dibutyl phthalate		26.6
Water		8.5
Solids content	62.5	
Viscosity	2500 - 3000 centipoises	

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Formula 6 Illustrates a Polyvinyl Acetate Adhesive for Padding

Ingredient	Parts by Weight
Polyco 117-H	42.3
Tricresyl phosphate	11.6
Water	4.6
Polyco 118	41.5

Add Polyco 118 to 117-H with good agitation. Then slowly add tricresyl phosphate with high-speed agitation. Blend water slowly.

Solids content	40
Viscosity	4000 - 5000 centipoises

For bonding moisture-proof cellophane to aluminum foil or paper or for bonding aluminum foil to paper, Formula 7 is especially useful. Adhesion develops rapidly, and good bond strength is maintained at high temperatures.

Formula 7—Polyvinyl Acetate-Emulsion Adhesive for Cellophane, Aluminum Foil, and Paper

Ingredient	Parts by Weight
Gelva S-55 polyvinyl acetate emulsion	100
Santicizer 160	9
Santolite MS-80%	13.5
Water	13.4

Polyvinyl acetate emulsions are used for grease-proof coatings on paper. Although Formula 8, for "flatboard," and Formula 9, for "flexible board," are not used in true adhesive applications, they are included to show the versatility of Monsanto's plasticizers in polyvinyl acetate formulations.

Ingredient	Parts by Weight Formula 8	Formula 9
Elvacet 81-900 polyvinyl acetate emulsion	100.0	100.0
Santicizer 141	8.25	13.75
York Whiting No. 7, superfine calcium carbonate	119.25	96.75
Rutile titanium dioxide	13.25	10.75
Tamol 731 dispersing agent (25% aq. soln.)	2.1	1.8
Elvanol 71-30 polyvinyl alcohol (10% aq. soln.)	30.0	30.0
Poly-G P-1200 polypropylene glycol	1.0	1.0
Water	34.0	34.0

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Properties	Formula 8	Formula 9
Total solids	65	65
Viscosity (26° C), centipoises	1600	2700
Pigment-to-binder ratio	2:1	1.5:1
PVAc resin-to-PVA resin ratio	18:1	18:1
PVAc resin-to-plasticizer ratio	6.6:1	4:1

To prepare these grease-proof coatings, the following procedure is suggested:

1. Prepare a stock solution by mixing polyvinyl alcohol in water at room temperature. Heat for 30 to 40 minutes at 185° to 190° F. The water required to adjust the solids content may be added to this stock solution.
2. Continue stirring, and add the *Santicizer* 141, Poly-G P-1200 defoamant, and Tamol 731 pigment-dispersant solution.
3. Add the pigments, stirring until dispersion is complete.
4. Add the polyvinyl acetate emulsion, and stir until a homogenous mixture is obtained.

A grease-resistant coating for wrapping papers, such as used for bakery goods, is illustrated in Formula 10. The composition may be applied with a roller coater provided with a smoothing roll to give a uniform, continuous film. About 140° F is required for optimum film formation, if it is to be used as a laminating adhesive.

Formula 10—Polyvinyl Acetate Grease-Resistant Paper Coating

Ingredient	Parts by Weight
Elvacet 81-900 polyvinyl acetate emulsion	100
Santicizer B-16	3.5
Titanium dioxide	7.0
Water	15 - 30
Quilon	0 - 5

For many applications, incorporation of a solid plasticizer to provide rapid heat-sealing is desirable. Formulas 11, 12, and 13 illustrate the technique of dispersing diphenyl phthalate, *Santicizer* 1-H, and triphenyl phosphate, respectively, in water, for convenient incorporation into a polyvinyl acetate adhesive.

Ingredient	Parts by Weight		
	Formula 11	Formula 12	Formula 13
Diphenyl phthalate	100	—	—
Santicizer 1-H	—	100	—
Triphenyl phosphate	—	—	100
Water	100	100	100
Polyvinylpyrollidone	4.7	4.4	4.4
Carboxymethylcellulose	1.3	1.3	1.3

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The procedure for preparation of these formulations is as follows:

1. Grind the solid plasticizer with dry ice to the desired particle size. The dry ice prevents coagulation of the solid plasticizer as a result of softening from frictional heat.

2. Add the thickening agents to the water, and agitate this mixture until solution is effected.

3. Slowly add the solid plasticizer to the water-thickener mixture with good agitation. This dispersion may be used in any desired polyvinyl acetate-emulsion formulation.

POLYSTYRENE-EMULSION ADHESIVES

Use of polystyrene-emulsion adhesives is increasing. *Santicizer* 160, *HB-40**, diethyl phthalate, dibutyl phthalate, *Aroclor* 1242, *Aroclor* 1248, and *Aroclor* 1254 are extensively used as plasticizers for this resin in adhesive emulsions.

Formula 14 illustrates a basic styrene-emulsion adhesive that is stable and has a high degree of wet tack. The caseinate imparts stability, wet tack, and film toughness. These properties may be varied by alteration of the caseinate concentration.

Formula 14—Styrene-Emulsion Adhesive

Ingredient	Parts by Weight
*Lustrex** Styrene 601-40	100
HB-40	18.0
Diethyl phthalate	5.0
Triton X155	2.5
Ammonium caseinate, 15% aqueous	34.0

HOT-MELT ADHESIVES

Hot-melt adhesives are utilized because they set rapidly after application. The molten adhesive is applied to the materials to be joined; the bond sets before the adhesive is cool.

Plasticizers play an important part in the successful manufacturing and application of hot-melt adhesives. Liquid plasticizers, such as *Santicizer* M-17, *Santicizer* 160, dibutyl phthalate, *Santicizer* B-16, and the *Aroclor* liquids, are frequently used.

Solid plasticizers, such as diphenyl phthalate, dicyclohexyl phthalate, *Santicizer* 1-H, *Santicizer* 9, and *Aroclor* 5460, are also utilized in many applications, since they melt at the processing

**HB-40; Lustrex:* Monsanto Chemical Company trademarks. Registered in U. S. Patent Office.

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temperature of the hot-melt adhesive. Upon application of the adhesive to the materials to be bonded, these plasticizers solidify as the temperature is reduced, thereby overcoming the problem of excessive softness frequently encountered with hot-melt adhesives.

Formulas 15 and 16 represent two starting formulations for bookbinding adhesives.

Formula 15

Ingredient	Parts by Weight
Nevillac Hard Resin	61.4
Santicizer 160	15.0
Paraffin Wax	6.4

Mix and heat the ingredients at 250° to 275° F until melted. Raise temperature to 300° to 325° F and add the following with agitation:

Vinylite AYAA	12.9
Ethyl Cellulose	4.3

Formula 16

Ingredient	Parts by Weight
Nevindene R-3 or Cumar W-1	30
Santicizer 8	15
Rosin WW	35
Vinylite XYHL	15
Mineral Oil	5
Paraffin Wax	5

Formulas 17 through 19 are good suggested starting points for the development of hot melts for application between 160° and 180° C. By changing the type of polyvinyl acetate resin utilized in the hot melt, the viscosity of the melt can be increased or decreased without changing the ratio of resin to plasticizer. For example, substitution of Gelva V-15 for Gelva V-7 in formulations 17 and 18 increases the melt viscosity.

	Parts by Weight		
Ingredients	Formula 17	Formula 18	Formula 19
Gelva polyvinyl acetate resin V-7	100	65	—
Ethyl cellulose	—	15	—
Gelva C-SV-16R	—	—	100
Santicizer 160	—	16	—
Rosin WW	75	—	75
Dibutyl phthalate	30	—	30
Aroclor 1254	55	4	55

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Polyvinyl butyral hot-melt adhesives are useful for joining cellophane, aluminum foil, glassine, and waxed glassine to themselves. The sealing temperature is usually 200° to 350° F. The pressure can range between 0.5 psi and 30 psi. Polyvinyl butyral hot melts are extremely fast setting—usually from 0.5 to 2 seconds. The molten adhesive is usually applied to both surfaces to be bonded and allowed to cool and set. The surfaces are then brought together, and the bond is formed under heat and pressure.

Formula 20—Polyvinyl Butyral Hot-Melt Adhesive

Ingredients	Parts by Weight
Butvar B-76	10.5
Opalwax	30.5
Poly-pale Ester #1	19.7
Staybelite Ester #10	14.7
Santicizer B-16	6.0
Armid HT	11.0

The procedure used to make Formula 20 is to dissolve the Butvar B-76 in ethanol. The wax is then added with agitation and slight heating until a homogeneous slurry is obtained. The alcohol is then distilled from the mixture, and the other ingredients are added to the molten Butvar-wax mix. To obtain a smooth formulation, the finished compound should be strained through two thicknesses of cheesecloth.

Formula 21 is a polymethyl methacrylate hot-melt adhesive used to join cloth for inner liners, fabrics, or backings.

Formula 21—Polymethyl Methacrylate Hot-Melt Adhesive

Ingredients	Parts by Weight
Polymethyl methacrylate	100
Santicizer 160	10
Chlorinated rubber	20

A typical cellulose acetate hot-melt adhesive is shown in Formula 22:

Formula 22—Celluloso Acetate Hot-Melt Adhesive

Ingredients	Parts by Weight
Cellulose acetate	50
Santicizer M-17	88
Inert filler	35

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Cellulose acetate butyrate is commonly used for hot-melt applications. Formula 23 is a typical starting formula.

Formula 23—Cellulose Acetate Butyrate Hot-Melt Adhesive

Ingredients	Parts by Weight
Half-second cellulose acetate butyrate	35.00
Aroclor 5460	30.00
Dioctyl phthalate	15.00
Newport V-40	19.89
*Santonox**	0.1
Syn Fleur #6	0.01

The above coating can be applied at about 350° F. Ventilation should be provided.

A typical starting formulation for an ethyl cellulose hot-melt adhesive is shown in Formula 24.

Formula 24—Ethyl Cellulose Hot-Melt Adhesive

Ingredients	Parts by Weight
Ethyl cellulose, 50 cpr	24
Lopor No. 45 Mineral Oil	57
Bakers No. 15 Castor Oil	5
Epoxy soybean oil	3
Paraffin wax (m.p. 135° F)	3
Santonox	1
Aroclor 5460	7

DELAYED-TACK ADHESIVES

Delayed-tack adhesives differ from hot-melt adhesives, which become nontacky upon cooling. Delayed-tack adhesives are normally tack-free at ordinary temperatures, after they are spread and dried on a surface. After subsequent heat activation they maintain tackiness for from several hours to several days over a fairly wide temperature range. This slow-setting property permits necessary mechanical handling before the adhesive cools and sets.

*Santonox: Monsanto Chemical Company trademark. Registered in U.S. Patent Office.

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Solid plasticizers, such as diphenyl phthalate, *Santicizer* 1-H, and *Santicizer* 9, make possible the delayed-tack properties of these unusual adhesives. The solid plasticizers are chosen for their compatibility with the base resin, their solvency action on the base resin, the temperature at which the adhesive is activated, their lack of disagreeable odor, and their crystallizing characteristics.

The patent literature relating to delayed-tack adhesives should be investigated by those desiring to produce them; for example, U. S. Patents 2,462,029; 2,608,542; 2,608,543; 2,613,156; and 2,613,191. Formulas 25 through 27 are quoted from the patents as indicated.

Formula 25—Delayed-Tack Adhesive

(U. S. Patent No. 2,462,029, Example 96)

Ingredients	Parts by Weight
Santicizer 1-H	50
Vinsol Resin	50
Thinned amine dispersant	250
Acrysol M.R.	10

"The thinned amine dispersant is a mixture composed of 1 part stearic acid, 1 part Poly-pale resin, a polymerized rosin containing approximately 40% dipolymers of abietic acid (Hercules Powder Co.), 1 part 2-amino-2-methyl-1-propanol (Commercial Solvents Corp.), and 3 parts water. This composition is designed solely as a dispersion assistant....." (from column 10 of this patent)

Formula 26—Delayed-Tack Adhesive

(U. S. Patent No. 2,462,029, Example 18)

Ingredients	Parts by Weight
Diphenyl phthalate	52.5
Nevindine R-3	30.0
Thinned amine dispersant (see formula 25)	198.0
Hycar OR-25	43.5

The above formulation is non-tacky at ordinary temperatures and is heat activated at about 150° F. The compound then remains adhesive through temperatures as low as 50° F. Once set, the adhesive continues to hold at ordinary temperatures.

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Formula 27—Polystyrene-Emulsion, Delayed-Tack Adhesive

(U. S. Patent No. 2,613,156, Example I)

"Ten (10) parts polystyrene (molecular weight 10,000 to 15,000) and 40 parts diphenyl phthalate are mixed and heated together at approximately 190° F, forming a clear fluid. While still at this temperature, the fluid is poured into a solution of 6 parts of a 25% aqueous solution of Aerosol OT and 4.5 parts polyvinyl alcohol (of the grade sold under the trademark Elvanol 50-42) in 75.5 parts water; the solution being at a temperature of approximately 190° F, constant agitation is maintained, resulting in a homogeneous emulsion. The emulsion is then permitted to cool." (This formulation is improved by the addition, after cooling, of 8 parts of Geon polyblend 550X20).

This adhesive forms a smooth, non-grainy film when spread evenly on paper and dries to a completely tack-free surface. When heated to 170° F the film becomes very tacky and powerfully adhesive.

Formula 28—Polyamide Delayed-Tack Adhesive

Ingredients	Parts by Weight
Versamid 940	100
Santicizer 9	31.6
Candelilla wax	5.9
Isopropyl alcohol	29.5
Toluene	29.5

SOLUTION ADHESIVES

Solution synthetic-resin adhesives differ from the emulsion adhesives in that solvents other than water carry the adhesive. The use of solution adhesives improves the "bite" or adhesion to many of the materials to be joined. Following is a discussion of various solution adhesives.

VINYL ADHESIVES

Formula 29 is a non-toxic, grease-resistant paper coating, which is readily heat sealable.

Formula 29—Vinyl Solution Coating

Ingredients	Parts by Weight
Vinylite VYHH	80
Vinylite VMCH	10
Vinylite VAGH	10
Santicizer 141 or *Santicizer* M-17	20
Acetone	250
Methyl ethyl ketone	100

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NITROCELLULOSE ADHESIVES

Nitrocellulose-lacquer coatings are frequently applied to make cellophane heat sealable and moisture resistant. Formulas 30 and 31 illustrate starting formulations for this type of application. Formula 32 is typical of a starting formulation for a nitrocellulose cement.

Formulas 30, 31, and 32—Nitrocellulose Lacquers and Cement

	Heat-Sealable Cellophane Lacquer		Nitrocellulose Cement
	Parts by Weight		
Ingredients	Formula 30	Formula 31	Formula 32
Nitrocellulose (½-sec.SS)	15	50	—
Nitrocellulose (30-40 sec.RS)	—	—	10
Dibutyl phthalate	8	7	—
Dicyclohexyl phthalate	—	20	—
Santicizer 160	—	—	5
Santolite MHP	16	12	—
Dammar wax	—	8	—
Santolite MS-80%	—	—	12
Paraffin wax	—	3	—
Denatured alcohol	15	50	—
Ethyl acetate	31	104	34
Acetone	—	—	34
Toluene	15	50	—

CELLULOSIC ADHESIVES

Formulations 33 and 34 illustrate suggested starting formulations for cellulose acetate butyrate.

Formula 33—For Sealing Paper to Paper or to Cellulose Acetate Butyrate

Ingredients	Parts by Weight
Cellulose acetate butyrate (half second)	15
Santolite MHP	15
Ethyl alcohol (95%)	15
Isobutyl acetate	10
Toluene	35
Hi-Flash naphtha	10

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Formula 34—For Sealing Paper to Cellulose Acetate

Ingredients	Parts by Weight
Cellulose acetate butyrate (half second)	12
Santolite MHP	18
Ethyl alcohol (95%)	15
Isobutyl acetate	10
Toluene	35
Hi-Flash naphtha	10

Formula 35 gives outstanding grease resistance and light stability.

Formula 35—Grease-Resistant Coating

Ingredients	Parts by Weight
Cellulose acetate LL-1	20
Santicizer M-17	10.2
Santicizer 8	2.5
Acetone	16.8
Methyl ethyl ketone	37
Methyl cellosolve acetate	7
Ethyl lactate	7

A formulation useful for self adhesion of ethyl cellulose is as follows:

Formula 36—For Self Adhesion of Ethyl Cellulose

Ingredients	Parts by Weight
Ethyl cellulose N-14	10
Lewisol 28	5
Dibutyl phthalate	1.5
Toluene-alcohol blend (4:1)	83.5

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POLYURETHANE ADHESIVES

The advent of urethane foam has increased the need for adhesives to bond it to itself or to other materials. Formula 37 is an example of a good starting formulation for this application.

Formula 37—Polyurethane Adhesive

Ingredients	Parts by Weight
Multranil 176	100
Mondur C	5
Ethyl acetate	50
Aroclor 1254	20

Formula 37 has a maximum work life of 48 hours. Excessive humidity or temperature shorten the work life. It is recommended that only enough adhesive for one day's use be mixed at a time. The formula may be diluted with acetone or ethyl acetate if desired.

This adhesive may be applied by a cold method. The adhesive is applied, allowed to stand at room temperature for 10 to 30 minutes until the solvent evaporates. The pieces to be joined are compressed at 50 psi for at least 15 seconds.

The adhesive surfaces may also be heated with infrared lamps to 130° F for 4 minutes to evaporate the solvent. While still warm, the pieces should be pressed together at 50 psi for 3 to 10 minutes.

CHLORINATED-RUBBER ADHESIVES

Chlorinated rubber is used in heat-sealing adhesives because of its low moisture-vapor transmission, chemical resistance, and heat sealability. Formula 38 is a suggested starting formulation for a heat-sealing chlorinated-rubber adhesive. When 5 to 7 pounds are applied to a ream of paper, this coating allows only 1/16 gram of moisture vapor to pass through 100 square inches of paper in 72 hours.

Ingredients	Formula 38 Heat-Sealing Chlorinated-Rubber Adhesive	Formula 39 Chlorinated-Rubber Label Adhesive
	Parts by Weight	
Parlon 125-centipoise type	60	20
Aroclor 1254	—	6
Aroclor 1260	—	6
Dibutyl phthalate	14	—
Paraffin Wax	5	—
Pentalyn H	21	—
Toluene	—	68
Solvent	as needed	—

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ZEIN ADHESIVES

Formulations 40 and 41, based upon zein, illustrate the versatility of Monsanto plasticizers to produce specialty formulations with unusual characteristics.

Formula 40—Zein Label Varnish

Ingredients	Parts by Weight
Zein	100
Rosin WW	100
Santolite MHP	20
Santicizer 8	25
Proprietary or 91% isopropanol	190

Formula 41—Zein Foil-Tinting Base

Ingredients	Parts by Weight
Zein A	100
Santolite MHP	65
Santicizer 8	70
91% Isopropanol	230
85% Phosphoric acid	2.3
Coloring	as needed

PRESSURE-SENSITIVE ADHESIVES

Pressure-sensitive adhesives are materials that are tacky at ordinary temperatures and require little or moderate pressure for fixing in place. Formulations 42 through 45 illustrate four pressure-sensitive adhesives.

Formula 42—Pressure-Sensitive Adhesive (calender onto fabric)

Ingredients	Parts by Weight
Cellulose acetate (type A-9, 40 mesh)	1
Santicizer 8	2.5-5
Santolite MHP	1-2

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Formula 43—Pressure-Sensitive Adhesive (calender onto fabric)

Ingredients	Parts by Weight
Vinylite AYAF (polyvinyl acetate)	5
Arofene 700 (100% phenolic resin)	36
Santicizer B-16	18

Formula 44—Pressure-Sensitive Adhesive (hot-melt type)

Ingredients	Parts by Weight
Pale crepe rubber	15-20
Vistanex (polyisobutylene)	5-15
Ester gum	20
Santolite MHP	20
Methyl abietate, *Santicizer* 160, dibutyl phthalate, *Aroclor*, or *Santicizer* B-16	25-50
Wax (Montan, paraffin, carnauba, or amorphous microcrystalline)	1-20

Melt all components except rubber at about 210° F. Add rubber, and reduce temperature to 180° F. Stir at this temperature for 1 to 2 hours until mixture becomes smooth. Hot cast on suitable surface.

Formula 45—Pressure-Sensitive Adhesive (solution type)

Ingredients	Parts by Weight
Parlon 1259 type	5
Staybelite Ester #10	10
Dibutyl phthalate	10
Acetone	52.5
Hexane	22.5

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ADHESIVE PRIMERS

Adhesive primers are used in the same fashion as paint primers; that is, one is applied as a preliminary coating so that the secondary coating can adhere better. The secondary coat may be any type of vinyl chloride, if the primer, such as the one illustrated in Formula 46, is first applied.

Formula 46—Adhesive Primer (for bonding vinyl to paper or cotton cloth)

Ingredients	Parts by Weight
Vinylite VYMS	18
Vinylite VMCH	2
Santicizer 160	15
Methyl ethyl ketone	25
Solvesso No. 1	17

Since synthetic fabrics, such as nylon or Dacron, have particularly non-adhesive surfaces, adhesive primers are especially useful. Formula 47 provides a very effective adhesive primer coat for nylon and Dacron, as well as for metal.

Formula 47—Adhesive Primer for Synthetic Fabrics

Ingredients	Parts by Weight
Vinylite VMCH Vinyl Resin	100
Dioctyl phthalate (DOP)	60
Methyl ethyl ketone	200
Mondur M	5

Formula 47 is made by mixing methyl ethyl ketone with the plasticizer, then adding the resin. The shelf life of the mixture is indefinite until the Mondur M is added. Upon addition of Mondur M the adhesivity of the compound decreases by 15 to 20 percent in 10 days. Accordingly, Mondur M is added last, just before the adhesive is to be applied; and only as much adhesive should be finally compounded as can be used within a day or so.

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EPOXY-RESIN ADHESIVES

Epoxy resins are widely used in adhesive applications. Monsanto Chemical Company's *Mod-Epox** organophosphorus compound improves the bond strength of epoxy adhesives (Formulas 48, 49, and 50). *Mod-Epox* also reduces the viscosity of epox adhesives, maintains chemical resistance, and lowers the cost considerably.

Formulas 48, 49, and 50 — Epoxy-Resin Adhesives

Ingredients	Formula 48	Formula 49	Formula 50
		Parts by Weight	
Liquid epoxy resin (EV-200)	100	100	100
Diethylenetriamine	12	8	13
Mod-Epox	—	25	—
Butyl glycidyl ether	—	—	13.5

Cure: 20 hours at room temperature plus 2 hours at 100° C.

Tensile Shear-bond Strength

	Formula 48	Formula 49	Formula 50
Aluminum - Aluminum	1880 psi	2590 psi	2010 psi
Steel - Steel	2000	3060	—
Glass - Glass	2750	4900[a]	—

[a] Cohesive failure of resin. Adhesive bond intact.

Aroclor and *Montar** chlorinated polyphenyls are frequently used to extend epoxy adhesives and coatings. The use of these materials greatly reduces costs with a minimum effect on chemical resistance or adhesive characteristics of the compounds.

*Mod-Epox; Montar: Monsanto Chemical Company trademarks. Registered in U. S. Patent Office.

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POLYURETHANE-RESIN ADHESIVES

Polyurethane resins are commonly used in flocking adhesives. The following formulation is typical of a flocking adhesive:

Formula 51—Polyurethane-Resin Flocking Adhesive

Ingredients	Parts by Weight
Part A —	
Multranil FLD	100
Aroclor 1254	20
Mondur C	5
Part B —	
Multranil FLD	100
Mondur C	5-10

Part A is applied to the fabric by knife coating and allowed to dry thoroughly. The fabric is then coated with Part B, and the material is flocked immediately.

TOXICOLOGICAL CHARACTERISTICS

The 1958 amendment to the Pure Food, Drug, and Cosmetics Act has caused some uncertainty about the kinds of materials that can be used in adhesives.

The Food and Drug Administration has ruled that it will approve any material that does not migrate from the adhesive into the food. Migration is determined by use of a suitable dye.

Monsanto offers six plasticizers that are approved by the Food and Drug Administration as being non-toxic. These products are:

Santicizer 141
Santicizer B-16
Santicizer E-15
Diethyl phthalate
Dioctyl phthalate
Diisooctyl phthalate
} (For foods with high water content only)

Use of these materials as plasticizers in synthetic adhesives should greatly aid acceptance of the adhesive.

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INGREDIENT INDEX

Ingredient	Identification	Supplier
Acrysol*	Synthetic-resin emulsions	Rohm & Haas Co.
Aluminum oxide		Reynolds Metal Co.
Ammonium caseinate		National Casein Co.
Armid*	Amides	Armour Industrial Chemical Co.
Arofene*	Modified phenolic and maleic resins	U. S. Industrial Chemicals, Inc.
Bakers castor oil		Baker Castor Oil Co.
Butvar*	Polyvinyl butyral resins	Shawinigan Resins Corp.
Butyl glycidyl ether		Shell Chemical Co.
Candelilla wax		Concord Chemical Co.
Carboxymethylcellulose		Antara Chemicals Division General Aniline & Film Corp.
Cellulose acetate		Eastman Chemical Products Co.
Cellulose acetate butyrate		Eastman Chemical Products Co.
Chlorinated rubber		Hercules Powder Co.
Cumar*	Coumarone-indene resins	Allied Chemical Corp.
Dammar wax		Hathaway Allied Products
Diethylenetriamine		Union Carbide Chemical Co.
Elvacet*	Polyvinyl acetate emulsion	E. I. du Pont de Nemours & Co.
Epoxy soybean oil		Rohm & Haas Co.
Ester gum		Glidden Company
Ethyl cellulose		Hercules Powder Co.
Gelva*	Polyvinyl acetate emulsion	Shawinigan Resins Corp.
Geon*	Polyvinyl materials	B. F. Goodrich Chemical Co.
Hycar*	Resins and synthetic rubber products	B. F. Goodrich Chemical Co.
Lewisol*	Rosin-modified maleates	Hercules Powder Co.
Lopor* No. 45	Mineral oil	Esso Standard Oil Co.
Methyl abietate		Hercules Powder Co.

*Trademark registered in U.S. Patent Office.

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Ingredient Index - Continued

Ingredient	Identification	Supplier
Methyl Cellosolve* acetate		Union Carbide Chemical Co.
Mondur*	Isocyanates	Mobay Chemical Co.
Montan wax		Beacon Company
Multranil*	Synthetic resin	Mobay Chemical Co.
Nevillac*	Phenol-modified coumarone-indene resins	Neville Chemical Co.
Nevindene*	Coumarone-indene resins	Neville Chemical Co.
Newport V-40*	Pine resin	Newport Industries, Inc.
Nitrocellulose		Hercules Powder Co.
Opalwax*	Castor oil, synthetic wax	Baker Castor Oil Co.
Parlon*	Chlorinated rubber	Hercules Powder Co.
Pentalyn*	Pentaerythritol esters of rosin	Hercules Powder Co.
Poly-G* P-1200	Polypropylene glycol	Olin Mathieson Chemical Co.
Poly-pale* esters	Glyceryl & glycol esters of polymerized rosin	Hercules Powder Co.
Polyco*	Polyvinyl acetate emulsion	The Borden Co.
Polymethyl methacrylate		Rohm & Haas Co.
Polyvinylpyrollidone		Antara Chemicals Division General Aniline & Film Corp.
Quilon*	Chrome complex	E. I. du Pont de Nemours & Co.
Solvesso*	Aromatic solvent	Esso Standard Oil Co.
Staybelite* esters	Hydrogenated rosin esters	Hercules Powder Co.
Syn Fleur*	Odorant	Syn Fleur Scientific Co.
Triton* X-155	Wetting, emulsifying, dispersing, scouring agents	Rohm & Haas Co.
Versamid*	Polyamide resins	General Mills, Inc.
Vinsol*	Pine resin	Hercules Powder Co.
Vinylite*	Vinyl resins	Union Carbide Plastics Co.
Vistanex*	Polyisobutylene resin	Enjay Company
York Whiting*	Superfine calcium carbonate	National Gypsum Co.
Zein		Corn Products Sales Co.

*Trademark registered in U.S. Patent Office.

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TECHNICAL LITERATURE ABOUT MONSANTO PLASTICIZERS

The following technical bulletins and brochures give technical information about the properties and applications of the Monsanto plasticizers and other products that are mentioned in this bulletin. Monsanto technical literature is continuously revised to contain the most recent and reliable information possible. Your request for any literature will be promptly and cheerfully filled—without obligation, of course.

General

"Monsanto Plasticizers"; Booklet containing technical data about all of Monsanto's plasticizers

"Seven Plasticizers for non-toxic applications"

"How you can benefit from Monsanto Solid Plasticizers"

Phthalate Plasticizers

Santicizer 160 (butyl benzyl phthalate):	Technical Bulletin PL-160
Dibutyl Phthalate:	Technical Bulletin PL-302
Diethyl Phthalate and Dimethyl Phthalate:	Technical Bulletin PL-303
Dicyclohexyl Phthalate:	Technical Bulletin PL-312
Di-(2-ethylhexyl) Phthalate (DOP):	Technical Bulletin PL-318
Diphenyl Phthalate:	Technical Bulletin PL-319

Phthalyl Glycollate Plasticizers

Santicizer E-15 (Ethyl phthalyl ethyl glycollate):	Technical Bulletin PL-15
Santicizer B-16 (Butyl phthalyl butyl glycollate):	Technical Bulletin PL-16
Santicizer M-17 (Methyl phthalyl ethyl glycollate):	Technical Bulletin PL-17

Phosphate Plasticizers

Santicizer 140:	Technical Bulletin PL-140
Santicizer 141 (non-toxic plasticizer):	Technical Bulletin PL-141
Triphenyl Phosphate (flame-retarding plasticizer):	Technical Bulletin PL-301
Tricresyl Phosphate (flame-retarding plasticizer):	Technical Bulletin PL-305

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Sulfonamide Plasticizers

Santicizer 1-H:	Technical Bulletin PL-1-H
Santicizer 8:	Technical Bulletin PL-8
Santicizer 9:	Technical Bulletin PL-9

Aroclor Plasticizers

The *Aroclors*:	Application Data Bulletin O-P-115
Aroclors 1221, 1232, and 1242 for polyvinyl acetate emulsion adhesives:	Technical Bulletin PL-321

Other Plasticizers

HB-40 (partially hydrogenated terphenyl):	Technical Bulletin O-104
Mod-Epox (epoxy-resin modifier):	Technical Bulletin PL-313

Resin Additives

Santolite MHP and *Santolite* MS-80% (Monsanto industrial resins):	Technical Bulletin PL-320

Preservatives and Stabilizers

Santobrite and Penta for the preservation of paints and water-base adhesives:	Technical Bulletin SC-2
Santonox and *Santonox* R, antioxidants for polyethylene:	Technical Bulletin PL-324
Sodium Benzoate, Technical:	Technical Data Sheet

Odor-Masking Agents

"Coumarin Monsanto":	folder
"Methyl Salicylate Monsanto":	folder
Santomask 11, Odor-Control Agent for Paint, Ink, Plastics, and Other Odorous Products:	Technical Bulletin PL-325
"Vanillin Monsanto":	folder

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SHIPPING INFORMATION

Most Monsanto plasticizers are shipped in bulk in tank cars or tank trucks (within established delivery zones) from six strategically-located bulk-storage stations. As supplier of the world's largest selection of plasticizers, Monsanto offers savings through mixed shipments of different plasticizers (compartmented tank cars and tank trucks or mixed trucklots of drums) for all of your plasticizer needs.

No shipping limitations apply to any of Monsanto's plasticizers. Shipping classifications and net contents of standard containers are tabulated below for the plasticizers mentioned in this bulletin.

Product	Classification	Standard Containers: 55-gal. drums (lb., net)	Standard Containers: 5-gal. drums (lb., net)
Dimethyl phthalate	Dimethyl phthalate	530	40
Diethyl phthalate	Diethyl phthalate	500	45
Dibutyl phthalate	Dibutyl phthalate	475	40
Dioctyl phthalate	Dioctyl phthalate	445	40
Dicyclohexyl phthalate	Dicyclohexyl phthalate	350	—
Diphenyl phthalate	Diphenyl phthalate	400	—
Santicizer 160	Butyl benzyl phthalate (Resin plasticizer)	500	40
Santicizer E-15	Resin plasticizer	535	45
Santicizer B-16	Resin plasticizer	500	40
Santicizer M-17	Resin plasticizer	550	50
Tricresyl phosphate	Resin plasticizer	530	45
Triphenyl phosphate	Resin plasticizer	225	—
Santicizer 140	Resin plasticizer	545	50
Santicizer 141	Resin plasticizer	495	45
Santicizer 1-H	Resin plasticizer	—	80[a]
Aroclor 1221	Synthetic resin	520	—
Aroclor 1232	Synthetic resin	550	—
Aroclor 1242, 1248, 1254, 1260	Synthetic resins	600	—
Aroclor 5460	Synthetic resin	500	—
HB-40	Resin plasticizer	450	40
Mod-Epox	Chemical, NOIBN	510	45
Santolite MHP	rail: synthetic resin without filler	—	60[b]
Santolite MS-80%	truck: synthetic resin, solid mass	540	45
Santomask II	Chemical, NOIBN	250[c]	45
Santonox	Chemical, NOIBN	150	—

[a] corrugated carton (16" x 8" x 9")
[b] 7 gallon
[c] 33 gallon

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