KETJENFLEX® 8

Technical Bulletin

KETJENFLEX® 8

Introduction

Few plasticizers are compatible in such a wide variety of resins as KETJENFLEX® 8. It is useful for nitro-cellulose, ethyl cellulose, and poly-vinyl acetate. Because of its high polarity, it is also compatible with resins normally more difficult to plasticize, such as nylon and other polyamides, shellac, cellulose acetate, zein and protein materials.
Because of its negligible solubility in petroleum hydrocarbons, KETJENFLEX® 8 may be used to produce grease- and oil-resistant coatings and adhesives. Nitro-cellulose lacquers resistant to grease and aliphatic hydrocarbons may be made by combining KETJENFLEX® 8 with KETJENFLEX® MH (a sulfonamide-formaldehyde resin).
In nylon and other polyamides KETJENFLEX® 8 aids processing by lowering the melting point and improving low-temperature flexibility. Cellulose acetate plasticized with it has a brilliance and polish not obtained with other plasticizers, and sheetings and films have a high tensile strength, elongation, and flexibility.
Polyvinyl acetate adhesives plasticized with KETJENFLEX® 8 show exceptional grease resistance, and have a quick tack and good adhesion for joining difficult surfaces, such as rubber to metal.
KETJENFLEX® 8 is an excellent dye solvent and pigment dispersing.

Physical and Chemical Properties

Physical Properties

Appearance	clear, light yellow viscous liquid
Odor	slight, characteristic
Specific gravity, 25°C/25°C	1.200 kg/m^3
Refractive index at 25°C	1.540
Solidification temperature,	< 0°C
Crystallization point,	< 40°C
Flash point (Cleveland open cup)	174°C
Boiling point (1.4 kPa)	196°C
Vapor pressure, 150°C	0.45 mm. Hg
200°C	5.5 mm. Hg
Surface tension, at 25°C	44.5 dynes/cm

Chemical Properties

Molecular Weight	199.22

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Resin Compatibility

As shown in table 1, KETJENFLEX® 8 is compatible with a wide variety of natural and synthetic resins.

Table 1 Compatibility of KETJENFLEX® 8 with various Resins

Resin	Compatibility of KETJENFLEX® 8 (phr)	Resin	Compatibility of KETJENFLEX® 8 (phr)
Polyvinyl acetate	100	Polyvinyl chloride	10
Polyvinylidene chloride	50	Polyvinyl butyral	100
Nitro-cellulose	80	Polystyrene	20
Cellulose acetate	90	Ethyl cellulose	60
Cellulose acetate-propionate	100	Cellulose acetate-butyrate	50
Styrene-butadiene	25	Chlorinated rubber	50
Polyamide	50	Acrylic	25
Protein	50	Casein	65
Shellac	40	Allyl starch	20
Epoxy	50	Polyester	10
Alkyd	25	Phenolic	50
Polyurethane	20	Melamine	50
Neoprene	50	Nitrile rubber	50

Heat Stability

KETJENFLEX® 8 possesses good heat stability. For critical applications (cellulose acetate molding compounds, nylon extruding and molding, and hot-melt adhesives) where high temperatures occur for long periods, heat stability may be further enhanced by the addition of heat stabilizers. The presence of 3-weight-percent triphenylphosphite (based on KETJENFLEX® 8) effectively improves heat stability. The results of an investigation to improve heat stability of KETJENFLEX® 8 are shown in table 2.

Table 2 Heat Stabilization of KETJENFLEX® 8

Additive (3 %)	Gardner color after 4 hours at 180°C
None (control)	18+
Trifenyl fosfite	1
Di-tertiary-butyl-para-cresol	6
Magnesium oxide	8
Epoxy resin (E.V. 200)	11

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Application in Resins

Polyvinyl acetate adhesives plasticized with KETJENFLEX® 8 have good grease resistance and flexibility, and the emulsion has quick tack. KETJENFLEX® 8 is especially useful for bonding metal to rubber. Polyvinyl acetate hot-melt adhesives for bookbinding and shoes are improved by its addition. The following are three suggested starting formulations for polyvinyl acetate adhesives:

Table 3 Formulations for polyvinyl Acetate Adhesives

Ingredients	Emulsion Adhesive	Quick-tack Adhesive	Book-binding Hot-Melt Adhesive (56-60°C)
Lacquer phase	Parts	Parts	Parts
Gelva S-55 PVAc resin	50	100	15
High-melting coumarine-indene resin	-	-	30
WW Rosin	-	-	35
KETJENFLEX® 8	5-20	12	15
n-Butyl benzyl-phthalate	-	12	-
Mineral oil	-	-	5
Paraffin wax	-	-	5
Toluene	43.5	-	-
Oleic acid	1.5	-	-
Water phase	parts	parts	parts
Water (distilled)	92	9	-
Aqueous ammonia (28%)	8	-	-

Table 4 compares performance of KETJENFLEX® 8 and other plasticizers in polyvinyl acetate-emulsion adhesives at concentrations of 11 phr:

Table 4 Plasticizer Performance in Polyvinyl Acetate Emulsion Adhesives

Plasticizer (11 phr)	Volatility 24 hrs., 87°C (over activated carbon)	Low-temp. flexibility (Clash & Berg)	Solvent Extraction, weight loss at 24 hrs. and 23°C with:		
			Kerosene	Peanut oil	Cotton seed oil
	Loss %	T_f, °C	%	%	%
KETJENFLEX® 8	3.6	6.4	0.43	0.60	0.64
n-Butyl benzyl-phthalate	2.1	1.9	0.20	0.39	0.34
Dibutyl phthalate	4.4	-6.1	0.59	0.51	0.59
Aroclor 1232	4.8	4.0	0.54	-	-

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KETJENFLEX® 8 imparts better rubber-to-metal adhesion of polyvinyl acetate-emulsion adhesive than does dibutyl phthalate. It also contributes excellent adhesion and flexibility to polyvinyl acetate adhesives.

Polyvinyl Chloride

Small quantities of KETJENFLEX® 8 (as little as 10 % of the total plasticizer) impart outstanding stain resistance to polyvinyl chloride compositions. Evaluation of KETJENFLEX® 8 is useful for any vinyl application where stain resistance is a critical requirement.

Ethyl Cellulose

KETJENFLEX® 8 is compatible with ethyl cellulose up to 60 parts of plasticizer per 100 parts of resin. Table 5 lists some typical formulations and properties for ethyl cellulose molding compositions with KETJENFLEX® 8. These formulations have improved resistance to gasoline and oil extraction.

Table 5 Formulations and Properties for Ethyl Cellulose Film

(Molding compositions)			
Ingredients	Parts	Parts	Parts
Ethyl cellulose (K-100B)	85	85	85
KETJENFLEX® 8	-	5	15
Dibutyl phthalate	15	10	-
Octyl phenol	2	2	2
Properties of molded disc (15 min. at 200°C under 2250 kg. pressure)			
Compatibility	Good	Good	Good
Discoloration	None	None	None
Appearance	Clear	Clear	Clear

Performance of KETJENFLEX® 8 and other plasticizers in ethyl cellulose is compared in table 6:

Table 6 Plasticizer Performance in Ethyl Cellulose (48 to 49.5 % ethoxy content)

Plasticizer (15phr)	Tensile Strength	Elonga -tion	Yield Point	Hardness index*	Resistance to volatilization loss	Flexibility retention on exposure to light
	Psi	%	Psi			
None (control)	8960	30	6755	100	-	Excellent
KETJENFLEX® 8	6900	34	4625	70	Good	Excellent
Dibutyl	5120	38	3625	55	Good	Excellent

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Phthalate						
Tricresyl Phosphate	. 7470	48	4550	70	Excellent	Excellent

* Yield point, plasticized film x 100
Yield point, unplasticized film

Nitrocellulose

KETJENFLEX® 8 is highly compatible with nitro-cellulose and imparts adhesion, flexibility, and moisture resistance to nitro-cellulose lacquers. Its resistance to grease and aliphatic hydrocarbons makes it especially useful in lacquers. Suggested nitro-cellulose-lacquer formulations with KETJENFLEX® 8 are as follows.

Table 7 Nitro Cellulose Lacquer Formulation

	Spray	Brushing	Fingernail
Ingredients	parts	parts	parts
Nitro-cellulose (RS 0.5 sec.)	5.0	7.0	10
KETJENFLEX® 8	2.5	3.5	5
KETJENFLEX® MH	7.5	14.0	10
Ethyl alcohol	8.5	-	5
Butyl alcohol	-	7.5	-
Ethyl acetate	-	-	20
Butyl acetate	34.0	23.0	15
Toluene	42.5	-	35
Xylene	-	45.0	-

Evaluations of plasticizer performance in nitro-cellulose film are compared for KETJENFLEX® 8 and other plasticizers in Table 8:

Table 8 Plasticizer Performance in Nitro Cellulose Film (0.3 mm)

	Tensile Strength (psi)	Elongation (%)	Schopper Fold Cycle		Moisture Permeability (%)	
Plasticizer	50 phr	50 phr	25 phr	50 phr	25 phr	50 phr
None (control)	8533	6	20	20	100	100
KETJENFLEX® 8	2275	11	22	16	31	63
n-Butyl-benzyl phthalate	3555	10	11	14	10	19
Dibutyl phthalate	2700	4	25	10	36	65
Tricresyl phosphate	1210	24	20	-	16	28

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Cellulose Acetate

Cellulose acetate compositions plasticized with KETJENFLEX® 8 have brilliance and polish not obtainable with other plasticizers. It imparts good water and scuff resistance, oil-proof ness and adequate heat and light stability. Since it imparts good forming characteristics, KETJENFLEX® 8 is useful in cellulose acetate sheets for vacuum forming. KETJENFLEX® 8 is compatible in proportions up to 85 parts per 100 parts of resin. Listed in Table 9 are two formulations that illustrate cellulose acetate compositions with and without KETJENFLEX® 8.

Table 9 Formulations and Properties for Cellulose Acetate Compositions

Ingredients	Parts	Parts
Cellulose acetate	70	70
KETJENFLEX® 8	24	16
Dimethyl Phthalate	-	8
Triphenyl Phosphate	6	6
Properties		
Compatibility	Good	Good
Discoloration	None	None
Appearance	Clear	Clear

In Table 10 are presented comparative performance evaluations of KETJENFLEX® 8 and other plasticizers in cellulose acetate molding compositions:

Table 10 Plasticizer Performance in Cellulose Acetate Molding Compositions (low acetyl content)

Plasticizer (34phr)	Solution Temp.	Hardness, 70°C	Flexural Strength	Water Absorbed 48 hr., 23°C
	°C	Rockwell "A"	Psi	%
KETJENFLEX® 8	133	75	6860	0.94
Methyl-phthalyl – ethylglycolate	148	65	7110	0.77
Diethyl Phthalate	140	15	5680	1.20

KETJENFLEX® 8 imparts flexibility, good strength, and resistance to aliphatic hydrocarbons and grease in cellulose acetate adhesives, such as the following suggested starting formulations:

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Table 11 Formulations for Cellulose Acetate Adhesives

	Glass adhesive	Hot-melt or calendered pressure-sensitive tape	Grease-resistant coating
Ingredients	parts	parts	parts
Cellulose acetate	10	10	20
KETJENFLEX® 8	2	10-20	2.5
Methyl phthalyl ethyl glycolate	-	-	10.2
KETJENFLEX® MH	-	25-50	-
Acetone	40	-	16.8
Methyl ethyl ketone	-	-	37
Toluene	10	-	-
Methyl cellosolve* acetate	10	-	7
Ethyl lactate	-	-	7

Epoxy Resins

As a reactive diluent in epoxy resins KETJENFLEX® 8 effectively lowers viscosity (Figure 1) without impairing physical properties other than heat-distortion temperature.

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Figure 1 Reduction of viscosity of epoxy resin (E.V. 200) by the addition of Ketjenflex 8.

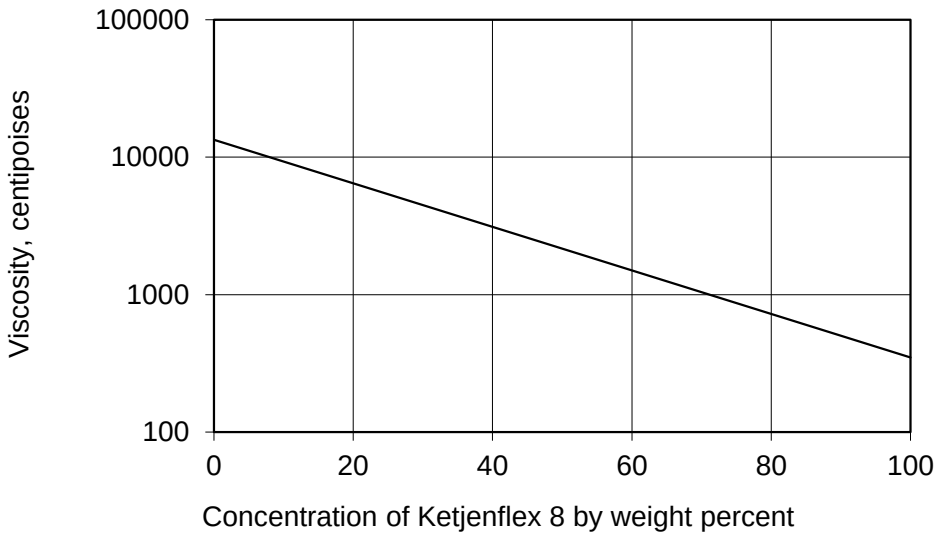

Table 12 shows that the use of KETJENFLEX® 8 improves some properties while causing a reduction only in the heat-distortion temperature.

Table 12 Performance of KETJENFLEX® 8 as an Epoxy-Resin Reactive Diluent (Diethylenetriamine cured)

Ingredients		Parts	Parts	Parts
Epoxy resin (E.V. 200)		100	100	100
KETJENFLEX® 8		-	25	25
Diethylenetriamine		12	10	8
Properties @				
Hardness	Rockwell "M"	105	105	98
Heat-distortion temperature	°C	112	66	71
Flexural strength	Psi	19,200	20,900	17,600
Compressive strength	Psi	36,350	34,000	39,400
Compressive strength at failure	%	43	46	54.5
Compressive yield strength	Psi	15,400	17,200	15,900
Compressive strength at yield	%	10.0	5.4	5.5
Modulus of elasticity before yield	Psi x 10^{-6}	0.39	0.48	0.45
Modulus of elasticity after yield	Psi x 10^{-6}	0.30	0.43	0.39

@ All specimens gelled at room temperature followed by post cure at 100 °C for 8 hours.

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These data show the optimum concentration of amine curing agent for an epoxy resin formulation containing KETJENFLEX® 8 at 25 phr. Since KETJENFLEX® 8 reacts with some of the epoxy groups, less amine (10 phr instead of 12 phr) is required for the best results. Higher compressive strength and heat-distortion temperature are achieved at a diethylenetriamine concentration of 8 phr.

Blending of amine curing agents in KETJENFLEX® 8 provides the first successful means of diluting curing agents for easier and more accurate handling. Since curing agents comprise only a minor percentage of the total resin volume, measuring errors are easily made, resulting in either over- or under-curing. The greater volume of the mixture of curing agent and KETJENFLEX® 8 minimizes the magnitude of metering inaccuracies. Development of an exotherm during mixing of the amine curing agent and the KETJENFLEX® 8 does not affect either the curing or cured resin.

Performance of the two formulas in Table 13 demonstrate the effect of KETJENFLEX® 8 in an epoxy cured with methyl Nadic* anhydride. (* trademark of Allied Chemical Corp.)

Table 13 Performance of KETJENFLEX® 8 as an Epoxy-Resin Reactive Diluent (Methyl Nadic Anhydride cured)

Ingredients		Parts	Parts
Epoxy resin (E.V. 200)		100	100
KETJENFLEX® 8		-	25
Methyl Nadic Anhydride		75	75
DMP-30**		0.5	0.5
Properties			
Hardness	Rockwell "M"	105	104
Heat-distortion temperature	°C	103	71
Flexural strength	Psi	20,500	17,300
Compressive yield strength	Psi	19,400	16,700
Compressive strength at yield	%	6.5	6.3
Modulus of elasticity before yield	Psi x 10^{-6}	0.47	0.45
Modulus of elasticity after yield	Psi x 10^{-6}	0.42	0.36

(** trademark of Rohm and Haas Corp.)

Phenolic and Melamine Resins

KETJENFLEX® 8 imparts slight flexibility and improved punching characteristics to laminates of phenolic and melamine resins.

Polyamides

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KETJENFLEX® 8 aids processing of nylon and other polyamides by lowering the melting points. End properties of the polyamides show improved toughness, flexibility, and low-temperature flexibility. Other properties are not greatly affected. KETJENFLEX® 8 is the best-known plasticizer for these products. Evaluations of it in Zytel* 101 nylon are shown in Tables 14 and 15:
* Trademark of Dupont Company

Table 14 Evaluation of KETJENFLEX® 8 in Nylon

Plasticizer	Stiffness at 25 °C	Hardness	Tensile Strength	Elongation	Moisture Absorption
	Psi	Shore "D"	Psi	%	%
None (control)	35,900	67	5,700	320	2.00
KETJENFLEX® 8 (25phr)	12,700	40	1,830	250	1.98

Table 15 Effect of Concentration of KETJENFLEX® 8 on Performance in Nylon

Concentration of KETJENFLEX® 8@	Low Temperature Flexibility		Volatility after 24 hrs at 105°C	Water immersion	
	Dry	W et		Solubles lost	Water absorbed
phr	T_f,°C	T_f,°C	%	%	%
0	28	1	-	0.01	5.52
11	14	3	24.1	-	-
25	5	8	31.8	-	-
33.33	1	10	37.1	2.58	6.04
43	4	14	42.1	-	-
100	12	24	43.9	-	-

* Mixture of nylon powder, KETJENFLEX® 8, and 0.5 % sodium stearate milled on roll mill for 5 minutes at 160 °C.

Proteins

KETJENFLEX® 8, compatible for at least 50 parts per 100 parts of protein materials, improves flexibility, water resistance, gloss and adhesion. In zein label varnishes, it prevents label curling. The following are suggested starting formulations for zein-based coatings:

Table 16 Formulation for Zein Lacquers

	Label Varnish	Foil Tinting	Wood Sealer
Ingredients	parts	parts	parts
Zein	100	100	100
WW Rosin	100	-	50

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KETJENFLEX® 8	25	70	40
KETJENFLEX® MH	20	60	50
85% Phosphoric acid	-	2.3	-
Titanium dioxide	-	-	88
Lithopone	-	-	44
91% isopropanol	190	230	-
95% ethanol	-	-	400

In casein, about 40 percent KETJENFLEX® 8 (based on weight of dry casein) confers excellent flexibility and scuff and grease resistance when applied from an ammonia-water solution. Coatings based on such formulations are valuable for greaseproof papers.

KETJENFLEX® 8, compatible in proportions greater than 20 phr, is suggested for use with allyl starch in furniture and greaseproof paper.

Shellac

KETJENFLEX® 8 increases the flexibility and softens shellac without impairing adhesion. The following is a suggested starting adhesion formula and procedure:

Table 17 Shellac Adhesive Formulation

Ingredients	Parts
Shellac	100
Formaline	50
Urea	15
KETJENFLEX® 8	10
95 % Ethanol	200

Procedure

1. Reflux shellac and formaldehyde at 120 °C.
2. Add ethanol and urea, and reflux.
3. Add KETJENFLEX® 8.

Dyes and pigments

KETJENFLEX® 8 is an exceptional good and non-volatile solvent for oil- and spirit-soluble dyes. KETJENFLEX® 8 is also useful as a grinding or dispersing medium for pigments.

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