ELVACITE®

ACRYLIC RESINS

A MEMBER OF THE LUCITE® FAMILY OF PRODUCTS

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Lucite International
Going further

INTRODUCTION

LUCITE INTERNATIONAL: GOING FURTHER

Lucite International is the world's largest producer of MMA and we have been since 1993. However, we believe leadership is more than sales. That's why for over 60 years, our employees have delivered premium-quality acrylic products and the highest level of service to customers like you. It's also why our technical specialists, highly skilled in the areas of material and application development, stand side by side with yours to ensure that the exact specifications for your project are met.

Evidence of this commitment can be seen across thousands of applications worldwide. Lucite International products include Lucite® cast acrylic sheet used in baths and spas, Lucite® extruded sheet used in lighting, glazing and architecture and Elvacite® acrylic resins used in coatings, inks and adhesives.

Let us show you how Lucite International can put six decades of experience to work for you. Our technical staff can be reached at **1-800-4-LUCITE** and **901-381-2111**. Or, visit us on the web at **www.luciteinternational.com**.

ELVACITE® ACRYLIC RESINS

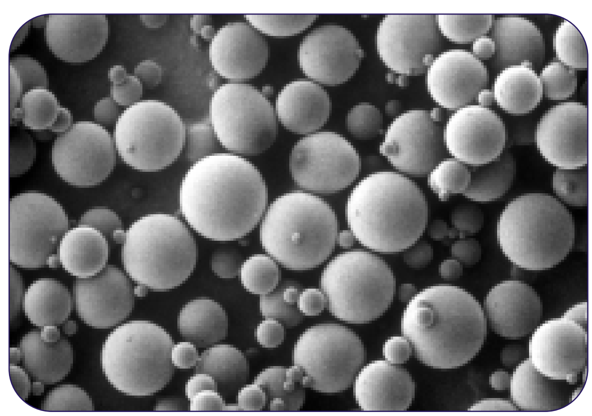
Elvacite® acrylic resins are polymers or copolymers of methyl methacrylate or other acrylic monomers for use in solvent-applied lacquers, inks, adhesives and specialty coatings. Elvacite® resins offer the distinctive combination of properties associated with high-quality coating resins:

- Outstanding resistance to ultraviolet degradation
- Excellent weatherability
- Superior abrasion resistance
- Excellent resistance to water, alcohol, dilute acids and alkalies, chemical fumes and corrosive and oxidizing environments
- High gloss and hardness
- Generally low pigment reactivity
- Water-white color and transparency
- Resistance to discoloration from heating

Elvacite® resins are available as minute spherical beads in grades that differ widely in such properties as hardness, flexibility, solubility and solution viscosity. Compatibility with a variety of film formers and plasticizers permits further modification to achieve the exact properties desired.

Elvacite® resins are thermoplastic. They are thermally stable up to 177-232°C (350-450°F), well above their softening range. At higher temperatures, i.e. about 260°C (500°F) or above, they undergo smooth depolymerization to monomers, leaving negligible ash.

Elvacite® acrylic resins have a wide range of molecular weight, flexibility and functionality, and are particularly well suited for protective and decorative coatings for plastics, metals, concrete, wood and paper.



Actual photo-micrograph of Elvacite® acrylic bead resins; magnified approximately 60 times.

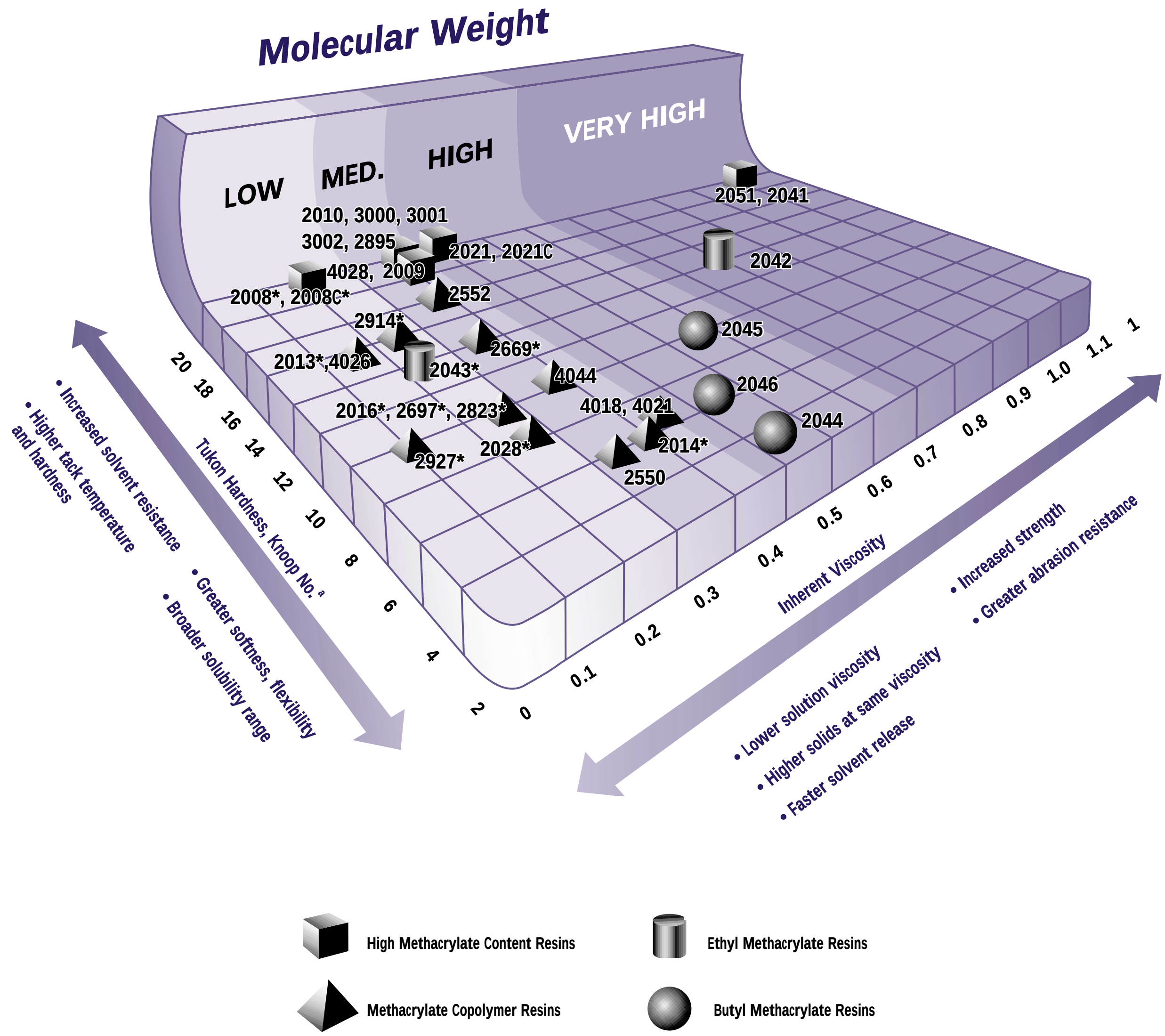
TABLE I: ELVACITE® ACRYLIC RESINS

Elvacite® Grade Numbers	Polymer Type	Typical Inherent Viscosity[a]	Molecular Weight	Principal Characteristics and Uses
2008	Methyl methacrylate	0.18	Low	Low molecular weight grade. Used in lacquers and gravure inks requiring low viscosity at high solids. Highest tack temperature. Good pigment dispersion.
2008C	Methyl methacrylate	0.18	Low	Nonreactive version of 2008 for use in reactive systems. Improves rheology.
2009	Methyl methacrylate	0.39	Medium	A more soluble, softer version of Elvacite® 2010. Shows unusual chip resistance for a hard polymer.
2010	Methyl methacrylate	0.40	Medium	General-purpose grade for lacquer coatings such as barrier topcoatings for vinyl fabric. High tensile strength and hardness.
2013	Methyl/n-butyl methacrylate copolymer	0.17	Low	Fast-dissolving, low-viscosity grade with quick solvent release for use in industrial lacquers, aerosols, inks, and coatings for plastics. Softer than the methyl methacrylate polymers.
2014	Methyl methacrylate copolymer	0.40	Medium	Soft and flexible Elvacite® copolymer resin. Good pigment wetting. Useful for clear, translucent or pigmented metal lacquers, e.g. for aircraft. Also useful for "Electrofax" copy paper coatings and seamless flooring.
2016	Methyl/n-butyl methacrylate copolymer	0.25	Low	Fast-dissolving, low-viscosity general-purpose resin for lacquer and toner use.
2021	Methyl methacrylate	0.50	High	A higher molecular weight version of Elvacite® 2010 for better abrasion resistance in vinyl topcoats.
2021C	Methyl methacrylate	0.50	High	Nonreactive version of 2021 for use in reactive systems. Improves toughness and rheology.
2028	Methacrylate copolymer	0.24	Low	Unique in its broad solubility and compatibility. Designed for flexographic inks, general purpose lacquers and metal coatings.
2041	Methyl methacrylate	1.25	Very High	A very high molecular weight grade. Used in barrier topcoating of vinyl fabric for dielectric heat sealability, maximum abrasion resistance, block resistance, and slip.
2042	Ethyl methacrylate	0.83	Very High	Tough, alcohol-tolerant, broadly compatible grade for use in abrasion-resistant coatings such as high-gloss clear lacquers for decals and outdoor signs. Slightly softer than Elvacite® 2013.
2043	Ethyl methacrylate	0.21	Low	Fast-dissolving, low-viscosity resin with alcohol solubility for flexographic inks. Most compatible grade. Has excellent pigment wetting ability and broad solubility for use in lacquers for solvent-sensitive substrates. Equal in hardness to Elvacite® 2042.
2044	n-Butyl methacrylate	0.52	High	Softest, most flexible bead grade. Useful in adhesives for smooth plastic films and aluminum, and in silk-screen inks. Will plasticize and improve adhesion of harder butyl grades (Elvacite® 2045 and 2046) and nitrocellulose. Improves outdoor durability of vinyl chloride resins in pigmented lacquers.
2045	Isobutyl methacrylate	0.64	High	Hardest of the weak-solvent-soluble butyl grades. Useful in topcoats for vacuum metallized plastics and in lacquers for other solvent-sensitive substrates. Softer than Elvacite® 2042 and 2043. Clean burn-out for ceramic inks.

a) Inherent viscosity of a solution containing 0.25g polymer in 50 ml methylene chloride, measured at 20°C using a No. 50 Cannon-Fenske viscometer.

Elvacite® Grade Numbers	Polymer Type	Typical Inherent Viscosity[a]	Molecular Weight	Principal Characteristics and Uses
2046	n-Butyl/isobutyl methacrylate copolymer	0.54	High	Medium-hardness butyl grade. Soluble (like Elvacite® 2044 and 2045) in mineral spirits, VM & P naphtha, and some alcohols. Useful in aluminum finishes, ceramic coatings, and aerosol snows.
2051	Methyl methacrylate	1.25	Very High	Nonreactive. Excellent abrasion resistance, block resistance and slip.
2550	Methyl/n-butyl methacrylate copolymer	0.32	Medium	Soft, flexible grade with excellent adhesion to metal substrates. Useful in staple cement applications because of flexibility.
2552	Methyl/lauryl methacrylate copolymer	0.32	Medium	Unique resin designed for general metal finishes where high depth of gloss is important. Resists cracking and glazing in multiple-coat systems. Also useful for high-gloss coatings on plastic substrates. Excellent resistance to UV degradation and has excellent exterior durability.
2614	Methyl/n-butyl methacrylate copolymer	0.21	Low	Low-odor version of 2013 without sulfur-containing compounds. Fast-dissolving grade with quick solvent release useful in industrial lacquers, inks, and coatings for plastics.
2669	Methyl methacrylate copolymer	0.32	Medium	Water reducible for use in coatings and inks. Allows for very low VOC formulations.
2697	Methyl methacrylate / n-butyl methacrylate copolymer	0.25	Low	Nonreactive version of 2016 for use in reactive systems.
2776	Butyl methacrylate copolymer	0.10	Low	Water reducible for use in coatings and inks. Allows for very low VOC formulations.
2823	Methyl methacrylate / n-butyl methacrylate copolymer	0.23	Low	High solids coatings and inks. Patented technology allows for higher solids while maintaining low viscosity.
2895	Methyl methacrylate copolymer	0.38	Medium	Amine functionalized methyl methacrylate copolymer.
2896	Methyl methacrylate	1.40	Very High	Very high molecular weight for viscosity control and maximum hardness and abrasion resistance.
2914	Methyl methacrylate	0.39	Medium	Use to improve pigment dispersion in coatings and inks. Can be used in coatings, inks, and adhesives to control viscosity.
2927	Methyl/n-butyl methacrylate copolymer	0.12	Low	High solids coatings and inks. Patented technology allows for higher solids while maintaining low viscosity.
3000	Methyl methacrylate copolymer	0.23	Low	High solids coatings and inks.
3001	Methyl methacrylate copolymer	0.38	Medium	Plastic and vinyl coatings and inks.
3003	Methyl methacrylate copolymer	0.40	Medium	Medium viscosity methyl methacrylate for viscosity control in plastic and vinyl coatings and inks.
3004	Methyl methacrylate copolymer	0.40	Medium	Medium viscosity methyl methacrylate for viscosity control in plastic and vinyl coatings and inks.
4018	Methyl methacrylate/n-butyl methacrylate copolymer	0.43	High	Highly flexible non-reactive resin suitable for use in reactive flooring and solid surface manufacture.
4021	Methyl methacrylate/n-butyl methacrylate copolymer	0.44	High	Highly flexible, high elongation resin for use as covercoats and decals.
4026	Methyl methacrylate copolymer	0.13	Low	Acrylate functional resin for inclusion in UV inks and coatings formulations.
4028	Methyl methacrylate/n-butyl methacrylate copolymer	0.41	High	General purpose grade for solvent based inks and coatings.
4044	Methyl methacrylate/n-butyl methacrylate copolymer	0.38	High	General purpose grade with FDA compliance for heat seal lacquers.

FIGURE 1: A WIDE RANGE OF PERFORMANCE OPTIONS



*Modifed for improved pigment wetting and adhesion.

GRADE SELECTION AND PROPERTIES

Elvacite® bead resins are listed by grade number in Table 1 (page 4). In selecting the Elvacite® resin offering the best balance of properties for a given end use, it is helpful to consider performance differences in terms of two main variables, chemical composition and molecular weight.

Figure 1 (page 6) shows at a glance how the Elvacite® resins differ in two dominant properties – inherent viscosity, which is related to molecular weight, and hardness, which is related to chemical composition. The horizontal and vertical arrows below and at left of the chart indicate the direction in which other use-related properties vary with differences in inherent viscosity and hardness, respectively. In addition to differences in these two dimensions, some grades of Elvacite® (marked with asterisks) are modified to enhance pigment wetting and gloss, and to improve adhesion to metals and other nonporous surfaces.

CHEMICAL TYPE

Elvacite® resins may be classified in one of four major types: MMA resins; MMA copolymers; EMA resins; and BMA resins. As shown in Figure 1 and Table II (page 9), the methyl methacrylate resins form harder films than the ethyl or butyl methacrylate resins and have higher softening points as indicated by glass transition temperature values. The copolymer resins are intermediate in hardness and tack temperature between the methyl methacrylate and softer butyl methacrylate resins. A good balance between film flexibility and hardness can often be achieved with a properly selected copolymer. The softer butyl resins provide optimum adhesion to nonporous surfaces.

Chemical type also has an important effect on solubility and compatibility. The methyl methacrylate resins are less broadly soluble than other types of Elvacite® resins and, as a corollary, give more solvent-resistant coatings. At the other end of the scale, the butyl methacrylate resins are soluble in low-cost aliphatic hydrocarbons such as mineral spirits of low aromatic content and VM & P naphtha. These grades, like the ethyl methacrylate resins and some of the copolymers, also show high tolerance for alcohols.

All of the Elvacite® acrylic resins are highly resistant to deterioration by ultraviolet light and aging. The methyl methacrylate resins in particular show outstanding color stability and gloss retention on weathering.

In addition to these differences among the four principal resin types, some grades contain carboxylic acid groups to enhance pigment wetting and gloss, and to improve adhesion to metallic and cementitious substrates.

MOLECULAR WEIGHT

The inherent viscosities (i.v.) in Figure 1 afford a convenient basis for comparing molecular weights of Elvacite® resins of the same chemical type. The higher the inherent viscosity, the higher the molecular weight. The molecular weight ranges from a low of about 37,000 for Elvacite® 2008 (i.v. = 0.2) to a high of about 450,000 for Elvacite® 2041 (i.v. = 1.3) as determined by gel permeation chromatography using a polystyrene standard.

For applications requiring low solution viscosity at high solids, the lower molecular weight grades offer a good balance between mechanical strength and low viscosity. Low molecular weight also favors fast solvent release. At the other end of the range, Elvacite® 2041 and 2042 are higher in molecular weight than most other commercial acrylic resins. These high molecular weight Elvacite® resins have generally better toughness and abrasion resistance and are less readily attacked by solvents than lower molecular weight resins of similar composition.

PACKAGING AND SHIPPING[c]

Table III (page 10) shows shipping specifications and standard packages for Elvacite® acrylic resins. See explanatory footnote (b) for Elvacite® 2044 and Elvacite® 2550.

BLENDING GRADES OF ELVACITE®

Intermediate properties can be obtained by using a combination of compatible grades of Elvacite® resins. Table IV (page 11) shows the mutual compatibility of the various Elvacite® resins. Optimum compatibility is generally observed on blending grades of the same chemical type. For example, a low molecular weight methyl methacrylate polymer such as Elvacite® 2008 may be modified with a higher molecular weight methyl methacrylate resin to improve toughness and abrasion resistance at intermediate solution viscosities, or a soft butyl resin such as Elvacite® 2044 may be modified with a harder butyl resin, i.e., Elvacite® 2045 or 2046, to increase film hardness while taking advantage of the superior adhesive properties of Elvacite® 2044. The mutual compatibility of most of the copolymer grades makes it possible to blend a soft copolymer such as Elvacite® 2014 with a harder copolymer such as Elvacite® 2013 to obtain intermediate film properties.

SOLVENT SYSTEMS

RESIN SOLUBILITY

As shown in Table V (page 17), Elvacite® acrylic resins are soluble in many solvents commonly used in formulating lacquers, adhesives, inks and related products. Ketones, esters and the lower boiling aromatics are practical solvents for all grades of Elvacite®. Xylene is an effective solvent for Elvacite® 2013, 2042 and the butyl methacrylate polymers, but not for the methyl methacrylate resins with the exception of Elvacite® 2009.

Aliphatic hydrocarbons have essentially no solvent action on the methyl methacrylate resins. However, the butyl methacrylate resins are readily soluble in VM & P naphtha and some grades of mineral spirits. Solutions of Elvacite® 2044, 2045 and 2046 in these low-cost hydrocarbon solvents have workable viscosities even at solids contents as high as 30-40% by weight.

All grades of Elvacite® are soluble in cyclic ethers and in some organic acids. Tetrahydrofuran (THF)[1]* is particularly effective. Since THF is also a powerful solvent for high-molecular-weight vinyl resins, including polyvinyl chloride, it is a convenient medium for applying combinations of Elvacite® and vinyl resins in applications such as vinyl fabric topcoating.

Alcohols as a class are poor solvents for methacrylate polymers. The butyl methacrylate resins are soluble in the higher (C_3-C_{10}) aliphatic alcohols including cyclohexanol, and in benzyl and furfuryl alcohols. Alcohols with an aromatic character are solvents for the other grades of Elvacite® as well as the butyl resins.

Elvacite® 2043 and 2028 are low-viscosity resins designed particularly for application from alcohol-based solvent systems. They form clear solutions in some of the lower alcohols at room temperature, and show excellent solubility in alcohol/ester mixtures containing relatively small amounts of an ester such as ethyl or propyl acetate of ethylene glycol monoethyl ether acetate. This permits their use in flexographic inks and other applications where more active solvents are undesirable because of their effect on rubber rolls or sensitive substrates. Elvacite® 2043 is also soluble in ethyl alcohol/water/ammonia mixtures; clear films can be obtained by including a small amount of a higher-boiling active solvent.

Elvacite® 2013, although it is not soluble in aliphatic alcohols, can be applied from alcohol/ester and other alcohol-rich mixtures. Like Elvacite® 2043, it is soluble in ethyl alcohol/water/ammonia mixtures, but it tolerates less water and requires the addition of more high-boiling active solvent to deposit clear films.

* Superscript numbers refer to List of Suppliers, page 40.

TABLE II: TYPICAL PROPERTIES OF ELVACITE® ACRYLIC RESINS

Grade	Density kg/m³	Density lb/gal	Specific Gravity 25°C g/ml	Tg °C	Molecular Weight Mw '000	Inherent Viscosity	Tukon Hardness Knoop No.[a]	Acid Number[a]	Tensile Strength 23°C / 73°F 50% RH, MPa	Tensile Strength psi	Elongation at Break 23°C 50%RH, %[a]	Typical Viscosity In Toluene, mPa·s (cP) at 25°C (% Solids)	
METHYL METHACRYLATE RESINS													
2008	1183	9.87	1.18	105	37	0.18	18	9	28	4000	0.5	1000	(37.5%)
2008C	1183	9.87	1.18	105	37	0.18	18	9	28	4000	0.5	1000	(37.5%)
2009	1143	9.54	1.14	87	83	0.39	17	0	66	9500	3.5	1700	(37.5%)
2010	1196	9.98	1.20	98	84	0.40	19	0	72	10500	3.5	3500	(37.5%)
2021	1196	9.98	1.20	100	119	0.50	20	0	103	15000	4.0	450	(30%)
2021C	1196	9.98	1.20	100	119	0.50	20	0	103	15000	4.0	450	(30%)
2041	1193	9.96	1.19	105	447	1.25	19	0	54	7800	1.0	1400	(17.5%)
2051	1247	10.41	1.25	105	412	1.25	19	0	-	-	-	-	
2896	1247	10.41	1.25	105	600	1.40	19	0	-	-	-	-	
2914	1150	9.60	1.15	105	108	0.39	18	9	-	-	0.5	-	
METHACRYLATE COPOLYMERS													
2013	1150	9.60	1.15	80	34	0.17	13	5	11	1600	0.5	200	(37.5%)
2014	1140	9.51	1.14	40	119	0.40	4	13	24	3500	18.0	500	(30%)
2016	1127	9.41	1.13	59	60	0.25	8	3.5	16	2300	2.0	175	(37.5%)
2028	1110	9.26	1.11	45	59	0.24	6	12	6	800	75.0	70	(30%)
2550	1043	8.70	1.04	36	98	0.32	4	17	-	-	-	2200	(37.5%)
2552	1079	9.0	1.08	76	75	0.32	16	0	-	-	-	1100	(37.5%)
2614	1151	9.6	1.15	80	52	0.21	13	14	-	-	-	1120	(37.5%)
2669	1196	9.98	1.20	70	58	0.32	13	124	-	-	-	-	
2697	1127	9.41	1.13	50	61	0.25	8	2	16	2300	2.0	175	(37.5%)
2823	1108	9.24	1.11	50	48	0.23	8	3.5	-	-	-	48.6	(30%)
2895	1177	9.82	1.18	100	70	0.38	19	0	-	-	-	740	(30%)
2927	1127	9.41	1.13	45	19	0.12	8	3.5	-	-	-	78	(40%)
3000	1188	9.86	1.18	105	39	0.23	19	0	-	-	-	99.4	(30%)
3001	1182	9.86	1.18	99	77	0.38	19	0	-	-	-	386	(30%)
3003	1173	9.79	1.17	93	82	0.40	18	0	-	-	-	450	(30%)
3004	1179	9.84	1.18	86	82	0.40	17	0	-	-	-	264	(30%)
4026	1186	9.89	1.19	75	33	0.13	-	0	-	-	-	22.5	(30%)
4028	1170	9.76	1.17	85	108	0.41	-	0	-	-	-	369	(30%)
4044	1160	9.68	1.16	44	110	0.38	-	0	-	-	-	84.3	(30%)
ETHYL METHACRYLATE RESINS													
2042	1106	9.23	1.11	63	221	0.83	11	0	37	5400	25.0	7500	(37.5%)
2043	1140	9.51	1.14	65	50	0.21	11	8	7	1000	0.6	300	(37.5%)
BUTYL METHACRYLATE RESINS													
2044	1062	8.86	1.06	15	142	0.52	<1	0	3	500	300.0	150	(30%)
2045	1088	9.08	1.09	55	193	0.64	8	0	25	3600	1.0	250	(30%)
2046	1083	9.04	1.08	35	165	0.54	4	0	15	2100	175.0	200	(30%)
2776	1088	9.08	1.09	45	16	0.10	-	80	-	-	-	-	
4018	1082	9.03	1.08	40	135	0.43	-	0	-	-	-	125	(30%)
4021	1079	9.02	1.08	38	145	0.44	-	0	-	-	-	134	(30%)

a) See text procedures, page 40.

TABLE III: TYPICAL SPECIFICATIONS AND PACKAGING[a]

Elvacite® Grade	Inherent Viscosity[b]	Moisture % Max.	Packages (Fiber Drums, Nonreturnable)
2008	0.172 - 0.194	0.50	125 kg (275 lb net)
2008C	0.172 - 0.194	0.50	125 kg (275 lb net)
2009	0.369 - 0.415	0.50	125 kg (275 lb net)
2010	0.383 - 0.415	0.50	125 kg (275 lb net)
2013	0.156 - 0.174	0.35	136 kg (300 lb net)
2014	0.370 - 0.430	0.50	125 kg (275 lb net)
2016	0.230 - 0.255	0.50	136 kg (300 lb net)
2021	0.469 - 0.527	0.50	125 kg (275 lb net)
2021C	0.469 - 0.527	0.50	125 kg (275 lb net)
2028	0.226 - 0.257	0.80	125 kg (275 lb net)
2041	1.137 - 1.367	0.75	125 kg (275 lb net)
2042	0.768 - 0.896	0.50	125 kg (275 lb net)
2043	0.180 - 0.238	0.35	125 kg (275 lb net)
2044	0.470 - 0.560	0.30	100 kg (220 lb net[c])
2045	0.590 - 0.680	0.30	125 kg (275 lb net)
2046	0.500 - 0.570	0.40	125 kg (275 lb net)
2051	1.137 - 1.367	0.50	125 kg (220 lb net)
2550	0.300 - 0.340	0.50	100 kg (220 lb net[c])
2552	0.300 - 0.340	0.50	125 kg (275 lb net)
2614	0.190 - 0.215	0.35	125 kg (275 lb net)
2669	0.285 - 0.350	2.20	125 kg (275 lb net)
2697	0.230 - 0.255	0.50	125 kg (275 lb net)
2776	0.085 - 0.105	1.00	125 kg (275 lb net)
2823	0.210 - 0.245	0.50	125 kg (275 lb net)
2895	0.200 - 0.550	0.40	125 kg (275 lb net)
2896	1.150 - 1.650	0.40	125 kg (275 lb net)
2914	0.360 - 0.410	0.50	125 kg (275 lb net)
2927	0.110 - 0.130	0.65	125 kg (275 lb net)
3000	0.200 - 0.260	0.50	25 kg sacks, 1 te octaboxes
3001	0.350 - 0.410	0.50	25 kg sacks, 1 te octaboxes
3003	0.370 - 0.430	0.50	25 kg sacks, 1 te octaboxes
3004	0.370 - 0.430	0.50	25 kg sacks, 1 te octaboxes
4018	0.390 - 0.470	0.50	25 kg sacks, 50kg fibreboard kegs
4021	0.400 - 0.480	0.50	25 kg sacks, 50kg fibreboard kegs
4026	0.110 - 0.150	0.50	25 kg sacks, 50kg fibreboard kegs
4028	0.390 - 0.450	0.50	25 kg sacks, 50kg fibreboard kegs
4044	0.340 - 0.420	0.50	25 kg sacks, 50kg fibreboard kegs

a) Typical Specifications and Packaging are subject to change without notification. Please consult your Lucite International represenative for the latest information.

b) Inherent viscosity of a solution containing 0.25g polymer in 50ml of methylene chloride measured at 20°C using a No. 50 Cannon-Fenske viscometer.

c) Like other Elvacite® resins, Elvacite® 2044 and Elvacite® 2550 are produced in the form of the fine spherical beads. Both resins are shipped in 100kg (220lb) drums. Because of its low softening temperature, Elvacite® 2044 tends to form aggregates during shipping and storage. The resin is shipped in drums containing twenty-two 4.5Kg (10 lb) polyethylene-wrapped packs of bead for convenience in handling.

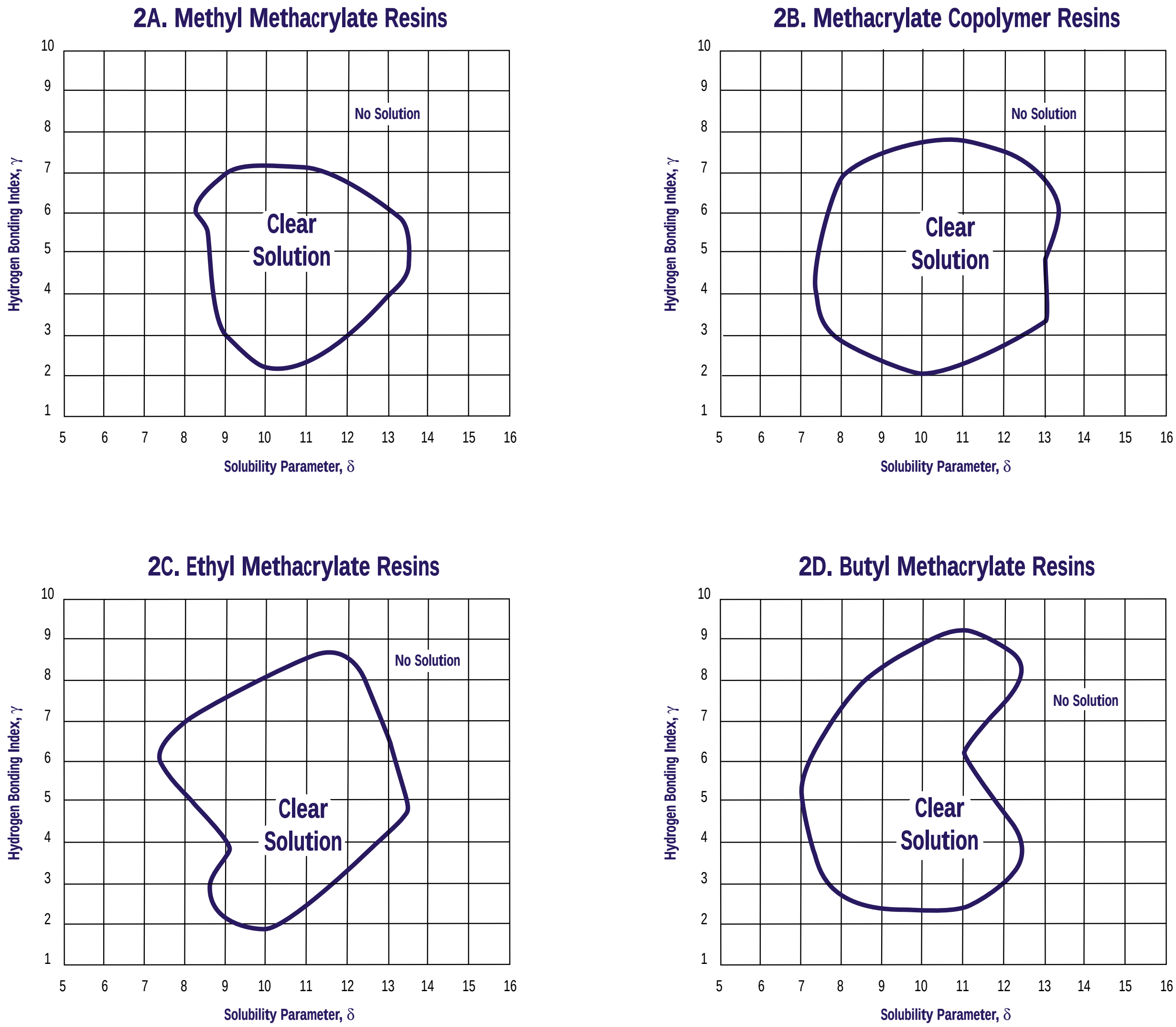
TABLE IV: MUTUAL COMPATIBILITY OF ELVACITE® ACRYLIC RESINS IN AIR-DRIED FILMS

C = Compatible; clear film H = Film appears homogeneous; but hazy I = Incompatible

	Methyl Methacrylate Resins		Methacrylate Copolymer Resins				Ethyl Methacrylate Resins		Butyl Methacrylate Resins	
Elvacite® Grade	2008,2008C, 2009,2010, 2914, 2021, 2021C, 75 50 25 %*	2041, 2051 75 50 25 %*	2013 75 50 25 %*	2014 75 50 25 %*	2927 2697, 2823 2016 75 50 25 %*	2028 75 50 25 %*	2042 75 50 25 %*	2043 75 50 25 %*	2044, 2046 75 50 25 %*	2045 75 50 25 %*
METHYL METHACRYLATE RESINS										
Elvacite® 2008, 2008C, 2914, 2009, 2010, 2021, 2021C,	C C C	C C C	C C C	I[a] I H	I I I	I I I	H[c] I I[b]	H H H[d]	I I I	I I I
Elvacite® 2041, 2051	C C C	- - -	C C C	I I H	I I I	I I I	I I I	I I I	I I I	I I I
METHACRYLATE COPOLYMER RESINS										
Elvacite® 2013	C C C	C C C	- - -	C C C	C C C	C C C	C C C	C C C	I I I	I I I
Elvacite® 2014	H I I[a]	H I I	C C C	- - -	C C C	C C C	C C H	C C C	H I H	H I H
Elvacite® 2016, 2823, 2697	I I I	I I I	C C C	C C C	- - -	C C C	C C C	C C C	I I I	C I I
Elvacite® 2028	I I I	I I I	C C C	C C C	C C C	- - -	C C C	C C C	C C C	C C C
ETHYL METHACRYLATE RESINS										
Elvacite® 2042	I[b] I H[c]	I I I	C C C	H C C	C C C	C C C	- - -	C C C	H I H	H I H
Elvacite® 2043	H[d] I H	I I I	C C C	C C C	C C C	C C C	C C C	- - -	H H H	C H H
BUTYL METHACRYLATE RESINS										
Elvacite® 2044, 2046	I I I	I I I	I I I	H I H	I[e] I I	C C C	H I H	H H H	C C C	C C C
Elvacite® 2045	I I I	I I I	I I I	H I H	C I I	C C C	H I H	H H C	C C C	- - -

a) Elvacite® 2008, H.
b) Elvacite® 2009, H.
c) Elvacite® 2008, C.
d) Elvacite® 2010, I.
* Weight percent, based on total solids; blends prepared using polymers dissolved in methyl ethyl ketone at 30% solids.

FIGURE 2: SOLVENT FORMULATING MAPS

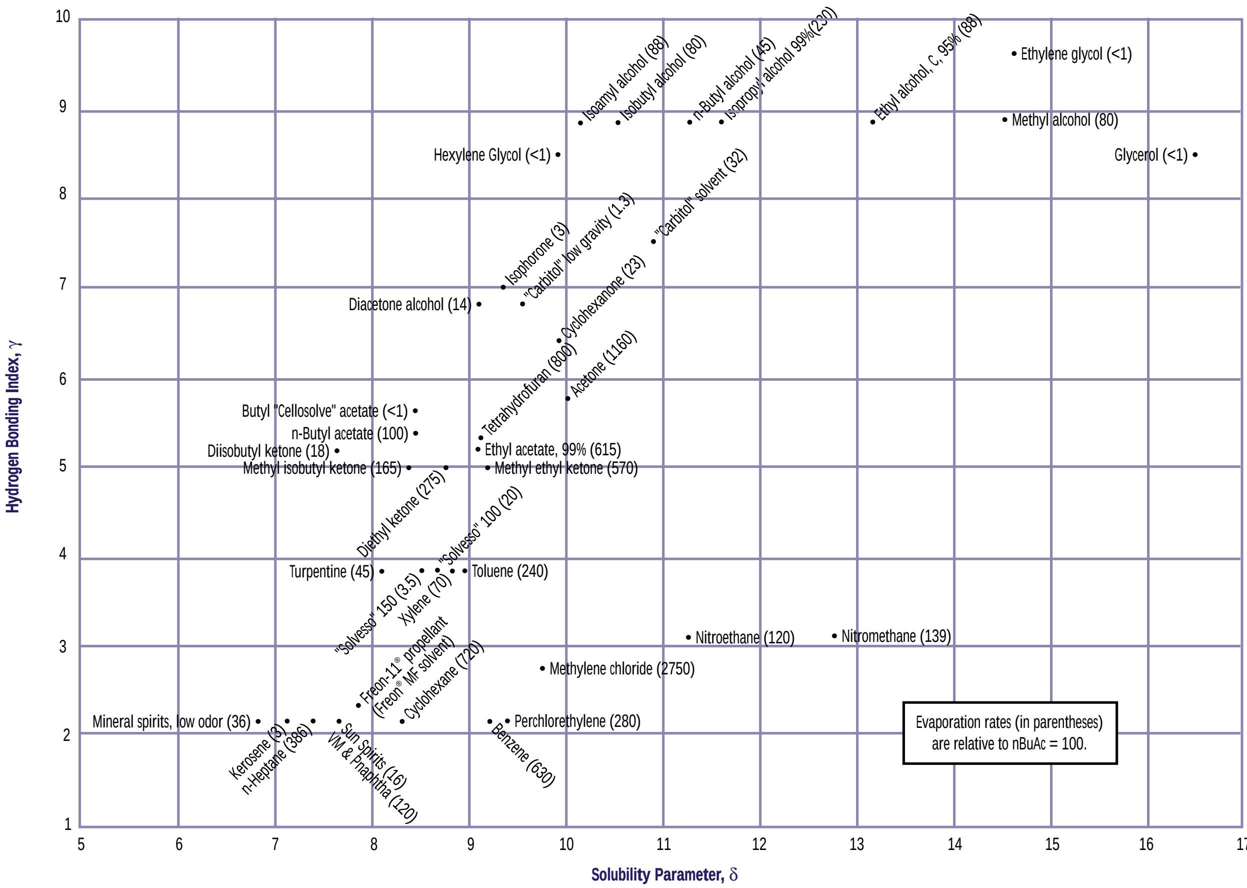


SOLVENT FORMULATING MAPS

As an aid to selection of solvents and solvent blends for use in lacquer and ink formulations, solvent formulation “maps” have been developed for most of the commercial Elvacite® acrylic resins. These maps, shown in generalized form in Figure 2, can be used to predict with reasonable assurance the solubility of any of the Elvacite® resins in specific solvents or blends. The maps are based on the concept that solvent action depends primarily on the two characteristics of the solvent, Hildebrand’s solubility parameter, delta (δ), and hydrogen bonding capacity, conveniently expressed as hydrogen bonding index, gamma (γ). On a grid plotting solubility parameter vs. hydrogen bonding index, any solvent or solvent blend can be represented by a single point. The solubility of a particular resin is conveniently defined in terms of an area on the grid (map) within which active solvents for the resin are located and outside of which complete solubility is generally not attained.

Specific solvents are located on the grid in Figure 3 (page 13). By determining the δ and γ values for a particular solvent from Figure 3 and locating them on a map in Figure 2, the solubility of one of the classes of Elvacite® acrylic resins in that solvent can be predicted with a fair degree of accuracy. For instance, VM & P naphtha (δ = 7.6; γ = 2.2) is a solvent for the butyl methacrylate grades but not for the

FIGURE 3: PARAMETER LOCATIONS AND RELATIVE EVAPORATION RATES FOR TYPICAL SOLVENTS



other grades of Elvacite® acrylic resins. This is indicated since the location for VM & P naphtha falls within the map of the butyl grades. Figure 3 also gives the evaporation rates of specific solvents relative to n-butyl acetate, a factor of considerable importance in developing solvent formulations.

When two solvents are blended, the δ and γ values for the resultant mixtures fall on a straight line connecting the points representing the individual components. Location of the point describing a blend depends on the ratio *by volume* in which the components are mixed. A blend of one volume of solvent A and two volumes of solvent B for example, would be represented by a point 2/3 of the distance from point A *towards point B*. The point, which describes a blend of two solvents, is always closer to the point representing the constituent present in the greater amount. A solvent represented by a point outside the "clear solution" area for a given resin can often be blended with a true solvent for the resin to give useful mixtures. The proportion of diluent which can be included without impairing solubility can be estimated by observing how far along a line connecting the points for the two components the blend point must be located to keep it within the "clear solution" area. This graphic approach can also be extended to multicomponent blends.

PREPARING SOLUTIONS

Please read "Precautions in Handling" section on page 39 before preparing solutions of Elvacite® acrylic resins.

Elvacite® resins dissolve at room temperature but require constant agitation to prevent solvent-swollen granules of polymer from forming agglomerates and sticking to the walls of the vessel. *Important:* The polymer beads should be sifted directly into the vortex of the stirred solvent to speed wetting-out and dispersion. Continuous low-shear agitation for periods of 1-12 hours, depending on the grade and concentration of resin, is recommended. Solution time can be reduced by heating; most common solvents can be heated to approximately 49°C (120°F) without the need for reflux equipment. High-shear agitation also cuts dissolving time, but requires care to avoid overheating and excessive solvent loss. Stirring should continue until a clear solution forms. Any cloudiness or residue may indicate that some polymer remains undissolved. The presence of water in the system can also cause cloudiness.

Because of the low softening temperature of Elvacite® 2044, beads of this grade may agglomerate during shipping and storage, especially in warm weather. Breaking up the aggregates before adding the resin to the stirred solvent can reduce solution time. Chilling Elvacite® 2044 below its glass transition temperature (15°C/59°F) facilitates mechanical reduction. Chunks or slabs of aggregated beads tend to float on the surface of organic solvents. Installing a horizontal screen just beneath the surface of the liquid to keep the resin submerged may be helpful in maintaining maximum contact with the solvent.

In actual practice, Elvacite® polymers are often applied from multicomponent solvent/diluent blends. More economical solvent blends can sometimes be achieved, and solutions prepared more rapidly, by first dissolving the resin in a portion of the final blend rich in active solvents, then cutting with the remaining diluent-rich mixture. The precautions normally observed in handling solvents are necessary when preparing and using solutions of Elvacite® acrylic resins (see "Precautions in Handling", page 39).

SOLUTION VISCOSITY

Figure 4 (page 15) compares the viscosity of Elvacite® resins in representative solvents. Solutions of Elvacite® resins in toluene, methyl ethyl ketone, and isopropyl acetate are consistently lower in viscosity than corresponding solution in "Cellosolve"[2]* solvent.

Solution viscosity varies widely with the grade of Elvacite® as well as with the solvent. Elvacite® 2008, 2013, 2016, and 2043 give the lowest viscosities at high solids, or permit the highest solids content at a given viscosity of the commercial grades. At the other end of the range, Elvacite® 2041 and 2042 give the highest solution viscosities.

* Superscript numbers refer to List of Suppliers, page 40.

THINNERS

Solutions of Elvacite® acrylic resins in strong solvents such as toluene or methyl ethyl ketone generally show good tolerance for xylene and aromatic naphthas. Except for the butyl methacrylate resins, which show considerable solubility in aliphatic hydrocarbons, Elvacite® resins tend to precipitate on addition of aliphatic petroleum thinners such as mineral spirits or VM & P naphtha.

Solutions of the butyl methacrylate resins show good tolerance for ethyl alcohol and can be mixed in any desired proportion with higher (C_3-C_5) alcohols, which are solvents for the resins. Solutions of ethyl methacrylate resins and the copolymer resins all show greater tolerance for lower alcohols than solutions of the methyl methacrylate resins.

In actual practice, lacquers prepared at package viscosity are generally thinned before use with a mixture of solvents and diluents balanced to give the desired application properties. The following mixture has been found generally useful as a thinner for solutions of Elvacite® resins.

GENERAL-PURPOSE THINNER

	Wt%	Vol%
Methyl isobutyl ketone	25	26.38
Isopropyl alcohol	10	10.76
Toluene	59	57.28
Methyl amyl ketone	6	5.58
	100	100.00

Resultant solubility parameter, δ 9.0
Resultant hydrogen bonding index, γ 4.8

The general-purpose thinner is also useful as the solvent for preparing solutions of some resins such as Elvacite® 2013, 2016 and 2046.

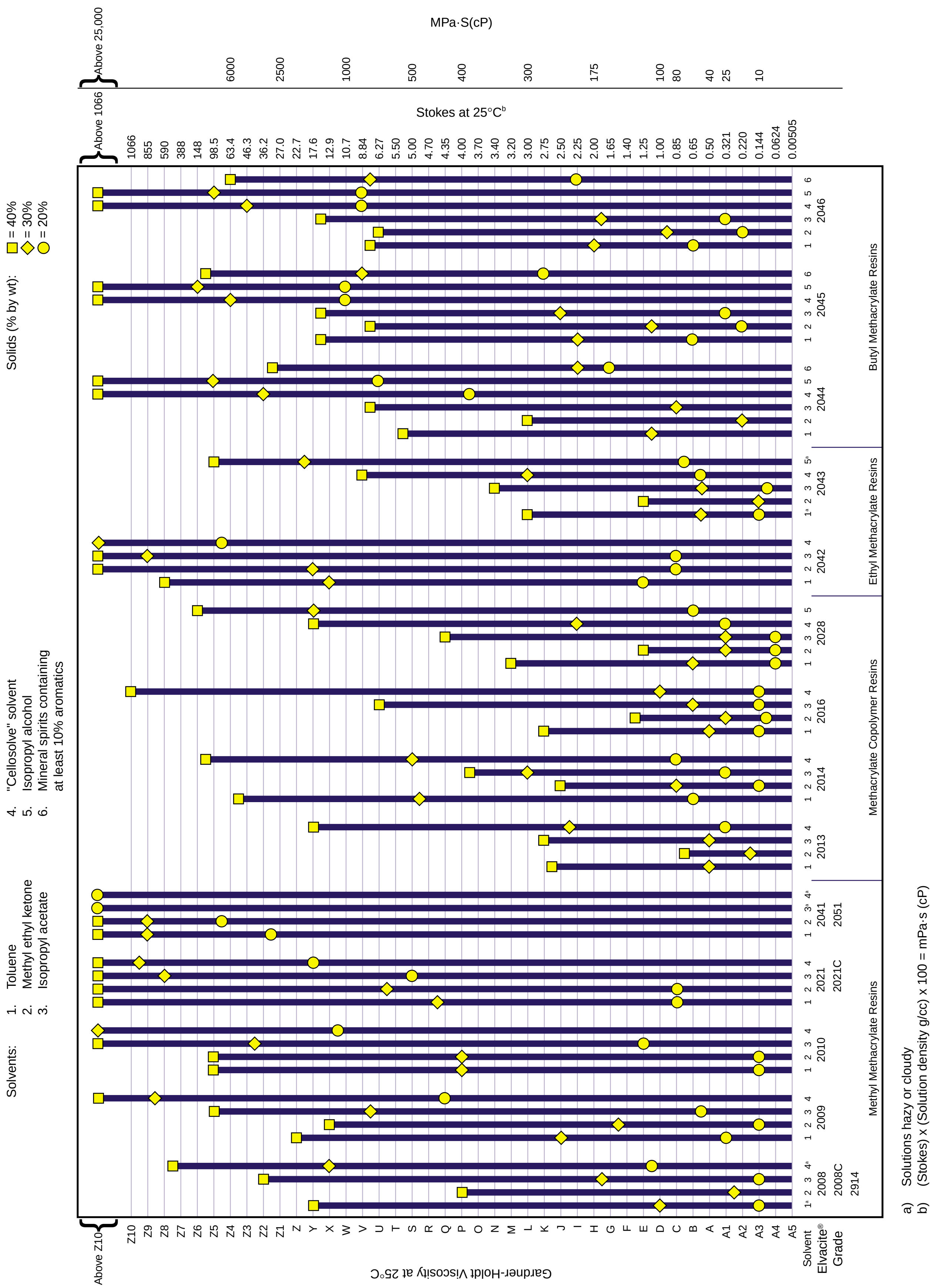
For greater economy, Elvacite® butyl and copolymer resins in solution can be thinned with the following blend:

"4–2–1" THINNER

Solvents	Parts by Wt	% by Wt	% by Vol
n-Heptane	4	57.15	60.51
Isopropyl alcohol, 99%	2	28.56	27.02
n-Butyl acetate	1	14.29	12.47
		100.00	100.00

Resultant solubility parameter, δ 8.6
Resultant hydrogen bonding index, γ 4.4

FIGURE 4: GARDNER-HOLDT VISCOSITY OF ELVACITE® IN SELECTED SOLVENTS



COMPATIBILITY

The compatibility of Elvacite® resins with a variety of plasticizers and resins permits wide latitude in the formulation of lacquers, adhesives, inks and related products.

RESINS

The compatibility of Elvacite® acrylic resins with one another is shown in Table IV (page 11). As previously discussed, a combination of compatible Elvacite® grades can sometimes be used to advantage to obtain an optimum balance of properties for a particular application.

Table VII (page 20-21) shows the compatibility of various Elvacite® resins with a variety of other film formers in air-dried films.

Resins are customarily referred to as compatible when they can be mixed to give clear solutions that deposit clear films. In some instances, designated "X" in Table VII, hazy solutions may deposit clear films. The solvent in which resins are combined has an important bearing on compatibility. Apparent incompatibility sometimes results merely from an improperly balanced solvent system. Unless the solvent blend provides adequate solvency for both resins, some degree of separation will occur on mixing or as applied films dry.

Assuming a favorable solvent system is used, resin compatibility depends on the chemical identities and molecular weights of the resins, and on the proportions in which they are combined. The acrylic resins are polar in nature and therefore more apt to be compatible with other polar resins (e.g., cellulosic and epoxy resins, rosin) than with nonpolar resins (e.g., unmodified alkyd and hydrocarbon resins). Improved compatibility can sometimes be obtained by using a lower molecular weight modifying resin of a given type.

Resins of the types mentioned below have been found particularly useful in formulations based on Elvacite® acrylic resins.

ALKYD RESINS

While alkyd resins as a class show poor compatibility with acrylic resins, some grades of Elvacite® can be combined with properly selected alkyds to form useful blends. Acrylic-modified alkyds generally show better compatibility than other types. Certain other alkyds such as "Aroplaz" 1351[16]* (Table VII, page 20), also show a useful degree of compatibility with Elvacite® resins.

The Elvacite® copolymer resins and the ethyl methacrylate resins are in general more compatible with alkyds than the methyl or butyl methacrylate types. Copolymers such as Elvacite® 2013 and Elvacite® 2028 may be combined with a suitable alkyd resin for gloss and improved pigment wetting. A 70/30 ratio of Elvacite® resin to alkyd (solids basis) is suggested as a starting point in formulating clear or pigmented lacquers with good outdoor durability. Higher alkyd levels may be detrimental to gloss retention or chalk resistance as well as to film hardness.

CELLULOSICS

Nitrocellulose and cellulose acetate butyrate (CAB) show useful compatibility with the Elvacite® resins. The cellulosics increase the hardness and block resistance of formulations based on the softer acrylics such as Elvacite® 2014 and 2028 copolymer resins or butyl methacrylate resins. Conversely, the softer acrylic resins improve the flexibility and durability of the cellulosics. The tendency of acrylic/nitrocellulose blends to yellow slightly on exposure to light increases with the nitrocellulose content. Yellowing can be restricted to a level acceptable for many formulations by limiting the nitrocellulose content to 20% of the total binder. At a level of 40% nitrocellulose, the addition of one percent of a light absorber such as "Uvinul" M=35[27] (based on the total solids) improves the resistance to ultraviolet light.

In exterior finishes based on hard methyl methacrylate resins such as Elvacite® 2010 and 2008, CAB is used in conjunction with plasticizers and other ingredients to achieve an optimum balance between low-temperature craze resistance and high-temperature print resistance. Although these harder resins have limited compatibility with CAB alone, the addition of plasticizers such as benzyl butyl phthalate greatly improves compatibility. Formulations based on the softer Elvacite® resins, particularly 2028, have shown promise in furniture finishes. Combinations of Elvacite® 2028 and Elvacite® 2013 with nitrocellulose or CAB are particularly useful in inks for printing on packaging films. Elvacite® 2028 shows excellent compatibility with alcohol-soluble butyrate and with alcohol-soluble nitrocellulose grades such as "SS" 30 - 35 cP and "SS" 1/4 ⁄ sec as well as with conventional lacquer-type cellulosics. These combinations can be applied from alcohol-rich (30 - 40 wt. %) solvent systems containing relatively small amounts of more active solvents.

In preparing formulations based on combinations of Elvacite® resins with nitrocellulose, the preferred procedure is to dissolve the alcohol-wet nitrocellulose flake in an active solvent such as an ester or ketone and then add the Elvacite® solution. Once dissolved, nitrocellulose tolerates the addition of fairly large amounts of hydrocarbons such as toluene.

* Superscript numbers refer to List of Suppliers, page 40.

TABLE V: SOLUBILITY OF ELVACITE® ACRYLIC RESINS[a]

S = Soluble C = Cloudy I = Insoluble

	Methyl Methacrylate Resins					Methacrylate Copolymer Resins							Ethyl Methacrylate Resins		Butyl Methacrylate Resins	
Solvent	2914 2008C 2008	2009	2010	2021C 2021	2051 2041	2013	2669** 2014	2927 2823 2697 2016	2028	2776** 2550	2552	2614	2042	2043	2044 2046	2045
ALCOHOLS																
Methyl alcohol	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Ethyl alcohol	I	I	I	I	I	I	I	I	S	I	I	I	I	S	I	C
n-Propyl alcohol	I	I	I	I	I	I	I	I	I				I	S	S	S
Isopropyl alcohol	I	I	I	I	I	I	I	I	S[c]	S	I	I	I	C	S	S
Isoamyl alcohol	I	I	I	I	I	I	I	I	C				I	S[c]	S	S
Cyclohexanol	I	I	I	I	I	I	I	I	S				I	I	S	S
Ethylene glycol	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Glycerol	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
AMIDES																
Formamide	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Dimethyl formamide (DMF)	S[b]	S[b]	S[b]	S	S	S	C	S	S				S	S	S	S
CHLOROHYDROCARBONS																
Methylene chloride	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Ethylene dichloride	S	S	S	S	S	S	S		S				S	S	S	S
Perchloroethylene	C	C	C	I	I	C	S		C				S	S	S	S
1,1,1-Trichloroethane	I	I	I	I	I	S	I	S	I		S*	S	S	C	S	S
ESTERS																
Methyl formate	S	S	S	S	S	S	S	S	S				S	S	S	S
Ethyl acetate	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Isopropyl acetate	S	S	S	S	C	S	S	S	S				S	S	S	S
n-Butyl acetate	S	S	S	C	I	S	S	S	S	S	S	S	S	S	S	S
n-Amyl acetate	C	C	C	C	C	S	S	S	S				S	S	S	S
Butyl lactate	S	S	S	S	S	S	S	S	S				S	S	S	S
Propylene glycol monoethyl ether acetate	S	S	S	S	I	S	C	S	S				S	S	C/S	S
Methyl amyl acetate	I	I	I	I	I	S	C	S	S				S	S	S	S
ETHERS																
Diethyl ether	I	I	I	I	I	C	I	S	S				S	S	S	S
Diisopropyl ether	I	I	I	I	I	I	I		I				I	I	I	I
Tetrahydrofuran (THF)[1]	S	S	S	S	S	S	S	S	S				S	S	S	S
“Cellosolve” solvent[2]	C	S	S	S	C	S	S	S	S				S	S	S	S
HYDROCARBONS																
Toluene	C	S	S	S	I	S	S	S	S	S	S*	S	S	C	S	S
Xylene	I	S	I	I	I	S	S	S	S	S	S*	S	S	C	S	S
n-Hexane	I	I	I	I	I	I	I	I	I	I	I	I	I	I	C	C
Cyclohexane	I	I	I	I	I	I	I	I	I				I	I	S	S
VM & P naphtha	I	I	I	I	I	I	I	I	I				I	I	S	S
Mineral spirits	I	I	I	I	I	I	I	I	I				I	I	S[d]	S[d]
Turpentine	I	I	I	I	I	I	I	I	I				I	I	S	S

TABLE V: SOLUBILITY OF ELVACITE® ACRYLIC RESINS[a], CONTINUED

S = Soluble   C = Cloudy   I = Insoluble

	Methyl Methacrylate Resins					Methacrylate Copolymer Resins							Ethyl Methacrylate Resins		Butyl Methacrylate Resins	
Solvent	2914 2008C 2008	2009	2010	2021C 2021	2051 2041	2013	2669** 2014	2823 2697 2016 2927	2028	2776** 2550	2552	2614	2042	2043	2044 2046	2045
KETONES																
Acetone	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Methyl ethyl ketone	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Methyl isobutyl ketone	C	C	C	I	I	S	S	S	S	S	S	S	S	S	S	S
Diisobutyl ketone	I	I	I	I	I	S	C	S	S	S	I	I	S	S	S	S
Cyclohexanone	I	S	I	I	I	S	S	S	S				S	S	S	S
Isophorone	I	I	I	I	I	S	S		S				S	S	S	S
Diacetone alcohol	C	S	S	C	C	S	S	S	S				S	S	S	S
Methyl amyl ketone	I	S	I	I	I	S	S	S	S				S	S	S	S
NITRILE																
Acetonitrile	S	S	S	S	S	S	S		S				S	S	I	I
NITROPARAFFINS																
Nitromethane	S	S	S	S	S	S	S	S	S				S	C	I	I
Nitroethane	S	S	S	S	S	S	S		S				S	C	S	S
VEGETABLE OILS																
Castor Oil	I	I	I	I	I	I	I	I	I	I	I	I	I	I		
Linseed Oil (alkali-refined)	I	I	I	I	I	I	I	I	I	I	I	I	I	I		

a) Solubility of 20% (wt) resin at room temperature,
b) Two liquid phases.
c) Two liquid phases below 24°C (75°F).
d) Soluble in mineral spirits containing at least 10% aromatics.
** Soluble in alkaline solutions having a ph ± 9-10.

VINYL CHLORIDE RESINS

Elvacite® acrylic resins show excellent compatibility with many vinyl chloride copolymer resins. Elvacite® bead polymers are also compatible with vinyl chloride homopolymers when combined using tetrahydrofuran (THF[1*]) as a mutual solvent.

The combination of properties afforded by blends of Elvacite® acrylic resins with vinyl chloride resins is ideally suited for many coating applications. In such blends, the acrylic resin provides improved abrasion resistance, gloss retention, soil resistance and slip. Suggested starting formulations for vinyl fabric top-coating lacquers based on Elvacite® resin/vinyl chloride resins combinations are discussed on page 30. The acrylic resin serves as an effective barrier, preventing escape of the plasticizer from the vinyl fabric.

* Superscript numbers refer to List of Suppliers, page 40.

CHLORINATED RUBBER

A 10 centipoise chlorinated rubber ("Pergut" S 10[32]) is shown in Table VII (page 20) to be broadly compatible with most grades of Elvacite®. Aromatic hydrocarbon-rich solvent systems are suggested for optimum compatibility. In blends with the harder Elvacite® resins, chlorinated rubber improves adhesion and flexibility. The presence of ultraviolet-light-sensitive chlorine atoms, however, could tend to impair the excellent outdoor stability which characterizes the acrylic resins.

Blends of the chlorinated rubbers with Elvacite® acrylic resins, particularly Elvacite® 2013 and 2028 are attractive coatings for primed steel in marine environments and for concrete coating such as swimming pool and traffic paint. In these applications, the Elvacite® resins enhance gloss and gloss retention and improve resistance to yellowing.

TABLE VI: COMPATIBILITY OF ELVACITE® ACRYLIC RESINS WITH PLASTICIZERS[a]

C = Compatible at 50/50 resin/plasticizer ratio I = Incompatible at 90/10 resin/plasticizer ratio LC = Compatible at 90/10 resin/plasticizer ratio but incompatible at 50/50

	Methyl Methacrylate Resins	Methacrylate Copolymer Resins				Ethyl Methacrylate Resins	
Plasticizer	2008C, 2008, 2009, 2010, 2021, 2021C, 2051, 2041	2013	2014	2927, 2823 2697 2016	2028	2042	2043
"Abalyn"[4]* (methyl abietate)	LC	LC	C	—	C	C	C
Dibutyl phthalate	C	C	C	—	C	C	C
Dibutyl sebacate	LC	LC	LC	—	C	C	C
Di – (2 – ethylhexyl) azelate	C	C	C	—	C	C	—
"Hercoflex" 600[10] (pentaerythritol ester)	LC	LC	LC	C	C	C	C
"Hercoflex" 707[10] (polyol ester)	LC	LC	LC	—	C	C	C
"Santicizer" 8[14] (N-ethyl toluene sulfonamides)	C	C	C	C	C	C	C
"Santicizer" 97[34] (dialkyl adipate)	C	C	C	C	C	C	C
"Santicizer" 160[34] (butyl benzyl phthalate)	C	C	C	C	C	C	C
"Santicizer" 261[34] (isooctyl benzyl phthalate)	C	C	C	—	C	C	C
"Santicizer" 278[34] (benzyl phthalate)	C	C	C	—	C	C	C
"Santicizer" B-16[34] (butyl phthalyl butyl glycolate)	C	C	C	—	C	C	C
Tricresyl phosphate.	C	C	C	C	C	C	C

a) Films for these tests were cast from MEK solutions.
— Not tested.

MISCELLANEOUS

As illustrated in Table VII (page 20), a variety of other resins including rosin esters and coumarone-indene, ketone, silicone, epoxy and selected amine/formaldehyde resins are compatible with some or all grades of Elvacite® resins. Some of these are low-cost resins that may be useful as extenders or tackifiers in formulations based on Elvacite® resins. Others can be used to enhance specific performance properties. In pigmented metal finishes, for example, minor amounts of Dow Corning's DC-840[15] silicone resin assists initial color development and contributes to the superior outdoor durability of finishes based on Elvacite® acrylic resins.

The softer Elvacite® acrylic resins such as 2044, 2043 and 2028 have shown promise as modifiers and extenders for silicone resins such as DC-840. At levels of up to 25% Elvacite®, the exterior durability was excellent and the hardness of the coating could be modified at will by the choice of the resin grade.

* Superscript numbers refer to List of Suppliers, page 40.

PLASTICIZERS

Table VI shows the compatibility of Elvacite® resins with various plasticizers. The phthalate esters in particular are generally effective plasticizers for use with Elvacite® resins. The low volatility and consequently greater permanence of isooctyl benzyl phthalate ("Santicizer" 261[14]) and benzyl phthalate ("Santicizer" 278[14]) are advantageous for high-temperature or prolonged-service applications. "Santicizer" 97[14] (dialkyl adipate) adds flexibility and cold check resistance.

Adding a plasticizer to an Elvacite® resin-based formulation improves the flexibility of the resulting film, but at some sacrifice in film hardness, block-resistance, tensile strength and possible chemical resistance.

The butyl methacrylate grades of Elvacite® acrylic resin do not normally require plasticization. However, Elvacite® 2044 will accept any of the plasticizers listed in Table VI. Softening of Elvacite® 2045 or 2046 is preferably accomplished by blending with Elvacite® 2044.

TABLE VII: COMPATIBILITY OF ELVACITE® ACRYLIC RESINS WITH OTHER RESINS

Blending Resin	Form of Blended Resin Tested	Methyl Methacrylate Resins: 2008C, 2021C 2008, 2009 2010, 2021 %** 75	50	25	2051 2041 %** 75	50	25
ALKYD							
"Aroplaz" 1271[16] (Long linseed drying oil)	As received (30% in MEK)	I	I[c]	I[d]	—	I	I
"Aroplaz" 1351[16] (Long castor nondrying oil)	30% in MEK	C[c]	H[f]	H[e]	—	C	H
"Chempol" 13-1410[8] (Safflower drying oil, acrylate modified)	As received (50% in xylene)	—	I	I[g]	—	I	I
"Paraplex" RG-2[28] (Nondrying oil, sebacic)	30% in MEK	I	I	I	I	I	I
"Blagden" 3105[33] (Short coconut nondrying oil)	As received (60% in xylene)	—	H	H	—	H	H
CELLULOSIC							
Cellulose acetate 39-5-5B[10]	30% in acetone or MEK	I	I	I	I	I	I
Cellulose acetate butyrate, 1/2 - sec.[4]	30% in MEK	C[O]	C[O]	C[O]	I	I	I
Ethyl cellulose N-7[10]	30% in MEK	I	I	I	I	I	I
Nitrocellulose "RS", 1/2-sec Isopropyl[10]	MEK/alcohol soln.	C	C	C	C	C	C
EPOXY							
"Epon" 828[3]	As received 100% Resin	C	—	C	C	—	C
"Epon" 1001[3]	30% in MEK	C	C	C	C	C	C
ELASTOMERS							
EMD-504[11] (Polyisobutylene)	30% in toluene	I	I	I	I	I	I
"Hypalon" 30[10] (Clorosulfonated polyethylene)	15% in toluene	I	I	I	I	I	I
Neoprene AC-Soft[30] (Polychloroprene)	15% in toluene	I	I	I	I	I	I
ROSIN DERIVATIVES							
Ester Gum 8L[4]	30% in MEK	H	I	I	H	I	I
"Pentalyn" 255[4] (Pentaerythritol ester)	30% in MEK	H[d]	H	H	—	H	H
"Pentalyn" 830[4] (Pentaerythritol ester)	30% in MEK	H	H	H	—	H	H
VINYL CHLORIDE RESINS							
"UCAR® Solution Vinyl" VAGH[2] (Copolymer)	30% in MEK	C	C	C	C	C	C
"UCAR® Solution Viny" VMCH[2] (Copolymer)	30% in MEK	C	C	C	C	C	C
"UCAR® Solution Viny" VYHH[2](Copolymer)	30% in MEK	C	C	C	C	C	C
"UCAR® Solution Viny" VYNS[2] (Copolymer)	15% in MEK	C	C	C	C	C	C
"Exon" 450[12] (Copolymer)	15% in MEK	C	C	C	C	C	C
"Exon" 9290[12] (Homopolymer)	15% in THF	C	C	C	C	C	C
"Geon" 103 EP[13] (Homopolymer)	15% in THF	C	C	C	C	C	C
OTHER TYPES							
"Arochem" 650[16] Maleic-modified hard resin	30% in MEK	—	C	C	—	C	C
"Aroset" 4110[28] Acrylic resin	30% in MEK	C	H	H	—	H	H
Dammar	30% in toluene	H	I	H	H	I	H
DC-840[15] Silicone resin	As rec'd (60% in toluene)	C	C	C	C	C	C
"Pergut" S 10[32] Chlorinated rubber	30% in MEK	I[h]	I[h]	I[h]	I	I	I
"Piccoumaron"[10] Coumarone-indene resin	30% in MEK	C	I	I	C	I	I
"Santolite" MHP[14] Sulfonamide-formaldehyde	30% in MEK	C	C	C	C	C	C
Shellac	30% in methanol	H	I	I	H	I	I
"Super-Bechacite" 2000[16] Permanently fusible phenolic	30% in MEK	C	C	C	C	C	C

* Superscript numbers refer to List of Suppliers, page 40.

** Weight percent Elvacite® based on total solids in blends prepared by combining blending resin in form indicated with a 30% solution of Elvacite® (15% or 20% solution of Elvacite® 2041); all grades were dissolved in MEK.

*** 2016,2823 or 2697 not tested. Estimated to be similar to 2013.

a) Ethyl alcohol or isopropyl alcohol-wet flake dissolved in MEK at 20% or 30% solids.
b) Combined with solutions of Elvacite® polymers in THF.
c) Elvacite® 2008, C.
d) Elvacite® 2010, H.
e) Elvacite® 2010, I.
f) Elvacite® 2009, C; Elvacite® 2010, I.
g) Elvacite® 2008, X; Elvacite® 2009, H.

C = Compatible in solution and film   H = Film appears homogeneous but hazy   — = Not determined   I = Incompatible   X = Solution hazy, film clear

Methacrylate Copolymer Resins									Ethyl Methacrylate Resins						Butyl Methacrylate Resins						
2697, 2016*** 2927, 2823, 2013 %**			2014 %**			2028 %**			2042 %**			2043 %**			2044 %**			2045, 2046 %**			
75	50	25	75	50	25	75	50	25	75	50	25	75	50	25	75	50	25	75	50	25	Blending Resin
																					ALKYD
C	H	H	H	H	H	X	H	I	X	I	I	C	H	H	X	X	H	X	X	I	"Aroplaz" 1271[16]
C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	H	C	C	C	C	"Aroplaz" 1351[16]
C	C	C	—	H	H	C	C	C	—	C	H	C	C	C	—	I	I	—	I	I	"Chempol" 13-1410[8]
I	I	I	X	C	C	H	H	I	I	I	I	C	H	H	I	I	I	I	I	I	"Paraplex" RG-2[28]
—	H	H	—	H	H	H	I	H	—	H	H	C	H	H	—	I	H	—	I	I	"Blagden" 3105[33]
																					CELLULOSIC
I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	Cellulose acetate[10]
C	C	C	C[j]	C[j]	C[j]	C	C	C	C	C	C	C[j]	C[j]	C[j]	I	I	H	H[m]	I	C	CAB[4]
I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	Ethyl cellulose[10]
C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	Nitrocellulos[10]
																					EPOXY
C	—	C	C	—	I	C	C	H	C	—	C	—	C	C	—	H	H	—	H	H	"Epon" 828[3]
C	C	C	H	H	H	H	H	I	C	I	I	C	C	H	I	I	I	I	I	I	"Epon" 1001[3]
																					ELASTOMERS
I	I	—	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	EMD-504[11]
I	I	—	I	I	—	I	I	—	I	I	—	X[k]	I	—	I	I	—	I	I	—	"Hypalon" 30[10]
I	I	—	I	I	—	I	I	—	I	I	—	I	I	—	I	I	—	I	I	—	Neoprene AC-Soft[30]
																					ROSIN DERIVATIVES
—	H	H	C	H	H	C	C	C	C	H	H	C	H	H	C	C	C	C	C	C	Ester Gum 8L[4]
H	H	H	H	H	H	C	H	H	H	I	H	C[l]	C	H[l]	H	H	H	H[n]	H	H	"Pentalyn" 255[4]
H	H	H	H	H	H	H	H	H	H	H	H	X[l]	H[l]	H[l]	H	H	H	H	H	H	"Pentalyn" 830[4]
																					VINYL CHLORIDE RESINS
C	C	C	X	X	X	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	"UCAR® Solution Viny" VAGH[10]
C	C	C	H	X	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	"UCAR® Solution Viny" VMCH[2]
C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	"UCAR® Solution Viny" VYHH[2]
C	C	C	I	H	C	C	C	C	C	C	C	C	C	—	C	C	C	C	C	C	"UCAR® Solution Viny" VYNS[2]
C	C	—	I	H	C	C	C	C	C	C	—	C	C	—	C	C	—	C	C	—	"Exon" 450[12]
C	C	C	—	—	—	C	C	—	C	C	C	—	—	—	—	—	—	—	—	—	"Exon" 9290[12]
C	C	C	—	—	—	C	C	—	C	C	C	—	—	—	—	—	—	—	—	—	"Geon" 103 EP[13]
																					OTHER TYPES
C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	"Arochem" 650[16]
C	C	C	C	C	C	C	C	H	C	C	C	C	C	C	H	—	H	H	H	H	"Aroset" 4110[16]
I	I	H	I	I	I	I	I	I	I	I	H	H	I	I	I	I	H	I	I	H	Dammar
C	C	C	C	C	C	C	C	C	C	C	C	—	C	C	C	C	C	C	C	C	DC-840[15]
C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C[m]	C[m]	C[m]	"Pergut" S 10[32]
C	C	C	H	H	H	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	"Piccoumaron"[10]
C	C	C	H	H	H	C	H	H	C	C	C	C	C	C	I	I	I	I	I	I	"Santolite" MHP[14]
H	I	I	I	I	I	I	I	I	H	I	I	I	I	I	H	I	I	H	I	I	Shellac
C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	"Super-Bechacite"[14]

h) Methyl methacrylate resins are compatible with "Pergut" S 10 in toluene rich solvent systems.
i) Elvacite® 2014 mixed with 20% CAB in 50/50 ethyl acetate/isopropyl alcohol.
j) Resins combined in 50/50 ethyl acetate/isopropyl alcohol.
k) Tested at 85% Elvacite® 2043; I at 65%.
l) Resins combined in 80/20 ethyl alcohol/n-propyl acetate.
m) Elvacite® 2045, I.
n) Elvacite® 2046, I.
0) 20% total solids in 55/25/20 toluene/MEK/n-butyl acetate.

FORMULATION GUIDE

TYPICAL FORMULATIONS

Elvacite® acrylic resins are used alone or in combination with other resins and modifiers In a variety of coating applications including metal finishes; coatings for plastic, wood, concrete, and other substrates; "Electrofax" paper coatings; flexographic and gravure inks; overprint lacquers; and numerous specialty applications.

Elvacite® grades suggested for various uses are shown in Table IX. Alternate grades for the same application are shown with an indication of why the alternate might be selected. Further guidance may be obtained by referring to Figure 1 (page 6) and selecting an Elvacite® grade which appears to offer promising properties.

Starting formulations for typical applications are included in the sections that follow. For further assistance in utilizing Elvacite® acrylic resins to your best advantage, consult your Lucite International representative.

METAL FINISHES

In metal finishing lacquers, Elvacite® acrylic resins provide a distinctive combination of high gloss, clarity and hardness with excellent weatherability and resistance to ultraviolet light. They are used in a variety of clear and pigmented finishes for aluminum, bronze, steel and bright metals such as brass and copper. Aerosol formulations based on Elvacite® are ideal for touch-up operations on automotive parts, appliances and the like.

The preferred grade of Elvacite® will depend on the end use. Elvacite® 2014 and 2028 copolymer resins offer an outstanding balance of properties for general use in metal finishes. The harder copolymers and methyl methacrylate resins are preferred where greater hardness or high-temperature print resistance is required. For some applications, the butyl methacrylate resins may be selected because of their greater flexibility and solubility in low-cost solvents.

The following pages suggest starting formulations for evaluating various grades of Elvacite® in metal finishes. As with any organic coating, the metal surface must be thoroughly cleaned before finishing to insure good adhesion of the film.

CLEAR LACQUERS

Table VIII shows that in clear lacquers for metals, Elvacite® 2028 offers performance far superior to general-purpose acrylic resins. The overall performance, especially for bright metals such as silver, copper and brass, is superior to a competitive high-adhesion acrylic resin. This rating is based on appearances under use conditions which include exposure to liquid water or aqueous solutions, high concentrations of moisture vapor and protection of the substrate from discoloration by atmospheres containing sulfur compounds. The lacquers used for these tests were prepared according to Formula 1 (page 25). Note that the lacquer prepared from Elvacite® 2028 was applied at much

TABLE VIII:
Performance of Acrylic Resin Clear Metal Coatings

	Elvacite® 2028	High Adhesion Acrylic	General Purpose Acrylic
Gloss on Black Glass (%)			
20°	86.2	86.6	86.9
60°	76.8	76.9	78.3
Adhesion (%)[a]			
Aluminum	100	100	80
Brass	100	100	5
Steel	100	100	20
Mandrel Bend			
(Smallest Diameter Passed, In.)[b]			
Aluminum	1/8	1/8	>1/2
Brass	1/8	1/8	>1/2
Steel	⁄	⁄	>1/2
Impact Resistance c			
Aluminum, (48 in.-lb.)			
Concave	6	10	2
Convex	4	10	3
Brass, (9.6 In-lb.)			
Concave	10	10	2
Convex	7	10	4
Steel (48 in-lb.)			
Concave	9	9.5	0
Convex	6	10	4
Chemical Resistance[d]			
Peanut Oil			
Brass	10/10	10/10	10/10
Aluminum	10/10	10/10	10/10
Liquor			
Brass	5/9	3/5	5/10
Aluminum	5/10	3/5	5/10
Citric Acid 10% Aqueous			
Brass	10/10	7/8	10/10
Aluminum	10/10	10/10	10/10
Tarnish Resistance[e]			
Brass	Excellent	Poor	
Moisture Resistance[e]			
Brass	Excellent	Poor	

a) Cross-hatch tape pull.
b) Smallest diameter tested was 1/8" with aluminum panels ⁄ with steel panels
c) 10-No visible failure 0-Complete loss of film
d) Three drops under watch glass for 4 hours. Panel washed with mild soap and water and the effect noted. Panel allowed to recover for 4 hours ambient conditions. Comparison: 0-10 = Poor to excellent before recovery/poor to excellent after 4 hr. recovery
e) Exposed to cut hard-boiled egg in closed glass jar overnight.

TABLE IX: APPLICATIONS FOR ACRYLIC RESINS

Use	Requirements	Start	Grade Suggested Alternative	Alternate Reason
VINYL TOPCOATING				
Automotive, Upholstery	Hardness, toughness, plasticizer barrier	2021	2008 2041	Higher solids Thinner, tougher films
METAL COATINGS				
Steel	Hardness, adhesion (to primer)	2013	2008 2014 2016 2552	Harder, pigment dispersion Flexibility, pigment dispersion Flexibility Gloss, abrasion resistance
Marine/Container Paints	Flexibility, toughness, adhesion, low cost, low viscosity	2016	2927 2823	Higher solids Higher solids
Aluminum	Adhesion, toughness	2028	2014 2044	Abrasion resistance Flexibility
Bronze, Brass, Copper	Adhesion, hardness, tarnish resistance	2028	2014	Flexibility
PLASTICS				
Barrier	Solvent barrier	2013	2008	Harder films
Decoration	Flexibility, toughness	2016	2009	Harder films
Heat Seal Lacquers	Adhesion, vinyl compatibility, FDA compliance, strength	2550 4044		
MASONRY COATINGS	Adhesion moisture resistance	2013	2010 2016	Harder films Flexibility
Road Marker Paints	Salt spray resistance, brittleness to allow chaulking, adhesion, low cost	2016	2008 2009 2927 2823	Alkyds to replace Chlorinated rubber Higher solids Higher solids
GRAPHIC ARTS				
Flexographic Inks	Solubility, compatibility	2028	2043	Harder films
Rotogravure Inks	Adhesion, hardness	2013	2008	Harder films
Screen Inks	Solubility, nonplugging	2045 4028	2013 4026	Harder films Improved crosslink density
Roll Leaf (for hot stamping)	Adhesion, flexibility	2013	2008	Clean break
Toners	Solubility	2016	2045	Flexibility
Binder	Electrical properties	2045	2014	Flexibility
WOOD PUTTY	Toughness	2042	2046	Higher solids
TEMPORARY BINDERS	Clean "burn out"	2045	2046	Greater flexibility
DECALS	Toughness/brittleness	2042 4021	2045	Flexibility, higher solids
ADHESIVE	Softness	2044	2550	Harder films
Construction Bolt Cement	Solubility in MMA, storage stability, adhesion, mechanical performance	2008C	2021C	Tougher
PVC Pipe Cement	Softness, vinyl compatibility, adhesion, bond strength	2008	2013	Flexibility
Staple Cements	Adhesion, flexibility	2550	2044	Flexibility
AEROSOL LACQUER	Sprayability	2013	2010	Harder films
Silly String	Stringing on spraying, flexibility, high molecular weight	2045		
WOOD FINISHES				
Decoupage	Transparency, color, solids	2014		
WALL COVERINGS	Mar resistance, cleanability	2008	2013	Flexibility
ART	Adhesion, flexibility	2044	2045	Harder films
REACTIVE COATINGS				
UV (as non-reactive)	No reactivity, viscosity modification, control shrinkage, reduce cost, improve adhesion and flexibility	2008C 2021C 2028 2697		
WATER REDUCIBLE COATINGS	Water reducible, adhesion	2669	2776	Increased water resistance
SELF-LEVELING FLOORING		2697	4018	Flexibility

higher solids than the competitive high-adhesion acrylic, yet developed hardness more rapidly. Modification of the solvent system resulted in film which developed 24-hour Sward Rocker hardness of 32 with 2028 compared to 12 with the competitive resin.

As demonstrated in Table X, clear coatings of Elvacite® 2014 show good adhesion, flexibility, and corrosion resistance even on untreated, unprimed aluminum. The chromate conversion coatings widely used as prepaint treatments for aluminum, further enhance the adhesion and effective flexibility of coatings of Elvacite® 2014 and extend the range of conditions under which the coatings show excellent performance.

For spray application, Elvacite® 2014 can be diluted to 15% solids with the general-purpose thinner on page 14. The "4-2-1" thinner shown on page 14 is suggested for use with Elvacite® 2014 in formulating to comply with air pollution regulations. Dilution to 15.5% solids by weight with "4-2-1" thinner reduces the toluene content of the final solvent system to 20% by volume. The diluted solution may require further modification for satisfactory spray application.

Elvacite® 2014 and 2028 are also useful in coatings for bright metals such as brass, copper, and silver. For example, Formula 1 has shown excellent outdoor durability on brass and copper. This lacquer can be thinned for spray application as noted, or adapted for aerosol application by modifying the volatile portion.

Where some sacrifice in light resistance and gloss retention can be tolerated, Elvacite® 2014 and 2028 may be combined with nitrocellulose to reduce cost and promote fast solvent release for quick drying. Blends containing 15-20% nitrocellulose based on total solids are suggested for trial. Coatings based on Elvacite® 2014 and 2028 and nitrocellulose in this proportion have show good resistance to yellowing on exposure to ultraviolet light. High-gloss lacquers utilizing Elvacite® 2552 may be formulated based on Formula 8 (page 28).

Elvacite® 2013 may be used alone or combined with Elvacite® 2014 for greater economy or to obtain a harder finish. The harder copolymers show good tolerance for diluents as a result of their lower inherent viscosity, and release solvent more rapidly than Elvacite® 2014. On metals with a high thermal coefficient of expansion, however, coatings of Elvacite® 2014 are more resistant than Elvacite® 2013 to cracking on prolonged exposure under conditions involving severe temperature fluctuations. Relatively thin coatings, i.e., 0.3 mil or less, generally show better stress-crack resistance than thicker films.

In cases where the maximum tolerance for low-cost or nonpolluting diluents are required, Elvacite® 2028 is the best of the copolymer resins for coatings on ferrous and nonferrous metals, wood and other substrates. High levels of ethanol, isopropanol and mineral spirits of low aromatic content are useful with this resin.

Elvacite® 2044 acrylic resin shows outstanding adhesion to aluminum. Clear lacquers with good outdoor durability can be prepared by blending this tough, flexible butyl methacrylate resin with half-second nitrocellulose to increase hardness and speed solvent release. Formula 3 (page 26), for example, can be applied to aluminum to give coatings that pass "Scotch" tape adhesion, mortar resistance, and 100% humidity tests. Although Elvacite® 2044 is a relatively high molecular weight resin, it can be sprayed when properly formulated. Film properties can be varied by adjusting the ratio of nitrocellulose to Elvacite® 2044 in Formula 3. Lowering the nitrocellulose content improves resistance to yellowing on exposure to ultraviolet light, but reduces film hardness as shown in Table XI. Resistance to yellowing can be improved by adding a light screen such as "Uvinul" N-35[27] or reducing the nitrocellulose content to 25 percent of the binder.

TABLE X: Performance of Elvacite® 2014 as a Coating for Unprimed Aluminum

(0.3-0.5 mil coatings, air-dried 12 hrs)

Adhesion, cross-cut test, % removed by "Scotch" tape[ab]	0
Mandrel bend, diameter for failure (0.3 mil coating)[a]	<3.2 mm (<1/8 in.)
Gardner impact, joules (in.- lb.) for failure (0.3 mil coating)[a]	>0.23, 0.45 (>2, <4)
Salt spray test, 120-hr exposure[b]	No effect
CASS test, 24-hr exposure[b]	Some whitening at panel edges
"Corrodkote" test, 16-hr exposure[b]	No effect

a) On 1100-H14 and 2024-T3 aluminum.
b) On 3003-H14 aluminum.
c) Film < 0.5 mil thick on thoroughly cleaned metal; > 0.5 mil coatings may require force drying

TABLE XI: Effect of Nitrocellulose Content on Hardness

Wt Ratio Elvacite® 2044/ Nitrocellulose	Tukon Hardness[a], Knoop No. Dried 16 hrs at Room Temp	Dried 1 hr at 93°C (200°F)
100/0	3	4
75/25	10	10
60/40	12	14

a) Tested as 0.4 mil coatings on 25mil 3003-H 14 aluminum, "Alodine" 1200S treated

PIGMENTED LACQUERS

Pigmented finishes prepared using Elvacite® 2013 have shown good outdoor durability on aluminum panels exposed in Delaware and Florida. Formulas 4 and 5 (page 27) are suggested as starting points for white and pastel-to-medium-tinted metal finishes. In formulating deep-color lacquers, the titanium dioxide content would be reduced or eliminated. "Ti-Pure" R960[1]* titanium dioxide is recommended for general use in exterior finishes since it combines excellent chalk resistance with good gloss and hiding. For interior applications, "Ti-Pure" R-900[1] is suggested for maximum hiding power and ease of gloss development on dispersing at relatively low shear.

Elvacite® 2028, a copolymer resin of somewhat higher acid number than Elvacite® 2013, is suggested as a vehicle for metal lacquers where extra ease of pigment wetting is desired to assure optimum gloss and color development. Improved pigment wetting also can be obtained by combining Elvacite® 2013 with a suitable modifier. For example, substituting DC-840[15] silicone resin for 10% of the Elvacite® 2013 in Formula 5 enhances color development on tinting. In blue lacquers containing 1% "Monastral" Blue BT-425-D[1]* pigment, both the all-acrylic binder and the 90/10 acrylic/silicone blend have shown good overall durability and color stability on weathering. The good gloss retention typical of Elvacite® 2013 acrylic resin is further improved by addition of 10% silicone resin. Higher silicone levels tend to impair gloss retention.

Of the softer copolymer resins, Elvacite® 2014 and 2028 show particularly good pigment wetting properties. Translucent finishes that give a striking appearance when applied on polished aluminum can be prepared by incorporating pigment colors at low concentrations so that very little hiding is introduced. Formula 6 (page 27) is a typical translucent lacquer of this type. For a darker tone finish, the pigment content can be increased to double the quantity shown. Other pigments including the following may be substituted to vary the color:

"Monastral" Red B, RT-796-D[1]
"Monastral" Blue B, BT-284-D[1]
"Monastral" Violet R, RT-887-D[1]
"Monastral" Maroon, RT-792-D[1]
Green Gold YT 562-D

Blends of Elvacite® 2044 with vinyl resins are useful in pigmented metal coatings where high flexibility is required. For example, a 15% PVC lacquer containing a 50/50 blend of Elvacite® 2044 acrylic resin and "UCAR® solution Vinyl" VMCC[2] vinyl chloride-acetate copolymer resin as binder has shown good outdoor durability when tinted with 1% "Monastral" Blue BF, BT-425D[1] pigment.

Pigmented lacquers prepared from Elvacite® 2008 and 2010 methyl methacrylate resins are used in the automotive industry for spray applications to preformed steel, aluminum, and other metal substrates. Elvacite® 2008, which contains polar carboxyl groups, is superior in its ability to disperse difficult-to-wet pigments and thereby develop optimum gloss. Elvacite® 2010, the carboxyl-free companion grade, effectively disperses easily wetted pigments such as titanium dioxide and provides maximum resistance to water and diluted alkalies. The two grades can be blended to optimize the properties obtained with a given pigmentation. Formula 7 (page 27), which contains Elvacite® 2008 and 2010, has shown excellent chalk-fade resistance on outdoor exposure.

Formula 1: Comparison of Acrylic Resins in Application Properties

Formulation:

Ingredients	% by Wt
Acrylic resin	30.0
Methyl isobutyl ketone	17.5
Isopropyl alcohol	7.0
Toluene	41.3
Methyl amyl ketone	4.2
	100.0

Properties

Time to dissolve (min.)	Elvacite® 2028	High Adhesion Acrylic	General Purpose Acrylic
Ball Mill	3	160	130
Air Stirrer	12	42	83
Solids at spray viscosity [a] (%)	28	16	26
Tack-free time (min.)	11.5	13.0	11.0
Sward Rocker hardness (% of glass)			
1 hr	6	4	14
2 hr	6	4	16
3 hr	8	8	18
4 hr	10	8	20
24 hr	14	14	26

a) Diluted with solvent blend shown above to improve spray performance.

* Superscript numbers refer to List of Suppliers, page 40.

Formula 2: Clear Coating for Bright Metals[a]

Ingredients	% by Wt	Binder % by Wt
Elvacite® 2014	29.75	97.12
Toluene	55.43	—
Ethyl alcohol, 2B, 95%	5.01	—
Isopropyl alcohol	8.93	—
1,2,3 – Benzotriazole	0.44	1.44
"Admex" 711 epoxidized soybean oil[6]*	0.44	1.44
	100.00	100.00

Nonvolatiles (solids), % by weight	30.6
% by volume	24.5
Volatiles,	
Resultant solubility parameter, δ	9.6
Resultant hydrogen bonding index, γ	4.3
Typical viscosity, #4 Ford cup, sec	47

PREPARATION – Dissolve Elvacite® 2014 in toluene and alcohols, then add other ingredients.

SUGGESTED SPRAY DILUTION – Ten to 12% solids with a solvent blend such as 80/20 (wt) xylene/toluene or 60/20/20 (wt) xylene/toluene/methyl amyl ketone. Avoid or minimize oxygenated solvent to prevent blushing at high humidity. Spray viscosities are about 14 sec in a Ford #4 cup or a 10 mPa.s (cP) Brookfield at 25°C.

a) Adapted from acrylic lacquer formula developed by International Copper Research Associations (INCRA).

Formula 3: Clear Lacquer for Aluminum

Ingredients	% by Wt	Binder % by Wt
Elvacite® 2044	11.97	59.39
Thinner (see below)	47.81	—
Nitrocellulose "RS", 1/2 sec isopropyl[10]	11.70	40.61
Methyl Isobutyl Ketone	28.52	—
	100.00	100.00

Thinner Composition	% by Wt	% by Vol.
Methyl amyl acetate	6	5.40
Methyl isobutyl ketone	34	34.70
Isopropyl alcohol, 99%	35	36.43
Toluene	25	23.47
	100	100.00

Resultant solubility parameter, δ	9.7
Resultant hydrogen bonding index, γ	6.2

LACQUER PROPERTIES

Nonvolatiles (solids), % by weight	20.2
% by volume	14.0
Volatiles,	
Resultant solubility parameter, δ	9.3
Resultant hydrogen bonding index, γ	5.9
Typical viscosity, #4 Ford cup, sec	460

PREPARATION – Dissolve Elvacite® 2044 in prescribed thinner, dissolve nitrocellulose in MIBK, and combine.

SUGGESTED SPRAY DILUTION – Reduce to 14% solids with additional thinner. Typical Brookfield viscosity at spray dilution = 67 mPa.s (cP) (#2 spindle, 60 rpm).

In commercial practice, blends of Elvacite® 2008 and 2010 can be used in combination with cellulose acetate butyrate, a plasticizer such as butyl benzyl phthalate, and sometimes other modifiers such as gellants to product high-gloss spray lacquers with good solvent release and flow properties and a good balance between craze resistance at low temperatures and print resistance at high temperatures.

In Formula 7, cellulose acetate butyrate serves to increase flow in a thermal reflow (bake-sand-bake) lacquer.

AEROSOL LACQUERS

Formula 9 (page 28) is a convenient form in which to apply tough, flexible coatings of unmodified Elvacite® 2014 resin to metals or other substrates. For applications not requiring the superior resistance of Elvacite® 2014 resin to cracking under severe exposure conditions, aerosol clears can be formulated at lower cost using Elvacite® 2013 as illustrated in Formula 10 (page 28). The relatively high concentrations at which these lower viscosity resins can be sprayed, their high tolerance for diluents, and compatibility with many modifying resins allow unusually broad formulating latitude. Elvacite® 2013 is useful in pigmented as well as clear aerosols, including some metallic finishes. Formula 11 (page 28) is an example of a metallic lacquer containing a suitable grade of metal powder.

The use of hydrocarbon propellant does not usually affect the performance of the copolymer resins. Critical pigments such as metallics may dictate the use of an Elvacite® acrylic resin having maximum tolerance for hydrocarbons, such as Elvacite® 2028 or one of the butyl grades.

Resultant solubility parameter and hydrogen bonding index values for the final solvent mixture in an aerosol lacquer, including the propellant, are often outside the "clear solution" area on the solvent formulating maps in Figure 2 (page 12). This does not impair utility, since the propellant is charged under pressure and escapes rapidly on spraying. However, the solvent system in the concentrate must be properly balanced to maintain good solvency during drying.

* Superscript numbers refer to List of Suppliers, page 40.

Formula 4: White Metal Lacquer for Outdoor Exposure

Ingredients	% by Wt	Binder % by Wt
Elvacite® 2013	10.34	83.37
Methyl ethyl ketone	68.81	-
Methyl amyl acetate	8.09	-
"Santicizer" 160 plasticizer[14]	2.06	16.63
"Ti-Pure" R-960 titanium dioxide[1]	10.70	
	100.00	100.00

Thinner Composition	% by Wt	% by Vol.
Methyl amyl acetate	6	5.40
Methyl isobutyl ketone	34	34.70
Isopropyl alcohol, 99%	35	36.43
Toluene	25	23.47
	100	100.00

Nonvolatiles (solids), % by weight	23.1
% by volume	12.5
Pigment volume concentration, %	20.0

Volatiles,

Resultant solubility parameter, δ	9.2
Resultant hydrogen bonding index, γ	5.0

PREPARATION – Dissolve Elvacite® 2013 in solvents, add plasticizer and pigment, and disperse in pebble mill.

Formula 5: Tint-Base Metal Lacquer for Outdoor Exposure

Ingredients	% by Wt	Binder % by Wt
Elvacite® 2013	10.54	83.37
Methyl ethyl ketone	71.28	-
Methyl amyl ketone	8.39	-
"Santicizer" 160 plasticizer[14]	2.10	16.63
"Ti-Pure" R-960 titanium dioxide[1]	7.69	-
	100.00	100.00

Nonvolatiles (solids), % by weight	20.3
% by volume	11.7
Pigment volume concentration, %	15.0

Volatiles,

Resultant solubility parameter, δ	9.2
Resultant hydrogen bonding index, γ	5.0

PREPARATION – Dissolve Elvacite® 2013 in solvents, add plasticizer and pigment, and disperse in pebble mill. Tint as desired by adding dry color(s) in the mill or color dispersion(s) after milling.

Formula 6: Translucent Green Metal Lacquer

Ingredients	% by Wt
Elvacite® 2014	28.99
"Monastral" Green B, GT-674-D[1]	0.15
Methyl ethyl ketone	18.05
Propylene glycol monoethyl ether	9.31
Toluene	43.50
	100.00

Nonvolatiles (solids), % by weight	29.1
% by volume	23.1
Pigment volume concentration, %	.3

Volatiles,

Resultant solubility parameter, δ	9.1
Resultant hydrogen bonding index, γ	4.5

PREPARATION – Pebble mill pigment with Elvacite® 2014 dissolved in one-half of the toluene. Reduce with remaining solvents.

Formula 7: White Metal Reflow Lacquer

Ingredients	% by Wt	Binder % by Wt
Grind		
"Ti-Pure" R-960 titanium dioxide[1]	6.24	—
Ethylene glycol monoethyl ether acetate	2.53	—
Elvacite® 2008	1.61	12.86
Toluene	2.24	—
Let Down		
Elvacite® 2010	4.07	32.51
Elvacite® 2008	0.58	4.63
Cellulose acetate butyrate, 1/2 sec	2.50	19.97
Propylene glycol monoethyl ether acetate	17.88	—
Methyl ethyl ketone	23.95	—
"Santicizer" 160 or 278[14]	3.76	30.03
Toluene	34.64	
	100.00	100.00

Volatiles,

Resultant solubility parameter, δ	8.9
Resultant hydrogen bonding index, γ	4.1

PREPARATION – Dissolve grind portion of resin in solvents, then add pigment and disperse. Dissolve let down portion and mix.

Formula 8: High Gloss Clear Acrylic Lacquer Formulation Based on Elvacite® 2552

Propylene glycol monomethyl ether acetate	84.71g
Toluene	89.56g
Butyl benzyl phthalate	9.68g
Elvacite® 2552 Solution [1]	624.52g
Tinuvin 328 (Ciba-Geigy)	2.42g
Silicone solution [2]	0.31g
Cellulose acetate butyrate solution [3]	188.80g
	1000.00g

PREPARATION – Mix well, filter and dilute to spray viscosity (17 seconds in #2 Zahn Cup) [4]. Air dry or force dry at 200°F (93°C) x 30 minutes.

[1]	Elvacite® 2552	400.00g
	Toluene	360.00g
	Methyl ethyl ketone	240.00g
		1000.00g
[2]	Dimethyl silicone fluid SF69 (General Electric)	2.00g
	Xylene	98.00g
		100.00g
[3]	Cellulose acetate butyrate (CAB 381-2, Eastman)	25.00g
	Propylene glycol monomethyl ether acetate	5.15g
	Acetone	69.85g
		100.00g

[4] A recommended acrylic lacquer thinner is 3602S from DuPont. This lacquer has the following physical properties after appplication and drying according tot the above directions. (Dry Film Thickness 2.5 mils/64 microns.)

Tukon Hardness	6 Knoops
60° Gloss	89
20° Gloss	77

Formula 9: General Purpose Clear Aerosol Lacquer

Ingredients	% by Wt	Binder % by Wt
Elvacite® 2014	6.9	100.00
Toluene	26.1	—
Methylene chloride	12.8	—
Methyl isobutyl ketone	4.6	—
Propylene glycol monoethyl ether acetate	4.6	—
Propellant		
A-70 hydrocarbon propellant[26]	45.0	—
	100.0	100.00

Nonvolatiles (solids), % by weight	6.8
% by volume	6.6
Volatiles,	
Resultant solubility parameter, δ	7.8
Resultant hydrogen bonding index, γ	3.3

Formula 10: Low-Cost Clear Aerosol Lacquer

Ingredients	% by Wt	Binder % by Wt
Elvacite® 2013 or 2614[a]	6.8	87.22
Toluene	26.2	—
Acetone	13.8	—
Aromatic 100 Solvent[18]	4.6	—
Hi-Flash naphtha[34]	3.6	—
"Santicizer" 160 plasticizer[14]	1.0	12.78
Propellant		
A-70 hydrocarbon propellant[26]	44.0	—
	100.0	100.00

Nonvolatiles (solids), % by weight	7.8
% by volume	7.0
Volatiles,	
Resultant solubility parameter, δ	8.0
Resultant hydrogen bonding index, γ	3.5

Formula 11: Metallic Aerosol Lacquer

Ingredients	% by Wt
Elvacite® 2013[a] or 2614	4.78
Toluene	60.13
Rich Pale Gold MD 650-A23	6.06
Propellant	
A-70 hydrocarbon propellant[26]	29.03
	100.00

Nonvolatiles (solids), % by weight	10.8
% by volume	5.1
Pigment volume concentration, %	5.5
Volatiles,	
Resultant solubility parameter, δ	8.2
Resultant hydrogen bonding index, γ	3.5

CONCENTRATE PREPARATION – Dissolve Elvacite® 2013 in toluene. Incorporate pigment in small portion of acrylic solution under high shear and combine with remaining solution.

a) If a hydrocarbon propellant such as A-70 (supplied by Phillips Petroleum) is required, Elvacite® 2028 must be substituted for 2013.

* Superscript numbers refer to List of Suppliers, page 40.

COATINGS FOR PLASTICS

The gloss, clarity, hardness, barrier properties, and scuff resistance of the Elvacite® acrylic resins have led to their use in topcoating lacquers for vinyl fabrics and in decorative and functional coatings for many other plastic substrates. In most of these applications, the methyl methacrylated resins or the harder copolymer resins such as Elvacite® 2013 are preferred. Blends of methyl methacrylate resins with more flexible modifying resins are also widely used. Typical plastic coating formulations based on Elvacite® resins are discussed in the paragraphs that follow.

VINYL TOPCOATING LACQUERS

Elvacite® resins of the methyl methacrylate type are widely used in combination with vinyl chloride homopolymers or copolymers in topcoating lacquers for vinyl-coated fabric and vinyl sheeting. These Elvacite® resins improve the plasticizer barrier properties, hand, and slip of the coatings and impart good dielectric heat-sealability. Elvacite® 2041 is preferred for use in high-quality vinyl topcoatings for such demanding uses as automotive upholstery. Because of its unusually high molecular weight, this resin contributes maximum abrasion resistance and is highly resistant to dielectric burning ("arching") during sealing. Formulas 12 and 13 (page 30) are prototype formulations based on blends of Elvacite® resins and typical vinyl chloride homopolymer resins. The ratio of acrylic to vinyl resin in Formula 12 can be increased to at least 50/50 to aid surface slip without significantly impairing adhesion. Formula 13 is an example of a high-slip formula containing a more readily soluble vinyl chloride resin that permits economies in the solvent system.

For less demanding applications not requiring dielectric heat sealing, Elvacite® 2010 or 2021 can be substituted for all or part of the Elvacite® 2041. Further modifications are possible for special purposes. Elvacite® 2009 is helpful in obtaining the required flexibility at high acrylic levels. Elvacite® 2008, the lowest molecular weight grade in the methyl methacrylate group, can be used to increase solids content at a given viscosity, or the lower viscosity at a given solids level. Vinyl chloride copolymers such as "UCAR® Solution Vinyl" VYNS or VYHH [2]* can also be used in place of the vinyl chloride homopolymer resins to take advantage of their solubility in lower-cost solvents, and their generally lower solution viscosities.

A blend of Elvacite® 2008 and 2010 is suitable for topcoating vinyl fabric for furniture. Formula 14 (page 31) represents a coating with a good solids/viscosity relationship for gravure printing and an average molecular weight (acrylic and vinyl copolymer) for quite adequate abrasion and scuff resistance.

The acid functionality of Elvacite® 2008 in Formula 14 aids in pigment dispersion where an initial colored ink coat is to be used before the clear topcoat. Substituting Elvacite® 2021 for the blend in Formula 14 affords somewhat better abrasion and scuff resistance.

Where a matte finish is preferred, gloss can be reduced by adding a flatting agent such as "Santocel" 62 silica "Aerogel," "Syloid" 244 silica hydrogel, or for ease of dispersion, "Syloid" 378. From 1 to 5% additive, based on total resin solids, is generally required, depending on the degree of flatness or gloss required.

DECORATIVE COATINGS

Elvacite® 2013 acrylic resin is suggested for a general-purpose base for decorative lacquers for plastics. Formulations based on Elvacite® 2013 are used on such plastic substrates as acrylonitrile-butadiene styrene (ABS); treated or primed polyethylene and polypropylene; polystyrene; and polyvinyl chloride. The following solvent blend, in which weak solvents predominate, is suggested for use in applying Elvacite® 2013 to plastics.

Solvent for Elvacite® 2013 in Spray Lacquers for Plastics

Solvent	% by Wt	by Vol
Toluene	15	13.58
Methyl ethyl ketone	20	19.59
n-Heptane	25	27.35
Isopropyl alcohol, 99%	35	35.13
Methyl amyl ketone	5	4.35
	100	100.00

Volatiles,
Resultant solubility parameter, δ 9.5
Resultant hydrogen bonding index, γ 5.5

This blend can be used to prepare Elvacite® 2013 solutions at package viscosity, and as a thinner for reduction to spray consistency.

Elvacite® 2014 is also useful in decorative lacquers for plastics. This versatile resin can be dissolved in the “4-2-1” thinner (page 14) for application to sensitive plastic substrates. Formula 15 (page 31) is a lacquer based on a blend of Elvacite® 2014 and cellulose acetate butyrate. It is suitable for use as a spray lacquer for ABS, acrylic, or cellulosic plastics. Formula 16 (page 32) illustrates the use of Elvacite® 2010 resin in a stain-resistant white gloss lacquer for ABS plastic articles.

BARRIER COATINGS

Elvacite® 2013 is suggested for use in barrier coatings on high-impact polystyrene to protect the plastic against attack by strong solvents used in subsequent finishing operations. This is important in the furniture industry where the solvents in conventional wood finishing lacquers tend to cause crazing of unprotected polystyrene components. Elvacite® 2013 can be applied from relatively weak solvent systems, yet it is sufficiently resistant to many solvents that attack polystyrene to provide an effective barrier.

Because of its low molecular weight, Elvacite® 2013 gives low viscosity solutions at high solids and releases solvent rapidly. This permits the escape of potentially damaging solvents during spray application before they have an opportunity to attack the substrate, and reduces blocking when the semifinished parts are stacked immediately after coating.

Formula12: Typical Vinyl Topcoating Lacquer

Ingredients	% by Wt	Binder % by Wt
Elvacite® 2041	2.96	29.73
Methyl ethyl ketone	26.99	—
“UCAR® Solution Vinyl” QYNV vinyl chloride dispersion resin[2]	6.99	70.27
Tetrahydrofuran (THF)[1]	63.06	—
	100.00	100.00

Nonvolatiles (solids), % by wt 10.0
% by vol 6.7

Volatiles,
Resultant solubility parameter, δ 9.2
Resultant hydrogen bonding index, γ 5.2

PREPARATION – Dissolve Elvacite® 2041 in MEK,

Formula13: High-Slip Vinyl Topcoating Lacquer

Ingredients	% by Wt	Binder % by Wt
Elvacite® 2021	5.41	54
Methyl ethyl ketone	44.30	—
“Geon” 103 general-purpose vinyl chloride resin[13]	4.59	46
Tetrahydrofuran (THF)[1]	31.81	—
Toluene	13.89	—
	100.00	100

Nonvolatiles (solids), % by wt 10.0
% by vol 6.8

Volatiles,
Resultant solubility parameter, δ 9.2
Resultant hydrogen bonding index, γ 4.9

PREPARATION – Dissolve Elvacite® 2021 in MEK, dissolve vinyl resin in THF, combine and dilute with toluene.

Formula 17 (page 32) affords a starting point for designing barrier coatings based on Elvacite® 2013. It contains as the solvent portion the blend suggested for general use in applying Elvacite® 2013 to plastics, and can be thinned as desired with additional quantities of the same solvent mixture. Alcohol-soluble cellulose acetate butyrate may be substituted for a portion of the acrylic resin in Formula 17. For example, good results have been obtained with coatings containing a 90/10 blend (by weight) of Elvacite® 2013 acrylic resin and alcohol-soluble butyrate.

Formula14: Vinyl Topcoat for Furniture Upholstery

Ingredients	% by Wt	Binder % by Wt
Elvacite® 2010	4.45	24.8
Elvacite® 2008	1.50	8.3
"UCAR® Solution Vinyl" VYNS vinyl chloride-acetate resin[2]*	12.05	66.9
Methyl ethyl ketone	82.00	
	100.00	100.0

Nonvolatiles (solids), % by wt	18.0
Volatiles,	
Resultant solubility parameter, δ	9.3
Resultant hydrogen bonding index, γ	5.0

PREPARATION – Dissolve acrylic and vinyl resins in MEK. Pigment or not as desired.

Solvent for Elvacite® 2008 in Spray Lacquers for Plastics

Solvent	% by Wt	by Vol
Toluene	15	13.90
Methyl ethyl ketone	60	60.17
n-Heptane	10	11.20
Isopropyl alcohol, 99%	10	10.27
Methyl amyl ketone	5	4.46
	100	100.00

Volatiles,	
Resultant solubility parameter, δ	9.2
Resultant hydrogen bonding index, γ	4.9

The superior solvent resistance of methyl methacrylate resins such as Elvacite® 2008 and 2010, as compared with Elvacite® 2013 copolymer resin, suggests their utility in barrier coatings. However, the advantage in solvent resistance must be balanced against the need to use stronger solvents systems for applying the methyl methacrylate resins. The solvent blend suggested on page 30 for use with Elvacite® 2013 resin contains too high a proportion of diluents to dissolve Elvacite® 2008. The above modification, in which part of the heptane and isopropyl alcohol have been replaced by MEK, can be used as a solvent and thinner in spray lacquers based on Elvacite® 2008 acrylic resin.

In barrier coatings for polystyrene, good craze resistance can be obtained using 50/50 blends of Elvacite® 2008 with alcohol-soluble butyrate or half-second cellulose acetate butyrate. Formula 18 (page 33) is suggested for trial.

Formula 15: White Lacquer for Plastics[a]

Ingredients	% by Wt	Binder % by Wt
Elvacite® 2014	6.0	40
Ethyl Acetate	9.8	—
Isobutyl acetate	14.0	—
Propylene glycol monoethyl ether acetate	10.0	—
Half-second butyrate[4]	6.0	40
Sucrose acetate isobutyrate[4]	3.0	20
'Ti-Pure' R-960 titanium dioxide[1]	5.0	—
Toluene	46.2	—
	100.0	100

Pigment volume concentration, %	8.9
Nonvolatiles (solids), % by wt	20.0
% by vol	13.4
Volatiles,	
Resultant solubility parameter, δ	8.8
Resultant hydrogen bonding index, γ	4.5

PREPARATION – Dissolve half-second butyrate and sucrose acetate isobutyrate in ester solvents and combine with Elvacite® dissolved in toluene. Add pigment and disperse in pebble or sand mill.

a) Adapted from formula developed by Eastman Chemical Products, Inc.

SCUFF-RESISTANT COATINGS

Blends of Elvacite® methyl methacrylate resins with vinyl resins, similar to those used for vinyl fabric topcoating, also perform well as abrasion-resistant topcoatings for other plastic substrates such as ABS. These lacquers can be adapted for spray application by using a blend of solvents varying in evaporation rate. Formula 19 (page 33), in which Elvacite® 2041 is used to provide maximum toughness and abrasion resistance, is suggested for trial as a scuff-resistant topcoat for luggage and similar items. The "Syloid" 378 in this formula prevents blocking when coated stock is vacuum formed and stacked while hot.

Lower molecular weight methyl methacrylate resins such as Elvacite® 2010 or 2021 provide adequate abrasion resistance for many applications, and can be used alone or in combination with Elvacite® 2041 to permit spraying at higher solids content. The pigmented coating shown in Formula 16 (page 32) is an example of a spray lacquer based on Elvacite® 2010. As discussed under "Overprint Varnishes," coatings of unmodified acrylic resin are useful as abrasion-resistant, light-stable protective coatings for plastic decals. Elvacite® 2042, a high molecular weight ethyl methacrylate resin with high alcohol tolerance in solution is particularly well suited for this application.

Formula 16: Stain-Resistant White Spray Lacquer for Plastics

Ingredients	% by Wt	Binder % by Wt
Elvacite® 2010	6.04	45.92
Xylene	14.60	—
Methyl ethyl ketone	9.53	—
"UCAR® Solution Vinyl" VYHH vinyl chloride-acetate resin[2]	6.04	45.92
Methyl ethyl ketone	47.31	—
Aromatic 100 solvent[18]	1.87	—
n-Butyl acetate	6.84	—
Dibutyl sebacate	1.08	8.16
"Bentone" 34 gellant[22]	0.94	—
"Ti-Pure" R-900 titanium dioxide[1]	5.75	—
	100.00	100.00

Pigment volume concentration, %	15.3
Nonvolatiles (solids), % by wt	19.8
% by vol	11.4
Volatiles,	
Resultant solubility parameter, δ	9.1
Resultant hydrogen bonding index, γ	4.8
Typical viscosity, Brookfield, mPa.s (cP)	13
#4 Ford Cup, sec	13

PREPARATION – Dissolve Elvacite® 2010 in a mixture of xylene with the indicated portion of the MEK. Dissolve vinyl resin in remaining solvents and combine with Elvacite® solution. Add plasticizer (dibutyl sebacate), gellant, and pigment and disperse in pebble mill or sand mill.

MOLD RELEASE COATINGS

Elvacite® acrylic resins are effective as release coatings for the silicone rubber or other flexible molds used for forming rigid polyurethane articles. The coating adheres to the polyurethane when the molded part is separated from the mold, and serves as a primer or tie coat for subsequent finish coats. Resins of the butyl methacrylate type are preferred for this use. The solubility of Elvacite® 2044, 2045 and 2046 in weak solvents such as mineral spirits permits their application from solvent systems that do not attack the molds.

VACUUM METALLIZING

Elvacite® acrylic resins are useful as base coats and topcoats for vacuum metallized plastics. Low viscosity grades such as Elvacite® 2008 and 2013 are effective as smooth, adherent base coats. They can be applied at high solids, release solvent rapidly, and have good flow properties to insure hiding of minor surface flaws and scratches. As in other plastic coating applications, proper choice of a solvent system is important in order to avoid crazing of the substrate. Elvacite® 2008 methyl methacrylate resin requires a stronger solvent system for application than Elvacite® 2013 but is more resistant to solvent attack during topcoating of the metallic deposit.

Elvacite® 2045 and 2046 butyl methacrylate resins are suggested for use as clear, high-gloss, scuff-resistant topcoatings since they can be applied from weak solvents such as VM & P naphtha to minimize attack on the base coat. Harder coatings can be obtained using Elvacite® 2043 and 2028, which can be applied from alcohol-rich solvent systems.

Formula 17: Barrier Coating for Polystyrene Based on Elvacite® 2013

Ingredients	% by Wt	Binder % by Wt
Elvacite® 2013 or 2614	18.46	100
Spray solvent for Elvacite® 2013 (page 30)	73.85	—
"Ti-Pure" R-900 titanium dioxide[1*]	6.59	—
Yellon iron oxide, LL, YLO-1788[23]	1.10	—
	100.00	100

Nonvolatiles (solids), % by weight	26.2
% by volume	16.0
Pigment volume concentration, %	10.5

PREPARATION – Dissolve Elvacite® 2013 in solvent blend. Add pigments and disperse in pebble mill or sand mill.

* Superscript numbers refer to List of Suppliers, page 40.

Formula 18: Barrier Coating for Polystyrene Based on Elvacite® 2008

Ingredients	% by Wt	Binder % by Wt
Elvacite® 2008	9.23	50
Alcohol soluble butyrate	9.23	50
Spray solvent for Elvacite® 2008 (page 31)	73.85	—
"Ti-Pure" R-900 titanium dioxide[1]*	6.59	—
Yellon iron oxide, LL, YLO-1788[23]	1.10	—
	100.00	100

Nonvolatiles (solids), % by weight	26.2
% by volume	16.1
Pigment volume concentration, %	10.7

PREPARATION – Dissolve Elvacite® 2008 in half of the prescribed solvent blend; dissolve alcohol-soluble butyrate in remaining solvent and combine. (Note: Mixture may be hazy.) Add pigments and disperse in pebble mill or sand mill.

Formula 19: Abrasion-Resistant Spray Lacquer for Plastics

Ingredients	% by Wt	Binder % by Wt
Elvacite® 2041	1.25	25.07
Methyl ethyl ketone	11.84	—
Diisobutyl ketone	5.90	—
Methyl Isobutyl ketone	11.78	—
"UCAR® Solution Vinyl" VYHH	3.73	74.93
Acetone	11.82	—
Xylene	17.73	—
Toluene	35.46	—
"Syloid" 378[21]	0.49	—
	100.00	100.00

Nonvolatiles (solids), % by weight	5.5
% by volume	3.4
Pigment volume concentration, %	5.6
Volatiles,	
Resultant solubility parameter, δ	8.9
Resultant hydrogen bonding index, γ	4.57
Typical Brookfield Viscosity, (cP)	7.5
#4 Ford cup, sec.	10
Abrasion resistance, wt. loss, mg[a]	
50 cycles	3.4
280 cycles	7.5

a) Taber Abraser with CS-10 wheel and 1,000 g load.

COATINGS FOR CONCRETE

CONCRETE COATINGS AND SEALANTS

Elvacite® 2014 copolymer resin is an excellent base for clear sealers for concrete and other masonry substrates. Formula 20 is an example of a spray lacquer that meets the requirements of ASTM specifications C-156 and C-309 as a concrete sealant.

Elvacite® 2014 can also be used as a sealer for concrete, terrazzo, and similar surfaces as the base for durable pigmented coatings. Formula 21 for example, has shown excellent durability as a concrete coating. The slow-evaporating hydrocarbon solvent used in this formula retards evaporation of the resultant solvent blend sufficiently to permit application by hand roller or brush.

Many coatings for concrete are based on chlorinated rubber because of its toughness, adhesion and durability. Better pigment dispersion for higher gloss and better resistance to yellowing can be achieved by replacing from 25-50% of the chlorinated rubber with an acid functional Elvacite® acrylic resin such as Elvacite® 2013, 2014, or 2028. Elvacite® 2044 lends greater flexibility to chlorinated rubber formulations.

Formula 20: Clear Sealer for Concrete

Ingredients	% by Wt	Binder % by Wt
Elvacite® 2014	20	100
Xylene	27	—
Toluene	42	—
Isopropyl alcohol	11	—
	100	100

Nonvolatiles (solids), % by wt	20.0
% by vol	25.4
Volatiles,	
Resultant solubility parameter, δ	9.26
Resultant hydrogen bonding index, γ	4.27
Typical viscosity, Brookfield, mPa.s (cP)	100.00

PREPARATION – Dissolve Elvacite® 2014 in solvent blend. Add pigments and disperse in pebble mill or sand mill.

Formula 21: White Coating for Concrete

Ingredients	% by Wt
Elvacite® 2014	7.62
G hydrocarbon solvent[34]*	69.71
"Ti-Pure" R-960 titanium dioxide[1]	5.42
Toluene	12.45
Isopropyl alcohol	4.80
	100.00

Nonvolatiles (solids), % by weight	13.0
% by volume	7.8
Volatiles,	
Resultant solubility parameter, δ	8.00
Resultant hydrogen bonding index, γ	2.78

* Superscript numbers refer to List of Suppliers, page 40.

COATINGS FOR WOOD

WOOD FINISHES

Elvacite® acrylic resins are useful in furniture finishes, particularly where ultraviolet light resistance is important, for example in clear lacquers for blond woods or in white pastel pigmented lacquers.

Blends of Elvacite® copolymer resins such as 2013 and 2028 with cellulose acetate butyrate, suitably plasticized, are useful for furniture finishes. Plasticizers which are compatible with resins include "Santicizer" 97, 160 and 278[14]* and combinations thereof. "Santicizer" 278 adds permanency to a plasticizer system whereas "Santicizer" 97 contributes cold-crack resistance. Formula 22 is suggested as a starting formulation.

Formula 22: Acrylic Lacquer for Wood Finishes

Ingredients	% by Wt	Binder % by Wt
Elvacite® 2028	9.0	36.7
Cellulose acetate butyrate, 1/10 sec	12.5	51.0
Toluene	35.0	—
Ethyl alcohol (190 proof)	10.0	—
Ethylene acetate	15.5	—
n-Butyl acetate	15.0	—
"Santicizer" 97 plasticizer[14]	3.0	12.3
	100.0	100.0

Nonvolatiles (solids), % by wt 24.5

Volatiles,
Resultant solubility parameter, δ 9.5
Resultant hydrogen bonding index, γ 5.1

Solution Appearance Slightly Cloudy
Three one mil coatings on maple panel
Coated panel conditioned ten days at 23°C, 50% RH

STAIN RESISTANCE:

24 hour	Covered	Uncovered
Water	No effect	No effect
Vinegar	No effect	No effect
Lemon Juice	No effect	No effect
Orange Juice	No effect	No effect
Grape Juice	No effect	No effect
Ketchup	No effect	No effect
Coffee	No effect	No effect
Olive Oil	No effect	No effect
1 hour French's Mustard	Slight Stain	Slight Stain

Print Resistance:	4 hr. 72°F	4 hr. 120°F
1 PSI	0	0
2 PSI	0	0
4 PSI	0	0

0 = no print; 6= very heavy print
a) Developed by Technical Research Corp., Seattle, WA

COATINGS FOR REPRODUCTION PAPERS

Elvacite® 2014 acrylic resin solution is an effective binder for the zinc oxide photoconductive pigment in coatings for "Electrofax"** copy papers. These coatings cover a wide range of copier settings. The high imaging speed of coatings based on acrylic resins such as Elvacite® 2014 is an important advantage in developing copy papers for applications requiring high-speed operation. The image density obtained using Elvacite® 2014 can be increased by blending with other resins. Formula 23 is suggested as a starting point for developing "Electrofax" paper coatings based on Elvacite® 2014. Other grades of zinc oxide or a combination of grades may be substituted in this formula. Elvacite® 2044 in a zinc oxide binder lends added flexibility.

Formula 23: Coating for "Electrofax" Copy Paper

Ingredients	% by Wt	Binder % by Wt
Elvacite® 2014	3.09	59.86
Toluene	35.14	—
"Gelva" 264 vinyl acetate multipolymer[14] (55% Solids)	3.76	40.01
AZO 661 zinc oxide[24]	56.69	—
Dye sensitizer solution	1.32	0.13
	100.00	100.00

Pigment volume concentration, %	63.30
Pigment/binder ratio, by weight	10.97
Nonvolatiles (solids), % by wt	61.20
% by vol	28.20

Volatiles,

Resultant solubility parameter, δ	9.2
Resultant hydrogen bonding index, γ	4.1

PREPARATION – Add toluene and resin solutions to an explosion-proof or air-purged blender and mix at low speed. Add zinc oxide, blend at low speed for two minutes, then at high speed for 4-5 minutes or until Hegman fineness of 5-6 is attained. Cool to room temperature and add sensitizer solution.

* Superscript numbers refer to List of Suppliers, page 40.

** RCA Corp. Trademark, Reg. U.S. Patent and Trademark Office

INKS AND OVERPRINT VARNISHES

As binder components in flexographic, gravure, and screen inks and as clear overprint coatings, Elvacite® acrylic resins contribute excellent adhesion to most packaging films and foil and outstanding resistance to discoloration by ultraviolet light and heat as well as resistance to grease, oil, and water. Compatibility with other commonly used binders such as nitrocellulose, cellulose acetate butyrate, chlorinated rubber, vinyl resins, and many rosin derivatives provides broad latitude in formulation to meet specific performance requirements.

FLEXOGRAPHIC INKS

Elvacite® 2028 resin offers a good combination of properties for use in flexographic inks. The resin is specially designed for optimum solubility in alcohol-rich solvent systems and its highly compatible with alcohol-soluble grades of nitrocellulose and cellulose acetate butyrate. As a result of its low molecular weight, Elvacite® 2028 provides good flow and leveling and fast solvent release properties. Inks based on Elvacite® 2028 show outstanding adhesion to polymer-coated films as well as to polystyrene and cellulosics, and are heat sealable. They are particularly useful for laminated film structures and heat-seal packaging films, since they resist discoloration by heat as well as by UV light.

Blends of 3-4 parts Elvacite® 2028 with 1 part nitrocellulose (“SS” 30-35 cP isopropyl)[10*] and/or alcohol-soluble butyrate (ASB)[4] can be used to obtain the desired combination of heat-smear resistance, adhesion, flexibility, and resistance to yellowing. The proportion of ester or other active solvents required to maintain good solution and film compatibility in alcohol-based systems varies with the type and amount of cellulosic binder and the total binder solids. Substitution of ASB for part or all of the nitrocellulose lowers the viscosity for a given solids content. Viscosities can also be reduced with ethylene glycol monoethyl ether acetate as desired. Pigmentation can be accomplished by milling dry pigment into the vehicle or by using pigment predispersed in nitrocellulose.

Elvacite® 2013 offers many of the performance features of Elvacite® 2028 but requires the use of solvent blends containing significantly higher ratios of active solvent to alcohol. For special applications where high viscosity can be accommodated, higher molecular weight grades such as Elvacite® 2042 or the butyl methacrylate resins may be considered.

GRAVURE INKS

Low viscosity Elvacite® resins are useful in binder systems for a variety of gravure inks, particularly for printing on packaging films or in other applications where improved adhesion and/or resistance to yellowing are desired. Elvacite® 2013 is generally preferred for use in gravure inks. A 1/1 blend of Elvacite® 2013 and 1/4 second, regular-soluble nitrocellulose (11.8-12.2% nitrogen) dissolved in an 80/20 mixture of n-propyl acetate and toluene is suggested as a starting point for formulating Type C inks. Elvacite® 2013 can also be combined with alcohol-soluble nitrocellulose for use in Type E inks. The lower viscosity methyl methacrylate resins can also be used alone or in combination with cellulosic binders, vinyl resins, or chlorinated rubber in some types of gravure inks. Elvacite® 2008, 2009, and 2010, for example, can be used to improve the plasticizer barrier properties of Group VI inks for printing on plasticized vinyl film.

SCREEN INKS

Elvacite® resins are used in screen inks to improve durability and adhesion. They can be used as modifiers for vinyl, cellulosic, or other binders, or as the major binder component to optimize adhesion to vinyl and polystyrene plastics. The clarity, gloss, and nonyellowing properties of the Elvacite® resins are valuable, for example, in fluorescent inks formulated at low pigment loading for use on decals to obtain special “depth” effects. Elvacite® 2043 and 2013 offer a good balance of properties for general use in screen inks. Where aliphatic hydrocarbon solvents are preferred to avoid damage to sensitive substrates and to minimize air pollution problems, the butyl methacrylate resins are suggested.

OVERPRINT VARNISHES

The clarity, gloss, adhesion and nonyellowing characteristics of Elvacite® acrylic resins as well as their oil, grease, water, and chemical resistance are used to advantage in overprint lacquers for paperboard, films, and foils for such applications as outdoor posters, beverage cartons, soap wrappers, cosmetic boxes, and book covers. As in ink formulations, the acrylic resins can be used alone or in combination with such binders as nitrocellulose, vinyl resins, or chlorinated rubber to meet property requirements for a given end use.

Since weak solvent systems are usually preferred in order to avoid smearing of the print, the butyl methacrylate resins, Elvacite® 2045 and 2046, are particularly suitable because of their solubility in aliphatic hydrocarbons. These grades also show excellent gloss. Formula 24 is a typical starting point. Elvacite® 2044 is not recommended because of blocking.

Thin coatings of Elvacite® 2042 acrylic resin on imprinted plastic or paper decals provide hard, durable, protective films that are resistant to ultraviolet light and abrasion. The clarity of the films is such that they impart depth to the legend. Legends on transparent plastic substrates retain the

Formula 24: High Gloss Overprint Lacquer Based on Elvacite® 2045/2046

Ingredients	% by Wt	Binder % by Wt
Elvacite® 2045	15	50
Elvacite® 2046	15	50
Sun Spirits[6]*	35	—
Acetone	35	—
	100	100

Nonvolatiles (solids), % by wt	30.0
% by vol	23.6
Volatiles,	
Resultant solubility parameter, δ	8.8
Resultant hydrogen bonding index, γ	3.9
Typical viscosity, Brookfield, MPa·s (cP)	72.0

Formula 25: Film/Foil Laminating Adhesive

Ingredients	% by Wt	Binder % by Wt
Elvacite® 2044	36.00	89.98
Methyl ethyl ketone	54.00	—
"UCAR® Solution Vinyl" VMCC vinyl chloride- acetate resin[2]	4.01	10.02
Toluene	5.99	—
	100.00	100.00

Nonvolatiles (solids), % by wt	40.0
% by vol	33.3
Volatiles,	
Resultant solubility parameter, δ	9.3
Resultant hydrogen bonding index γ	4.9
Typical peel strength, 90°, polystyrene/aluminimum foil, g/in.[a]	500

PREPARATION-Dissolve "UCAR® Solution Vinyl" VMCC and Elvacite® 2044 in MEK and dilute with Toluene.

a) Adhesive applied with a 1.5 mil Bird applicator to 1 mil uncoated, zero-temper, soft aluminum foil, air-dried 3 hours, and heat-sealed to 4 mil oriented polystyrene film at 250°F under 77 psi pressure for a dwell time of 1.5 second; peel strength for 0.5 in. strips determined on Instron tensile tester at 2 in./min cross-head speed.

appearance of direct imprints on the article to which the decal is transferred.

The solubility of Elvacite® 2028, 2043, and to a lesser extent Elvacite® 2013, in alcohol-rich solvent mixtures can be used to advantage in formulating overprint lacquers for use in alcohol-resistant ink types. Elvacite® 2009 is also useful in overprint lacquers. A 30/70 blend of Elvacite® 2009 and nitrocellulose can be applied from a solvent blend to give tough, abrasion-resistant, nonyellowing coatings with good resistance to blocking.

Substitution of Elvacite® 2008 for Elvacite® 2009 provides even greater resistance to blocking but gives poorer abrasion resistance and alkali resistance. Use of Elvacite® 2009, plasticized with 20-25% butyl benzyl phthalate as the sole resinous binder, reduces the applied cost of the coating since it permits the use of a lower-cost solvent mixture such as a 3:1 blend of toluene and methyl ethyl ketone.

ADHESIVES

Elvacite® 2044, the softest and tackiest of the Elvacite® resins, is the preferred grade for many specialty adhesive applications, particularly for bonding coated "Mylar" polyester film and other nonporous plastic films and foil. Formula 25, for example, is suggested for trial as a heat-seal adhesive for laminating biaxially oriented polystyrene film to aluminum foil.

Elvacite® 2044 and the harder butyl grades, Elvacite® 2045 and 2046, are frequently blended with other resins to provide increased toughness, flexibility, and adhesion. Elvacite® 2044 and 2046, because of their relatively low softening temperature range, are preferred for use in hot-melt systems.

Elvacite® 2014 resin also finds use in specialized adhesive applications where clarity and light-fastness are required. The solvent system can be adjusted readily for ease of handling on conventional adhesive applicators.

Because of their clean burnout on firing, Elvacite® resins are particularly well suited for use as temporary binders in the ceramics and electronics industries. The flexibility of films of the butyl methacrylates permits high pigment loading without excessive embrittlement.

COLOR CONCENTRATES

Elvacite® acrylic resins are useful as vehicles for color concentrates or tinting dispersions for incorporation in acrylic-based lacquers and inks. Elvacite® 2028 is particularly well suited for this use because of its low molecular weight, excellent pigment-wetting properties, and broad solubility and compatibility. For some systems, Elvacite® 2013 copolymer resin or Elvacite® 2008 or 2009 in the methyl methacrylate group may be preferred.

* Superscript numbers refer to List of Suppliers, page 40.

SAFETY AND ENVIRONMENTAL

PRECAUTIONS IN HANDLING

Under normal conditions of use, the Elvacite® acrylic resins themselves present no known significant hazards to health. However, trace amounts of residual monomer could result in allergic type skin reactions in sensitized persons.

Elvacite® acrylic resin particles are mechanically irritating to eyes, as are other inert materials. Particles in the eye should be removed by flushing with clean water.

The small spherical particles of Elvacite® can cause a slipping hazard. Therefore, spills should be cleaned up promptly.

Most applications of Elvacite® acrylic resins involve dissolution in flammable organic solvents. Care should be taken to eliminate fire hazards when preparing or handling solutions of Elvacite® and adequate ventilation should be provided to maintain solvent concentration below the lower explosive limit. Nonsparking motors and tools should be used in areas where resin solutions are prepared or handled. Open flames shall be prohibited, and other possible ignition sources shall be avoided. Smoking shall be prohibited in areas where flammable solvents are handled. Further precautions for handling flammable solvents are contained in *Flammable and Combustible Liquids Code.*[a]

Static electrical discharge is another potential hazard, which must be avoided when flammable solvents are used. To prevent generation of static electricity, metal containers of solvent must be grounded whenever solvent is transferred from one container to another or into mixers, tanks, etc. One of the most common sources of static electricity is free-fall of solvents. When solvents or solutions in solvents are transferred, the inlet pipe should reach nearly to the bottom of the receiving vessel or be angled so the liquid flows down the wall of the receiver. Either of these techniques minimizes free-fall and the potential for generation of static electricity associated with it.

Addition of nonconductive solids to flammable liquids also may result in generation of static electricity. Precautions must be taken to dissipate the static charges which may be generated when Elvacite® acrylic resin are transferred from the shipping container to a mixer containing flammable liquids. Two techniques which may be employed to minimize the static charges that may be generated when Elvacite® is poured from the polyethylene-lined shipping container are:

- Transfer of Elvacite® to a grounded metal container at a location away from the area in which flammable vapors may be present. The metal container of Elvacite® can then be grounded to the mixer before the resin is transferred. A funnel should be used in the transfer operation and the funnel outlet should direct the resin to the wall of the mixer. This technique minimizes regeneration of static charges on free-falling particles
- A grounded nonferrous metal funnel, tray or trough may be mounted at the mixer charging port. The Elvacite® acrylic may be transferred to the funnel, tray or trough at a point about six feet from the mixer opening and where adequate ventilation is available to avoid flammable concentrations of solvent vapors. The Elvacite® should travel at least two feet in contact with the grounded metal device before it enters the tank. As described above, resin should be directed to the wall of the tank to minimize free-fall.

If Elvacite® acrylic resins are subjected to high temperatures that might cause depolymerization [260°C (500°F) and higher], the formation of methacrylate monomers could create a hazard. Methyl methacrylate is highly flammable; it has a Tag closed cup flash point of 11°C (51°F). The U.S. Department of Labor, Occupational Safety and Health Administration[b] has established a threshold limit value (TLV) of 100 parts by volume methyl methacrylate in a million parts by volume of air (or 410 mg/m^3) as the eight-hour time-weighted average concentration to which employees may be exposed.

Higher alkyl methacrylate monomers flash at higher temperatures than the methyl ester. Although limits of eight-hour time-weighted average concentrations have not been established for higher methacrylated monomers, a potential health hazard should be presumed.

Since we have no control over properties and quality of materials produced by others suggested for use with Elvacite® acrylic resins, we cannot comment on their proper handling and use. It is strongly recommended that you obtain instructions for the proper handling of other raw materials from the suppliers of those products, including other departments of Lucite International, prior to working with such materials.

The above suggestions are not intended to be all-inclusive. They should be supplemented by good manufacturing procedures, prevailing industry standards and the recommendations of equipment manufacturers.

a) NFPA Standard No. 30, *Flammable and Combustible Liquids Code*, National Fire Protection Association, 470 Atlantic Avenue, Boston MA 02210.

b) Occupational Safety and Health Standards, Title 29, Code of Federal Regulations Part 1910.1000.

WASTE DISPOSAL

Spilled or scrap Elvacite® acrylic resins may be incinerated or buried. However, method of disposal must be in compliance with local, state and federal regulations.

FDA STATUS

Elvacite® acrylic resins are compliant for use in several food contact applications. In some instances, compliance is subject to extraction studies made on the final coating. Compliance is based on the definition of specific ingredients in the polymeric binders.

Under FDA Regulation 175.105 (Adhesives) the following grades are compliant: Elvacite® 2008, 2010, 2013, 2014, 2016, 2028, 2041, 2042, 2043, 2044, 2045, 2046, 2051, 2550, 2627, 2669, 2697, 2717 and 2776. Under FDA Regulation 175.300 (Resinous and Polymeric Coatings) the following grades are compliant: Elvacite® 2008, 2010, 2013, 2014, 2016, 2028, 2041, 2042, 2043, 2044, 2045, 2046, 2051, 2550, 2627, 2669, 2697, 2717, 2776, 2823 and 2927.

Under FDA Regulation 176.170 (Paper and Paperboard Coatings in Contact with Aqueous and Fatty Foods) the following grades are compliant: Elvacite® 2008, 2010, 2013, 2014, 2016, 2028, 2041, 2042, 2043, 2044, 2045, 2046, 2051, 2550, 2627, 2669, 2697, 2717 and 2776.

Under FDA Regulation 176.180 (Paper and Paperboard Coatings for Dry Foods) the following grades are compliant: Elvacite® 2008, 2010, 2013, 2014, 2016, 2028, 2041, 2042, 2043, 2044, 2045, 2046, 2051, 2550, 2627, 2669, 2697, 2717 and 2776.

TEST PROCEDURES

DENSITY AND BULKING VALUE

Calculated from density (ASTM D-1475) of 20% solutions of Elvacite® resins in methyl ethyl ketone.

SPECIFIC GRAVITY

Calculated from density, using water = 997 kg/m^3 (8.32 lb./gal).

GLASS TRANSITION TEMPERATURE

Measured by differential thermal analysis as described in ASTM D-3418.

TUKON HARDNESS

Measured at 23° C (73°F) and 50% RH on the Tukon tester as 25 g load using a 1.6 mm (1/16 in.) thick disc prepared by compression molding bead polymer.

Hardness readings on these molded specimens reflect inherent hardness on the resin without the reinforcing effect of a rigid substrate; they are consistently lower than corresponding hardness readings for thin coatings on glass or metal.

ACID

Milligrams potassium hydroxide per gram polymer.

TENSILE STRENGTH

Determined using compression-molded samples.

LIST OF SUPPLIERS

Suppliers of proprietary products cited in this booklet are listed below. Mention of another company's product(s) does not imply an unqualified recommendation by Lucite International; there may be others of similar type that are equally or better suited for the purpose.

1. E.I. duPont de Nemours & Company
2. Union Carbide Corp., Chemicals and Plastics Div.
3. Resolution Performance Products
4. Eastman Chemical Products, Inc.
5. Sun Co., Inc.
6. Velsicol Chemical Corp.
7. Freeman Chemical Corp.
8. Cook Composites and Polymers
9. Cargill, Inc.
10. Hercules Inc.
11. ExxonMobile Chemical Company
12. Firestone Plastics Co.
13. B.F. Goodrich Chemical Co.
14. Solutia Inc.
15. Dow Corning Corp.
16. Reichhold Chemicals, Inc.
17. Cambridge Industries of America, Inc.
18. Exxon Co., U.S.A.
19. Union Oil of California, Amsco Div.
20. Alcan Aluminum Corp., Alcan Metal Powders Div.
21. W.R. Grace and Co., Davison Chemical Div.
22. Rheox
23. Pfizer, Inc., Mineral, Pigments and Metals Div.
24. American Zinc Sales Co.
25. U.S. Zinc
26. Phillips Petroleum Co.
27. BASF Corporation
28. C. P. Hall Company
29. Dupont Dow Elastomers
30. BP Amoco
31. Monsanto
32. Bayer
33. Blagden Chemicals Ltd.
34. Ferro Corporation