EASTMAN

Eastman cellulose esters for formulated products

Enhancing performance, productivity, and appearance

Contents

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Enhancing performance, productivity, and appearance

Your business operates in an increasingly competitive world. Eastman's extensive portfolio of cellulose esters enable the creation of innovative products that meet the challenges of this competitive environment. For example:

- Automotive manufacturers need effective, efficient, and aesthetically pleasing coatings with superior performance and application latitude.
- Formulators seek additives that enhance the application and appearance properties of general industrial, can, and other metal coatings.
- Printers want inks that can be run at high speeds, providing quicker turnaround times and improved productivity.
- Wood cabinet and furniture manufacturers want light-colored coatings that have excellent application properties and maintain their color over time.

Eastman cellulose esters are versatile problem solvers that aid in a wide variety of coatings, printing inks, and related applications.

This publication provides formulators with information on cellulose esters that are used as additives, modifiers, or main film formers. These biobased polymers provide a competitive edge in application by enabling higher production rates, as well as in the final product by eliminating defects and improving appearance.

The following information covers the types of cellulose esters and the benefits they bring to a wide range of products. The unique values they add in each application will depend on the problems the formulator is trying to solve. Common specific targets are drying times, antisag, flow and leveling, color and gloss control, rheology adjustments, and controlled release. Cellulose esters do not contribute discoloration to nonyellowing systems.

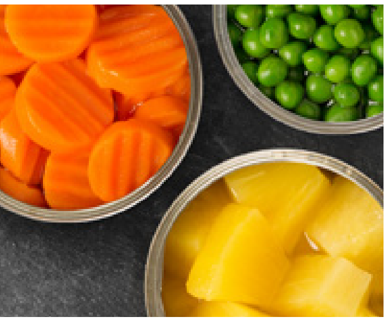
Eastman cellulose esters can be categorized based on their composition—cellulose acetate butyrate (CAB), cellulose acetate propionate (CAP), and cellulose acetate (CA).

Cellulose acetate butyrate (CAB) esters are used as binders in protective and decorative coatings for metal, wood, cloth, paper, plastic, and leather. They impart excellent pigment wetting and color retention, toughness, flexibility, flow control, and good weather resistance. CABs provide a significant performance edge as coatings additives, offering good flow and leveling, faster drying, sag resistance, viscosity control, and metal flake orientation. They are compatible with many resins and soluble in low-cost solvent systems.

Cellulose acetate propionate (CAP) esters are used in applications that require low odor. They have excellent hardness, allowing high production speeds, especially in printing. Their compatibility and solubility are less broad than CABs.

Cellulose acetate (CA) esters are the least soluble and compatible of Eastman's portfolio of cellulose esters. While they require stronger solvents for formulation, they offer films with excellent chemical resistance. They have high glass transition temperatures (T_g) and produce tough, hard films.

Eastman Solus™ performance additives were specifically engineered to help formulators bring cellulose ester benefits in lower-VOC systems. Solus 2100 and 2300 are for solventborne and radiation-curable systems, while Solus 3050 is specifically for waterborne systems.



Eastman offers several food contact grade cellulose esters for inks, adhesives, tapes and labels, and internal can coating applications. They meet requirements for certain food contact applications under regulations of the U.S. Food and Drug Administration (21 CFR), European Commission (Regulation 10/2011), and the Switzerland Ordinance of the FDHA on materials and articles intended to come into contact with foodstuffs (817.023.21, Annex 10). They are manufactured, stored, handled, and transported under conditions adhering to current Good Manufacturing Practices (cGMP) for food contact applications. Contact your Eastman representative or authorized distributor for specific regulatory compliance documentation.

This brochure provides basic information to help you select the right cellulose esters for your needs. The first sections provide an overview of working with cellulose esters, formulation guidance, and technical information; the following sections detail the benefits cellulose esters provide in various applications.

Properties and performance information for specific esters, formulation guides, and application details are available on **eastman.com/CE**. Eastman's chemistry and formulation experts or your authorized Eastman distributor are available to help you select the best cellulose ester for your specific application needs.

Eastman also makes cellulose-based polymers for controlled drug delivery. They're produced under strict manufacturing conditions required by the U.S. Food and Drug Administration. Cellulose esters are also used as film formers in nail polish formulations. For more information, visit **eastman.com** or contact the Eastman care chemicals group, an Eastman technical representative, or an authorized Eastman distributor.

Abundant natural, renewable resources from sustainably managed forests

There is an increased demand for biobased products to replace chemicals derived from fossil fuels. Eastman cellulose esters are based on cellulose, one of the most abundant natural renewable resources, primarily from trees harvested from sustainably managed forests.[a]

Eastman's range of cellulose esters for formulated products has approximate new carbon calculations ranging from 36% to 63%. The percentage of new carbon is the differentiator for carbon-based substances contained in living organisms compared to carbon-based substances from fossil sources. The use of carbon from living organisms such as trees and crops can help create a neutral carbon footprint.

For more details, see Eastman publication CE-COAT-10415 ***Sustainability and biobased content of Eastman cellulose esters for formulated products*** or contact your Eastman representative or authorized Eastman distributor.

[a]A few Eastman cellulose ester products are manufactured from other sustainable sources of cellulose.

Working with Eastman cellulose esters—types and chemical structure, benefits, and formulating guidance

Types of Eastman cellulose esters

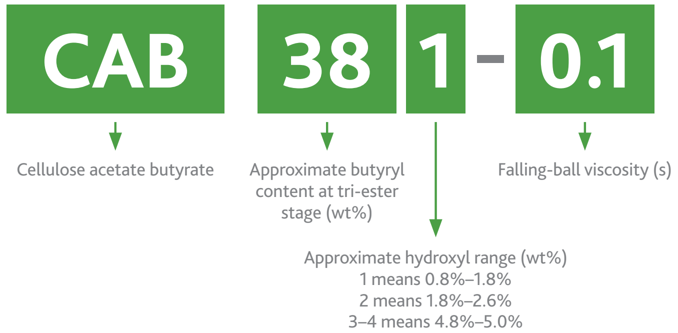
Eastman cellulose esters are available with a range of substituents and molecular weights that determine their solubility, compatibility, viscosity, film formation, and hardness. The size of the acyl group—acetyl, propionyl, or butyryl—on the cellulose backbone affects the packing density and polarity of the cellulose chains. The cellulose backbone provides three hydroxyls per anhydroglucose unit, which are replaced during esterification with acyl groups. The extent of this replacement of the hydroxyl group can be expressed as degree of substitution with a range of 0 (cellulose) to 3 (tri-ester) or in weight percent of acyl and hydroxyl.

In addition to the composition, the molecular weight also affects the properties of the cellulose ester. Products with high molecular weights are excellent film formers but also add significant viscosity to a formulation. Low-molecular-weight products bring benefits such as flow and leveling and reduction in drying time but with less increase in viscosity.

Nomenclature

The nomenclature of many cellulose esters includes viscosity, which serves as a proxy for the molecular weight. These viscosities are determined using the falling-ball method, according to ASTM D1343 in the solution described as Formula A in ASTM D817 and expressed in seconds. The converted value in poise is also commonly provided. In Eastman nomenclature for cellulose esters, the viscosity of each individual ester is typically indicated in its product code. For example, Eastman CAB 381-2 has a viscosity of 2 seconds, Eastman CAB 381-20 has a viscosity of 20 seconds, and Eastman CAP 504-0.2 has a viscosity of 0.2 seconds. An example of the code designation using Eastman CAB 381-0.1 is shown in Figure 1.

Figure 1. Code designation of Eastman cellulose esters, using Eastman CAB 381-0.1



Cellulose acetate butyrate (CAB)

There is a wide range of butyryl, acetyl, and hydroxyl levels available in Eastman CABs and, consequently, a wide range of properties. CABs are stable to ultraviolet light and do not react with dyes, fluorescent colors, or metallic pigments.

Products in the Eastman CAB 381 series, with a medium butyryl level, are broadly soluble and compatible with resins and plasticizers. They serve in many applications, including wood finishes, automotive topcoats, rubber and plastic coatings, cloth coatings, glass coatings, hot melts, and adhesives. They are used as a medium in which to disperse pigments on a differential-speed, two-roll mill. Because these products are useful in so many ways, they are commonly referred to as the general-purpose butyrates.

The Eastman CAB 551 series—esters with the highest practical butyryl level and appreciable hydroxyl levels—is used in cross-linked finishes to improve dry-to-touch time, reduce cratering, provide a better pigment-dispersion medium, and improve coating performance. Because they are soluble in many acrylate monomers, products in the Eastman CAB 551 series are valuable ingredients in ultraviolet-cured coatings and inks.

Certain Eastman CABs are manufactured at high hydroxyl levels to provide alcohol solubility. With their high hydroxyl content, these butyrates are useful in curing finishes such as baking enamels and acid-catalyzed coatings.

Cellulose acetate propionate (CAP)

CAP properties are intermediate between CA and CAB. They resemble CAs in many performance properties but with improved solubility and compatibility. Like acetates, CAPs have low odor and can be used where that is a requirement. These properties make propionates especially useful in inks, overprint varnishes (OPVs), plastic coatings, paper coatings, and various reprographic processes. The solubility of high-hydroxyl propionate in alcohol-water mixtures makes it useful in flexographic inks and OPVs to provide low odor, fast solvent release, and good adhesion to plastic films and paper.

Cellulose acetate (CA)

Cellulose acetates are soluble only in strong coatings solvents such as acetone, methyl ethyl ketone, and ethyl acetate. They have very low tolerance for hydrocarbons and limited compatibility with commercially available resins.

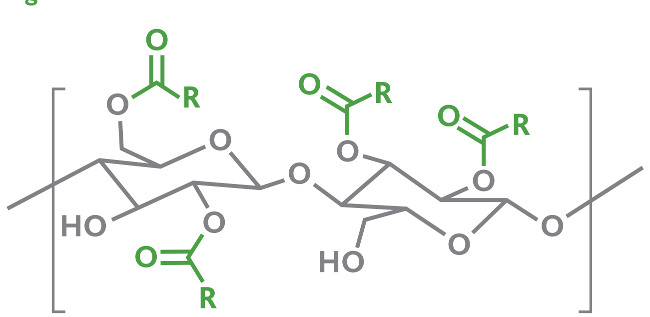
Only very active plasticizers, such as dimethyl phthalate or triacetin, will remain in the film without exudation. The hardness and melting point of CAs are relatively high.

These characteristics yield desirable properties for a number of applications, including solvent- and grease-resistant coatings for paper products, wire, and cloth; dopes and cements for model airplanes; lacquers for electrical insulation and for the manufacture of capacitors; barrier and release coatings for pressure-sensitive tapes; and protective coatings for plastic items such as shoe heels and pen barrels.

CA weathers well and is nonyellowing on long-term exposure to the sun, making it useful as a coating for signs and decals. The transparency of CA coatings and their ability to transmit sunlight have led to extensive use of these film formers for coating wire screening for greenhouse windows, poultry runs, and similar structures. The good physical strength of the coatings yields a tough, tear-resistant screen.

Figure 2 shows the chemical structures of Eastman cellulose esters.

Figure 2. Chemical structures of cellulose esters



Acyl groups in CEs
R = $-CH_3$ (acetyl)
$-CH_2$-CH2-CH3 (propionyl)
$-CH_2-CH_2-CH_3$ (butyryl)

Typical properties of cellulose esters

Table 1 provides a comparison of typical properties for Eastman cellulose esters by product category.

Table 1. Typical properties[a]

Product	Viscosity[b]		Intrinsic viscosity	Acetyl wt%	Butyryl wt%	Propionyl wt%	Hydroxyl wt%	Specific gravity	T_g,[c] °C	Melting range, °C	MW_n[d]
	poise	sec									
Cellulose acetate butyrate											
CAB 171-15	57.37	19	—	29	18	—	1.1	1.26	161	230–240	65,000
CAB 321-0.1	0.38	0.1	—	17.5	32	—	1.3	1.2	127	165–175	12,000
CAB 381-0.1	0.38	0.1	—	13.5	38	—	1.5	1.2	123	155–165	20,000
CAB 381-0.1, food contact	0.38	0.1	—	13.5	38	—	1.5	1.2	123	155–165	20,000
CAB 381-0.5	1.9	0.5	—	13.5	38	—	1.5	1.2	130	155–165	30,000
CAB 381-0.5, food contact	1.9	0.5	—	13.5	38	—	1.5	1.2	130	155–165	30,000
CAB 381-2	8	2	—	13.5	38	—	1.3	1.2	130	171–184	40,000
CAB 381-2, food contact	8	2	—	13.5	38	—	1.3	1.2	130	171–184	40,000
CAB 381-2 BP	8	2	—	14.5	35.5	—	1.7	1.2	133	175–185	40,000
CAB 381-20	76	20	—	13.5	37	—	1.8	1.2	141	195–205	70,000
CAB 381-20, food contact	76	20	—	13.5	37	—	1.8	1.2	141	195–205	70,000
CAB 381-20BP	20.8	16	—	15.5	35.5	—	0.8	1.2	128	185–195	70,000
CAB 500-5	19	5	—	3	51	—	1	1.18	96	165–175	57,000
CAB 531-1	5.6	2	—	3	50	—	1.7	1.17	115	135–150	40,000
CAB 531-1, food contact	5.6	2	—	3	50	—	1.7	1.17	115	135–150	40,000
CAB 551-0.01	0.038	0.02	—	2	52	—	2	1.16	85	127–142	16,000
CAB 551-0.01, food contact	0.038	0.02	—	2	52	—	2	1.16	85	127–142	16,000
CAB 551-0.2	0.76	0.2	—	2	52	—	1.8	1.16	101	130–140	30,000
CAB 551-0.2, food contact	0.76	0.2	—	2	52	—	1.8	1.16	101	130–140	30,000
CAB 553-0.4	1.14	0.3	—	2	47	—	4.8	1.2	136	150–160	20,000
CAB 553-0.4, food contact	1.14	0.3	—	2	47	—	4.8	1.2	136	150–160	20,000
Cellulose acetate propionate											
CAP 482-0.5	1.53	0.5	—	1.5	—	45	2.6	1.23	142	188–210	25,000
CAP 482-0.5, food contact	1.53	0.5	—	1.5	—	45	2.6	1.23	142	188–210	25,000
CAP 482-20	76.5	20	—	1.3	—	48	1.7	1.22	147	188–210	75,000
CAP 482-20, food contact	76.5	20	—	1.3	—	48	1.7	1.22	147	188–210	75,000
CAP 504-0.2	0.76	0.2	—	0.5	—	42.5	5	1.26	159	188–210	15,000
CAP 504-0.2, food contact	0.76	0.2	—	0.5	—	42.5	5	1.26	159	188–210	15,000
Cellulose acetate											
CA 394-60LF	228	34	—	40	—	—	4	1.32	180	240–260	—
CA 398-3	11.4	3	—	39.8	—	—	3.5	1.31	180	230–250	30,000
CA 398-3, food contact	11.4	3	—	39.8	—	—	3.5	1.31	180	230–250	30,000
CA 398-6	22.8	6	—	39.8	—	—	3.5	1.31	182	230–250	35,000
CA 398-30	114	30	—	39.7	—	—	3.5	1.31	189	230–250	50,000
Eastman Solus™ performance additives											
Solus 2100	—	—	0.08	2	53	—	1.6	1.2	75	—	—
Solus 2100, food contact	—	—	0.08	2	53	—	1.6	1.2	75	—	—
Solus 2300	—	—	0.095	19	30	—	1.6	1.22	~110	—	—
Solus 3050	1.02	0.3	—	1.9	46.7	—	2.8	—	130	—	—

[a] Properties reported here are typical average lots. Eastman makes no representation that the material in any particular shipment will conform exactly to the [b] Viscosity determined by ASTM D1343. Results converted to poises (ASTM D1343) using the solution density for Formula A as stated in ASTM D817 (20% cellulose ester, 72% acetone, 8% ethyl alcohol). [c] Glass transition temperature [d] Number-average molecular weight values, MW_n, are polystyrene-equivalent weights determined using size-exclusion chromatography.

Benefits of using Eastman cellulose esters in coating and ink applications

In today's market, appearance and production speed are everything. Eastman cellulose esters offer multifunctional performance and improve application robustness and final film appearance. The most notable improvements are reduced cratering, quicker dust-free time, and better pigment control in thermosetting finishes. In thermoplastic finishes, cellulose esters improve dry-to-touch times and give better pigment control. These benefits stem from four fundamental polymer properties of cellulose esters that are summarized in Figure 3.

Figure 3. **Benefits of using Eastman cellulose esters as additives or modifiers in coating and ink applications**

Due to their rapid viscosity build, cellulose esters prevent:

- Film distortions and craters
- Sags and runs
- Picture framing
- Poor metal flake orientation
- Color separation in multipigment systems
- Pigment flooding and floating
- Inconsistent gloss control with matting agents
- Poor holdout

Due to their near-Newtonian rheology, cellulose esters improve:

- Flow and leveling
- Rheology control
- Appearance (reduction of surface defects such as pinholes and craters)
- Spraying (atomization)
- Roll-coat application
- Curtain coat application (reduction of holes)

Due to their high T_g, cellulose esters provide:

- Rapid dry-to-touch times (reduced dirt pickup)
- Excellent hardness and hardness development

Due to their cellulosic polymer nature and pendant groups, cellulose esters have:

- Good UV stability
- Excellent dimensional stability (cold-crack resistance)
- Heat and moisture stability (exterior durability)
- Increased intercoat adhesion (attributed to the good wetting properties of CAB and the controlled level of solvent attack on one coat by a subsequent coat)

Selection considerations

There is no simple rule for which cellulose ester to use, but it must be soluble in and compatible with the balance of the formulation composition. Information on the solubility of cellulose esters in a range of common solvents can be found in Appendix A. The amount of cellulose ester required to solve a problem in a formulated product may vary from as little as 0.1% to as high as 40%–50% on solids. Cellulose esters can be used with both thermoplastic and thermosetting formulations as a pigment-dispersion medium.

In thermoplastic formulations, 20%–40% cellulose ester can be used to provide better sprayability, reduced dry-to-touch time, and better cold-crack and print resistance in wood lacquers.

In many thermosetting coating formulations, additions of 1%–5% cellulose ester can minimize cratering, running, and sagging of the finish. Levels of 1%–10% cellulose ester are used with thermosetting resins for flow control, quicker dust-free time, and better pigment control. The addition of 15%–30% cellulose ester in thermosetting formulations provides a coating that dries like a lacquer on a hard surface and can be sanded to remove orange peel, sags, or embedded dirt. Spot repairs can then be made with the original coating composition. During the final bake at converting temperature, the enamel reflows to eliminate sand marks and provides a glossy thermoset finish.

Cellulose acetate butyrates

The selection of a cellulose acetate butyrate depends on the application requirements. Where toughness with some heat resistance is of prime importance, as in cable lacquers, esters with low butyryl content, such as Eastman CAB 171-15, should be considered. If compatibility with a thermosetting resin is desired, a high-butyryl, low-viscosity ester such as one in the CAB 551 series may be more useful. Other ester types between these two in butyryl content offer intermediate properties and a choice of viscosity ranges.

The properties of CAB esters can be modified by the addition of plasticizers, impacting adhesion, flexibility, heat-sealing ability, moisture resistance, and other characteristics. Cross-linking with amino, isocyanate, or other reactive resins alters properties and performance significantly. As a rule, higher-butyryl esters permit wider variation in modification, compatibility, and solubility than lower-butyryl esters.

Another consideration is a CAB's chemical resistance. In laboratory comparisons made by immersing sample CAB films in various organic and inorganic reagent solutions, low-butyryl esters exhibited the best general chemical resistance.

To select the optimum Eastman CAB ester for a specific application, the formulator must consider the characteristic properties of each ester type. The effects of the composition and molecular weight of CABs are discussed in the following sections.

Effect of butyryl content on properties

The large size and low polarity of the butyryl group on the molecule cause the cellulose chains to spread farther apart, lowering the attraction between them. The degree to which this change occurs depends on the number of butyryl groups present.

Solubility and chemical resistance

In many coating and ink formulations containing CABs, a wide range of solvents is used to control evaporation rate, performance in application, and final film properties.

With increasing butyryl content, the solubility increases, allowing a wider range of solvents and resulting in lower viscosities. The Eastman CAB 381 series and other types with higher butyryl content will dissolve in aromatic hydrocarbon-alcohol mixtures. Those with high hydroxyl levels, such as Eastman CAB 553-0.4, will dissolve in alcohols and even tolerate some water. Information on solubility of cellulose esters in a range of common solvents can be found in Appendix A. The higher-butyryl esters will also dissolve in acrylate monomers and styrene used in ultraviolet-curable coatings and inks. In thermoplastic systems, chemical resistance is generally greater with lower-butyryl esters. In thermoset systems, the hydroxyl level determines the cross-link density, which is directly proportional to chemical resistance.

Using diluent (nonsolvent) without sacrificing film quality can lower cost but is restricted due to hazardous air pollutants (HAPs) and volatile organic compound (VOC) regulations. A higher butyryl content will increase the tolerance of diluents. The tolerance for aromatic hydrocarbons is much greater than for aliphatic hydrocarbons.

Compatibility with resins

Higher-butyryl esters are more compatible with modifying resins and other film formers than lower-butyryl esters. In general, CABs are compatible with most acrylics, polyesters, phenolics, ureas, and isocyanates. They are also compatible with some epoxies and polyvinyl acetates.

CABs have limited compatibility with most alkyds. However, some compatibility can be found with short-oil alkyds based on coconut, castor, and soya oils. If a CAB shows incompatibility, selecting a CAB with higher butyryl content often will improve compatibility. Resin compatibility information is available online or through your technical representative.

Flexibility and use of plasticizers

In thermoplastic systems, the amount of plasticizer required with each CAB to obtain a desired flexibility depends on the nature of the plasticizer, the molecular weight, and the butyryl content of the ester. Higher butyryl content increases compatibility with plasticizers as well as flexibility and lowers the plasticizer level for a given flexibility. Plasticizers may also influence the resistance to moisture, oils, and greases; toughness and hardness; electrical characteristics; and resistance to weathering. Generally, plasticizers that are useful with vinyl chloride-acetate resins perform well with CABs.

Moisture resistance

Eastman CAB films are water resistant, although they do transmit water vapor to a degree. Other factors being equal, the higher the butyryl content, the higher the resistance to moisture. This property may be altered by hydroxyl level or the addition of plasticizers, waxes, resins, or other additives.

Grease resistance

Where frequent contact with greases and oils is an important factor, esters with high hydroxyl content should be considered. As might be expected from the general trend of plasticizer compatibility, lower-butyryl esters have greater resistance to such materials.

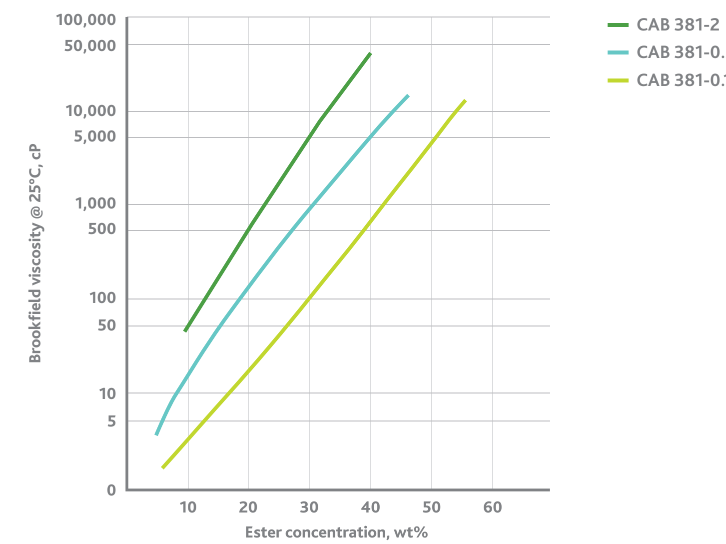
Tensile strength, hardness, and melting point

CABs have been selected for many applications because of their high tensile strength, hardness, and high melting point. Generally, these film properties decrease with increasing butyryl content. Higher molecular weight increases film properties such as toughness.

Effect of molecular weight on viscosity and film properties

Increasing the molecular weight increases the viscosity of a coating or ink and must be balanced with VOC regulations that drive higher solids in formulations. The viscosity of such higher solids on formulations must still allow proper application. Figure 4 shows the impact of molecular weight on Brookfield viscosity for three CAB 381 esters. At 20% in acetone, the viscosity increases from approximately 25 cP for CAB 381-0.1 to 200 cP for CAB 381-0.5 and 500 cP for CAB 381-2. It also shows this increase is even more pronounced at higher solids levels.

Figure 4. Impact of molecular weight on Brookfield viscosity



High-molecular-weight CABs are not usually a requirement when used as an additive in thermosetting finishes. Lower-molecular-weight esters permit a higher solids concentration at a given solution viscosity. The CAB cross-links and builds molecular weight during the curing process.

The molecular weight of a cellulose ester also has considerable influence on the physical film properties of thermoplastic systems. Films or coatings made from cellulose esters with higher molecular weight have greater toughness and better mechanical properties. Eastman CAB 381-2, CAB 381-20, and CAB 531-1 are effective in increasing cold-crack resistance due to improved dimensional stability. In general, these film properties are related to the butyryl content, hydroxyl content, and molecular weight of each CAB type.

Hardness, solubility, compatibility, density, and melting point

Increasing the molecular weight of a CAB results in a very small decrease in solubility and compatibility with virtually no change in hardness and density. The melting point, however, increases with viscosity. Eastman CAB 381-20, for example, melts at approximately 200°C (392°F); Eastman CAB 381-0.5 melts at approximately 160°C (320°F).

Effect of hydroxyl content on properties

The hydroxyl content varies from around 1% for CAB 500-5 to almost 5% for CAB 553-0.4. Most CABs are manufactured with a hydroxyl content best suited for general applications (about 1.5%), permitting good solubility, compatibility, and performance in coating applications. When considering the hydroxyl functionality in the stoichiometry of a cross-linking coating system, the following calculations may be useful:

Hydroxyl number = 33 x wt% hydroxyl

Hydroxyl equivalent wt = 1,700 ÷ wt% hydroxyl

Moisture regain

When exposed to the atmosphere, cellulose esters will regain moisture depending on relative humidity as shown in Table 2. Moisture regain increases with increasing hydroxyl content.

Table 2. Equilibrium moisture regain

	Relative humidity			
Eastman cellulose ester	25%	50%	75%	95%
CAP 482-0.5	0.7	1.0	2.8	4.5
CAB 381-0.5	0.4	0.9	1.8	2.6
CAB 531-1	0.4	0.8	1.5	2.2

Normally, CAB is shipped in multiwall bags to retard moisture regain. Near-moistureproof packages are used only for special requirements. If the powder is left exposed to a humid atmosphere, the moisture content will increase to 4%–5%. This increase may not be detrimental to most thermoplastic lacquer coatings but can cause difficulty with polyurethane coatings and catalyzed amino systems. For coatings in which the presence of water is detrimental, it may be necessary to dry the butyrate using oven heating, azeotroping, or a molecular sieve.

Water tolerance

All Eastman CABs will tolerate some water in lacquer solutions, especially if water-soluble solvents are present. The higher the hydroxyl level, the more water will be tolerated. If the hydroxyl level is as high as 5 wt%, as much as 40% water can be tolerated in the solution.

Moisture resistance

The moisture resistance of CAB films depends on the hydroxyl content of the ester, with hydrophilicity of the film increasing with hydroxyl content. Thus, if any degree of moisture resistance is required from a film of high-hydroxyl butyrate, it is necessary to react the hydroxyls with an isocyanate, amino resin, or some other reactive intermediate.

Solubility

The solubility of CAB in polar solvent systems varies with changes in the hydroxyl content of the ester. As the hydroxyl content increases, solutions tend to become clearer. When the hydroxyl content is greater than 4%, the ester is soluble in highly polar solvents such as alcohol/water blends but is much less tolerant of hydrocarbon solvents.

Reactivity

The reactive hydroxyl group that may be cross-linked with urea-formaldehyde, melamine, or polyisocyanate resins, provides the ability to formulate a variety of curing coatings and inks. Selecting higher-hydroxyl cellulose esters such as Eastman CAB 553-0.4 produces films with high cross-link density and, consequently, excellent chemical and physical properties.

CABs can be used as film formers, as additives to other film formers, and as reactive polyols in curing coatings. Even the lowest-molecular-weight CAB ester will function as an additive to improve application and performance characteristics while serving as a polyol and cross-linking with the reactive polymers to form hard, tough, insoluble coatings. The degree of hydrolysis selected for each Eastman CAB usually provides the best combination of solubility, weathering, moisture resistance, and other film properties. For example, Eastman CAB 553-0.4 is alcohol soluble and very reactive, which makes it ideal for acid-cured conversion varnishes.

Cellulose acetate propionates

Cellulose acetate propionates are virtually odorless and yield harder films than butyrates. These esters are less compatible than the more commonly used CABs and work in applications where high block and print resistance are required or where low odor is desired. The high hydroxyl level of Eastman CAP 504-0.2 provides high cross-linking and solubility in alcohol.

Cellulose acetates

The four cellulose acetates have the same chemical compositions but differ in molecular weight. Their selection depends on the application viscosity requirements.

Formulating techniques

Cellulose esters are supplied as white powders that perform best if put into a homogeneous solution before mixing with other ingredients.

The following instructions serve as a general guide for getting cellulose esters into a solution:

- Best practice is to precharge the solvent(s) in the mixing vessel. Slowly add cellulose ester powder under agitation.
- Sufficient agitation will quickly disperse cellulose ester powder, minimizing formation of lumps.
- High-speed shear and heat help the cellulose ester powder dissolve.
- Cellulose esters dissolve best in active oxygenated solvents.

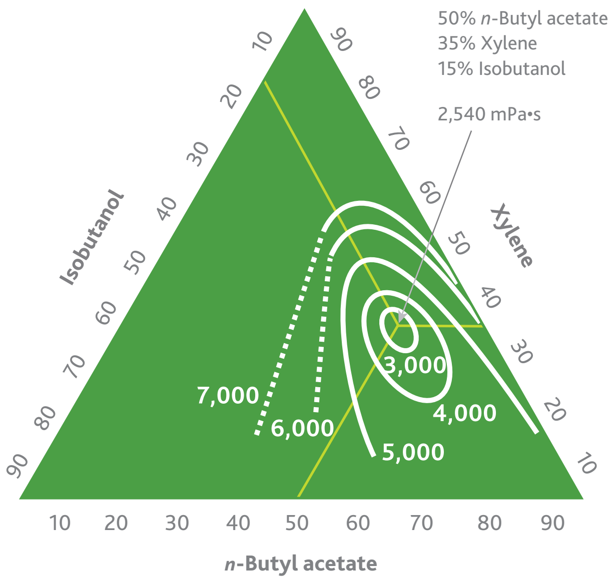
To prevent a static charge that could present a fire hazard from accumulating during the mixing process, do not charge cellulose ester powder to a tank of nonpolar solvent. Do not allow the solution to heat past the flash point of the solvent(s). See Eastman publication CE-COAT-9725, *Handling precautions for the use of cellulose esters in formulated products*, for more details.

Coatings are formulated with a solvent balance designed to give the best performance in the equipment used for application. Appropriate solvent selection for cellulose esters is a critical consideration.

In converting finishes where a cellulose ester is used as an additive, the solvent composition can be very lean (high in aromatic hydrocarbon content) and still accommodate the cellulose ester. If the butyrate in a CAB will not dissolve in the overall solvent blend, it can be predissolved in active solvents as a separate step and added to the formulation using agitation. Esters and ketones are most commonly used to make cellulose ester solutions.

Within a given solvent blend, the optimum ratio of solvents can reduce the viscosity significantly, as shown in the tertiary diagram in Figure 5. For example, with Eastman CAB 381-0.5, a blend of 50% *n*-butyl acetate, 35% xylene, and 15% isobutanol results in a viscosity of 2,540 cP (mPa•s); changing the ratio to 35% *n*-butyl acetate, 35% xylene, and 30% isobutanol would nearly triple the viscosity.

Figure 5. Solubility of Eastman CAB 381-0.5 25% solids solution of CAB 381-0.5 at 23°C (mPa•s)



Other resins as cosolvents

Eastman CAB 551-0.2 borders on being soluble in toluene and xylene. With this borderline solubility, it is often possible to achieve complete solubility by adding a resin such as a polyester or thermosetting acrylic. The low-molecular-weight converting resin performs as a cosolvent with the aromatic to dissolve the CAB.

Where Eastman cellulose esters provide unique benefits—substrates and applications

Many formulators regard Eastman cellulose esters as problem solvers in their coating and ink systems. While the first half of this brochure focuses on the cellulose esters themselves, the following pages focus on their use in terms of technologies, substrates, and applications. For an application guide of cellulose esters recommended for specific applications, see Appendix B.

Radiation-curable coating and ink systems

Radiation-curable coatings are continuing to grow rapidly. They are similar to solventborne systems in that acrylate monomers can be regarded as solvents. Cellulose esters are used as additives in radiation curing (RC). They provide similar benefits such as flow and leveling, improved gloss control, adhesion, and reduction of surface defects. Many ultraviolet (UV) coatings are referred to as 100% solids because no solvent leaves the coating. In some formulations, small amounts of solvents are used to control film thickness and viscosity.

Cellulose esters are used in curable industrial wood coatings, inks and overprint varnishes, and plastic coatings. Most commonly, the cellulose ester is dissolved in a monomer and then added to the formulation. Typical additive use levels are 0.1%–2%.

As the addition level of cellulose esters is often low (0.1–0.5 wt%), CAB 381 type esters such as the 0.1 and 0.5 grades are also used. The CAB 551 types offer the advantage of improved compatibility over the CAB 381 series esters; generally, however, the compatibility of these cellulose esters with most UV cure systems is good. Typically, customers use cellulose esters by dissolving the materials in reactive diluents such as hexanediol diacrylate (HDDA) or tripropylene glycol diacrylate (TPGDA) as a masterbatch, which is then used as an additive to the UV cure formulation to control the dosage more closely. Low-molecular-weight cellulose esters such as Eastman Solus™ 2100 and 2300 performance additives may offer advantages where viscosity is a limitation.

Table 3 shows the viscosities of certain CABs in a variety of monomers typically used in RC coatings and inks.

Table 3. Brookfield viscosities in common monomers at 5% concentrations and 24°C (75°F)

Cellulose ester	CAP 482-0.5	CAB 553-0.4	CAB 381-0.1	CAB 321-0.1	CAB 551-0.2	CAB 551-0.01	Solus 2100
Wt%	5%	5%	5%	5%	5%	5%	5%
Di(trimethylolpropane) tetraacrylate	I	180,000	15,000	116,000	18,600	4,500	2,300
Dipentaerythritol pentaacrylate	I	1,200,000	206,000	I	I	I	31,000
Ethoxylated trimethylolpropane triacrylate	I	5,300	940	1,320	1,700	350	170
Propoxylated (6PO) trimethylolpropane triacrylate	I	I	I	I	4,300	660	310
Propoxylated glycerol triacrylate	I	6,650	1,600	2,860	2,240	605	260
2-phenoxyethyl acrylate	280	1,390	110	140	180	50	25
Isobornyl acrylate	I	I	I	I	350	40	20
Tetrahydrofurfuryl acrylate	70	50	30	50	50	14	10
Trimethylolpropane triacrylate (TMPTA)	I	1,550	1,670	1,420	2,080	660	—
3-methyl 1,5 pentanediol diacrylate	155	240	60	70	90	30	13
Hexanediol diacrylate (HDDA)	—	1,550	60	50	90	30	20
Dipropylene glycol diacrylate (DPGDA)	—	1,190	110	90	140	40	—
Tripropylene glycol diacrylate (TPGDA)	—	40,000	180	130	200	60	—
Styrene	—	I	I	I	30	7	—

Legend:
Value = Brookfield viscosity of soluble solution I = Insoluble — = Not tested

New monomers and oligomers are continuously added to the arsenal of the RC formulator. Just as in solventborne systems where resins can be used as cosolvents, oligomers in RC coatings and inks can also bring cellulose esters into the formulation. Innovation in RC formulations also takes place on the curing equipment side. LED UV light sources are becoming common at lower cost and energy use. Eastman cellulose esters can provide benefits to the formulator to make RC systems even more attractive.

Coatings for metal

Eastman cellulose esters are used in both thermoplastic and thermosetting coatings for structural steel and aluminum, aluminum foil, stainless steel, chromium, brass, silver, and tin where protection of the metal surface and maintenance of the metallic luster are desired. Cellulose esters are formulated into clear or pigmented coatings that have good adhesion to metallic surfaces and are resistant to salt fog, oxygen, and other tarnishing and corroding elements. Eastman CABs also have excellent weathering properties. Common markets and applications where they are used include automotive original equipment manufacture (OEM) as well as refinish coatings, coil coatings, can coatings, general industrial/industrial maintenance and marine coatings, and coatings for a multitude of consumer goods.

Automotive coatings

Eastman cellulose esters have been used for decades in OEM base coats, clear coats, and monocoats and in refinish primers, base coats, clear coats, and monocoats. Eastman cellulose esters are often integral components in achieving desired color effects, particularly through consistent metallic flake orientation in automotive base coats. They also assist in color matching—even with difficult but valuable colors such as moonlight silver, antique gold, and stardust.

In addition, Eastman cellulose esters provide faster, more uniform drying properties as well as excellent redissolve resistance. These are valuable properties for achieving consistent color match, particularly under varied application conditions found in refinish shops.

Automotive base coats

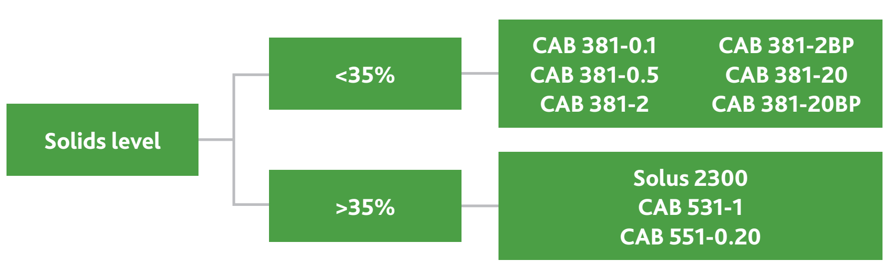
The use of cellulose esters in automotive base coats is primarily associated with color consistency and application latitude. Color harmony is an even bigger challenge with metallic and special-effect colors. If the metallic and pearlescent pigments are not uniformly oriented, each part will look different.

Eastman cellulose esters can help in the application and final appearance of base coats in a variety of ways. They help flake orientation, color consistency, color development, strike-in resistance, and early hardness development. Eastman cellulose esters also promote smoother films and faster solvent release from the paint film.

Selecting the best cellulose ester for your specific application depends on multiple factors, starting with the desired solids level, as depicted in Figure 6.

- In low-solids base coats (less than 35% solids), Eastman cellulose esters—specifically the CAB 381 series—are the first recommended products. They come in many grades of varying molecular weight. Selection of a specific ester or blend will depend on the desired formulation solids.
- For higher solids targets (greater than 35%) or if formulation incompatibilities are found, Eastman Solus 2300™ performance additive, Eastman CAB 531-1, or Eastman CAB 551-0.2 are recommended. Specifically engineered to maximize performance and throughput while meeting VOC goals, Solus 2300 is an ideal solution for formulators faced with the challenge of developing the next generation of high-solids compliant coatings.

Figure 6. Product selection guidelines based on base coat solids level



Automotive clear coats

To provide automotive clear coats that can be applied efficiently without defects like cratering or orange peel, formulators require a versatile additive. Eastman CABs can help.

They can also provide:

- Improved dry time and early hardness development
- Improved sag and flow/leveling balance
- Improved surface appearance and distinctness of image (DOI)
- Improved surface wetting, redissolve resistance, and reduced cratering

In clear coat applications, it is essential to first test the compatibility of the selected CAB with the binder/solvent system you are working with. In 2K polyurethane clear coats, the hydroxyl content must be calculated as a portion of the total polyol content for the stoichiometry with the isocyanate resin. Among Eastman cellulose esters, Eastman CAB 551-0.01, Eastman Solus 2100, and Eastman Solus 2300 are especially useful in formulating high-quality OEM clear coats with excellent application parameters and a smooth, consistent finished appearance. Solus 2100 was designed for high-solids clear coats, with up to 52%–55% spray solids in 1K clear coats and 60% spray solids in 2K clear coats.

Coil coatings

Eastman CABs offer multifunctional performance, formulation versatility, and production reliability for coil coating manufacturers who want to efficiently make aesthetically pleasing coils that meet consumer demands. From brightly colored metallic- and pearlescent-finished household appliances to decorative façade and cladding applications in building and construction, coils with high-quality appearance are specified with increasing regularity. High-performance Eastman CABs ensure fewer surface defects, improved metallic and pearlescent flake alignment, improved flow and leveling, better gloss consistency, and purer white color value.

Eastman CABs reduce or eliminate common defects, leading to the better gloss level control the market demands. Semigloss coil coatings for the building and construction market can be subject to gloss variation across the width of a typical 1.8-meter coil. Matting agents based on silica are one of the preferred choices in producing semigloss coil coatings. Eastman CAB 381-0.5 has demonstrated improved matting efficiency and consistency for coil coatings in white polyester-melamine formulations when dispersed into the resin with the matting agent and pigment.

Tighter gloss specifications were observed across the range of film thicknesses of 18–40 microns. Eastman CAB was most effective when incorporated into the grind, where it was dispersed under high shear in the formulation in conjunction with the matting agent and titanium dioxide pigment. Incorporating Eastman CAB as a post-additive was also effective in improving matting consistency but not as effective as adding Eastman CAB into the grind.

Leveling additives minimize irregularities in the surface and tend to have minimal effect on surface tension. Eastman CAB ensures that the coating remains smooth over the substrate after application and during curing. By maintaining an even surface tension throughout the film, undesirable flow as a result of surface tension differences is prevented. Eastman CAB also acts as a "force multiplier," bringing about synergistic effects with other commonly used flow and leveling additives.

The photographs in Figure 7 demonstrate how CAB significantly improves flow and leveling in coil coatings. The panel without Eastman CAB is marked with craters and unsightly orange peel, which reduces surface gloss and smoothness. The photograph shows a reduction in the reflection of a pencil held above the surface. The panel containing Eastman CAB has eliminated the orange peel effect, with gloss increasing so that the reflection of the pencil is much more pronounced.

Figure 7. Demonstration of flow/level improvement with the use of CAB

Without CAB
Poor flow/leveling
Distorted reflection of pencil
Gloss value = 90

With CAB
Good flow/leveling
Excellent reflection of pencil
Gloss value = 94

Eastman CABs are easily added to preexisting formulations. The most common technique is to predissolve Eastman CAB with a suitable coil coating solvent. Since the level and type may differ based on the desired aesthetic effect and nature of the substrate, different solvents may be required to achieve optimum solubility. Table 4 can be used to select the correct grade and loads for a specific use in a coil coating formulation.

Table 4. Eastman portfolio of CAB additives for coil coatings

Product	Use	Level (%)
CAB 531-1, CAB 551-0.2	Metallic, pearlescent flake alignment	0.5–1.0
CAB 381-0.5	Matting efficiency	0.5–1.0
CAB 551-0.01	Flow and leveling; surface defects	0.1–1.0
CAB 551-0.2, CAB 381-0.5, CAB 553-0.4	Pigment dispersion and co-dispersants	0.1–1.0
CAB 551-0.01	Increase gloss	0.1–1.0
CAB 553-0.4	Higher hydroxyl functionality can improve adhesion, reactivity.	0.1–1.0
CAB 381-20, CAB 381-2	High molecular weight. Overthinned batches can be brought into specification without drastically affecting other application properties.	0.5–5.0

For help selecting the best cellulose ester for your specific needs, contact your Eastman technical service representative or authorized distributor.

Can coatings

Eastman cellulose esters can help formulators who seek multifunctional additives that will enhance the application, appearance, and protection qualities of metal packaging, such as can coatings. Two of the most commonly used cellulose esters are Eastman CAB 551-0.01 and Eastman Solus™ 2100 performance additive. Both are available in regular and food contact grades.

The molecular composition of Eastman cellulose esters makes them particularly effective for metal packaging coatings, with excellent properties that enable production and appearance benefits. They also produce tack-free coatings, which means no blocking during application and handling. This results in reduced defects, excellent clarity, high gloss, and DOI, all of which contribute to stronger and more durable coatings with better appearance.

General industrial, industrial maintenance, and marine applications

General industrial, industrial maintenance, and marine coatings must perform across a wide variety of applications, technologies, end uses, and substrates—mainly metal. These coatings are designed to withstand harsh environments and are used to protect heavy-use equipment like railcars, earth-moving equipment, alloy wheels for vehicles, or machinery parts. The fitness-for-use requirements for these types of coatings are becoming more and more demanding, including the need for higher durability and chemical resistance, improved adhesion, and better appearance. In addition, coatings must be easy to apply and comply with the latest regulatory requirements.

Eastman CABs and CAPs offer improved appearance, formulation flexibility, processing, and durability to coatings for harsh environments. Cellulose esters bring durability and application benefits that will address these unique challenges.

The versatility of cellulose esters is a distinct advantage. The reactive hydroxyl groups contained in CABs and CAPs may be effectively cross-linked with urea-formaldehyde, melamine, or polyisocyanate resins. This provides the ability to formulate a variety of cured coatings. The selection of higher-hydroxyl cellulose esters such as Eastman CAB 553-0.4 for use in curing systems produces films with high cross-link density and, consequently, excellent chemical and physical properties. Due to their high T_g, Eastman cellulose additives provide excellent hardness and hardness development.

Table 5 provides guidance in selecting the correct cellulose ester and recommended loading for industrial formulations. Eastman cellulose esters are easily added to preexisting formulations. The most common technique is to predissolve the cellulose ester with a suitable industrial coatings solvent.

Table 5. Eastman portfolio of cellulose esters and suggestions for use

Product	Use	Level (%)
CAB 531-1, CAB 551-0.2	Metallic, pearlescent flake alignment	0.5–10.0
CAB 381-0.5	Matting efficiency	0.5–1.0
CAB 551-0.01	Flow and leveling; surface defects	0.1–1.0
CAB 551-0.2, CAB 381-0.5, CAB 553-0.4	Pigment dispersion and co-dispersants; pigment chips; reduced drying time	0.1–10.0
CAB 551-0.01	Increase gloss	0.1–1.0
CAB 553-0.4	Higher hydroxyl functionality can improve adhesion, reactivity.	0.1–10.0
CAB 381-20, CAB 381-2	High molecular weight. Overthinned batches can be brought into specification without drastically affecting other application properties. Reduced drying times.	0.5–5.0
Solus 2100, Solus 2300	High solids; low VOC; reduced drying times	0.1–10.0
CAB 381-20, CAB 500-5	CAB 381-20 or CAB 500-5 can be used in hot-melt strippable protective coatings.	15–50
CAB 551-0.01, Solus 2100	UV coatings; flow and leveling; surface defects	0.1–1.0
CAP 504-0.2	Low odor. High hydroxyl level provides good solubility and reactivity in alcohol-water mixtures. Good adhesion to plastic.	0.1–10.0

The general industrial market includes a wide variety of applications, technologies, and end uses. Eastman cellulose esters can perform many different functions in an industrial coating. They offer multifunctionality, versatility, and reliability in both durability and application for many coating systems and are consistently used throughout the global industrial coatings market.

Hot-melt strippable coatings

Hot-melt strippable coatings provide a flexible protective casing around a variety of metal items and machinery, preventing damage from impact from the time of manufacture through transport and storage to the time of use. Examples include saw blades, drill bits, gears, rotors, stators, bearings, and much more—in fact, any metal part that needs protection.

Hot-melt strippable coatings also provide very long-term protection by helping reduce corrosion to metal parts and machinery located in aggressive offshore and onshore environments such as those found in marine, mining, and offshore industries. In these hostile environments, metal components can be affected by corrosion, dust, dirt, chemical contamination, extremes of temperature, and high humidity. Less corrosion means parts can be stored longer while inspection and maintenance frequency can be reduced, leading to less downtime coupled with improved safety and aesthetics.

In addition, hot-melt strippable coatings can help facilitate the servicing or alteration of metal parts that need to be removed, such as cover flanges, bolted assemblies, casings containing bearings, and protective shields. This is where strippable coatings have a unique advantage over traditional corrosion-protection coatings. Traditional coatings cannot be removed easily; however, hot-melt strippable coatings can be peeled away, the part serviced, the hot-melt coating reapplied, and the part put back into service.

The composition of a hot melt typically includes CAB, plasticizer, oil, heat stabilizer, and corrosion inhibitor. Once applied to the substrate, the coating provides a finish that is very durable, tough, and resistant to UV oxidation as well as salt and humid environments. Over time, the retained oil exudes from the coating at a controlled rate and provides excellent long-term protection of metal parts from corrosion in challenging environments. Formulations can be designed so they have either low, medium, or high oil exudation. Eastman CABs have a unique and very beneficial property of retaining a high percentage of the synthetic or vegetable oil in the polymer matrix of the coating.

Since the formulation of hot melts varies widely depending on performance requirements, various Eastman CABs may be used. Generally, the Eastman CAB 381 series or Eastman CAB 500-5 are selected. These CAB products provide the best choice due to overall performance: excellent heat stability, toughness and, most importantly, a very good capability to retain a high percentage of synthetic or vegetable oil in the polymer matrix.

Hot-melt strippable coatings based on Eastman cellulose esters are generally 100% solid materials, usually supplied in block or chunk form. They do not contain any volatile solvents. Any used or unused material can be remelted and reused. The coating can be formulated to be transparent or colored to suit a company's logo colors or promotional design.

Figure 8 demonstrates the hot-melt strippable coating application and end result.

Figure 8. End of metal drill bit dipped in hot melt at 170°–175°C, cooled, and handled after 5 min

Coatings for wood

Eastman CABs help address requirements in both thermoplastic lacquers and thermoset coatings for wood, including not contributing to yellowing over time. They also help ease of handling and application, resolvation for repairs, and quick dry times.

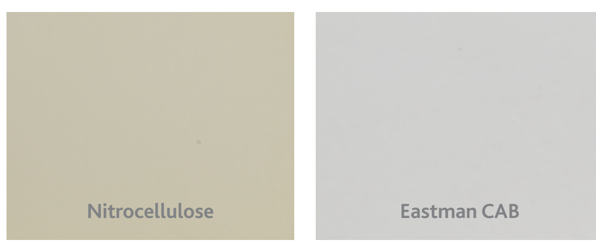
CAB/acrylic wood lacquers

A typical furniture lacquer consists of Eastman CAB, thermoplastic acrylic, plasticizer, and solvent. A silica flatting agent is often used to impart the desired sheen to the finish. Acrylic resins, known for good light stability and good resistance to stain and plasticizer migration, are often used in formulations where these properties are important. Hard resins with good color are used to improve sanding and rubbing properties, film depth, and clarity. Alkyd resins are used to obtain excellent film clarity, flow out and leveling, good depth, improved adhesion, and high nonvolatile content.

In addition, Eastman CAB has excellent sprayability and flow out, fast through-dry, and good film clarity. Full advantage of these qualities is being taken in coatings for furniture, plywood paneling, particleboard, and hardboard. A major use of CAB in wood lacquers is in a nonyellowing coating for white or pastel-painted furniture. Unlike nitrocellulose, CAB products are nonflammable and can be handled as dry powder with a long shelf life.

Figure 9 contrasts the difference between a white wood lacquer based on Eastman CAB and one based on nitrocellulose. The samples were placed in a QUVB chamber (313 nm wavelength) for 18 hours. The coating with nitrocellulose lacquer severely yellowed, while the coating with Eastman CAB was much more stable under UV light and retained a high degree of whiteness.

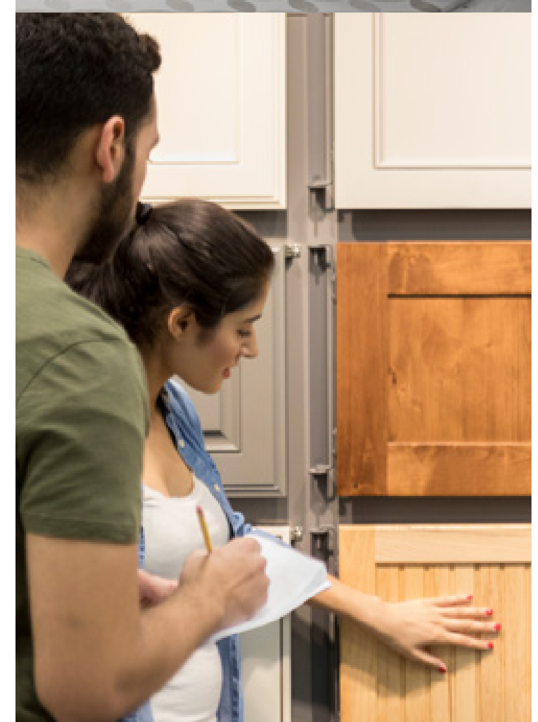
Figure 9. UV stability in white wood lacquer based on nitrocellulose or Eastman CAB



CAB/urea-formaldehyde wood coatings

A CAB/urea-formaldehyde composition may be used in coating kitchen cabinets, taking advantage of the high T_g of Eastman CAB to improve flow for lacquer-like drying. Urea-formaldehyde resins are used in curing coatings to obtain superior moisture resistance and color stability, excellent mar resistance, good sanding and rubbing qualities, and good adhesion to most surfaces. Nonoxidizing alkyds can be added to these formulas to create coatings that handle like lacquers and perform like synthetic finishes. Eastman CAB 553-0.4 provides ideal cross-linking and can be put in formulas that meet Kitchen Cabinet Manufacturers Association (KCMA) standards, a sought-after certification.

In some cases where a natural grain appearance is desired, formulators need to reduce solids content to produce less film build while still maintaining adequate viscosity to prevent sagging. CAB is an excellent modifying resin for this purpose, increasing viscosity at lower solids content and improving sag resistance and physical drying.



2K polyurethane wood coatings

In 2K polyurethane coats where silica flatting agents are used, Eastman CABs have been shown to reduce gloss differences as a function of film thickness. High-quality furniture finishes with outstanding toughness and chemical resistance can be prepared by blending CAB with an isocyanate prepolymer. Film thickness will be more constant using CABs, even at thicker coating areas on a substrate; commonly observed gloss differences will be reduced as well, resulting in a more even appearance.

Radiation-cured wood coatings

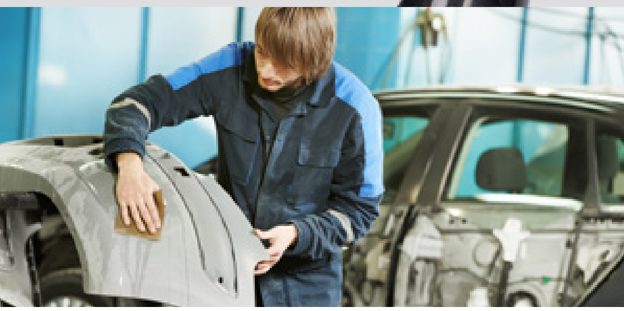
100% solids UV wood coatings are widely used in factory-applied industrial wood coatings for furniture and flooring applications. UV cure technology is an excellent technical fit for 2D substrates like knockdown furniture and factory-applied wooden flooring using application methods such as roller, slot die/flow coating, or pneumatic spray. 100% solids UV-cured coatings can often be constrained by high viscosity, particularly for spray application, which can result in poor flow and leveling that leads to film defects and poor appearance. Formulators typically use cellulose esters at low levels (0.1 to 0.5 wt%) to help with flow and leveling or to reduce the penetration (holdout) of the UV coating into porous substrates such as medium-density fiberboard (MDF) or some species of wood. Solvent-reduced UV cure systems (e.g., using butyl acetate) have been used to assist spray application where cellulose esters have been used to increase viscosity and provide a degree of physical predrying and film thickness control.

As the addition level of cellulose esters is often low (0.1 to 0.5 wt%), even the higher-molecular-weight 381 type esters such as the 0.1 and 0.5 grades are common. The 551 types are advantaged by having improved compatibility over the 381 series esters, but the compatibility of the cellulose esters with most UV cure systems is generally good. Typically, customers use cellulose esters by dissolving the materials in reactive diluents such as HDDA (hexanediol diacrylate) or TPGDA (tripropylene glycol diacrylate) as a masterbatch, which is then used as an additive to the UV cure formulation to control the dosage more closely. Low-molecular-weight cellulose esters such as Solus 2100 may offer some advantages where viscosity is a limitation.

Table 6 provides guidance about recommended Eastman cellulose esters for specific wood coating technologies.

Table 6. Selector guide for wood coating technologies

Type of wood finish	Typical use level, solids, wt%	Suggested Eastman cellulose ester for initial screening
Lacquer	30–60	CAB 381-0.5, CAB 531-1, CAB 551-0.2
2K alkyd/urea	10–40	CAB 553-0.4
1K precatalyzed	10–40	CAB 553-0.4
Sealers	10–30	CAB 551-0.2
2K polyurethane	5–60	CAB 381-0.1, CAB 381-0.5, CAB 551-0.01, CAB 551-0.2
High-solids cross-linked coatings	5–15	CAB 551-0.01, Solus 2100
UV-curable	1–5	CAB 381-0.5, CAB 551-0.01, Solus 2100
Unsaturated polyester	1–10	CAB 551-0.01, CAB 551-0.2



Cellulose esters for plastic applications

Eastman cellulose esters have been used with plastics as coatings, release coatings, and even in plastic formulations.

Coatings for plastic materials

CABs have been used for many years in coatings for various plastic materials. Portions of the surface of molded plastic articles are frequently coated with a lacquer that primarily serves a decorative purpose, e.g., in metallic coatings on consumer items like hair dryers or casings for other electronics such as remote controls. In automotive applications, clear plastic parts may be coated on the reverse side to match other interior colors or to give a metallic appearance.

A coating may also be functional, such as an aid to polish out machine and mold marks, a barrier coating to reduce or prevent plasticizer migration from molded articles, or an aid to reduce damage from marring, abrasion, and weathering.

Coatings for automotive parts often employ CABs to provide optimum color match and application properties such as physical drying, sag resistance, and broad application latitude.

CABs may be used in the barrier coat to protect the plastic from attack by strong solvents in subsequent coating layers. CABs are frequently used for aluminum flake orientation in CAB/acrylic metallic lacquers for casings of consumer electronics. Butyrate/acrylic compositions give good results when used on acrylonitrile-butadiene-styrene (ABS), acrylic, or cellulose plastics. Clear systems yield very hard, brilliant films; pigmented systems are bright and show exceptional gloss retention.

Plasticized polyvinyl chloride (PVC) products have found wide acceptance by consumers in diversified applications such as upholstery for automobiles and furniture; automotive door panels, dashboard pads, and headliners; drapery sheeting; purses and luggage; and garments. Vinyl plastics are coated for various reasons, including to:

- Change the color of the plastic
- Control surface gloss
- Impart a dry feel
- Retard or prevent plasticizer migration

Vinyl lacquers modified with CAB and an acrylic resin are suggested starting points for developing coatings for hard-to-coat vinyl plastics.

Coatings with exceptionally good flexibility can be prepared by blending Eastman CAB with urethane elastomers for application to thermoplastic elastomers. The coated elastomeric plastics are used in exterior auto parts, gears, seals, gaskets, valves, tubing, footwear, toys, and sports equipment.

Addition of Eastman CAB to 2K polyurethane coatings can provide faster drying properties while maintaining chemical resistance and weathering properties. Eastman CAB also improves the "hand" of 2K polyurethane films, providing a more natural feel to the finished coating. The use of Eastman CAB reduces the drying time of the coating and provides hydroxyl groups for subsequent cross-linking with isocyanate prepolymers.

Release coatings for plastics

Eastman CAB polymers are effective as release coatings for silicone rubber molds used in forming rigid polyurethane articles. The base release coating not only protects the mold from attack by the polyurethane components; it also becomes an integral part of the plastic article and serves as a tie coat for other coatings on the molded article.

Vacuum-metallizing and bronzing lacquers

Lacquers are used extensively in vacuum metallizing plastic articles. In this process, most plastics require a surface coating. A lacquer base coat, applied to the surface to be metallized, provides smoothness and functions as an adhesive link between the plastic surface and the metallic film. Then a lacquer is applied as a topcoat over the metallic film for protection against marring, rupture, oxidation, and abrasion. CAB/acrylic lacquers have performed satisfactorily over vacuum-metallized surfaces. Lacquers in which Eastman CAB is used as the film former excel as carriers of bronze powder, since they do not gel or show color drift.

Pigment dispersant for cast acrylic sheet

In some applications, the cellulose ester is formulated in the plastic item itself. Cast acrylic sheets can be found in signs display shelving and even countertops, but the largest application is bathtubs, spas, and shower panels—many featuring metallized and pearlescent effects. A challenge in acrylic sheet production is inconsistent color and blotchiness, which can result in an increased number of rejects and higher production costs for manufacturers.

Thermoformed cast acrylic sheet requires a uniform color on its front and back surfaces. Nonuniform colors can lead to poor color matching when front and back surfaces are interchanged. The cause of these color differences is often related to the flooding and floating of pigments—similar to that encountered in coatings—during the curing of the liquid formulation to create a solid cast acrylic sheet. Flooding is the tendency of pigments to rise to the surface during drying and curing. This produces a surface color that is different from the rest of the material. Floating occurs when pigments separate from each other and concentrate in certain areas, resulting in uneven color distribution.

Adding Eastman CAB products to formulations increases the pigment dispersion and often alters the rheology of the material. By preventing flooding and floating, Eastman CABs enable a more efficient process that delivers uniform color consistency that is more pleasing in appearance.




Coatings for cloth

Coated fabrics such as protective clothing, electrical tape, draperies, and shades are often purchased with emphasis on the properties of the surface coating rather than those of the textile fiber base. Flexible cloth lacquers made from Eastman CAB 381 are used in coating nonyellowing window shades and flame-resistant artificial leathers. More rigid formulations are used to stiffen loosely woven cloth for drapery linings and shirt collars.

Historically, Eastman CAB 171 has been used in airplane dope formulations because coated fabrics on aircraft require low dimensional changes over broad humidity and temperature ranges to maintain tautness while still providing superior weather and chemical resistance. CAB 171, one of the toughest CABs, now finds use in a variety of specific applications where these demonstrated requirements need to be met.

Elastomeric polyurethanes, when properly pigmented and applied, produce excellent coatings for fabrics used in the production of sportswear, rainwear, footwear, hats, coats, handbags, luggage, and upholstery for furniture and automobiles. CAB is used with urethane elastomers that are applied to cloth by the transfer-coating method. Blending CAB with these resins increases hardness, reduces tack, raises blocking point, improves slip, and reduces dirt pickup of the coating.

Coatings for paper

High-quality paper lacquers take advantage of the excellent clarity, gloss, and flexibility of films made from Eastman CAB 381. Its wide compatibility and possible high degree of modification permit the production of lacquers that possess good scuff and mar resistance, good resistance to grease and water, and excellent adhesion to most inked papers. Through amino-resin modification, it is possible to produce paper coatings that have the desirable properties of the butyrate ester as well as heat and solvent resistance.

Release coatings for paper

The use of metallized effects on paper or board surfaces—both holographic and nonholographic—is a growing trend for packaging applications where eye appeal is desired. Typical applications include cigarette carton packaging, inner liner for cigarette packet, packaging for luxury items such as chocolate or teas, and metallized labels on items like beer bottles.

Of the many metallization processes, the nonlamination transfer metallization process is known for providing shiny, vivid metallization and holographic effects and has played a dominant position in the metallization of cigarette cartons. Among transfer metallization processes, biaxially oriented polyethylene terephthalate (BOPET) transfer metallization is increasingly popular, especially since early 2000—driven by the recycling concept of using eco-friendly material to replace film-laminated metallization paper.

The BOPET transfer metallization process is the technology of transferring a decorative metallized layer from BOPET film surfaces onto paper or board surfaces. In the transfer metallization process, formulators of release coatings need to satisfy the requirements of paper makers for stable viscosity while maintaining the compatibility with thermal plastic acrylic (TPA). Performance related to gravure printing ability, clear and level coating film, release ability, flexibility, heat resistance, adhesion on metallized layer, ink printing ability, and metallized/holographic effects are also important features.

CAP 482-0.5 is recommended for holographic metallization applications. In the transfer metallization process, Eastman CAP 482-0.5 can help release coatings achieve better releasability and improve heat resistance and flexibility. This ensures a high-quality metallization effect on paper or carton packing that brings out a premium and appealing appearance. The consistent quality of Eastman cellulose esters also highly improves the productivity.

Coatings for leather

Because they are water-white, nonyellowing, tack-free materials, Eastman CABs are useful alone or in combination with other resins as film formers in solventborne lacquers and in lacquer emulsions for leather topcoats. CABs are used worldwide in topcoats for leather items such as automotive upholstery, footwear, and furniture. These topcoats containing CAB are tough and have good resistance to abrasion and plasticizer migration.

Eastman CABs can contribute slip and hand to topcoats of various thicknesses over fine or less expensive leathers. CABs remain stable and will not degrade or yellow in the presence of the amine accelerators found in polyurethane shoe soles and polyurethane upholstery foam. On contact with vinyl, CABs will not extract plasticizers. Compared with other cellulosic film formers, Eastman CABs have excellent light stability and can be used over white or other light-colored base coats.

Aerosol coatings

Eastman has solutions that address the needs for lacquer aerosol paints, which are widely used on metal, wood, or plastic. Combining CAB with acrylic resins enables fast drying and sag resistance. This combination also makes paint application easier and improves the look of the finished product.

While alkyd-based aerosols require an immediate repaint or a 24-hour wait before applying a new coat, the addition of CAB gives consumers flexibility. A new coat can be applied anytime without fear of wrinkling. Unlike nitrocellulose, CAB doesn't yellow over time. The application and performance advantages of CAB result in better appearance.

In the U.S., aerosol paints are regulated by maximum incremental reactivity (MIR) values based primarily on solvent choices. Maximum values are application specific. CAB provides the ability to adjust for desired values, ease of manufacturing, and broad solvent choices.

Eastman CAB 381-0.5 is the most commonly used cellulose ester for lacquer aerosol paints because of its good balance of properties. If compatibility of ingredients is an issue, CAB 531-1 is another excellent choice due to its broader overall compatibility and solubility.

Adding CAB makes lacquer aerosol paints easier to apply, saves time, improves appearance, and provides excellent results that will stand the test of time without yellowing.

Thermally reflowable lacquers

The basic principle of thermal reflow involves the application of a specially formulated lacquer to a substrate in sufficient quantity to produce a dry-film thickness of 1.5–2.0 mils. Following application, a 1-minute flash, and a low-temperature bake, the object is inspected, sanded, and repaired as necessary. The final high-temperature bake thermally softens the coating, allowing reflow and leveling.

Thermally reflowable lacquers are formulated to have adequate levels of plasticizer and retarder solvent to impart thermal reflow characteristics. Retarder solvents, such as ethylene glycol diacetate, are retained by the film during the low-temperature bake. During the high-temperature bake, the retarder solvents are volatilized. However, prior to volatilization of the solvents, the film becomes fluid enough to reflow and produces a coating with very high gloss and DOI, eliminating the polishing often required with lacquers.

Because of its low T_g and melting range compared to other CABs, Eastman CAB 551-0.2 ester is most useful in formulating thermally reflowable lacquers.

Graphic arts and printing inks

Cellulose esters have been used for many years as versatile ink formulating tools for printing packaging films, heat transfer printing inks, screen inks and, more recently, digital inks. They have been used as additives as well as modifiers or even main film formers. Eastman CAP and CAB are used to improve drying, enabling faster print speeds and improved blocking performance.

Digital

Digital printing allows for "mass customization" and is sometimes combined with gravure or flexographic printing for special events. Continuous inkjet (CIJ) technology is used for date/location/tracking numbers on packaging for identification purposes. The quality of the ink is low, but the speed is very high. The CIJ ink that is deflected and not deposited on the substrate is recycled. This requires an ink that is stable in viscosity and under heat and does not damage the ink jet. Ketones are often used, and a CAB 551 series product is a resin of choice.

Flexography

Many substrates are printed using flexography. The appropriate solvents for formulating flexographic inks have to be compatible with the image rolls and also substrates such as plastics films. Typical solvents are limited to alcohols, acetate esters, and glycol ethers. Cellulose esters that are used are limited to CAP 504-0.2 and CAP 482-0.5.

Gravure

In gravure, the images are engraved on steel printing rolls and therefore allow a wide range of solvents to be used. Gravure produces the highest quality prints but is only economical for long runs (> 1 million), which are common in food and cigarette packaging, textiles, and flooring. Solvents used include alcohols, ketones, esters, and glycol ethers, all of which allow cellulose esters to be used. In most cases, propionates are preferred over butyrates due to odor.

Eastman CAP and CAB have many excellent qualities for use as binder resins in inks for shrink-sleeve applications. This is a rapidly growing application area for liquid inks. The process allows the application of durable, eye-catching decorative designs onto substrates such as Eastman Embrace™ copolyester, PVC, and oriented polystyrene (OPS) used for bottles and other containers.

Whether the sleeve-shrinking process is by steam or dry heat and whether on glass or plastic substrates, Eastman CAP will provide superior quality compared to other resin systems. Details on moisture resistance, temperature resistance, blocking, and defect reduction, as well as starting formulations, can be found in publication TT-64 on our website.

In printing on difficult materials such as polyethylene, polypropylene, polyester, PVC, and OPS that are commonly used in packaging applications, different chemical approaches have been used to improve adhesion. Cellulose esters work well with many of these chemicals, including polyethyleneimine, organic titanates, and zirconium complexes.

PEI is an adhesion promoter that is widely used in printing inks to give improved adhesion to difficult substrates, particularly corona-treated polyolefins such as oriented polypropylene (OPP) or polyethylene. Some formulas may increase viscosity or even gel when using polyetherimide. However, the use of acetoacet-*o*-toluidide (AAOT) can greatly improve pot life. For details on this technology, consult the Eastman brochure TT-63B, *Adhesion promoters for cellulose ester-based inks*, on our website.

Screen

Screen printing is used for a wide range of applications, including textiles, containers (glass, plastic, and metal), signs, wallpaper, and printed circuit boards and solar panels. Screen printing can be done on curved and even textures surfaces with low capital investment, allowing short runs. A screen ink must not dry on the screen and must be viscous enough to hold out. Alcohols, acetate esters, and even ketones are used as solvents in screen formulations.

Overprint varnishes

Eastman cellulose esters are used in solventborne, clear overprint varnishes (OPV), mainly due to their high T_g. OPVs are used to provide a fast-drying, nontacky film that allows immediate stacking and subsequent handling of freshly printed materials. This increases printing productivity, possibly reducing overall production cost. Eastman CAP 504 and CAP 482 product lines typically find utility in this application due not only to their T_g but also the low odor attributes of CAPs. The hydroxyl functionality of CAPs also allows them to be used in thermosetting OPVs.

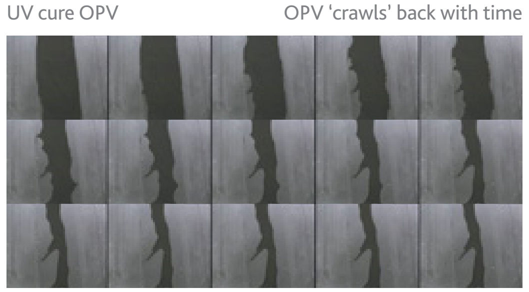
The use of CAPs as well as Solus products in UV-curable OPVs provides rheology/viscosity control, reduced misting in roll-coat applications, reduced film shrinkage for improved adhesion, improved sheen control with film thickness variation, and flow and leveling.

Figure 10 shows an acrylate OPV applied on a TPO substrate. Without Solus, the OPV exhibits crawling and poor wetting. The second panel set demonstrates that with the addition of Eastman Solus 2100 performance additive to the same formulation, wetting was improved and crawling eliminated.

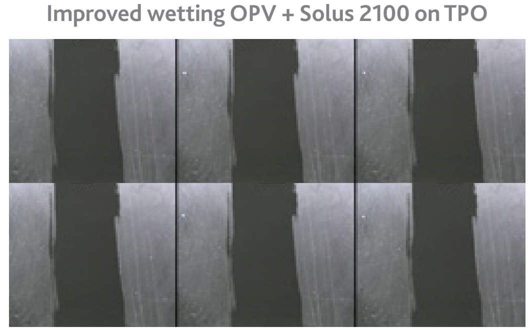
Figure 10. Wetting and crawl of an acrylate OPV without and with Solus 2100

Time-lapse wetting problem OPV on TPO

UV cure OPV — OPV 'crawls' back with time



Improved wetting OPV + Solus 2100 on TPO



Graphic arts and inks—food contact

Cellulose esters are used in both solventborne and radiation-curable systems. They improve flow and leveling, producing smoother finishes—especially in radiation-curable systems. They also offer better resistance to heat, grease, and UV degradation.

As part of our portfolio, Eastman offers cellulose esters for use in food contact inks and graphic arts applications. They are manufactured, stored, handled, and transported under conditions adhering to current Good Manufacturing Practices (cGMP) for food contact applications. Contact your Eastman representative or authorized Eastman distributor for specific regulatory compliance documentation.

Table 7 provides guidance about recommended Eastman cellulose esters for specific printing technologies.

Table 7. Selector guide for graphic arts applications

	Digital	Flexographic	Gravure	Screen	Overprint varnish
Cellulose acetate					
CA 398-3			•	•	•
CA 398-3, food contact[a]			•	•	•
Cellulose acetate butyrate					
CAB 381-0.1			•	•	•
CAB 381-0.1, food contact[a]			•	•	•
CAB 381-0.5			•	•	•
CAB 381-0.5, food contact[a]			•	•	•
CAB 381-2			•		
CAB 381-2, food contact[a]			•		
CAB 381-20				•	
CAB 381-20, food contact[a]				•	
CAB 500-5			•	•	
CAB 551-0.01	•	•	•	•	
CAB 551-0.01, food contact[a]	•	•	•	•	
CAB 551-0.2	•		•		
CAB 551-0.2, food contact[a]	•		•		
CAB 553-0.4		•	•	•	
CAB 553-0.4, food contact[a]		•	•	•	
Solus 2100	•	•	•	•	•
Solus 2100, food contact[a]	•	•	•	•	•
Solus 2300	•	•	•	•	•
Cellulose acetate propionate					
CAP 482-0.5	•		•	•	•
CAP 482-0.5, food contact[a]	•		•	•	•
CAP 482-20				•	
CAP 482-20, food contact[a]				•	
CAP 504-0.2		•	•		•
CAP 504-0.2, food contact[a]		•	•		•

[a] *Switzerland Ordinance on materials and articles intended to come into contact with foodstuffs (817.023.21, Annex 10)*

Other applications

Pigment dispersion

To achieve optimum colorimetric properties, pigment powders must be ground or dispersed. They are often ground at high concentrations in liquid, paste, or chip form and mixed into coating systems. Cellulose esters provide high-quality dispersions by effectively wetting and stabilizing pigments.

Pigments are expensive. Not achieving optimal color strength impacts formulation cost and performance. Difficult-to-disperse pigments such as carbon black, phthalocyanine blues and greens, transparent iron oxide, and perylene reds can be dispersed in CAB to provide easy-to-use chips. These chips can be added directly to coating formulations or predissolved to form a paste for addition to the coating.

To prepare pigment chips, two-roll milling is an effective dispersion method for full color development, transparency, tinting strength, and gloss. A mixture of pigment, cellulose ester, and plasticizer is heated on the two-roll mill until banding occurs. The high viscosity of the melt obtained with these resins gives good shear in the nip of the rolls, producing excellent pigment dispersions in sheet form, which is then granulated into chips for more rapid dissolution in use.

Due to their low flammability, CAP and CAB esters can be more safely handled on milling equipment than flammable film formers such as nitrocellulose. A typical pigment chip formulation prepared on a two-roll mill would contain 50% CAP 482-0.5 or CAB 553-0.4, 40% phthalocyanine blue pigment, and 10% Eastman 168™ non-phthalate plasticizer.

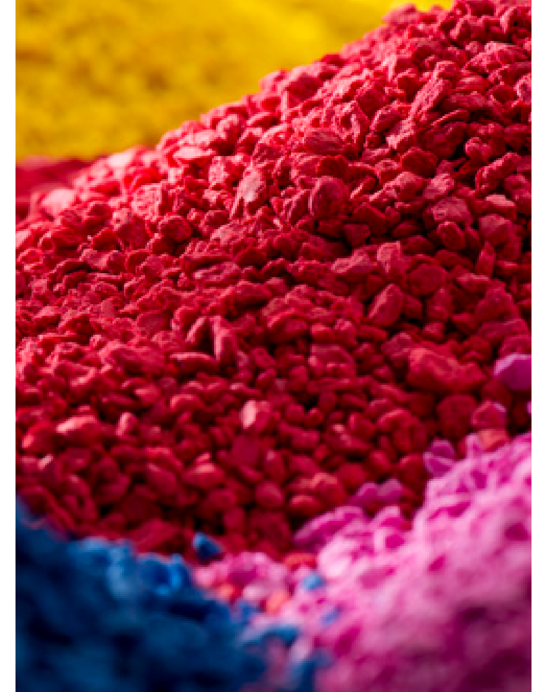
Pigment chips offer paint formulators great flexibility because the time-consuming and expensive step of dispersing the pigment has already been carried out. They simply dissolve the chips into their formulation by mixing via a stirrer to form the colored coating. Pigment chips provide better properties than dispersed powder pigments, including high color strength, transparency, gloss, and better storage stability. Their use is common in the ink industry and the automotive, plastic, wood, leather, and industrial coatings markets.

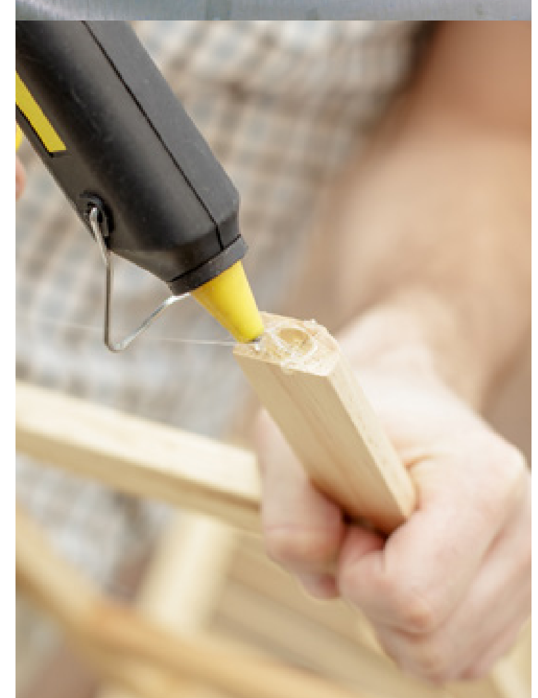
Because inks are applied in thin films, high levels of finely ground pigment are essential for desirable appearances. For flexographic ink systems, the alcohol-soluble cellulose esters CAP 504-0.2 and CAB 553-0.4 are ideal and can be pigmented with 50 wt% pigment or greater and as wet-press cakes.

Hot melts

Useful applications for butyrate hot melts include adhesive and decorative coatings for paper, wallboard, boxboard, and wire. In the electronics industry, hot melts are used for potting materials and for coating wire-wound coils and parts that may be subject to damage by oxidation, moisture, or handling. Butyrate hot melts are used as stop-off coatings in the plating industry and as protective strippable coatings for industrial and government-specification packaging.

Since the formulation of hot melts varies widely depending on performance requirements, various Eastman CABs may be used. Generally, Eastman CAB 381 or CAB 500 esters are selected. The composition of a hot melt consists, basically, of a cellulose ester, plasticizer, and stabilizers.





Sintering

Eastman cellulose esters can be used as sacrificial binders in a variety of sintering applications, such as metal pastes for solar cells and other electronics. They have clean burnout profiles at common sintering processing conditions. Cellulose ester-based organic binders have good shear thinning and thixotropic properties for smooth printing and pattern definition. Cellulose ester-based organic binders generally have good dispersions of metal particles, which improves the appearance of the metal paste.

Cellulose esters can be formulated with alcohols, acetate esters, and ketones as solvents or solvent blends to achieve the desired drying profile to best suit the specific drying conditions. Eastman offers CABs and CAPs with various compositions and molecular weights to promote compatibility in various metal paste formulations and to target different metal paste viscosities.

For an application guide of cellulose esters recommended for specific applications, see Appendix B. For help in selecting the best cellulose ester for your specific need, contact your Eastman technical representative or your authorized Eastman distributor.

Conclusion

Eastman cellulose esters provide a broad range of benefits on diverse substrates for a variety of end uses. They provide a competitive edge in the application by enabling higher production rates, as well as in the final product, eliminating defects and improving appearance.

The productivity and end-user satisfaction that formulators strive to achieve is important to Eastman. It is what motivates the Eastman team to build on our long history of reliably supplying customers with consistently high-quality cellulose esters for a variety of coating and ink applications. Our CABs, CAPs, and CAs are manufactured using advanced processes and controls to meet production and end-user demands.

Contact your Eastman technical representative or authorized Eastman distributor to discuss your formulating challenges and for help in selecting the best cellulose ester for your specific application. Additional information on the properties and performance of specific esters, formulation guides, and application details are available on **eastman.com/CE**.

For information on all Eastman products for coating applications, visit **eastman.com/coatings** or see Eastman publication ADD-COAT-021, *Eastman products for coating and ink formulations*. For information on all Eastman products for graphic arts and ink applications, see Eastman publication ADD-INK-3165, *Eastman products for graphic arts and inks*.

Appendix A

Solubility in common solvents at 10% NV concentrations[a]

Solvents	Evaporation rate	Eastman CA 398-3	Eastman CAB 171-15	Eastman CAB 321-0.1	Eastman CAB 381-0.5	Eastman CAB 381-20	Eastman CAB 500-5	Eastman CAB 531-1	Eastman CAB 551-0.01	Eastman CAB 551-0.2	Eastman CAB 553-0.4	Eastman CAP 482-0.5	Eastman CAP 504-0.2
Ketones													
Acetone	5.7	S	S	S	S	S	S	S	S	S	S	S	S
MEK (methyl ethyl ketone)	3.8	S	S	S	S	S	S	S	S	S	S	S	S
Eastman MPK (methyl *n*-propyl ketone)	2.3	I	S	S	S	S	S	S	S	S	S	S	PS
Eastman MIBK (methyl isobutyl ketone)	1.6	I	I	S	S	S	S	S	S	S	S	S	I
Eastman MIAK (methyl isoamyl ketone)	0.5	I	I	S	S	S	S	S	S	S	S	S	I
Eastman MAK (methyl *n*-amyl ketone)	0.4	I	I	S	S	S	S	S	S	S	S	S	I
Cyclohexanone	0.3	S	S	S	S	S	S	S	S	S	S	S	S
Eastman DIBK (diisobutyl ketone)	0.2	I	I	I	I	I	PS	PS	S	S	I	I	I
DAA (diacetone alcohol)	0.12	S	S	S	S	S	S	S	S	S	S	S	S
Eastman C-11 ketone	0.02	I	I	I	I	I	S	S	S	S	I	I	I
Esters													
Ethyl acetate (99%)	4.1	PS	S	S	S	S	S	S	S	S	S	S	I
Eastman isopropyl acetate	3.0	I	I	S	S	S	S	S	S	S	S	S	S
Eastman *n*-propyl acetate	2.3	I	S	S	S	S	S	S	S	S	I	S	I
Eastman isobutyl acetate	1.4	I	I	S	S	S	S	S	S	S	S	S	S
Eastman *n*-butyl acetate	1.0	I	I	S	S	S	S	S	S	S	I	I	I
Eastman IBIB (isobutyl isobutyrate)	0.4	I	I	I	I	I	PS	PS	S	PS	S	PS	I
Eastman *n*-butyl propionate	0.5	I	I	S	S	SI	S	S	S	S	I	I	I
Eastman EEP solvent	0.12	I	I	S	S	S	S	S	S	S	S	S	PS
Eastman 2-ethylhexyl acetate	0.03	I	I	I	I	I	I	S	S	S	I	I	I
DBE (dibasic esters)	0.007	PS	S	S	S	S	S	S	S	S	S	S	S
Eastman Texanol™ ester-alcohol	0.002	I	I	I	I	I	S	S	S	S	S	S	I
Glycol ethers													
Eastman PM solvent	0.7	I	I	S	S	S	S	S	S	S	S	S	S
EE (ethylene glycol monoethyl ether)	0.3	I	I	S	S	S	I	S	S	S	S	S	S
PTB (propylene glycol monotertiary butyl ether)	0.25	I	I	I	I	I	I	S	S	S	S	I	I
Eastman EP solvent	0.2	I	I	I	I	I	I	I	S	S	S	PS	S
PP (propylene glycol monopropyl ether)	0.2	I	I	I	I	I	I	I	S	S	S	I	PS
PB (propylene glycol monobutyl ether)	0.08	I	I	I	I	I	I	S	S	S	S	I	S
Eastman EB solvent	0.06	I	I	I	I	I	I	I	S	S	S	I	S
Eastman DM solvent	0.02	PS	PS	S	S	I	I	S	S	S	S	S	S
DPM (dipropylene glycol monomethyl ether)	0.02	I	I	S	S	S	I	S	S	S	S	S	S
Eastman DE solvent	0.02	I	I	S	S	S	I	S	S	S	S	S	S
Eastman DP solvent	0.01	I	I	S	S	S	I	S	S	S	S	S	S
Eastman DB solvent	0.003	I	I	I	I	I	I	S	S	S	S	S	S
Eastman EEH solvent 85/15 ethylene glycol/diethylene glycol 2-ethylhexyl ether	0.003	I	I	I	I	I	I	I	S	I	PS	I	I
Glycol ether esters													
Ethylene glycol monoethyl ether acetate	0.2	I	I	S	S	S	S	S	S	S	S	S	S
Eastman EB acetate	0.03	I	I	I	S	S	S	S	S	S	S	S	I
EGDA (ethylene glycol diacetate)	0.02	S	PS	S	S	S	S	S	S	S	S	S	S
Eastman DE acetate	0.008	PS	PS	S	S	S	S	S	S	S	S	S	S
Eastman DB acetate	0.002	I	PS	I	S	S	S	S	S	S	S	S	S
Eastman PM acetate	0.4	I	PS	S	S	S	S	S	S	S	S	S	S
Alcohols													
Ethyl alcohol (anhydrous)	1.9	I	I	I	I	I	I	I	I	I	S	I	I
Ethyl alcohol (95%)	1.7	I	I	I	I	I	I	I	I	I	S	I	S
Isopropyl alcohol (99%)	1.7	I	I	I	I	I	I	I	I	I	I	I	I
Miscellaneous solvents													
Chlorinated: methylene chloride	14.5	S	S	S	S	S	S	S	S	S	S	S	S
Aprotic: THF (tetrahydrofuran)	6.3	S	S	S	S	S	S	S	S	S	S	S	S
DMF (dimethyl formamide)	0.2	S	S	S	S	S	S	S	S	S	S	S	S
n-Methyl-2-pyrrolidone	0.04	S	S	S	S	S	S	S	S	S	S	S	S

[a] *Based on n-Butyl acetate = 1.*

Blends: Nonsolvents for CABs such as alcohols and aromatic hydrocarbons can be blended to produce very active solvent systems. For example, a 15% solution of Eastman CAB 381-0.5 in MPK has the same viscosity as the same concentration in a toluene/alcohol 80/20 blend. The tolerance of CABs for aromatic hydrocarbons in solvent systems is very high. They are also tolerant of aliphatic hydrocarbons such as VM&P naphtha, although to a reduced degree. The range of possible blending ratios can far exceed the 80/20 ratio used in this example, especially when more complex solvent systems are used. CABs are often added to the coating as a solution, and zero-VOC systems based on a mixture of parachlorobenzotrifluoride (e.g., Oxsol™ 100) and acetone (90/10) have been used as well as high-purity methyl acetate or acetone alone.

S = Soluble

SH = Soluble with slight haze

PS = Partially soluble

I = Insoluble

Appendix B

Recommended cellulose esters by application

Building and construction	Maintenance	Protective
CAB 381-0.5	•	•
CAB 381-2	•	
CAB 381-20	•	
CAB 381-20BP		•
CAB 500-5		•
CAB 531-1		•
CAB 351-0.2	•	•
CAB 482-0.5	•	
Eastman Solus™ 3050 performance additive		•

Consumables	Apparel	Can coatings	Ink	Packaging	Shrink film
CAB 398-3			•	•	
CAB 398-3, food contact			•	•	
CAB 381-0.1			•	•	•
CAB 381-0.1, food contact			•	•	•
CAB 381-0.5	•		•	•	•
CAB 381-0.5, food contact			•	•	•
CAB 381-2			•	•	•
CAB 381-2, food contact			•	•	•
CAB 381-20			•		
CAB 381-20, food contact			•		
CAB 500-5			•		
CAB 551-0.01		•	•		
CAB 551-0.01, food contact		•	•		
CAB 551-0.2	•		•	•	
CAB 551-0.2, food contact			•	•	
CAB 553-0.4			•		
CAB 553-0.4, food contact			•		
CAP 482-0.5			•	•	•
CAP 482-0.5, food contact			•	•	•
CAP 482-20			•	•	•
CAP 482-20, food contact			•	•	•
CAP 504-0.2			•		
CAP 504-0.2, food contact			•		
Eastman Solus™ 2100 performance additive		•	•		
Eastman Solus™ 2100 performance additive, food contact		•	•		
Eastman Solus™ 2300 performance additive	•		•		
Eastman Solus™ 3050 performance additive					

Durables	Coil	General industrial	Leather	Metal	Wood
CAB 321-0.1				•	
CAB 381-0.1					•
CAB 381-0.5	•	•	•	•	•
CAB 381-2			•	•	•
CAB 381-20		•	•	•	•
CAB 500-5			•		
CAB 531-1	•	•			•
CAB 551-0.01	•	•			•
CAB 551-0.2	•	•	•	•	•
CAB 553-0.4		•			•
CAP 482-0.5				•	
CAP 482-20		•	•		
Eastman Solus™ 2100 performance additive		•	•	•	•
Eastman Solus™ 2300 performance additive			•		
Eastman Solus™ 3050 performance additive		•	•	•	•

Electronics	Consumer	Device housing	Industrial
CAB 381-0.1	•	•	
CAB 381-0.5	•	•	•
CAB 381-2	•	•	
CAB 381-20	•	•	
CAB 531-1	•		
CAB 551-0.01		•	
CAB 551-0.2	•	•	•
CAP 482-0.5	•		
Eastman Solus™ 3050 performance additive	•		

Transportation	Aerospace	Auto OEM	Auto plastics	Auto refinish	General auto	Marine	Motorcycle	Bus/RV
CAB 321-0.1		•		•				
CAB 381-0.1	•	•		•		•	•	
CAB 381-0.5	•	•	•	•			•	
CAB 381-2		•	•	•	•			•
CAB 381-2BP		•			•			
CAB 381-20		•		•	•			
CAB 381-20BP		•						
CAB 531-1		•		•	•			
CAB 551-0.01	•	•	•	•				
CAB 551-0.2		•	•	•	•		•	•
CAB 553-0.4								
Eastman Solus™ 2100 performance additive	•	•		•	•		•	
Eastman Solus™ 2300 performance additive		•		•	•			
Eastman Solus™ 3050 performance additive		•		•				

Notes

Notes

As the world's leading supplier of specialty cellulose esters for more than 85 years, Eastman has a long history of reliably supplying customers with consistently high-quality products manufactured using advanced processes and controls. With a diverse portfolio of more than 50 cellulose esters—CA, CAB, CAP, and C-A-P—for a variety of applications along with years of formulating experience, our technical experts can provide guidance to help customers select the best cellulose ester or blend to achieve the specific performance desired for their unique application. Over the years, we've introduced innovative products that help meet customer needs and market demands—most recently Eastman Solus™ performance additive for high-solids coatings and Eastman membrane material products for membrane filtration. Eastman works with regulatory agencies and industry associations on behalf of our customers to advocate for policies that allow industries to thrive, enabling sustainable innovation. At Eastman, our goal is to enhance the quality of life in a material way.

EASTMAN
The results of **insight**™

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