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Eastman cellulose esters help produce coatings and inks with optimum colorimetric properties.

Application overview

Most paint or ink coatings are pigmented. To achieve the optimum colorimetric properties, pigment powder needs to be ground or dispersed. Pigments are often ground at high concentrates in the form of liquids, pastes, or pigment chips and then mixed into various coatings systems.

Producing high-quality pigment dispersions involves obtaining the maximum color strength from the pigment. Pigments are expensive, and not achieving the optimal color strength can have a significant impact on overall formulation costs and performance. Achieving good pigment dispersion depends on many factors; one is to have a good resin base or media that effectively wets pigments.

Because of its good pigment-wetting characteristics, particularly with the higher hydroxyl types, Eastman cellulose esters (CAB and CAP grades) are used as pigment dispersion media and provide high-quality pigment dispersions.

When pigments are not effectively stabilized, flooding and floating can occur. 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 cellulose acetate butyrate (CAB) can prevent flooding and floating—producing coatings with uniform color consistency that is more pleasing in appearance.

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 pigment chips.

High-quality black pigments are used to create automotive and plastic coatings with enhanced levels of black, often with a blue rather than brown undertone to create a visually attractive black color. These small, particle-sized powders are renowned for being difficult to disperse. Formulating with Eastman CAB and cellulose acetate propionate (CAP) alongside specially selected dispersing agents could enable the formulator to achieve excellent mass tone jetness and blue undertone.

The white pigment, titanium dioxide, usually disperses very well under high-speed dispersion without any dispersing agent. By adding cellulose esters to the grind phase, improved pigment dispersion occurs and a purer white color value can be produced.

To further improve pigment dispersion, especially designed pigment, dispersants and wetting aids may be used in conjunction with Eastman cellulose esters. These additives can be highly specific and may not be satisfactory or necessary in all dispersions.

Designers want to accentuate the character of their finished products to create stylish and exclusive designs. To achieve this, metallic and pearlescent flakes—often described as effect pigments—are a very important part of the coating, producing brilliant colors and iridescent effects that bring the curves, styling lines, and projections of coated articles to life. The ability to control the orientation of these flakes with minimal defects is critical in producing high-quality finishes that delight the eye and create a desirable color-changing experience. Eastman CAB acts as a viscosity control agent that “locks” the metallic and pearlescent flakes in the proper orientation—creating an optimized visual effect. And better flake alignment means formulators require fewer flakes to achieve the same—or better—desired aesthetic impact.

In combination with excellent pigment dispersion properties, Eastman CAB and CAP provide numerous benefits that further enhance coating formulations:

- Flexibility to be used as additives, modifiers, or co-resins. When used as co-resins, they provide a high-gloss surface due to their resinlike qualities.
- Can be cross-linked, particularly with isocyanates and amino resins (especially with the higher-hydroxyl grades of cellulose ester)
- Improved flow and leveling and defect control
- High resistance to UV light, salt, and oxygen that produces superior weatherability, durability, and outstanding yellowing resistance with time
- Consistent gloss control with silica matting agents, reducing gloss variation over the coating surface
- Solubility of high-hydroxyl CAP grades in alcohol-water mixtures makes them useful in coatings that require some water solubility
- Excellent hardness development, scratch resistance, and reduced blocking due to high T_g
- Reduced drying time (faster dry to touch) due to their high T_g and fast solvent release
- Nonflammable and safer to use when compared to nitrocellulose; perfect for improved plant and factory safety and producing articles that comply with nitrocellulose restrictions
- Excellent grease resistance due to good barrier properties

In addition, Eastman cellulose esters are based on cellulose, one of the most abundant natural, renewable resources. Many of the grades meet requirements for use in certain food contact applications under regulations of the U.S. Food and Drug Administration (21 CFR), European Commission (Regulation 10/2011), and the Swiss Ordinance on Materials and Articles in Contact with Food (SR 817.023.21). Contact your Eastman representative or authorized Eastman distributor for specific regulatory compliance documentation.

Product-in-use details

In the production of paints and inks, various milling and mixing equipment is used to produce pigment dispersions. The types of equipment that can be used to produce pigment dispersions in CAP and/or CAB esters are listed in Table 1.

Table 1. Milling equipment

Viscosity requirement (shear rate)	Physical form of dispersion	Mill type
Low	Fluid	Kady mill,[a] attritor, sand mill, shot mill, ball/pebble mill
Intermediate	Paste	High-speed disperser, three-roll mill
High	Chip	Banbury[b] (sigma blade), two-roll mill

[a] *Kinetic Dispersion Corporation*
[b] *HF Mixing Group*

The following formulation guidance details how CAB and CAP can be used to prepare pigment pastes, fluids, and chips that are subsequently used in many coatings and ink formulations.

1. Pigment chips for coatings and inks

Pigment chips are dust-free, predispersed, highly concentrated organic and inorganic pigment preparations usually contained in a resin matrix. They contain no solvents and are dry chip products. The use of pigment chips is very universal. They offer the formulator a great deal of flexibility because the time-consuming, dusty, and expensive step of dispersing the pigment powder has already been carried out. The pigment particles in pigment chips are very well separated, resulting in very high color development, transparency, and gloss. Often, the chroma and hue produced from pigment chips is much better than that achieved from the same dry pigment processed using conventional dispersion procedures. The paint formulator simply dissolves the pigment chips into their formulation by mixing via a stirrer to form the colored coating. They are used in the manufacture of many coatings that are applied to numerous substrates such as metal, wood, plastic, paper, and board and cover industries such as the automotive, furniture, and inks markets.

Starting point formulations for pigment chips

Eastman CAP 482-0.5, CAP 504-0.2, CAB 381-0.5, and CAB 553-0.4 are excellent choices to produce highly dispersed pigment chips.

Starting point formulations using these grades are outlined in Table 2. To prepare these formulations, two-roll milling is an effective dispersion method for obtaining full-color development, transparency, tinting strength, and gloss. The pigment/cellulose ester/plasticizer formulations are heated on a two-roll mill until banding occurs. The high viscosity of the melt obtained with these resins produces good shear in the nip of the rolls, producing excellent pigment dispersions in sheet form that are then granulated into pigment 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.

Table 2. Pigment dispersions prepared on a two-roll mill

Product	Wt%		
	1	2	3
CAP 482-0.5 or CAB 381-0.5	56	—	—
CAP 504-0.2 or CAB 553-0.4	—	28	50
Benzidine yellow pigment	30	—	—
Red lake C pigment	—	55	—
Phthalo blue pigment	—	—	40
Sucrose acetate isobutyrate (SAIB)	14	5	—
Eastman 168™ non-phthalate plasticizer	—	12	10
Total	**100**	**100**	**100**

2. Fluid ink dispersions

Flexographic and gravure inks are applied in thin films from low-viscosity solutions. A high level of finely ground pigment is essential for desirable appearance properties. Achieving finely ground particles is also important to minimize damage to the printing cylinders. The alcohol-soluble cellulose esters, CAP 504-0.2 and CAB 553-0.4, can be formulated into high-solids pigment dispersions with greater than 50 wt% pigment or as wet-press cakes. Fluid ink dispersions can be formulated by using 20% by weight of pigments such as Sunfast® Blue 249-3450 and Raven® 1020 black pigment with 5% to 8% by weight of CAP 482-0.5. To make the best fluid dispersions with cellulose esters, it is advisable to follow these guidelines:

- The pigment should be dispersed into solutions of cellulose esters without the presence of modifying resins or plasticizers. Because of high hydroxyl content, the alcohol-soluble-type cellulose esters wet and disperse most pigments more effectively than other cellulose esters.
- Aromatic hydrocarbon solvents (e.g., toluene and xylene) should be excluded from the mill during the dispersion process. These solvents can be added during the letdown phase.
- The presence of alcohols during the milling process improves color development and gloss of the pigment dispersions in the final formulations.
- Dispersants and wetting aids may be used to improve pigment dispersion, but these additives can be highly specific and may not be satisfactory in all dispersions.
- A processing viscosity of 50–75 Krebs units is desirable for either a sand mill or ball mill to obtain optimum shear rate during processing. In formulations that have poor rheology characteristics, the best pigment dispersions are obtained at the lower end of this viscosity range. However, a viscosity lower than 50 Krebs units may cause excessive wear on the milling equipment.
- A pigment/cellulose ester ratio of 2:1 or 3:1 by weight is generally optimum when dispersing organic pigments and carbon black. With inorganic pigments, a 5:1 to 10:1 weight ratio is more desirable.
- Cellulose ester/pigment dispersions can be prepared in a sand mill or ball mill at 25–35 wt% solids when using organic pigments and at 55–65 wt% solids when using inorganic pigments. This does not apply to cellulose esters CAP 482-20 or CAB 381-20, since these products produce much higher solution viscosities.

Starting point formulations for fluid ink dispersions

Pigment dispersion for use in fluid inks may be made according to the formulations in Tables 3 and 4. These dispersions may be prepared in ball/pebble mills, sand mills, or shot mills. The formulation in Table 4, which contains some titanium dioxide pigment, may also be prepared in a high-speed disperser (cold cut).

Table 3. CAP 482-0.5 pigment dispersions

Product	Wt%				
	1	2	3	4	5
Potomac Red 215-2360 pigment	20	—	—	—	—
Sunbrite® Yellow 274-0042 pigment	—	18	—	—	—
Sunfast® Blue 249-3450 pigment	—	—	20	—	—
Raven® 1020 black pigment	—	—	—	20	—
Unitane OR-580 white pigment	—	—	—	—	50
CAP 482-0.5	8	5	8	8	5
Ethanol, anhydrous	43	54	43	43	27
Ethyl acetate (99%)	18	23	18	18	11
n-Propyl acetate	11	—	11	11	7
Total	**100**	**100**	**100**	**100**	**100**
Stormer viscosity, Krebs units	62	76	64	68	69

[a] *Pigment dispersion can be prepared with CAB 553-0.4 instead of CAP 482-0.5 in the formulation. Adjustment of the solids content may be required to obtain the viscosity needed for optimum shear rate.*

Table 4. CAP 504-0.2 pigment dispersions

Product	Wt%				
	1	2	3	4	5
Potomac Red 215-2360 pigment	20	—	—	—	—
Sunbrite® Yellow 274-0042 pigment	—	20	—	—	—
Sunfast® Blue 249-3450 pigment	—	—	20	—	—
Raven® 1020 black pigment	—	—	—	20	—
Unitane OR-580 white pigment	—	—	—	—	50
CAP 504-0.2	10	10	10	10	8
Ethanol, anhydrous	59	59	59	59	36
Ethyl acetate (99%)	11	11	11	11	6
Total	**100**	**100**	**100**	**100**	**100**
Stormer viscosity, Krebs units	59	61	54	59	63

[a] *Pigment dispersion can be prepared with CAB 553-0.4 instead of CAP 482-0.5 in the formulation. Adjustment of the solids content may be required to obtain the viscosity needed for optimum shear rate.*

Table 5. Raw material suppliers

Product	Description	Supplier
CAP 482-0.5	Cellulose acetate propionate	Eastman
CAB 381-0.5	Cellulose acetate butyrate	Eastman
CAP 504-0.2	Cellulose acetate propionate	Eastman
CAB 553-0.4	Cellulose acetate butyrate	Eastman
Ethanol, anhydrous	Ethanol	Various
Ethyl acetate (99%)	—	Eastman
Potomac Red 215-2360	Red lake C toner—rosinated	Lansco Colors
Sunbrite® Yellow 274-0042	Diarylide yellow toner—AAOT	Sun Chemical
Sunfast® Blue 249-3450	Phthalocyanine, noncrystallizing	Sun Chemical
Raven® 1020	Furnace black	Birla Carbon
Unitane OR-580	Titanium dioxide, rutile	Kemira
Sucrose acetate isobutyrate	Sucrose ester	Eastman
Eastman 168™ non-phthalate plasticizer	Plasticizer	Eastman

3. Enhancing the whiteness of titanium dioxide dispersions in coatings

Titanium dioxide usually disperses very well without any dispersing agent. However, by adding cellulose esters to the grind phase, improvement in pigment dispersion can be achieved. To demonstrate this, a white coil-coating formulation was prepared using CAB 551-0.2 in the grind stage. The coating was then applied to an aluminum substrate with a dry film thickness of 20 microns. The coating was cured in a Werner Mathis oven at 250°C for 1½ minutes, which gave a peak metal temperature of 232°C for 10 seconds.

The results show that Eastman CAB is effective in enhancing pigment dispersion by producing an increase in whiteness and a bluer, less yellow tone. Aesthetically, a bluer white produces a coating that looks cleaner and more brilliant.

Starting point formulation for enhanced titanium dioxide dispersion in coil-coating formulation

Table 6. White coil-coating formulation

Ingredient	Standard	1% CAB 551-0.2	Description	Supplier
Novasynt™ S1402-65	45.5	44.4	Saturated polyester resin	Novaresine
Cymel® 303 LF	7.5	7.3	Melamine cross-linking agent	Allnex
Eastman CAB 551-0.2	0	1.0	Pigment dispersion additive	Eastman
PM acetate	3.9	3.9	Solvent	Eastman
Loxanol® CA 5308	3.9	3.9	Dibasic ester	BASF
BAS™ 150	7.7	7.7	Aromatic 150 solvent	Banner Chemical Group UK
Tioxide TR81	28.7	28.7	Titanium dioxide pigment	Venator Materials
Nacure™ 1051	0.4	0.4	Sulfonic acid catalyst	King Industries
Eastman CAB 551-0.01	0.4	0.4	Flow aid	Eastman
Eastman Optifilm™ enhancer 300	2.0	2.0	Retarder solvent	Eastman
Xylene	0	0.3	Solvent	Banner Chemical Group UK
Nonvolatile content	68.5	68.5	—	—
Total	**100.0**	**100.0**		

Note: *The specific gravity of the standard formulation and of the 0.4% CAB 551-0.2 formulation is 1.32 kg/L.*

The white coil-coating formulation detailed in Table 6 was prepared in the following order:

Grind stage

1. Novasynt S1402-65 was blended with Cymel 303 LF in a 250-mL container.
2. Tioxide TR81 and Eastman CAB 551-0.2 (formulation A) were premixed and added slowly to the resin while mixing at a shear rate of 11–12 Ncm.

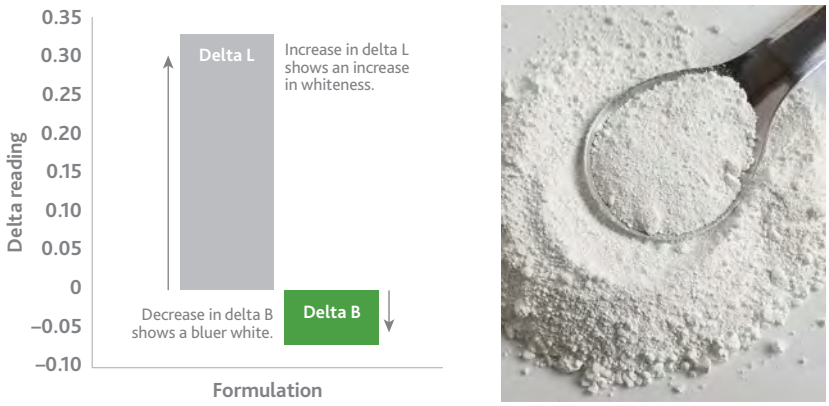
After 40 minutes, the Hegman gauge reading should be less than 5 µm.

Letdown stage

1. All other ingredients were blended and added slowly to the pigment dispersion.
2. Mixer shear was dropped to 8 Ncm for 20 minutes prior to final Hegman gauge check of < 5 µm.

The chart in Figure 1 demonstrates that Eastman CAB is beneficial in increasing the lightness value. A higher lightness value produces an increase in whiteness and an overall improvement in appearance. Eastman CAB is also beneficial at decreasing the delta B, resulting in less yellow and a bluer white.

Figure 1. Impact of CAB on pigment dispersion



4. Enhancing the dispersibility of carbon black in coatings

For high-quality, visually attractive black automotive ink and plastic coatings, excellent color strength, mass tone jetness, and blue undertone are often required. To achieve the very best dispersion of carbon black pigment, it is important that the correct choice of dispersing resin and specially selected dispersing agents is made. To demonstrate the carbon black pigment dispersion properties of CAB 553-0.4 and CAP 504-0.2, concentrated dispersions were prepared and compared against two common commercial pigment dispersion resins and the color strength measured via a tint strength test. A good pigment dispersion resin will effectively disperse carbon black pigment and will show excellent tint strength.

Table 7. Black coating formulation comparing dispersion resins with carbon black pigment

Part	Ingredient	CAB 553-0.4	CAP 504-0.2	Resin 1	Resin 2	Description	Supplier
Pigment grind							
A	Resin: 20% NVC in solvent*	33.0	33.0	33.0	33.0	Pigment dispersion resin dissolved in solvent	Various
B	Carbon Black-7	13.0	13.0	13.0	13.0	Carbon black	DIC
C	Solvent*	27.0	23.0	27.0	23.0	Solvent	Various
Letdown							
D	Solvent*	27.0	31.0	27.0	31.0	Solvent	Various
Total		**100**	**100**	**100**	**100**		

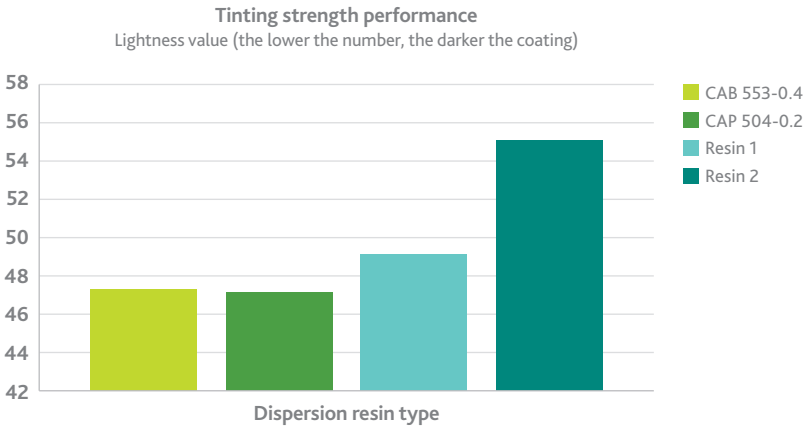
**Best solvent or solvent mixture selected for the dispersion resin*

Procedure

1. Prepare part A resin solutions (20% solids) by dissolving the solid resins by agitation with a suitable solvent composition.
2. Mix parts A, B, and C in order and high-speed disperse at 1000 rpm for 5 min.
3. Measure the pigment dispersion's viscosity by ICI viscosity meter at 25°C, and adjust the viscosity of each dispersion by adding a portion of part D to achieve a viscosity of 0.5 to 1.0 poise.
4. Add glass beads into pigment dispersions at weight ratio of 1.1:1.
5. Disperse the pigment dispersions by shaker for 60 min to a grind fineness of less than 15 microns.
6. Add remaining part D and shake the pigment dispersion for another 15 min.
7. Measure the final fineness of grind; it should be less than 15 microns.
8. Filtrate the glass beads from the pigment dispersions.
9. The tinting strength is evaluated by mixing the black dispersions with a fully formulated standard white acrylic/PU coating at weight ratio of 5:95 and then mixed by high-speed mixer at 1000 rpm for 5 min.
10. The gray coatings are bar coated at a wet film thickness of 50 microns onto Leneta charts and the tinting strength assessed by measuring the lightness values with a spectrometer (D65/10° mode).

Figure 2 demonstrates that carbon black dispersions based on Eastman CAB 553-0.4 and/or CAP 504-0.2 produce lower lightness values compared to that of two commercial dispersing resins. A lower lightness value produces an increase in blackness. A blacker or darker coating means that they are effectively dispersing carbon black pigment to produce a pigment paste that provides an improvement in tint strength. This improvement should enable a manufacturer to reduce formulation costs because less carbon black pigment dispersion should be required to achieve a specific shade of color.

Figure 2. Comparing dispersion resins with carbon black



Summary

The pigment and filler particles in coatings and inks need to be fully dispersed to ensure the best-performing coatings. Over many years, Eastman CAP and CAB have demonstrated that—either solely or in combination with other dispersing and wetting additives—they can create the very best coatings with optimum colorimetric properties. They help maximize color strength, optimize pigment particle spacing, and provide the necessary particle stabilization to ensure color consistency during storage and application of the coating.

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

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. Leveraging years of formulating experience and a diverse portfolio of more than 50 cellulose esters—CA, CAB, CAP, and C-A-P—for a variety of applications, 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.

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