Eastman cellulose esters provide a uniform appearance to cast acrylic sheets for bathtubs, shower enclosures, and spas.
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Application overview
Cast acrylic sheets applications

- Cast acrylic sheets are used for outdoor durability and water and UV resistance.

- The largest application is in bathtubs, spas, and shower panels, with many featuring metallized and pearlescent effects.
Challenge in bath application manufacturing

Challenge occurs when a thin acrylic sheet is pressed into shape by thermoforming and then reinforced on the underside with unsaturated polyester and fiberglass.

Thermoformed cast acrylic sheet requirement

Unfulfilled requirement: nonuniform colors

Uniform color on its front and back surfaces

Poor color matching when front and back surfaces are interchanged

Cause of color difference: flooding and floating of pigments
Adding Eastman CAB helps minimize the effect by increasing the pigment dispersion and rheology of the syrup.
Eastman cellulose acetate butyrate (CAB) products

- Increase the pigment dispersion and often alters the rheology of the material
- Enable a more efficient process, delivering a uniform color consistency that is more pleasing in appearance
How can Eastman products further optimize appearance?

- By reducing titanium dioxide sedimentation during polymerization, providing uniform distribution throughout the cast sheet

- By improving metallic flake and pearlescent flake alignment

- By reducing extender haziness or clouding, particularly for acrylic sheets containing barium sulfate
Product-in-use details
Eastman product benefits

- Eastman CAB 381-2 and Eastman CAB 381-20 are often used for cast acrylic sheet applications.

- Product benefits
  - High viscosity coupled with good solubility in PMMA syrup
  - Good compatibility with the PMMA syrup

- Eastman CAB 500-5 provides better compatibility with the syrup.
Typical cast acrylic formulation

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Description</th>
<th>Standard, wt%</th>
<th>With Eastman CAB, wt%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methyl methacrylate syrup</td>
<td>Polymerized less than 8%</td>
<td>98.85</td>
<td>97.35</td>
</tr>
<tr>
<td>Vazo™ 64</td>
<td>Initiator</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>Tinuvin® P</td>
<td>UV absorber</td>
<td>0.03</td>
<td>0.03</td>
</tr>
<tr>
<td>Aerosol® OT-100</td>
<td>Demolding agent</td>
<td>0.03</td>
<td>0.03</td>
</tr>
<tr>
<td>Eastman CAB 381-20</td>
<td>Pigment dispersion additive</td>
<td>—</td>
<td>1.5</td>
</tr>
<tr>
<td>60% TiO² + 40% DIBP plasticizer</td>
<td>White pigment paste</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>20% Special Black 100 + 40% DIBP plasticizer</td>
<td>Black pigment paste</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>100.0</strong></td>
<td><strong>100.00</strong></td>
</tr>
</tbody>
</table>

*Note: Eastman CAB-381-0.5 is recommended when the methyl methacrylate syrup is polymerized to higher than 8%.
In the preceding example formulation, the PMMA syrup formulation was polymerized to less than 8%; consequently, CAB 381-20 was used.*
Testing and results
Testing steps for casting acrylic sheet with and without CAB

- Methyl methacrylate monomer (MMA) was polymerized with an initiator.
  - The MMA solution was polymerized to less than 8% in a sealed, heated tank (approximately 85°C) to produce a low-viscosity syrup.
- The UV absorber, demolding agent, pigment paste, and Eastman cellulose acetate butyrate (CAB 381-20) were added to the syrup.
- The combination was mixed in sealed tanks and defoamed at full vacuum.
- The defoamed colored syrup was pumped between two large glass sheets that functioned as molds for the acrylic sheet.
- A PVC seal was used around the edge of the glass sheets to control the thickness of the gap between them.
  - The PVC seal also prevented the syrup from escaping.
Testing steps for casting acrylic sheet with and without CAB

- The acrylic sheets were lowered into a tank of water at 65°C for 200 minutes. The syrup was polymerized to approximately 90%. This reaction was exothermic; a circulating water bath helped remove the heat.

- The sheets were removed from the bath and the water drained off. The sheets were placed in an oven at 125°C for 120 minutes to complete the cure to 100% polymerization.

- The glass sheets were removed, and the acrylic sheet was cut via automatic saw to the required dimensions.

- A protective sheet was applied to the acrylic sheet to guard against scratching.

- The sheets were evaluated for color differences.
Results

- Visual color differences
- Magnified color differences
- Color differences measured via spectrophotometer
Visual color differences

- With Eastman CAB, a significantly more uniform gray color is produced on the front and back surfaces. The flooding and floating benefits are theorized to be the result of the CAB reducing the agglomeration of pigments and extenders.
Magnified color differences

• The system containing Eastman CAB produced a surface with a uniform gray color and no black specks.
Color differences measured via spectrophotometer

The results show low Delta E values in the cast acrylic sheet with Eastman CAB, signifying even color distribution.
Conclusion

- This study confirms that Eastman CAB considerably reduces flooding and floating of carbon black pigment in a gray cast acrylic sheet, which significantly reduces the color difference between the front and back surfaces.

- Using Eastman CAB 381-0.5 or Eastman CAB 381-20 in cast acrylic sheet formulations allows manufacturers to deliver a higher-quality cast acrylic product with enhanced efficiencies and uniform color consistency that is more aesthetically pleasing.
Eastman cellulose esters

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.