Eastman cellulose esters provide a uniform appearance to cast acrylic sheets for displays and outdoor signs.
Application overview

Cast acrylic sheets are used for their outdoor durability and water and UV resistance. Though they can be found in signs, display shelving, and even countertops, their largest application is in bathtubs, spas, and shower panels, with many featuring metallicized and pearlescent effects. A manufacturing 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.

The thermoformed cast acrylic sheet requires 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 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. Flooding occurs when pigments separate from each other and concentrate in certain areas, resulting in uneven color distribution.

Adding Eastman cellulose acetate butyrate 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 a uniform color consistency that is more pleasing in appearance.

Figure 1 illustrates a simple cast acrylic sheet composition. The blue dots represent a larger-diameter, higher-density pigment. The green dots are a smaller-diameter, less dense pigment. The yellow portion is the polymethacrylate (PMMA) syrup. The viscosity increases as the syrup polymerizes, but gravity can still pull the larger particles to the bottom. As the viscosity continues to increase, the pigments finally lock in place. The result can be an acrylic sheet with one side having a slightly different color hue. Adding Eastman CAB helps minimize the effect by increasing the pigment dispersion and rheology of the syrup.

Figure 1. Illustration of flooding and floating.

In addition to elimination of flooding and floating of colored pigments in polymerized acrylic sheets, various grades of Eastman cellulose acetate butyrate have provided formulation enhancements to cast acrylic formulation to further optimize appearance by:

- Reducing titanium dioxide sedimentation during polymerization and providing uniform distribution throughout the cast sheet
- Improving metallic and pearlescent flake alignment
- Reducing extender haziness or clouding, particularly for acrylic sheets containing barium sulfate

As a result of the pigment and particle control that cellulose esters provide, flooding and floating are reduced and a more uniform color is produced. This leads to a reduction in rejects, lowering production cost for the sheet manufacturer.

Product-in-use details

Eastman CAB 381-2 and Eastman CAB 381-20 are often used for cast acrylic sheet applications because they offer high viscosity coupled with good solubility in PMMA syrup. Compatibility with the PMMA syrup is also good. If better compatibility with the syrup is desired, consider Eastman CAB 500-05.

Table 1. 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>Total</td>
<td></td>
<td>100.0</td>
<td>100.00</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.
Magnified color differences
As shown in the magnified view of the acrylic sheet in Figure 3, the system without Eastman CAB produced a surface with noticeable black specks—evidence of pigment separation. The system containing Eastman CAB produced a surface with no black specks and a uniform gray color.

Figure 2. Cast acrylic sheet with and without Eastman CAB

Visual color differences
In Figure 2, flooding and floating have occurred in the system without Eastman CAB. This caused the black pigment to rise to the surface, resulting in the front surface being visually darker than the back. 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.

Results
Visual color differences

Figure 3. Cast acrylic sheet with and without Eastman CAB (magnified)

Figure 4. Delta E value comparison of acrylic sheet with and without Eastman CAB

Testing cast acrylic sheet with and without CAB
To document the impact of CAB as a pigment dispersion additive, the following steps were taken to prepare for testing:
• 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 then 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.
• 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, and a circulating water bath helped remove the heat.
• The sheets were removed from the bath and the water drained off. The sheets were then placed in an oven at 123°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 then evaluated for color differences.
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. A more uniform sheet color should result in reduced waste from product rejection. 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.

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

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