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The Effect of Particle Size, Morphology, and Loading Levels, of Aluminum Pigments in Polypropylene Molded Products

Abstract

- Investigate how different geometries, morphologies, and particle sizes, of aluminum pigments affect color, opacity, gloss and reflectance of polypropylene molded products
- Explore the effects of different pigment loading levels
- Present both visual and instrumental color comparisons
- Provide recommendations on pigment type and loading level to achieve the desired color and metallic appearance in polypropylene molded products

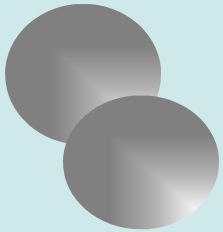
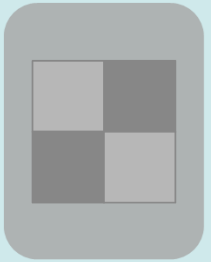
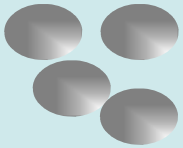
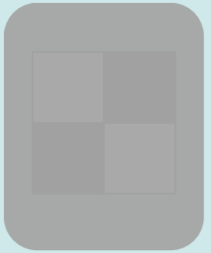
Product Appearance – The “Lingo”

- Hiding (opacity) - tinctorial strength of aluminum pigments
  - Direct relation to particle size distribution and particle thickness (aspect ratio) and geometry

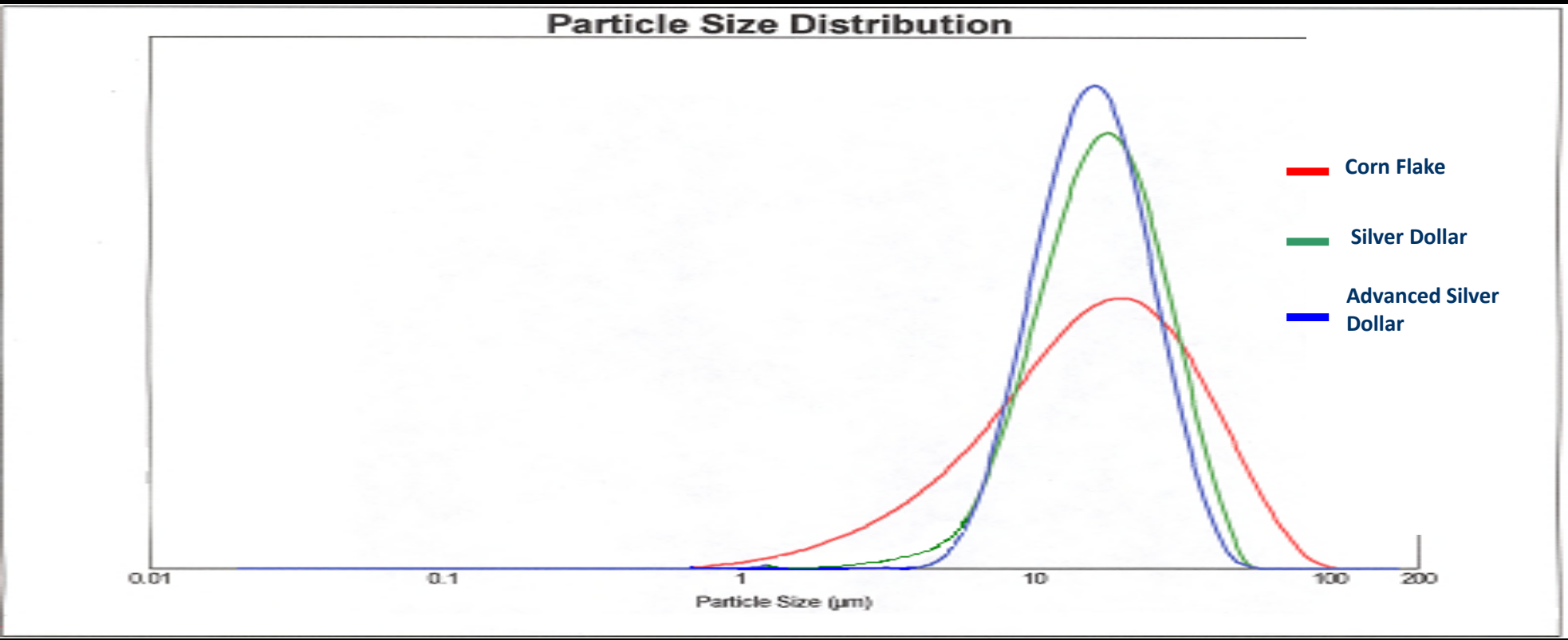
- Sparkle (patina) - coarseness/fineness of pigment grain
  - Based on a visual assessment made in direct illumination
  - Particle size, shape and contour dependent
  - BYK-MAC instrument

- Brightness (whiteness) - lightness or darkness
- (*L value in L*a*b* scale)
  - Whiter, brighter, grayer and darker
  - Measured by the amount of light reflected from the surface of the flake
  - Related to particle size distribution, shape and smoothness
  - Measured by X-Rite and Byk Mac instruments

Normal Aesthetic Relationships

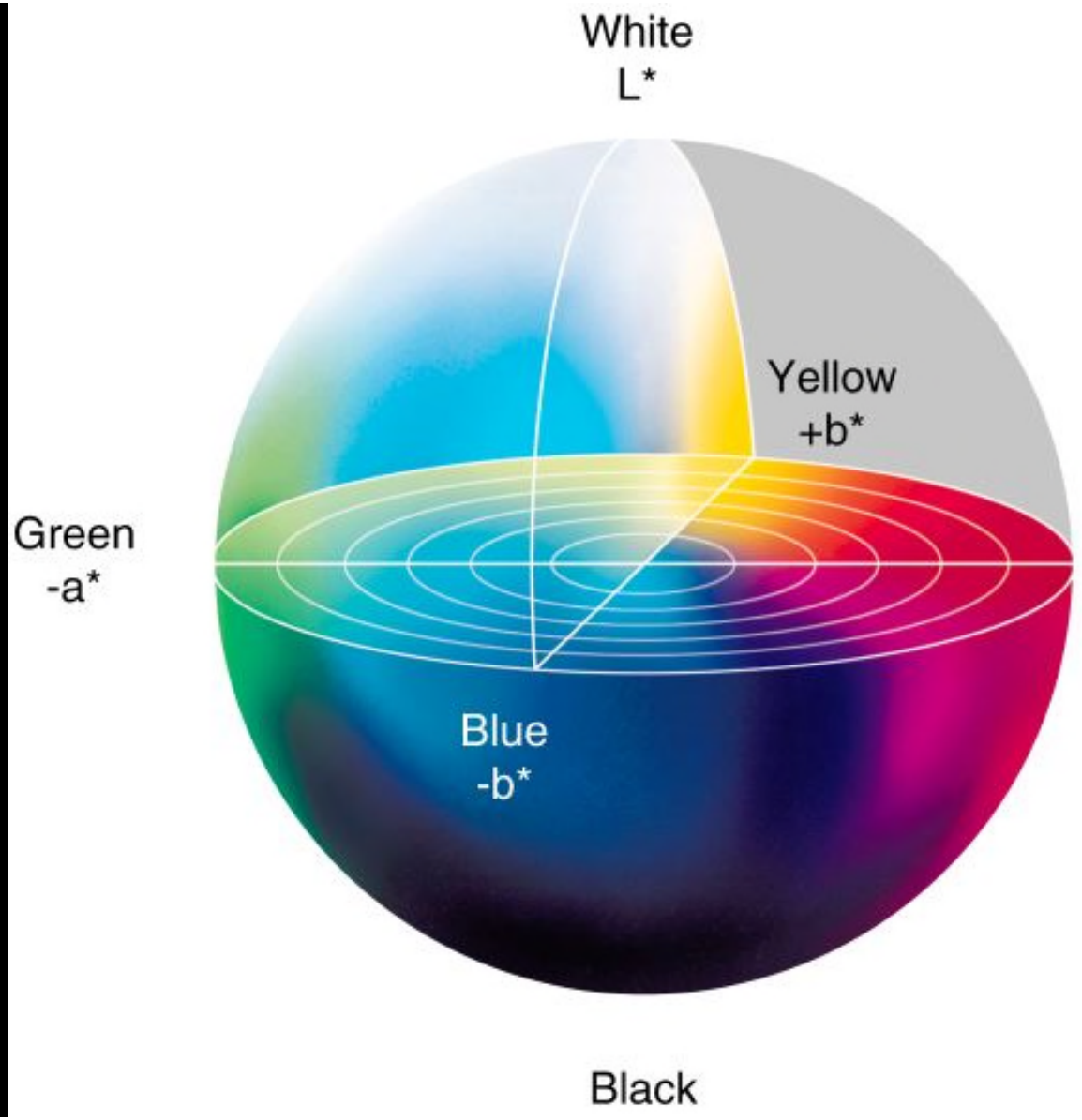
	Particle Size d(50)	Brightness	Sparkle	Hiding
Coarse				
Fine				

Particle Size Distribution

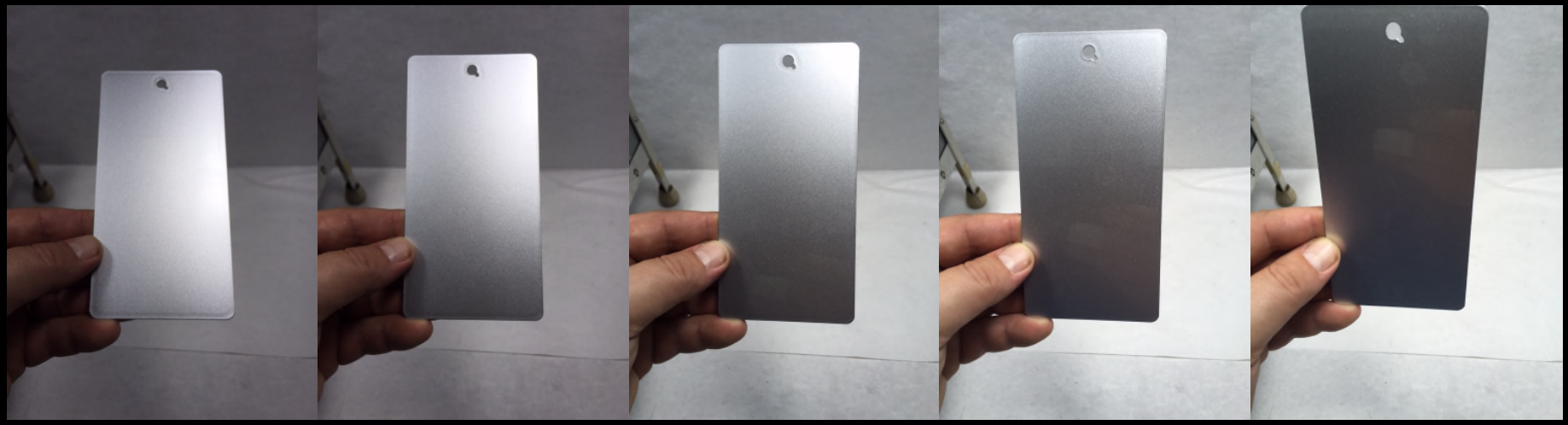


L*A*B* Color Sphere

- L* White/ Black
- A* Red/ Green
- B* Blue/ Yellow



Metallic Color Travel



$$\text{Flop Index} = \frac{2.69\left(L^*_{15^\circ} - L^*_{110^\circ}\right)^{1.11}}{\left(L^*_{45^\circ}\right)^{0.86}}$$

Silver Dollar vs Cornflake

Silver Dollar Aluminum Flake

reflects light in uniform direction

Cornflake Aluminum Flake

scatters light

Pellet Type

Pellet Type A

- Solid Compact Pellet
- 75%-80% Aluminum Content

Pellet Type B

- Less dense, Softer Pellet
- 70%-90% Aluminum Content

Compounding

- All six products for used in this study were processed under the same conditions using the same equipment
- Polypropylene (MFI 12) was chosen as the polymer
- Counter rotating, non intermesh, twin screw extruder (TSE)
- L:D = 25:1
- Temperature Profile: Zone 1=190C, Zone 2=200C, Zone 3=210C, Die=170C

Injection Molding

- Panels were made on a Boy 55A Injection Mold Machine
- Each product was used to make panels at 0.5%, 1.5%, 3.0%, and 6.0% aluminum loading.
- Panels were also made using the loading levels from above, but with 1% blue color concentrate added.

Temperature 1	Temperature 2	Temperature 3	Temperature 4	Mold Temperature
190°C	205°C	210°C	193°C	43°C

Table 2: Molding Processing Parameters

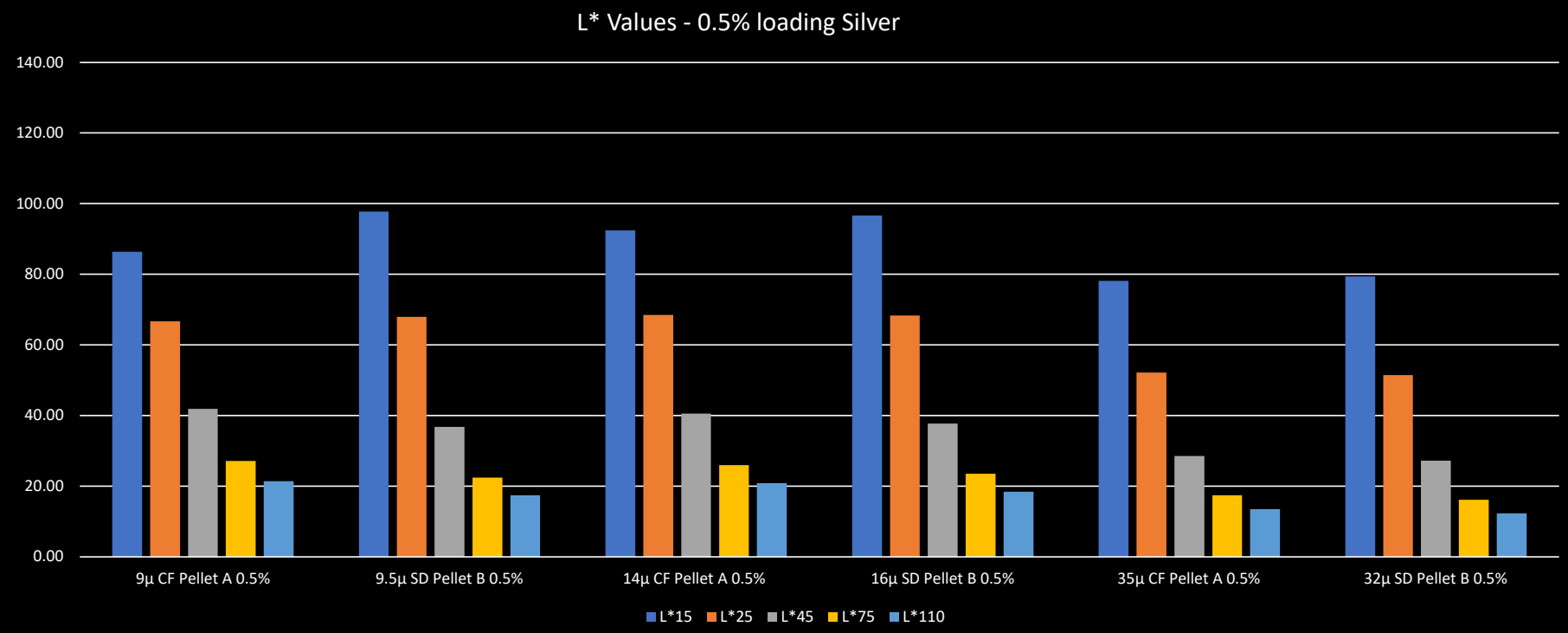
Data Collection

- L*A*B* value – Xrite MA 68II goniospectrophotometer
- Gloss – BYK Microgloss GB-4520
- Reflectance- Technidyne Total Reflectometer TR-2
- Optical Density- Xrite tabletop optical densitometer

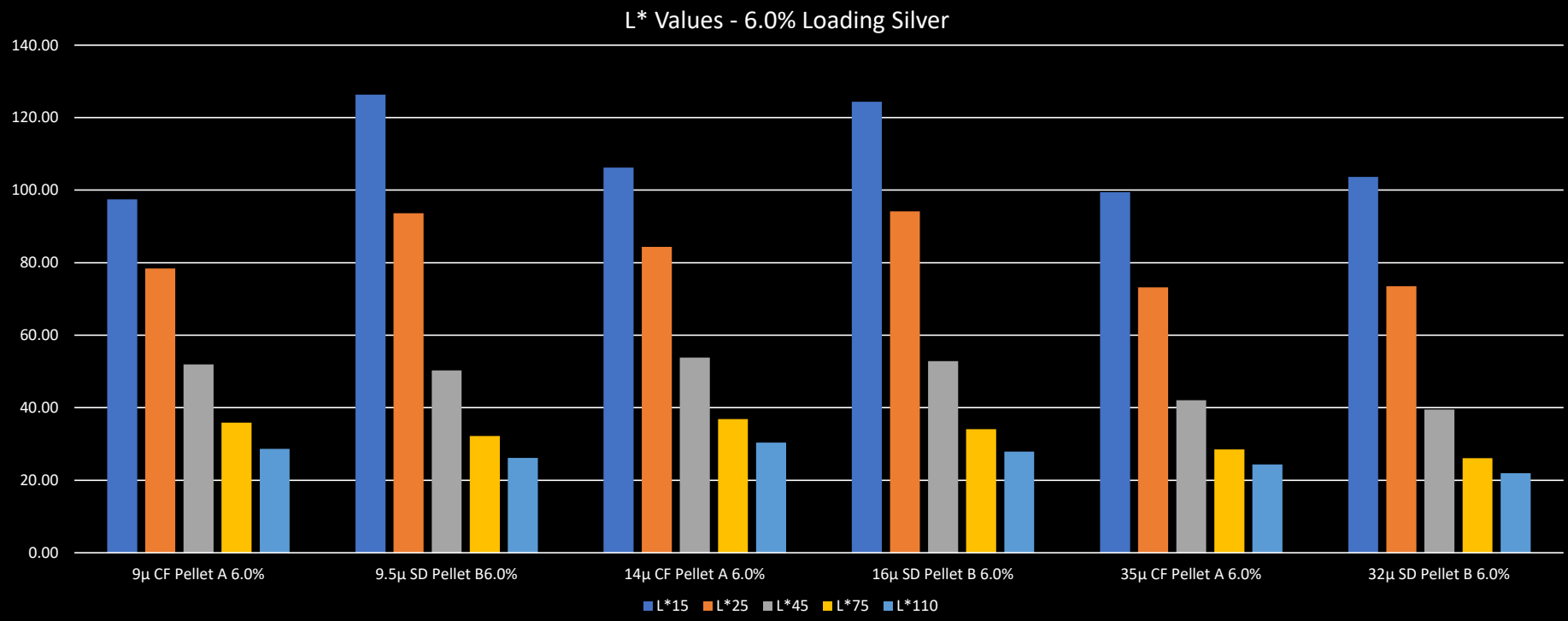
Masstone Color Conclusions

- In nearly all instances the effect of more aluminum pigment loading is a whiter, brighter, more metallic appearance at all measured angles
- More prevalent with finer silver dollar flakes
- This is due to polished face surface and narrow particle size distribution
- To achieve whiter, chrome like, metallic appearance, silver dollar flakes and higher aluminum concentrations should be employed during formulation

Masstone Color Conclusions



Masstone Color Conclusions



1% Blue Tint Color Conclusions

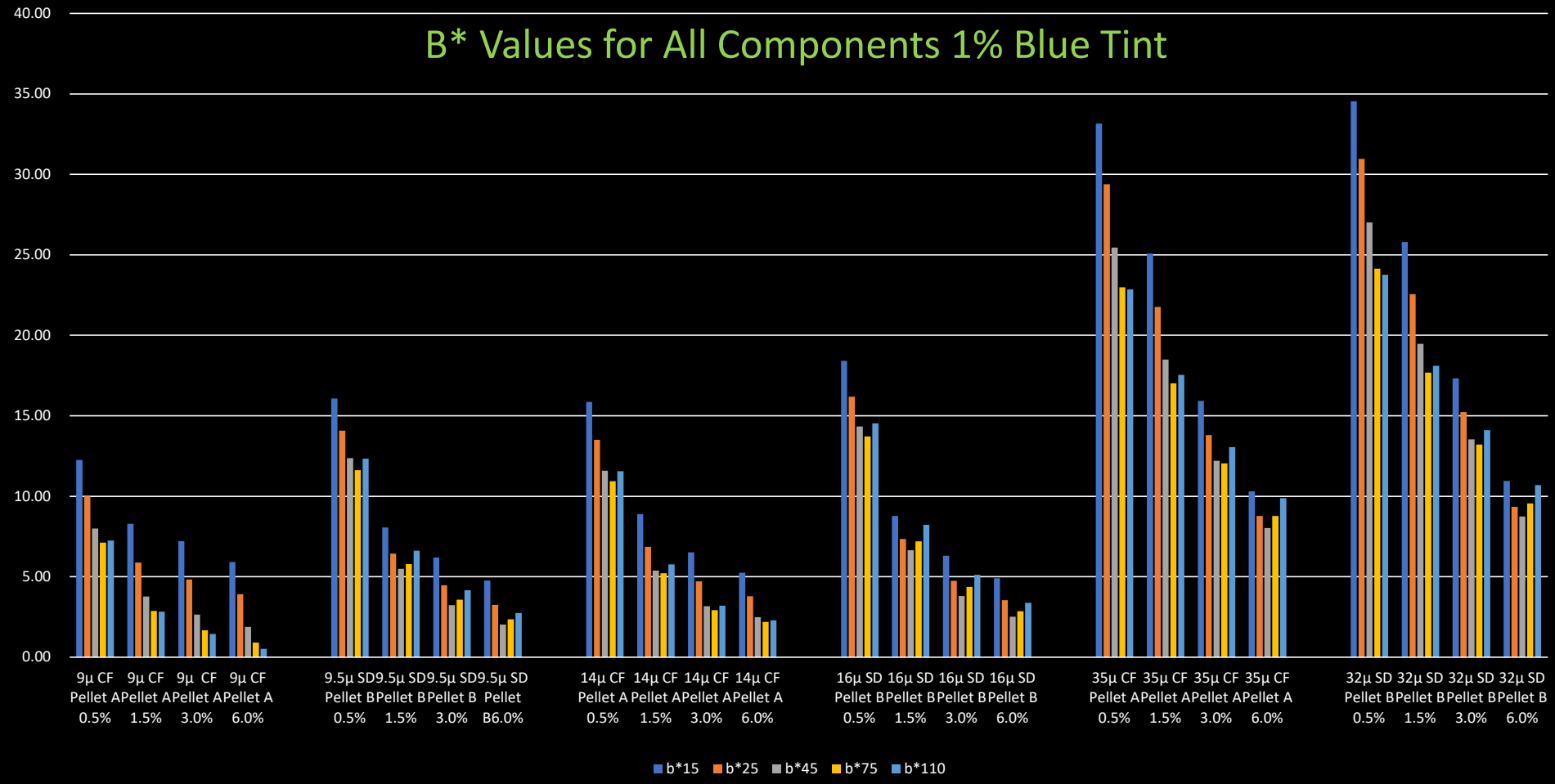
- Once again as with the masstone, in nearly all instances the effect of more aluminum pigment loading is a whiter, brighter, more metallic appearance
- The narrow particle size distribution of the silver dollar pigments creates a cleaner, more metallic color when combined with organic colored pigments
- The b* value shows the amount of blue that is lost or gained with different aluminum loading levels
- To achieve a bluer color use lower aluminum loading levels and a coarser aluminum flake

1% Blue Tint Color Conclusions

32 micron SD Pellet B
0.5% Al 1% Blue

9 micron CF Pellet A
0.5% Al 1% Blue

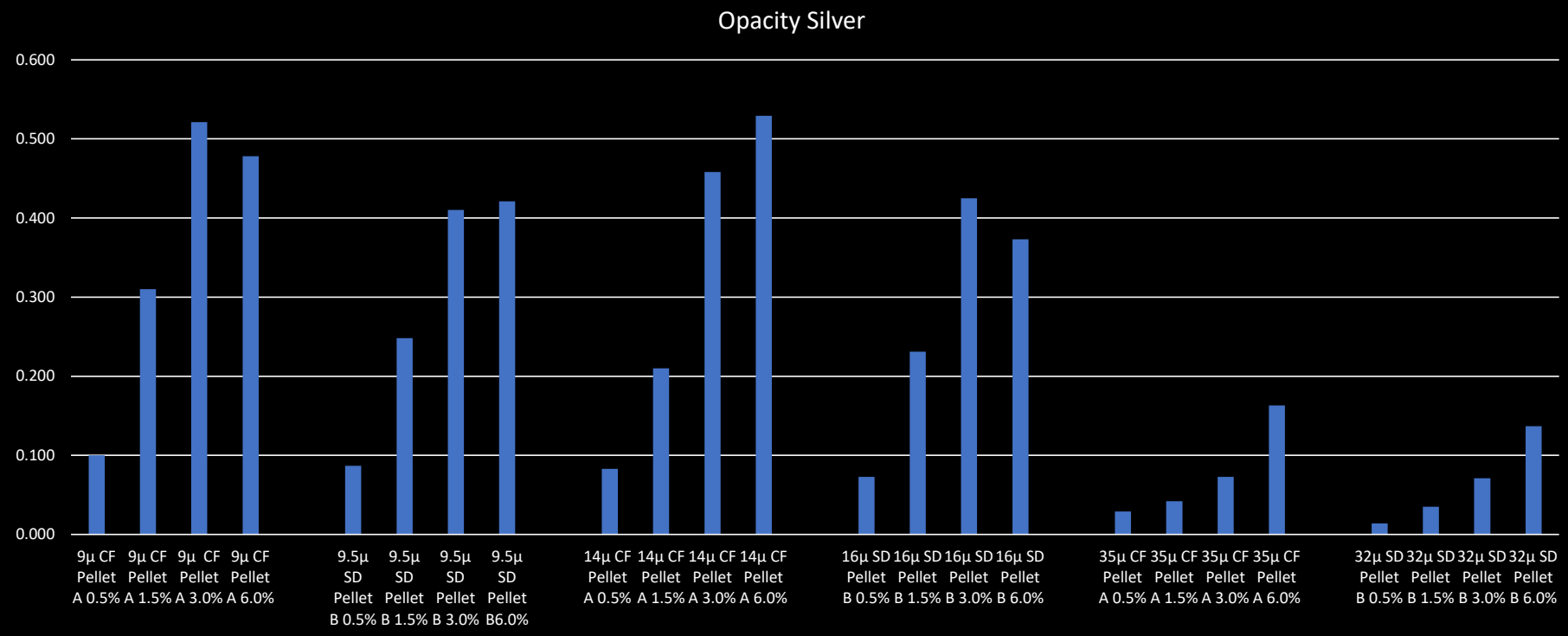
1% Blue Tint Color Conclusions



Opacity Conclusions

- The larger particle size pigments show a steady increase in opacity with increased aluminum loading of same pigment
- In the smaller particle size pigments opacity plateaus and will remain steady or slightly decrease with increased aluminum loading
- The reason for the slight decrease in opacity may be overcrowding of the flakes resulting in poor orientation
- Aluminum may be overloaded, especially in small particle size grades, which may result in less than ideal aesthetics and performance
- Small particle size pigments provide the most opacity

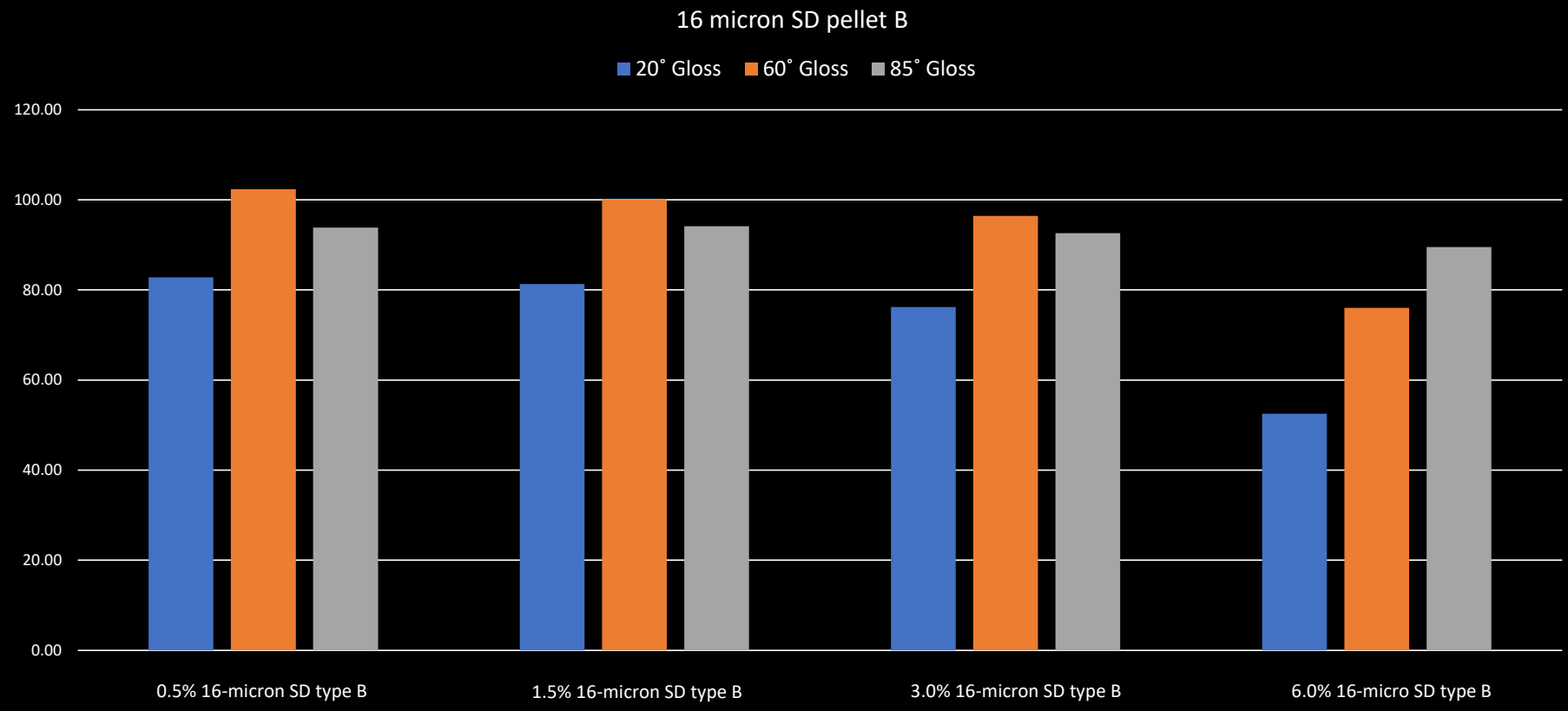
Opacity Conclusions



Gloss Conclusions

- Across all aluminum products used for this study increased loading lead to lower gloss at 20˚, 60˚, and 85˚
- Silver dollar pigments yielded higher gloss than cornflakes of similar particle size
- Increased aluminum loading has an adverse effect on gloss; however this is true of any pigmentation, not just aluminum.
- The highest gloss values can be achieved with a silver dollar flake at low loading levels.

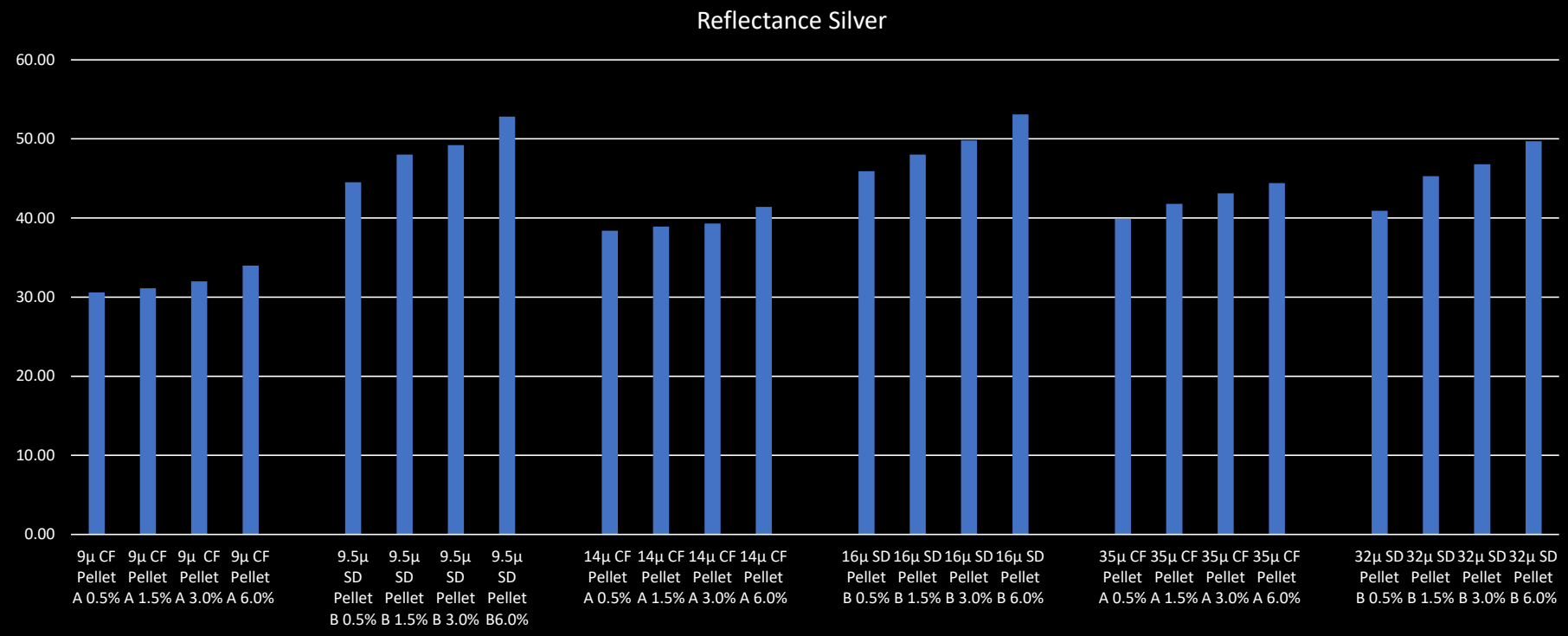
Gloss Conclusions



Reflectance Conclusions

- In all tests higher reflectance is achieved with higher aluminum concentration
- Silver dollar flakes have higher reflectance at all loading levels when compared to cornflake aluminums of a similar particle size
- To achieve higher reflectance aluminum concentration should be increased

Reflectance Conclusions



Summary

- Higher loading levels trend toward a whiter, brighter, more metallic effect.
- Some finer aluminums can give the appearance of “near chrome” or even a brushed aluminum look.
- To achieve the best possible metallic appearance, with cleaner tints, high opacity, and optimal reflectance, a silver dollar aluminum at minimum 3% loading is suggested.
- If gloss reduction becomes a concern, then aluminum loading can be reduced until desired gloss is achieved.

Summary

- Cornflake pigments are suitable for use in all applications; however their wide particle size distribution and rough surface may lead to a slightly duller, more washed out appearance. This is especially true when they are combined with other colored pigments.

- Pellet or granule type does not appear to play a significant role in the final appearance.

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Questions ?

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Thank You