Coloring of Plastics
Color Education

Presented by: The Color and Appearance Division

Education Committee

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Color Education

Purpose and Scope

This Color Education presentation provides fundamental concepts of color and appearance for use by anyone educating students, professionals, and organizations.

The scope of the presentation covers colorimetry with definitions and images selected by the Education Committee members of the Society of Plastics Engineers (SPE) – Color and Appearance Division (CAD) Board of Directors that best represents the theory and practice used in today's coloring of plastics industry.

Color Education

Sections I – VI

I. Color Science
II. Color and Appearance
III. Color Measurement and Test Methods
IV. Colorants
V. Plastics (Polymers)
VI. Definitions

Section II – Color and Appearance

Color and Appearance

Importance of ***Color and Appearance***

- Visual aesthetics of a plastic object
- Brand Identification / trademark color
- Store-shelf appearance
- Automotive interior / exterior parts
- Building materials interior / exterior aesthetics
- Design projects
- Communication of color and color differences

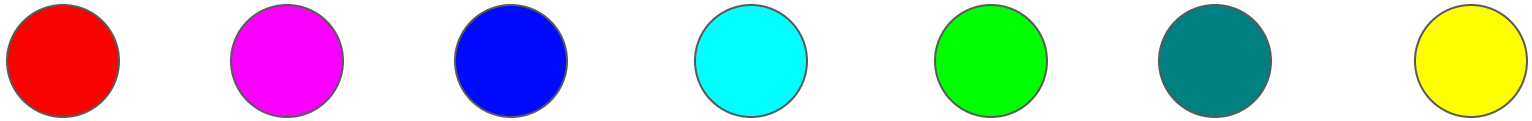
Spectral analysis *or Spectrum analysis is analysis in terms of a spectrum of* ***frequencies or related quantities such as energies****…*

Color and Appearance

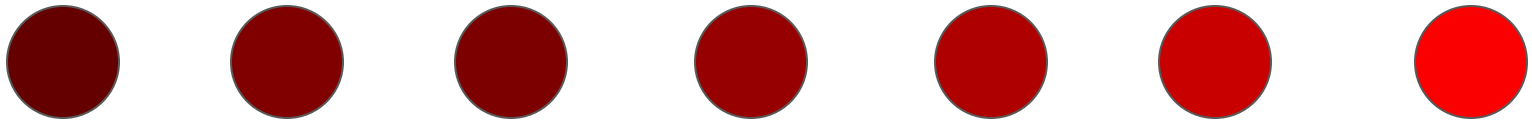
- Color Attributes
- Object
  - Surface texture (glossy or matte)
  - Opaque or Transparent
- Appearance Characteristics
  - Glint (sparkle)
  - Fluorescent (high chroma)

Color Attribute

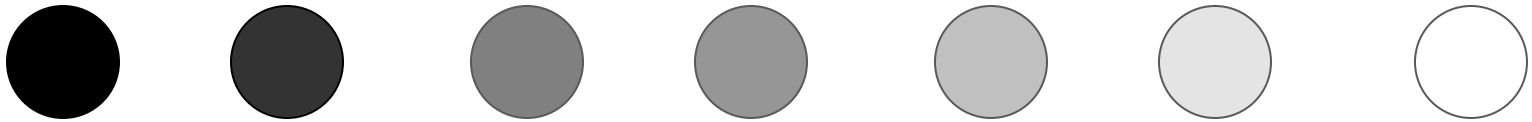
Hue



Chromaticity



Value or Lightness/Darkness



Color Attribute

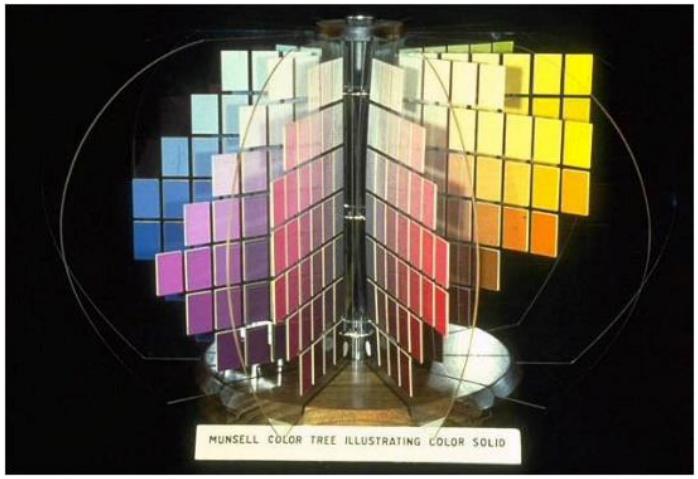
- Color shade within a similar hue

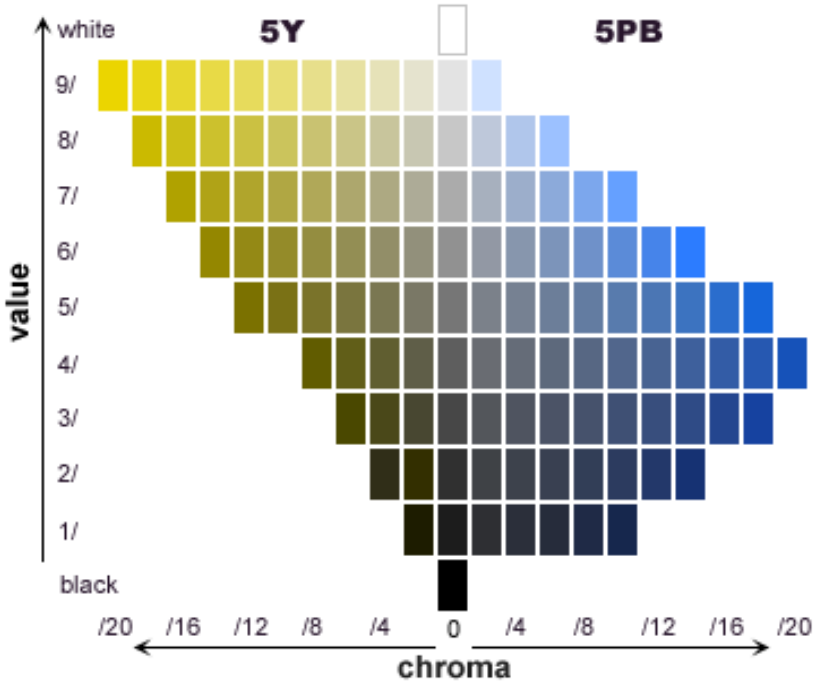
red-shade blue  *green-shade blue*

- Color strength or colorfulness

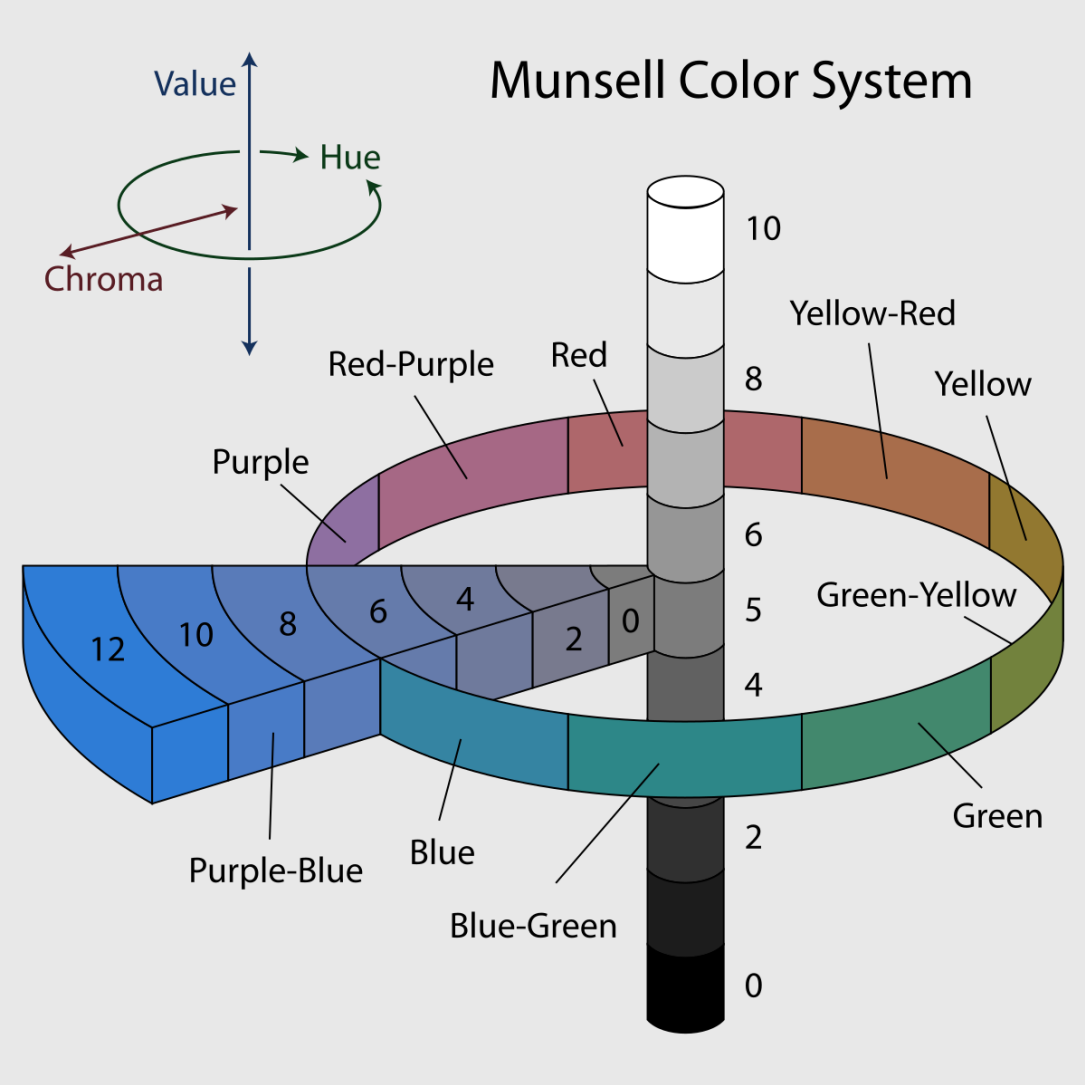
Strong
more chromatic  *Weak*
less chromatic

Munsell Color System





Munsell Color System



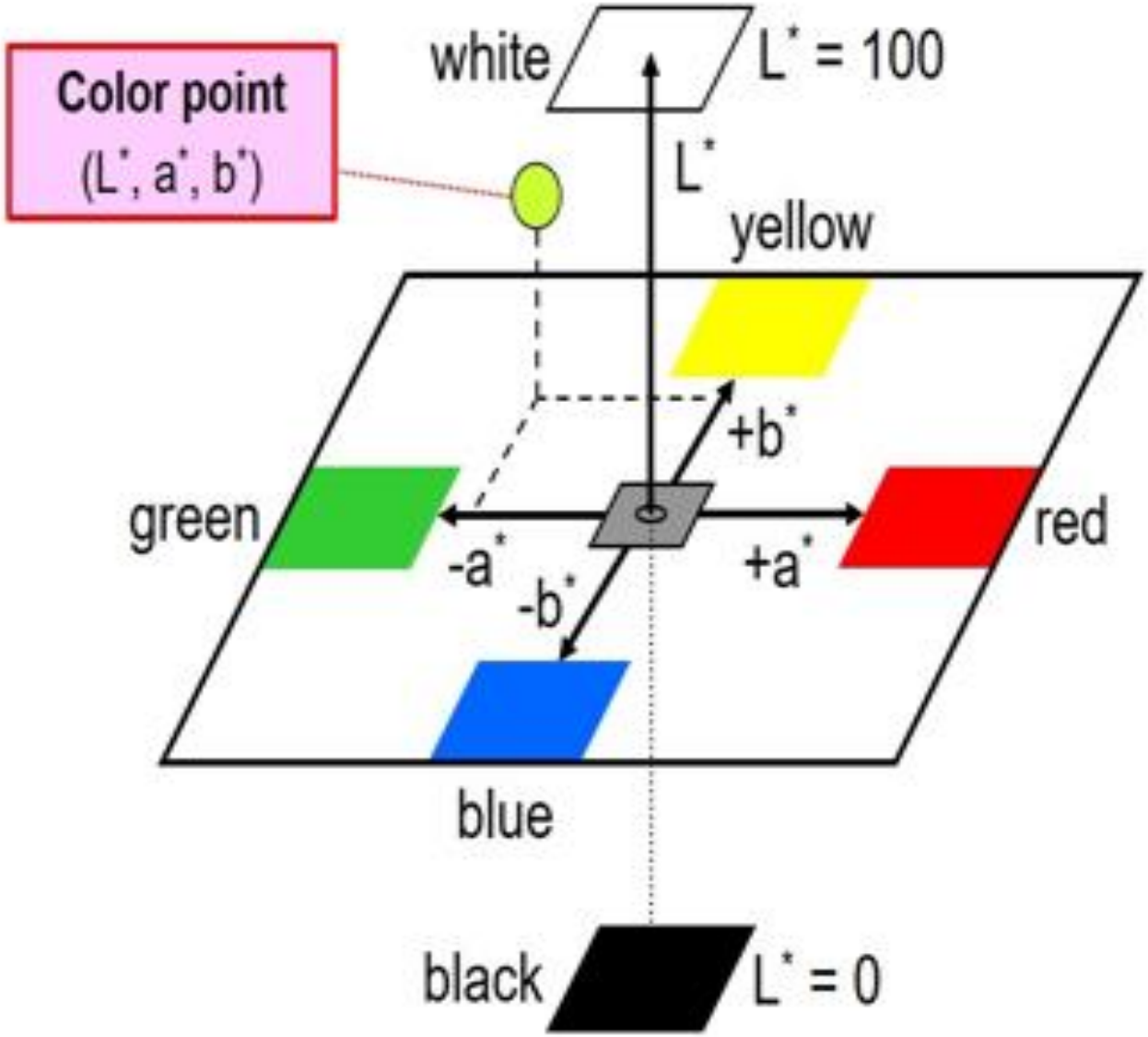
International Commission on Illumination
Commission Internationale de l'Eclairage
Internationale Beleuchtungskommission

Division 1: Vision and Colour

CIELab coordinate system

L*	Light/**Dark**	L*	Light/**Dark**
a*	**red**/**green**	C*	**chroma**
b*	**blue**/**yellow**	h	hue angle

http://www.cie.co.at/


Color point
(L*, a*, b*)
white
L* = 100
L*
yellow
+b*
green
-a*
-b*
+a*
red
blue
black
L* = 0

Standard plaque

Sample plaque

L*a*b* Color Difference

ΔL* = +4.03
Δa* = -3.05
Δb* = +1.04
ΔE* = 5.16

L* = 43.31
a* = 47.63
b* = 14.12

Absolute color values
L-a-b

L* = 47.34
a* = 44.58
b* = 15.16

Absolute color values
L-a-b

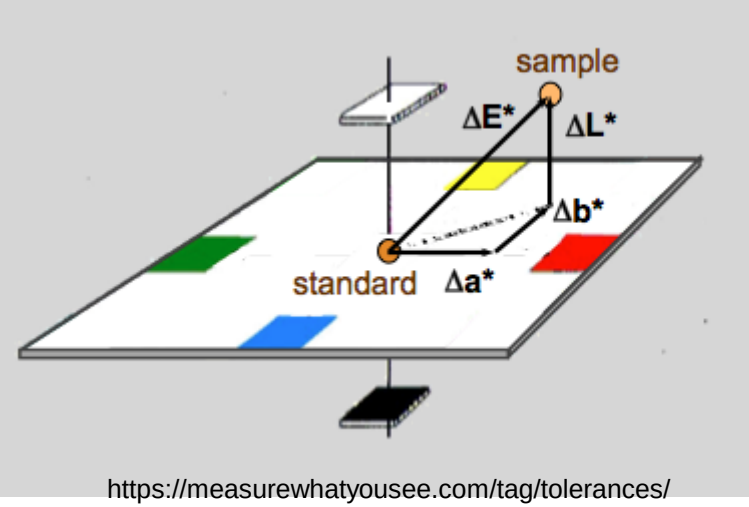
Deltas (total color difference)

Strength values included for example 85% strength (K/S)

Total Color Difference

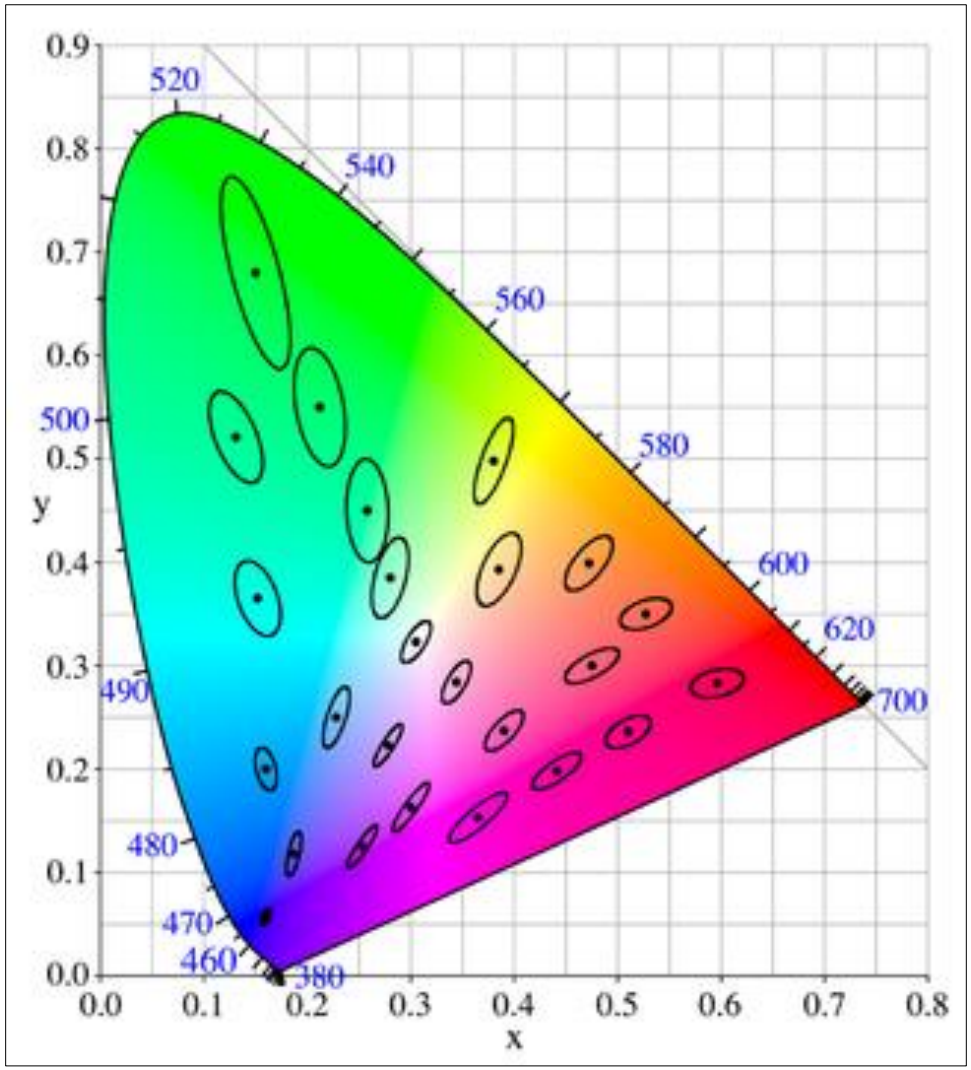
Delta E 1976

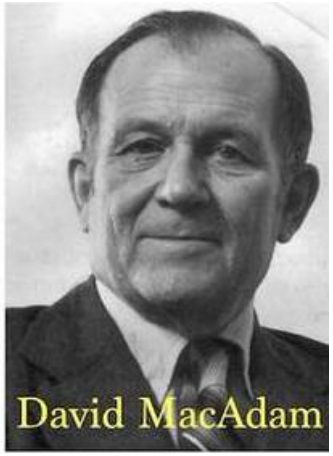
- DE = 1
  - most observers can begin to detect a slight difference
- DE = 2
  - Obvious differences to the majority of observers



https://measurewhatyousee.com/tag/tolerances/

McAdams Ellipses





Color Tolerance Equations

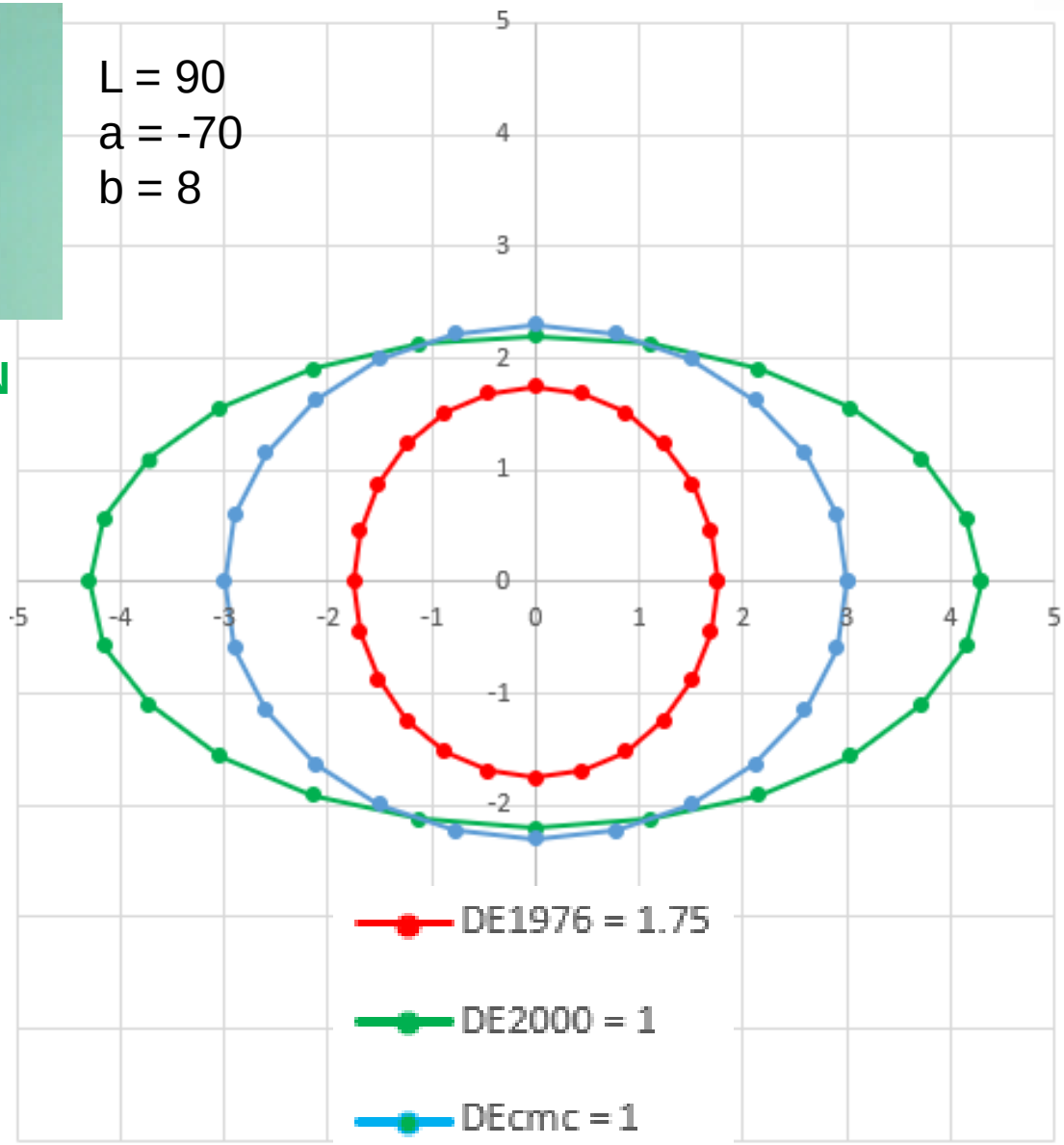
- CMC $DE_{cmc} = 1$ (*Color Measurement Committee*)
  - Developed for the textiles industry

- CIELab $DE_{2000} = 1$
  - Current CIE recommended tolerance equation
  - 50% of trained color inspectors visually observe color differences

elliptically shaped specifications

L = 90
a = -70
b = 8

GREEN

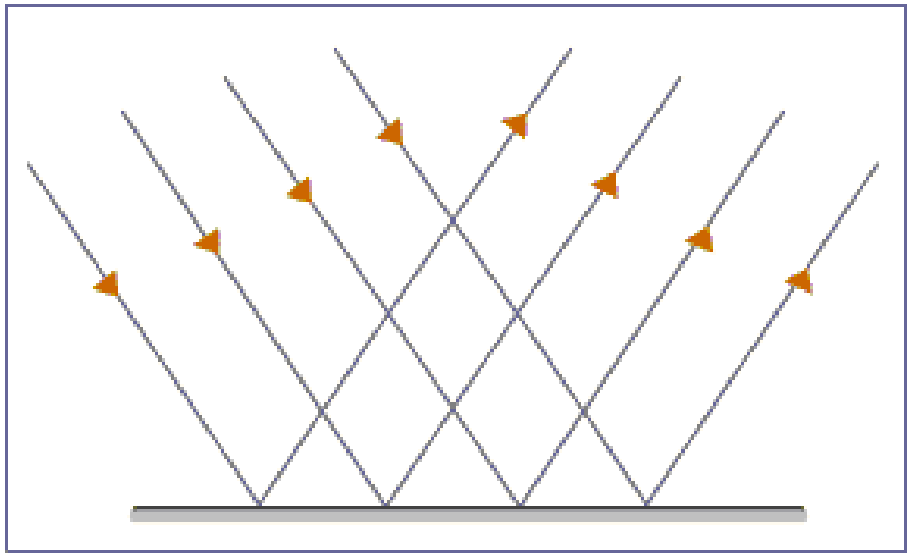


Factors Affecting Appearance

- Gloss
  - Specular Reflection
  - Diffuse Reflection
- Texture
- Substrate (polymer)
- Light Source
- Angle of incidence
- Observer's viewing Angle (typical observer)
- Components / formulation

Specular Reflection (high gloss)

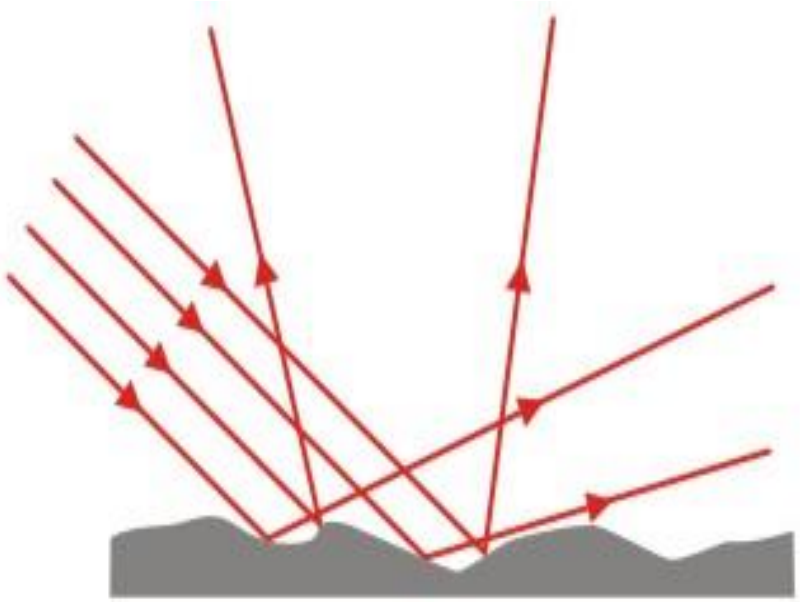
- Reflection – light reflects off the surface with little to no deviation



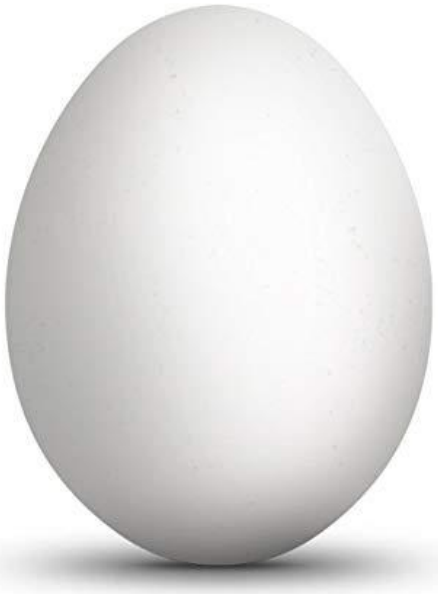
mirror-like
(metallic pigments, sparkle, glint)

Diffuse Reflection (low gloss)

- Scattering – light reflects off in all directions



matte finish

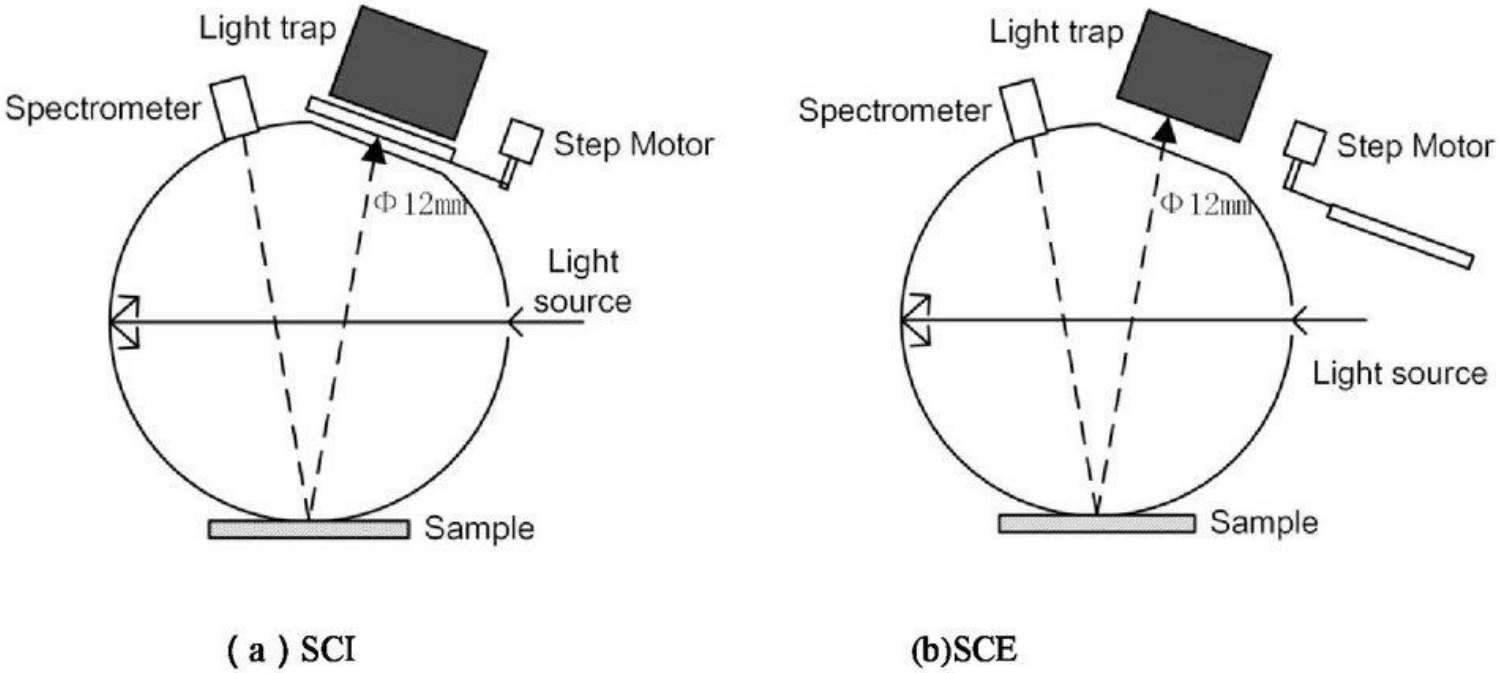


eggshell

(pigment particle surfaces)

Measuring with Gloss Differences

Specular included Specular excluded

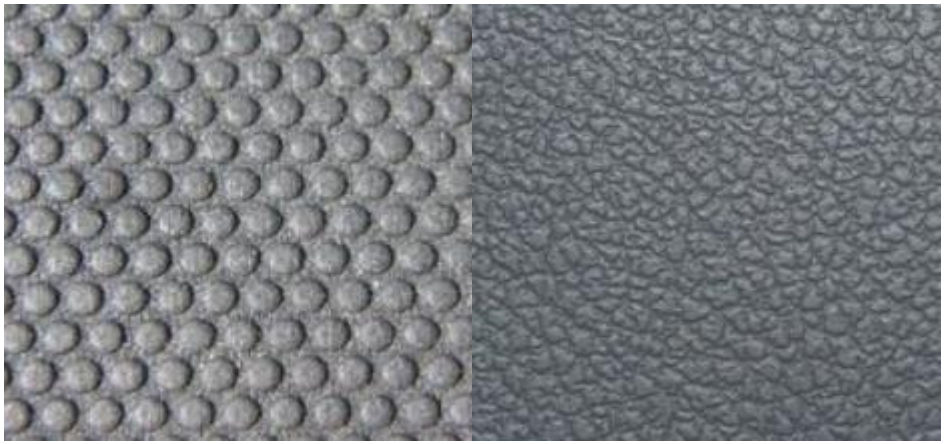


https://www.spiedigitallibrary.org

Glossy samples may read weaker in strength and the lightness value (L value) may read higher

Texture

Mold design

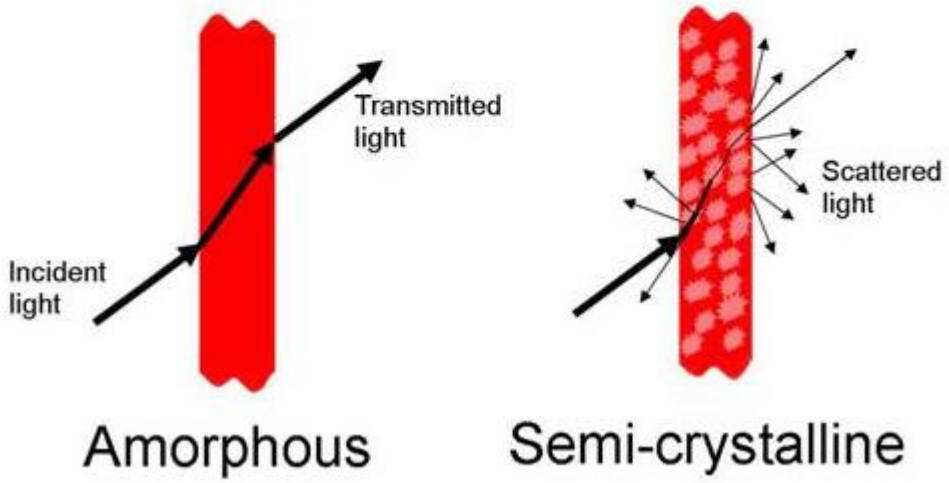


dimples animal skin

(not ideal conditions for color measurements)

- fabric versus plastic
- matting agents (fillers or additives)

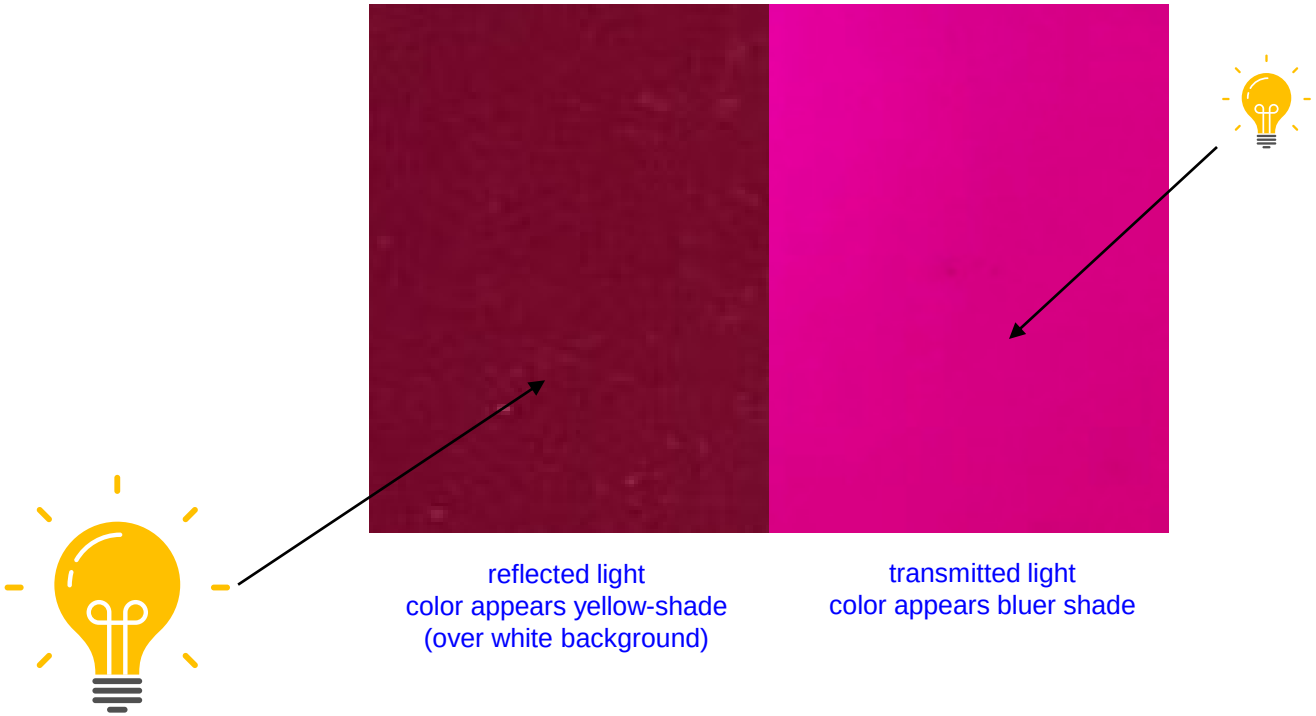
Substrate (type of plastic)



https://www.hardiepolymers.com/

highly crystalline polymers can also be very transparent

Reflected versus Transmitted Light



reflected light
color appears yellow-shade
(over white background)

transmitted light
color appears bluer shade

Thin film

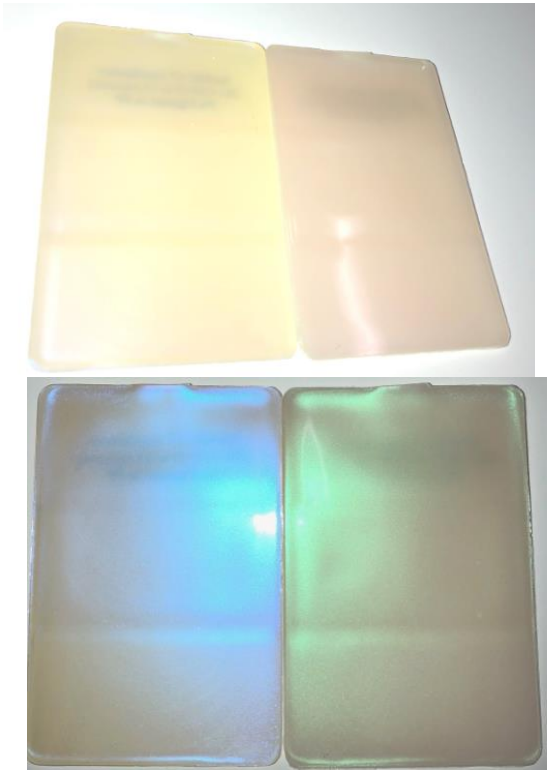
Transparency (Dye vs Pigment)

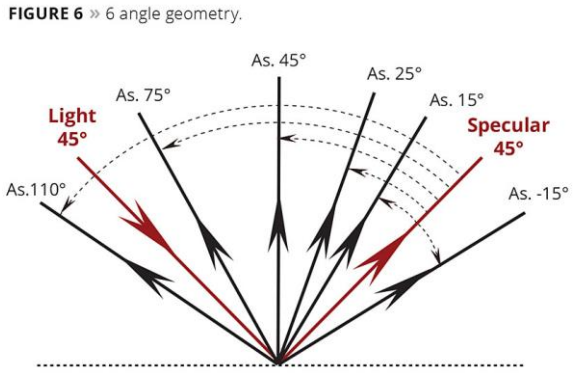
solvent dye
low light scattering

pigment
high light scattering

Viewing Angle Dependence

- Angle of incidence dependence
- Multi-angle color measurement
- Color travel pigments





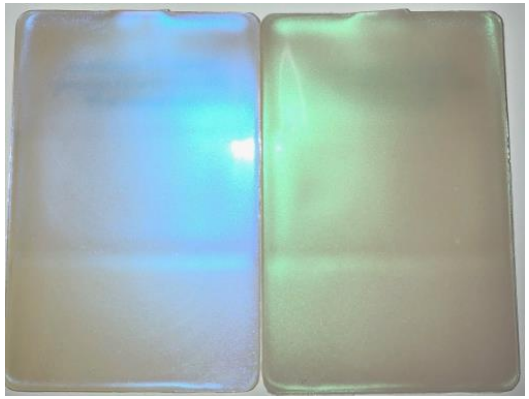
https://www.pcimag.com/

Color Flop / Bronzing

- Undesired color shift around curvatures
- Typically, a red or bronzing color

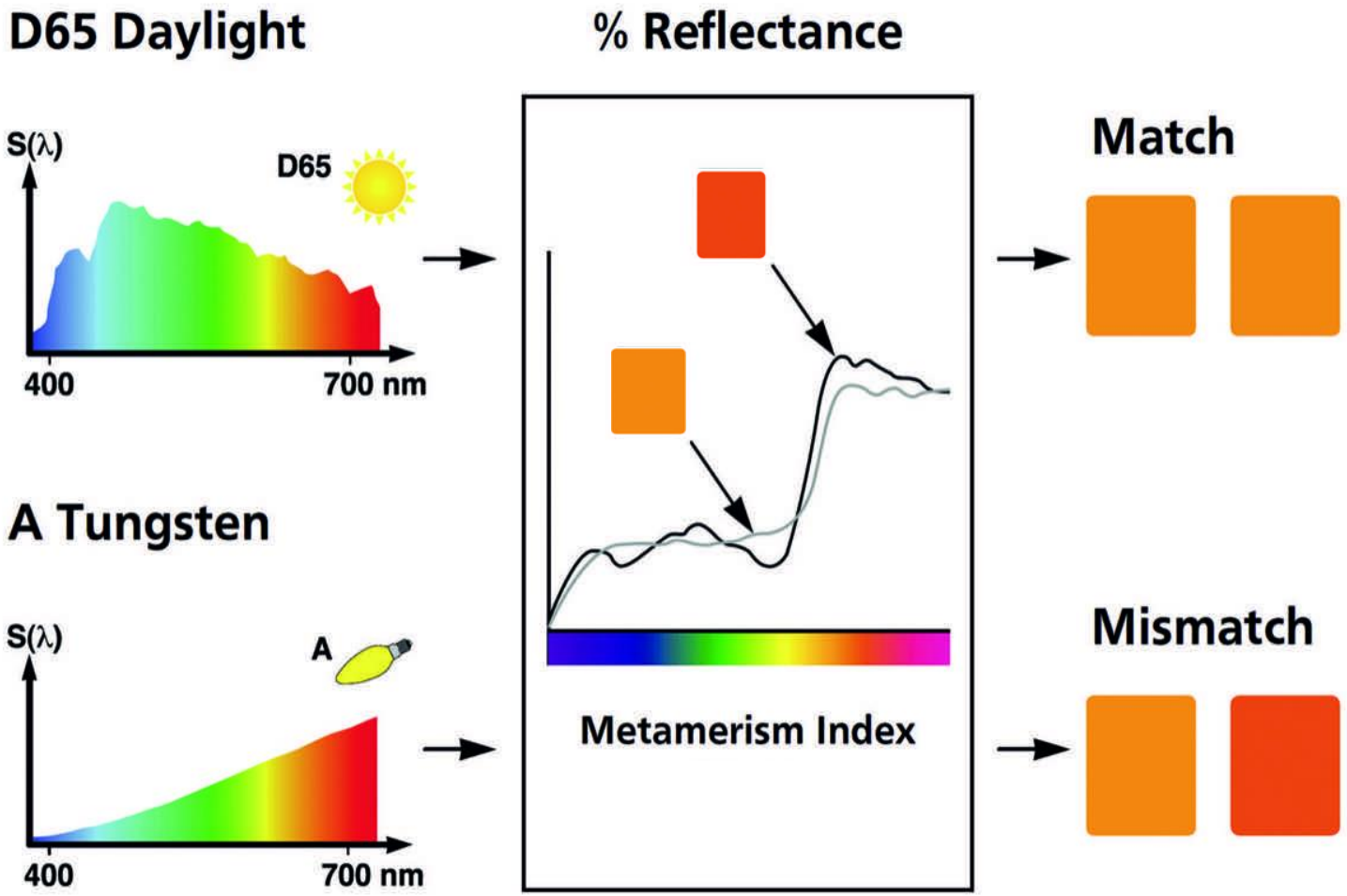
Contrast Ratio

- White background vs Black background



with black pigment added

Metamerism



http://stage-directions.com/current-issue/55-light-on-the-subject/8289-metamer-what.html

4 types: Illuminant, Observer, Instrument and Geometric

Fluorescent / Neon Appearance

- Optical Brighteners
- Upconverting pigments

Color and Appearance

Considerations for Visual Inspections

- Light – Source, Intensity, and Direction (angle of incidence)
- Observer – Viewing angle, Observer's Capabilities
- Object – Substrate (polymer, texture)
  Surroundings/Background
  Distance between objects when comparing
  Composition (pigments, dyes, additives)

End Section II – Color and Appearance

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Steve Goldstein, Inorganic - Organic Pigment Particles

Jack Ladson, Color Science Consultancy

Betty Puckerin, Ampacet Corporation

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