Coloring of Plastics
Color Education

Presented by: The Color and Appearance Division

Education Committee

Originally Created July 2007

Last Modification July 2020

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

Section IV – Colorants for Plastics

Colorants for Plastics




Fine Powders

Colorants by Function

Absorption (Chromophore)	**Organic Pigment**	
	Pigment	Insoluble
	Vat dye	Insoluble
	Toner	Insoluble
	Solvent dye	Soluble
	Disperse Dye	Soluble
	Inorganic Pigment	Insoluble
	Metal Oxides	Insoluble
	Complex Inorganic Color Pigment (CICP)	Insoluble
Interference	**Effect Pigment** (inorganic)	Insoluble
Reflecting	**Metallic Pigment** (inorganic)	Insoluble
Upconverting	**Optical Brightener** (organic)	Soluble
	Fluorescent dye (organic)	Soluble
	Fluorescent pigment (organic)	Insoluble
	Phosphorescent (inorganic)	Insoluble

Colorants - *Nomenclature*

sdc society of dyers and colourists
United Kingdom
A Chartered Society since 1963

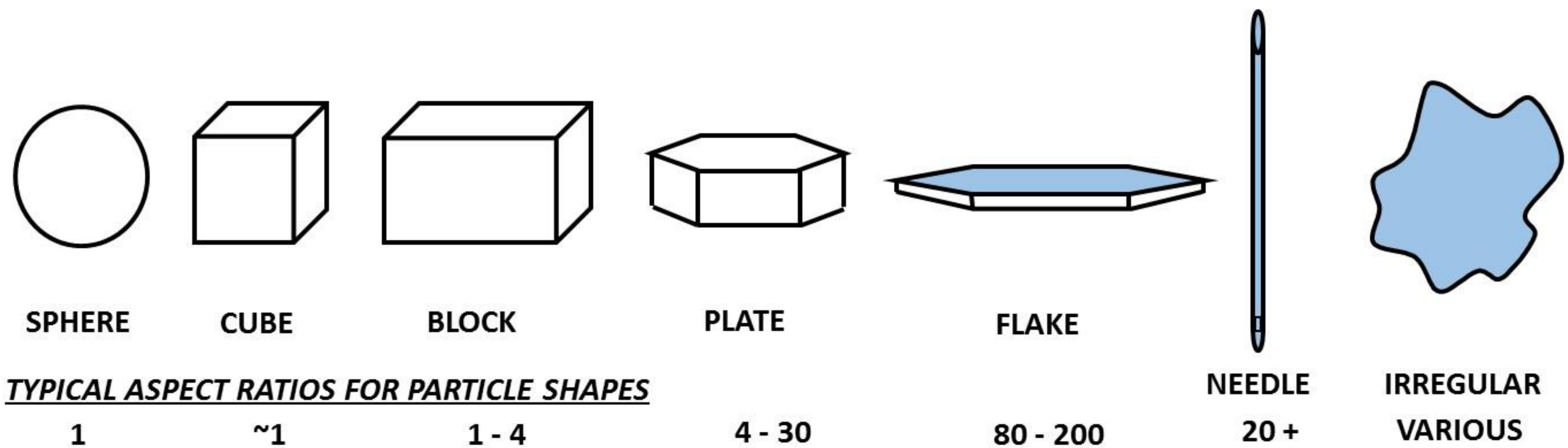
CAS
A DIVISION OF THE AMERICAN CHEMICAL SOCIETY
Columbus, Ohio

ECHA
EUROPEAN CHEMICALS AGENCY

FDA U.S. FOOD & DRUG ADMINISTRATION

Colour Index name ---------C.I. Pigment Red 57:1
Colour Index number -------C.I. 15850:1
Chemical Abstracts ---------CAS# 5281-04-9
European Inventory ---------EINECS 226-109-5
U.S. FDA ---------------------D&C Red 7
Industrial Name -------------calcium mono-azo, lithol rubine

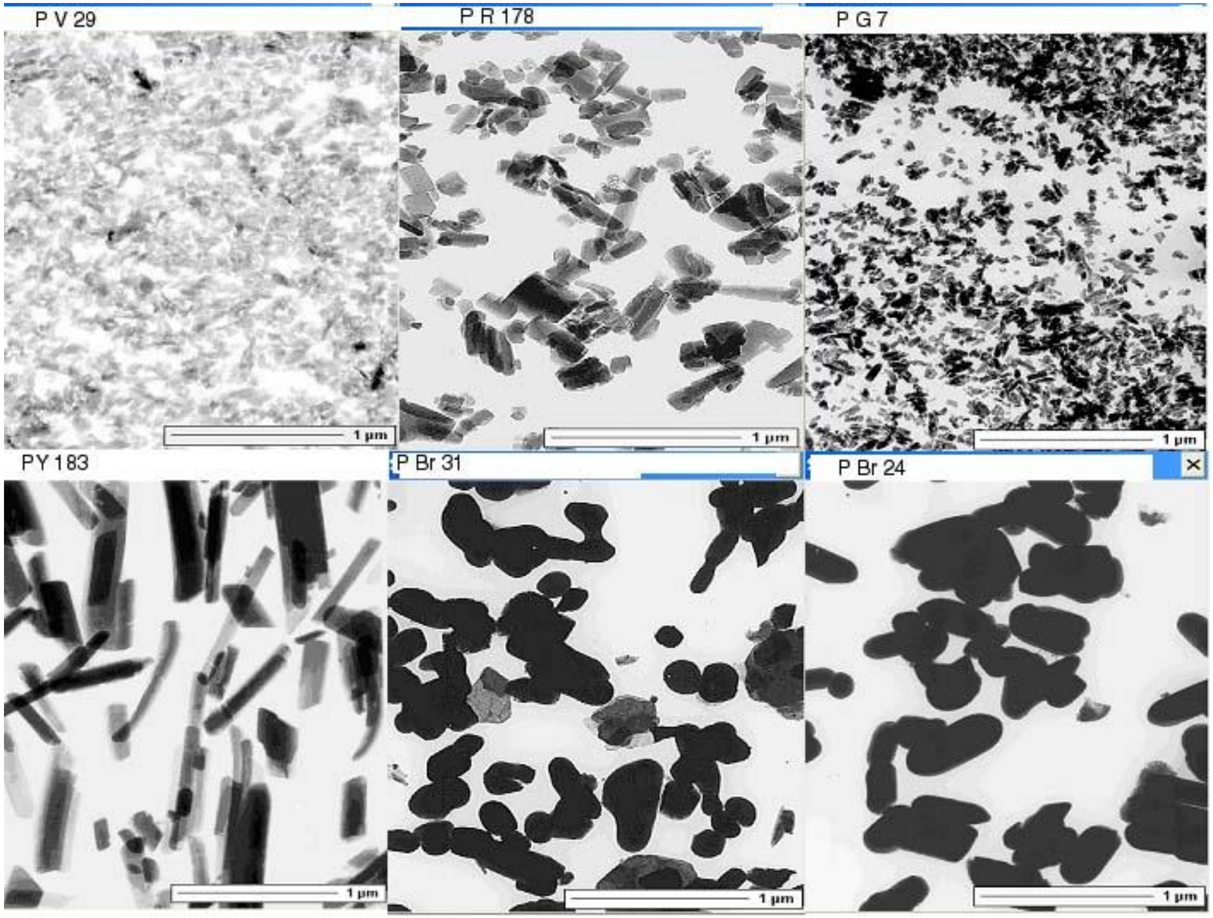
Colorants – *Particle Shape*



Colorants – *Primary Particles*

Organic

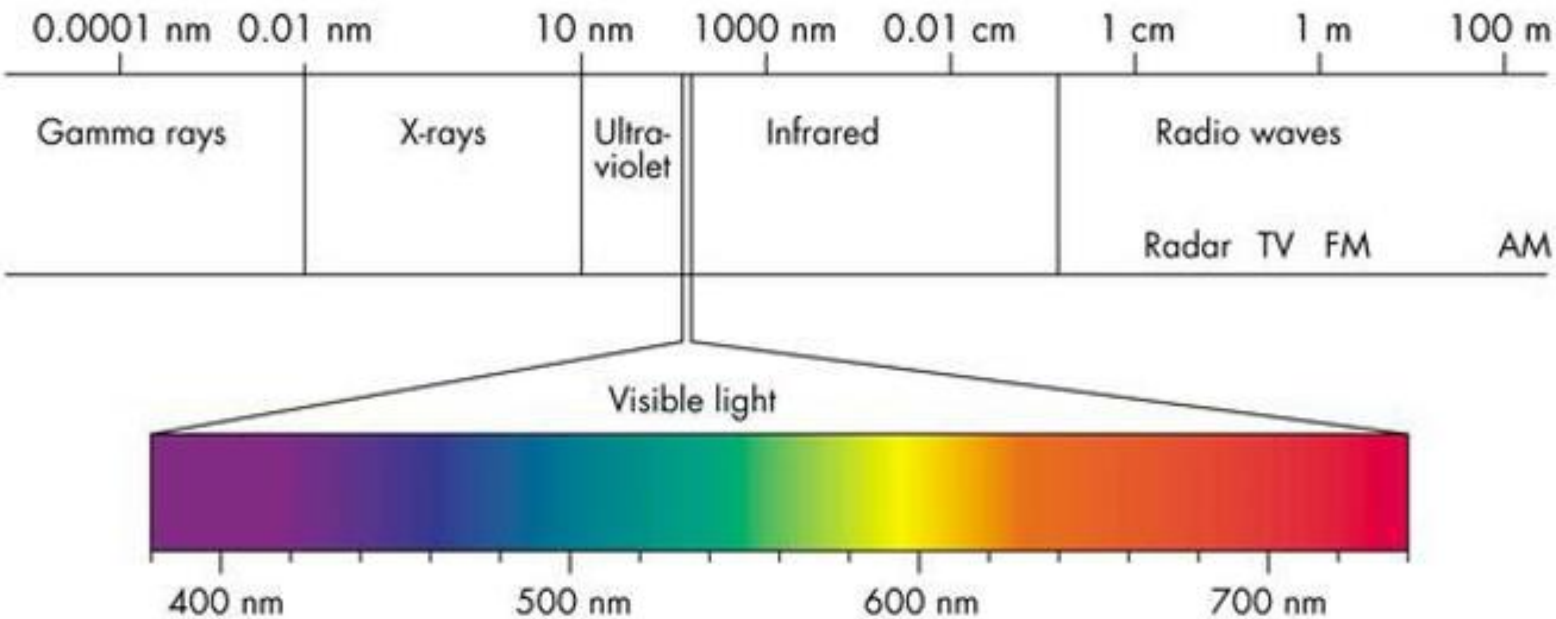
Inorganic



Transmission Electron Microscope ~100K x

Colorants – *Particle Size*

nanometer , submicron

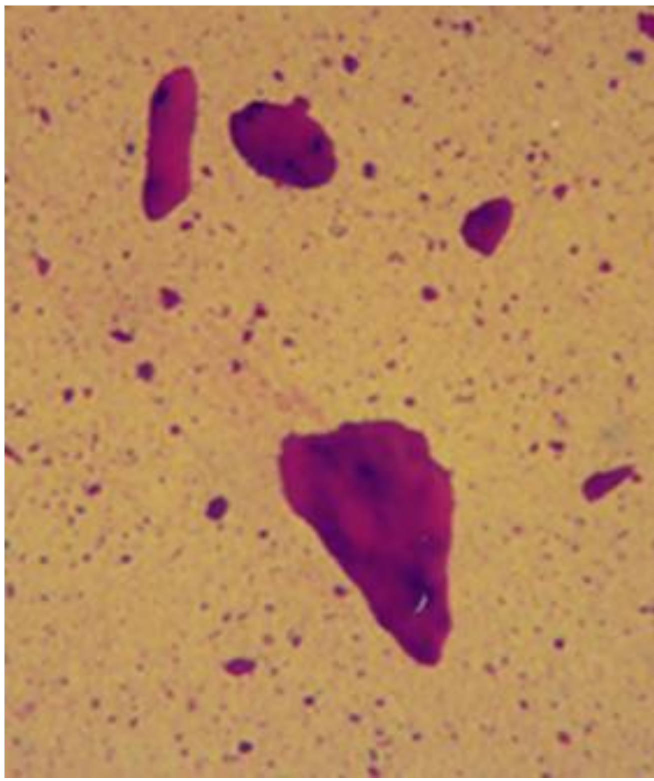


Colorants – *Physical Parameters*

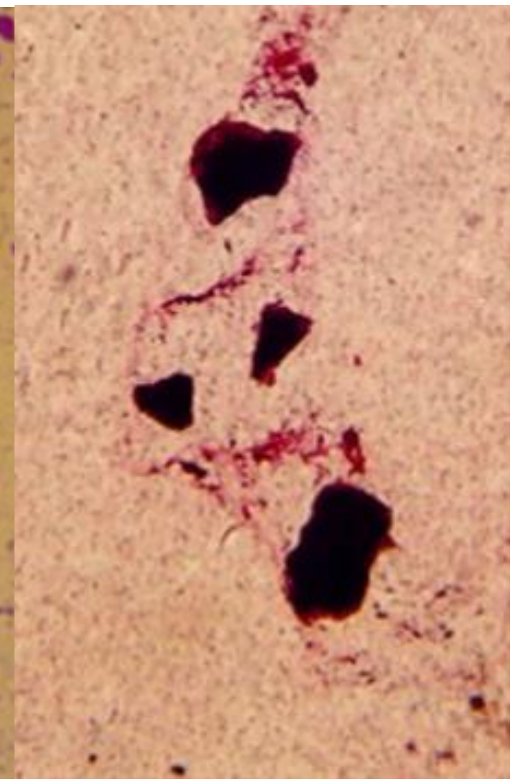
- Oil absorption (OA)
- Surface Area (SA)
- Pigment Volume Concentration (PVC)
- Average particle size (D_{50})
- Particle distribution
- Particle shape
- Texture
- Surface treatment
- Partial Solubility

- Moisture Content (%)
- Conductivity (mMHOs)
- Refractive Index (RI)
- pH
- Viscosity (η)
- Nucleating
- Shear Stability
- Inertness
- Hardness (Mohs)
- Density

Colorants – *Texture*



Aggregates
(Large Size Nibs)

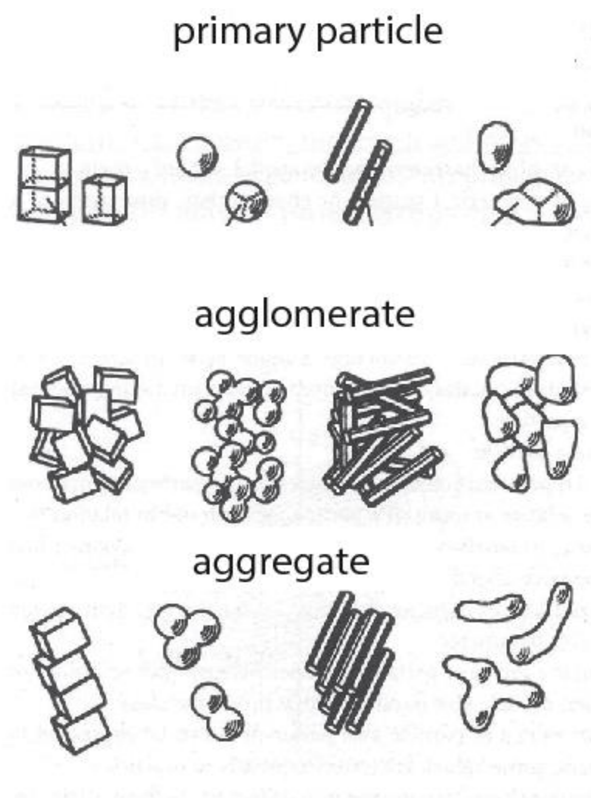


Agglomeration
(Softer texture)

Colorants – *Dispersibility*

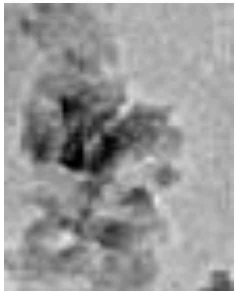
adhesion

sintered body
(crystal structure)

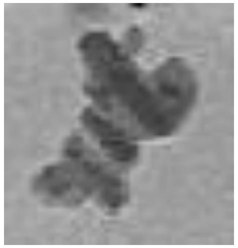


primary particles

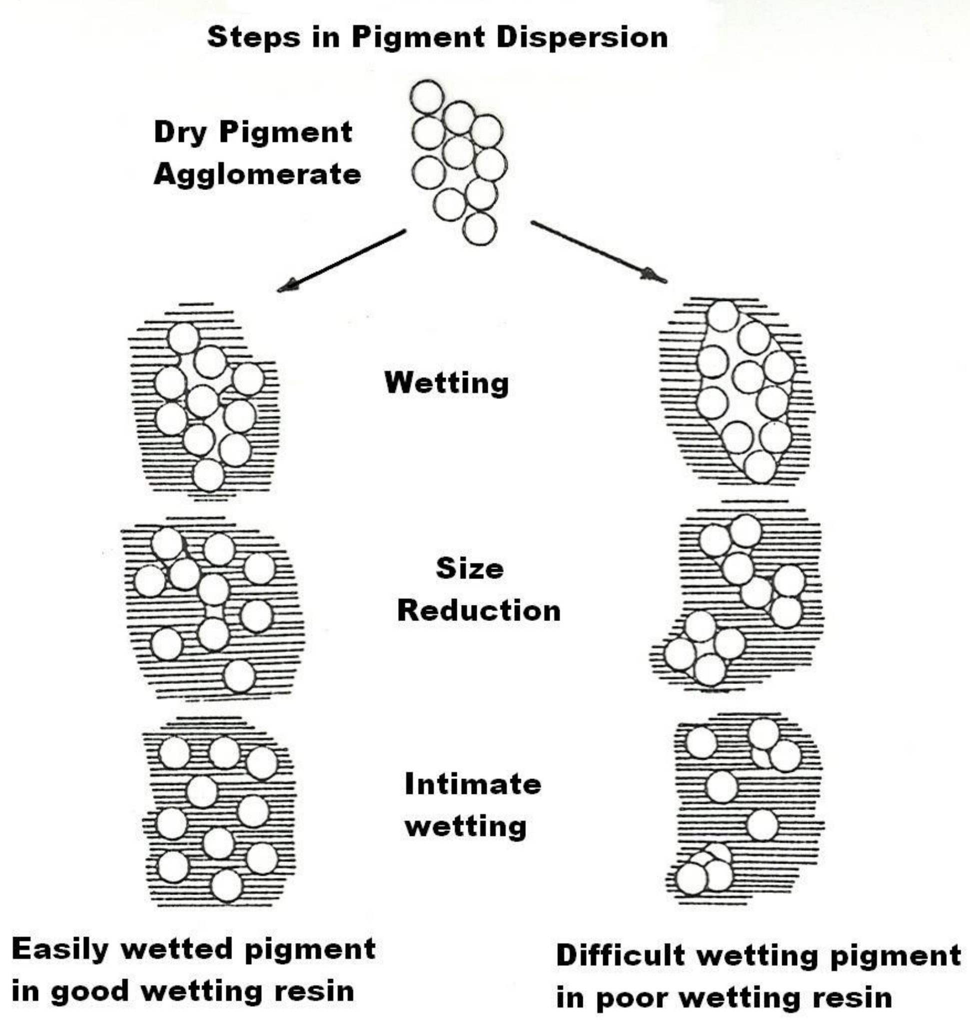
agglomeration by
physical interactions
of primary particles
(agglomerate)



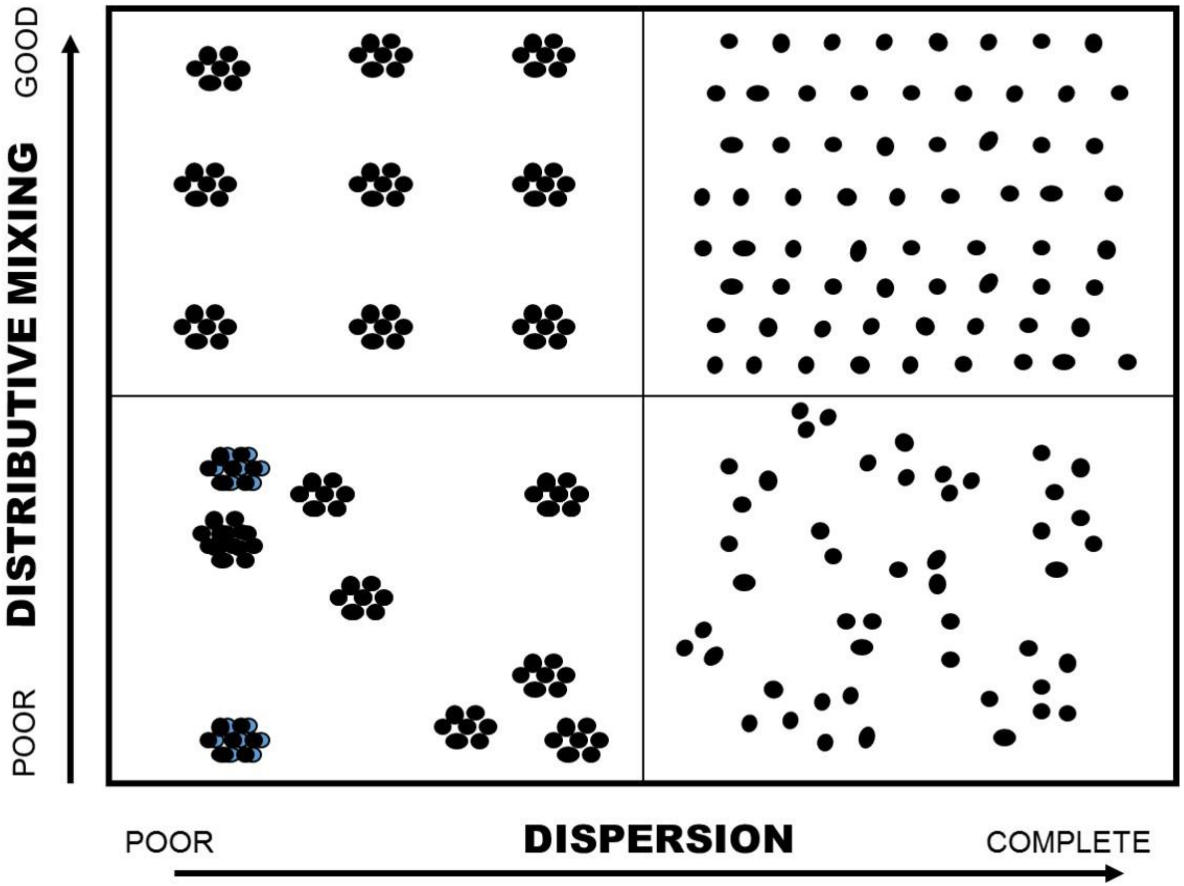
new formed particle
(aggregate)



Colorants – *Dispersion*

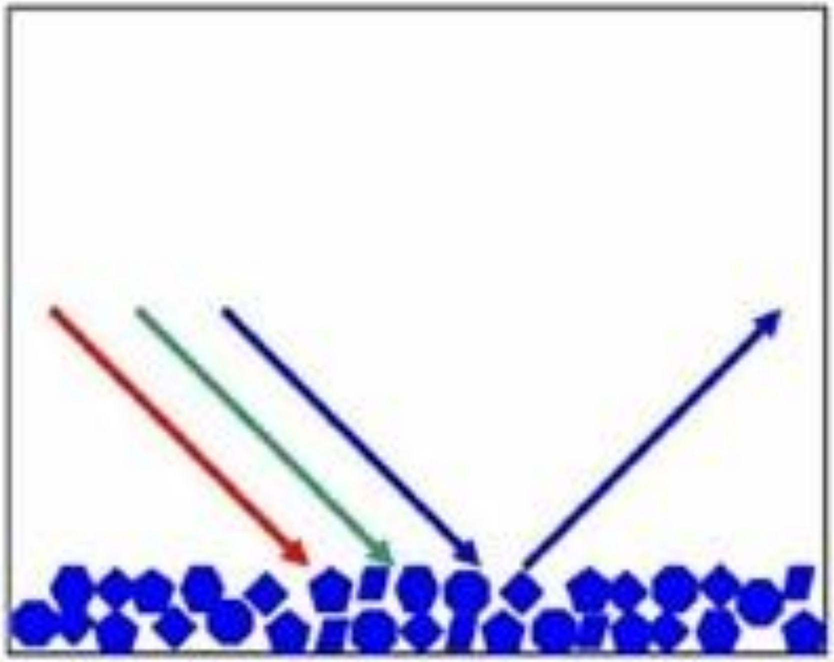


Colorants – *Dispersed*



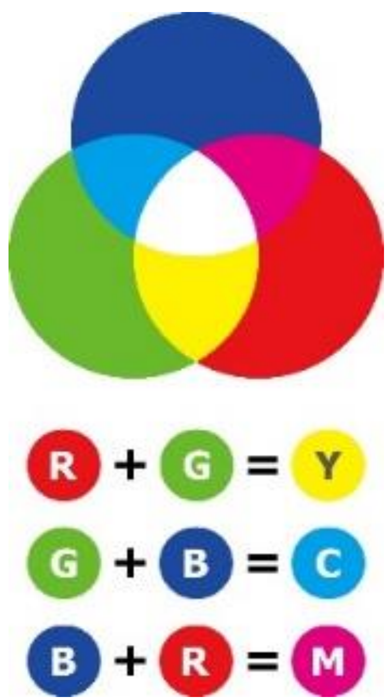
Colorants

Absorption Colorants (Chromophores)



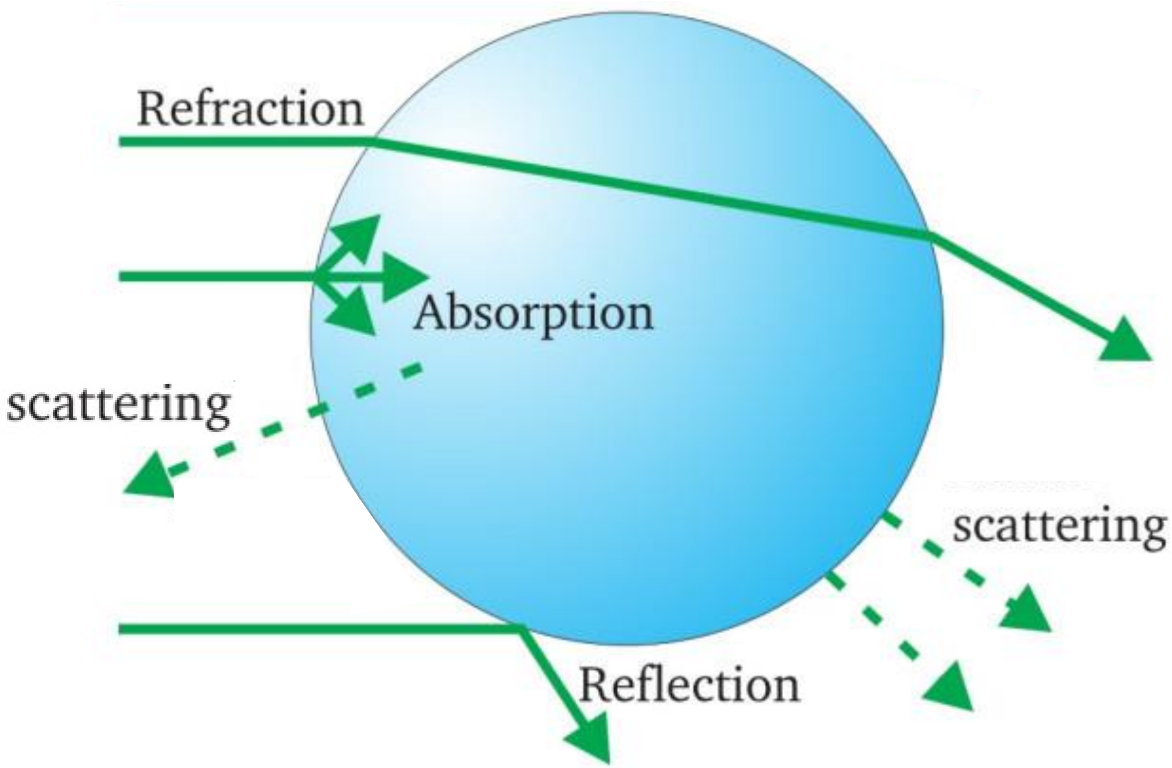
Colorants – *Absorption*

Additive Colorimetry



Subtractive Colorimetry

Colorants – *Light Interaction*



https://allaboutaerosol.com/optical-properties/

Colorants – *Size Affects*

Smaller	Particle Size Change	Larger
Yellower	Red*	Bluer
Yellower	Orange	Redder
Greener	Yellow	Redder
Yellower	Green	Bluer
Greener	Blues	Redder
Redder	Violets	Bluer
Bluer	White	Yellow
Redder	Black	Gray MT/Blue Tint
Yellower/lighter	Brown	Redder/Darker

* Quinacridones usually go bluer when smaller and yellower when larger

Colorants – *General Description*

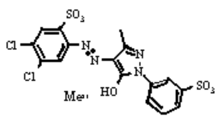
Organic

- Smaller particle size
  - larger surface area
- Transparent
- Heat stability
  - Variable range
- Light and Weather
  - Variable fastness range
- High chroma and tint strength

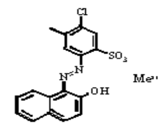
Inorganic

- Larger particle size
  - lower surface area
- Opaque
- Heat stability
  - Generally high
- Light and Weather
  - Generally high fastness
- Earthtone and pastel

Colorants – *Organic Pigment*



Naphthols



Monoazo

Acetoacetarylides

Arylides

Naphthanilides

Azo Type

-(-N=N-)-

Azo Condensation

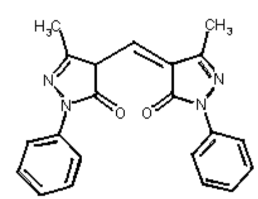
Insoluble metal salts of acid dyes

Diarylides

Disazo

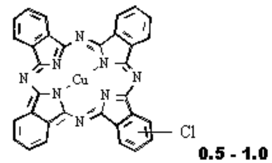
-(-N=N-)- -(-N=N-)-

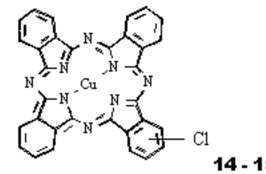
Pyrazolones



Colorants – *Organic Pigment*

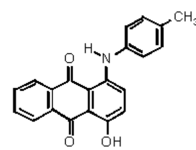
Phthalocyanines





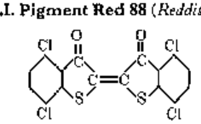
Vat Type

Anthraquinone



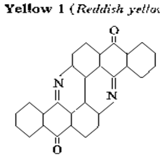
Thioindigo

C.I. Pigment Red 88 (*Reddish violet*)



Flavanthrone

C.I. Vat Yellow 1 (*Reddish yellow*)



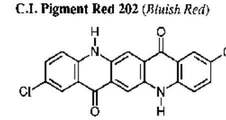
Miscellaneous

Triphendioxazine

Metal Complexes

Quinacridone

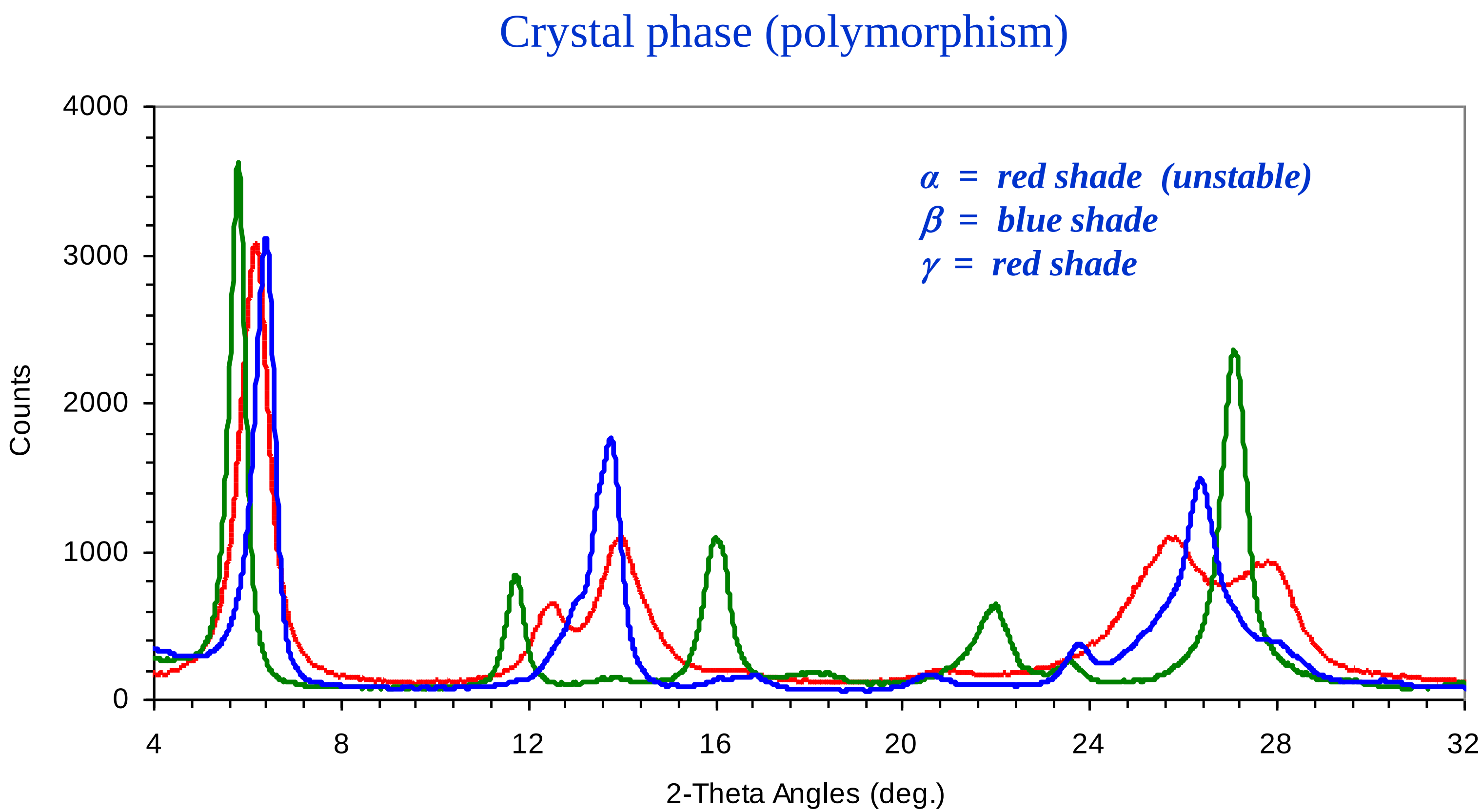
C.I. Pigment Red 202 (*Bluish Red*)



Basic Dyestuff Complexes

Carbon Black

Colorants – *Crystallinity*

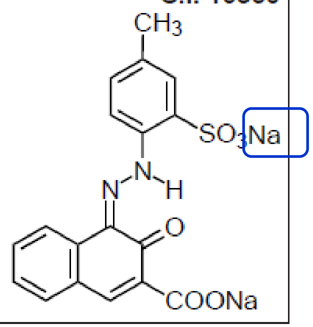


PV19: Alpha, Beta & Gamma Crystal Phases

Colorants – *C.I. distinctions*

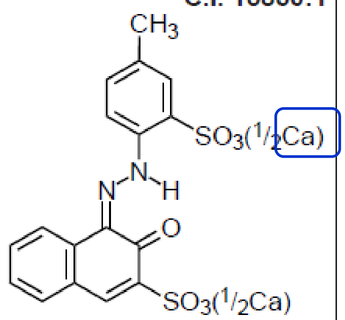
C.I. Pigment Red 57 — **C.I. 15850**

Hue	Bluish red
Chemical Class	Monoazo
Discoverer	R Gley and O Siebert 1903
First known product	Lithol Rubine [FIAT]
CAS (see note p. vii)	5858-81-1
EU No. (see note p. vii)	227-497-9



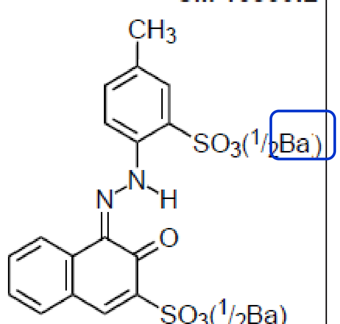
C.I. Pigment Red 57:1 — **C.I. 15850:1**

Hue	Red (tint pale reddish violet)
Chemical Class	Monoazo
Discoverer	R Gley and O Siebert 1903
First known product	Lithol Rubine [FIAT]
CAS (see note p. vii)	5281-04-9
EU No. (see note p. vii)	226-109-5



C.I. Pigment Red 57:2 — **C.I. 15850:2**

Hue	Bluish red
Chemical Class	Monoazo
Discoverer	R Gley and O Siebert 1903
CAS (see note p. vii)	17852-98-1
EU No. (see note p. vii)	241-806-4



Colorants – *Light Stability*

Chemical Class	Color Index	Days before Noticeable fade
Monozao Red Ba Salt	P.R. 53:1	4
Monoazo Red Sr Salt	P.R. 48:3	15
Diarylide Orange	P.O. 34	24
Diarylide Yellow	P.Y. 13	88
Monoazo Red Ca Salt	P.R. 48:2	88
Monoazo Yellow Ca Salt	P.Y. 62	162
Isindoline Yellow	P.Y. 139	236
Azocondensation Yellow	P.Y. 93	580
Quinacridone	P.V. 19	> 1000

Light Stability 0.2% Pigment with 2% TiO2 in PVC, Daylight in Northern Europe

Colorants – *Heat Stability*

Chemical Class	**Color Index**	**DE <2.0**
Monozao Red Ba Salt	P.R. 53:1	300
Monoazo Red Sr Salt	P.R. 48:3	250
Diarylide Orange	P.O. 34	200*
Diarylide Yellow	P.Y. 13	200*
Monoazo Red Ca Salt	P.R. 48:2	230
Monoazo Yellow Ca Salt	P.Y. 62	230
Isindoline Yellow	P.Y. 139	250
Azocondensation Yellow	P.Y. 93	280
Quinacridone	P.V. 19	300

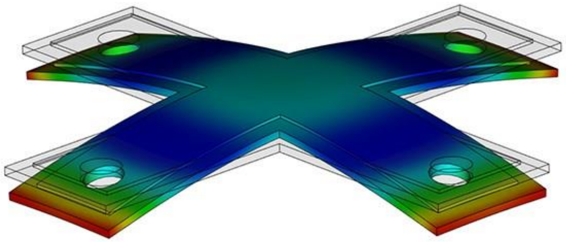
Heat Stability 0.1% Pigment with 1.9% TiO_2 in LDPE

Colorants – *Migration Resistance*

Chemical Class	Color Index	pPVC Migration
Monozao Red Ba Salt	P.R. 53:1	Yes
Monoazo Red Ba Salt	P.R. 48:1	No
Monoazo Red Ca Salt	P.R. 48:2	Yes
Monoazo Red Sr Salt	P.Y. 48:3	Yes
Diarylide Yellow	P.Y. 13	Yes
Monoazo Yellow Ca Salt	P.Y. 62	No
Isindoline Yellow	P.Y. 139	No
Benzimidazolone Yellow	P.Y. 151	Yes
Quinacridone	P.V. 19	No

Colorants – *Warpage*

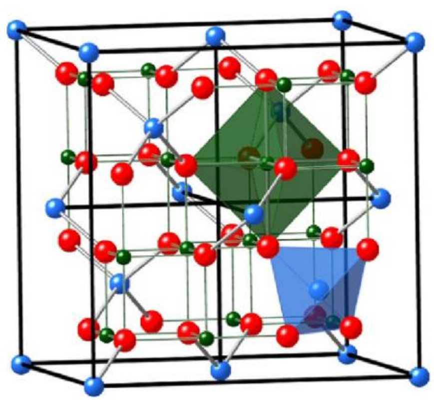
Chemical Class	Color Index	Nucleation Tendency
Monoazo Red Ca Salt	P.R. 48:2	No
Monoazo Yellow Ca Salt	P.Y. 62	Yes
Yellow	P.Y. 138	Yes
Benzimidazolone Yellow	P.Y. 151	No
Quinacridone	P.V. 19	Slight
Phthalocyanines	P.B. / P.G.	Yes



www.ptonline.com/articles/injection-molding-the-causes-of-warpage

Colorants – *Inorganic Pigments and Fillers*

Pigment Type	Examples
Precipitated Pigments	ZnS, Ce_2S_3 , $PbCrO_4$, CdS
Pyrolysis Pigments	Fe_2O_3, Mixed Metal Oxides, Spinels
Fillers	$BaSO_4$, $CaCO_3$



Unit Cells (Cages and Clusters)

Some heavy metal pigments have been phased out of use

Colorants – *Inorganic Pigments and Fillers*

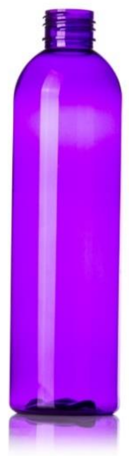
C.I. Pigment Red 101	**C.I. 77491** Fe_2O_3
Hue	Dull reddish orange → Dull yellowish red/Dull red → Dull bordeaux
Chemical Class	Inorganic
Classical Name	Red Haematite
First known product	Bauxite Red/Chinese Red
CAS (see note p. vii)	1309-37-1
EU No. (see note p. vii)	215-168-2
CPMA No.	3-06-7

C.I. Pigment White 22	**C.I. 77120** Barium sulfate $BaSO_4$
Hue	White
Chemical Class	Inorganic
Classical name	Barytes
CAS (see note p. vii)	7727-43-7
EU No. (see note p. vii)	231-784-4

Colorants – *Dyes*

Solvent Dyes / Disperse Dyes

- Solubilize in the polymer (PET, PS, etc.)
- High molar extinction coefficient
  (very chromatic)
- Transparent
  - Low to no light scattering
- Potential for bleeding (migration)
- High fastness to heat, light, weather (masstone transparent only)



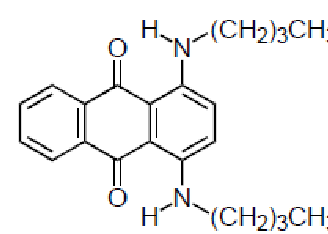
Colorants – *Dyes*

- Anthrapyridone
- Anthraquinone
- Azo
- Nigrosine
- Perinone
- Pyrazolone
- Quinoline
- Quinophthalone
- Xanthene

	C.I. Name	C.I. Number
	S.Y.163	58840
	S.Y.114	47020
	S.V.13	60725
	S.R.52	68210
	S.R.179	564150
	S.R.135	564120
	S.O.60	564100
	S.G.3	61565
	S.B.35	61554
	S.B.104	61568
	D.B.60	61104

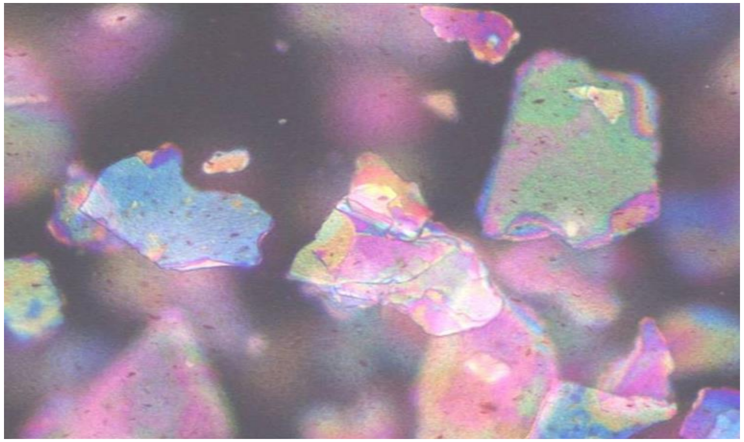
C.I. Solvent Blue 35 **C.I. 61554**

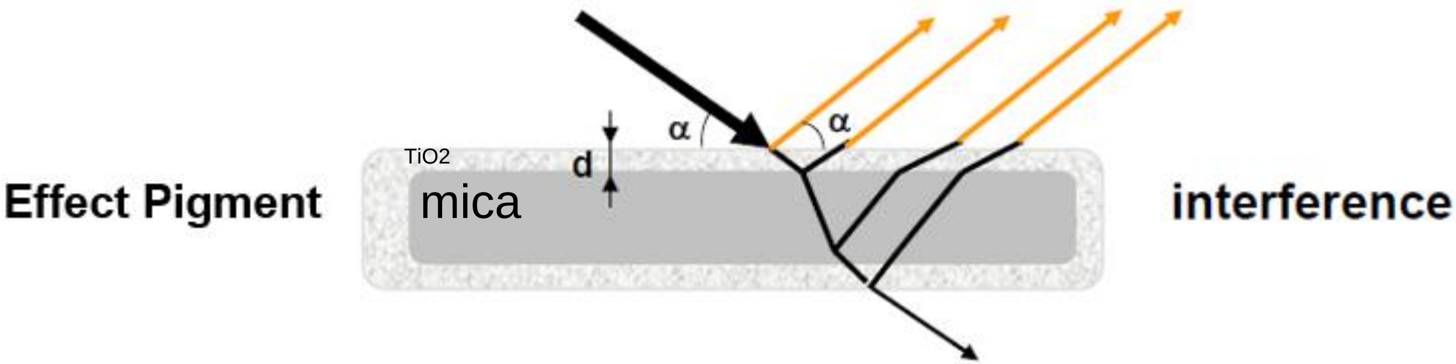
Hue	Bright greenish blue (NC lacquer)
Chemical Class	Anthraquinone
CAS (see note p. vii)	17354-14-2
EU No. (see note p. vii)	241-379-4



Colorants - *Interference*

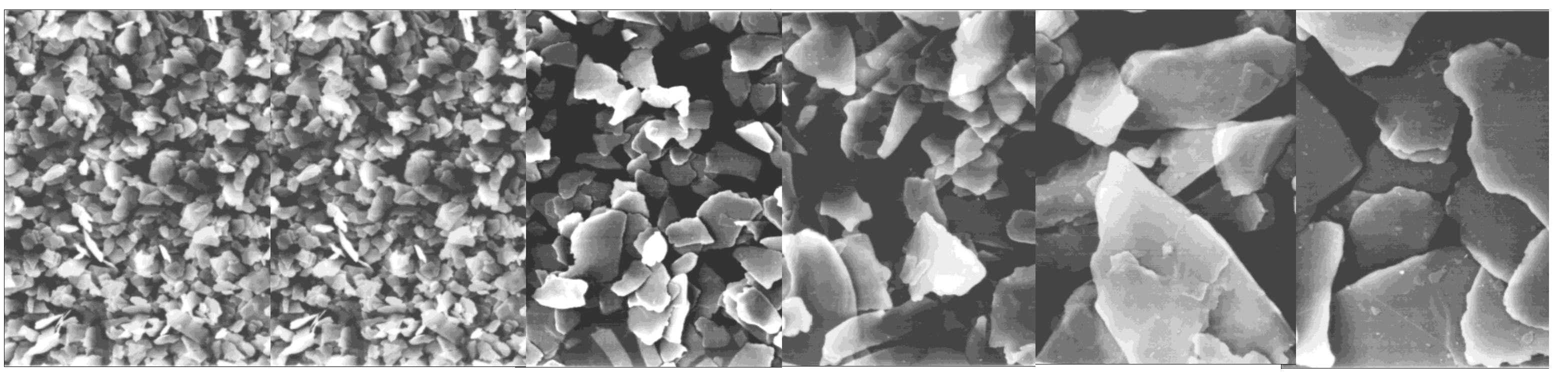
Effects, Pearlescent





Colorants - *Interference*

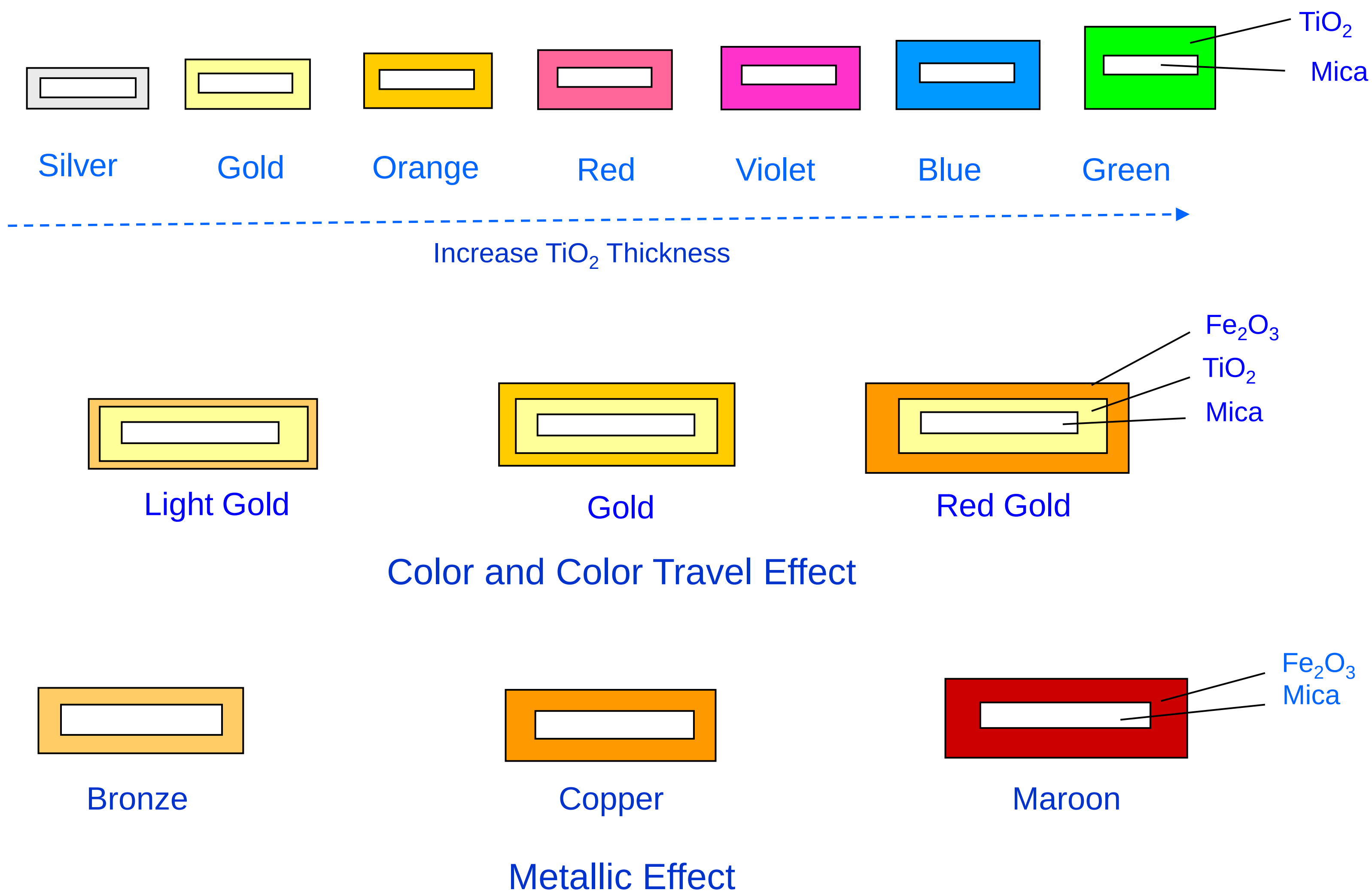
C.I. Pigment White 20	**C.I. 77019**
	Aluminium potassium silicate $H_2KAl_3(SiO_4)_3$
Hue	Off white
Chemical Class	Inorganic
Classical Name	Mica
CAS (see note p. vii)	12001-26-2



1-15µm 5-25µm 10-60µm 15-70µm 10-100µm 40-200µm

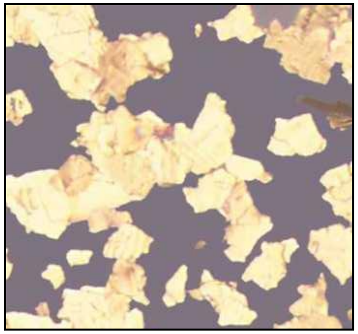
Increase in Hiding/Opacity

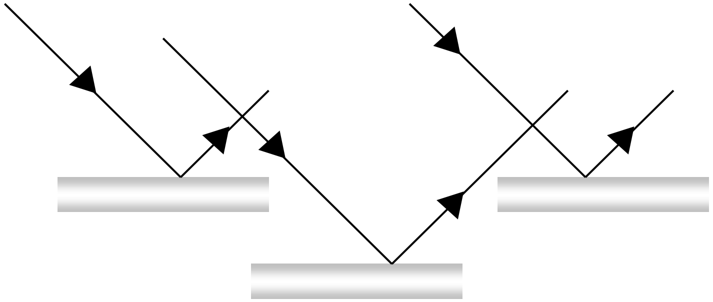
Colorants - *Interference*



Colorants - *Metallics*

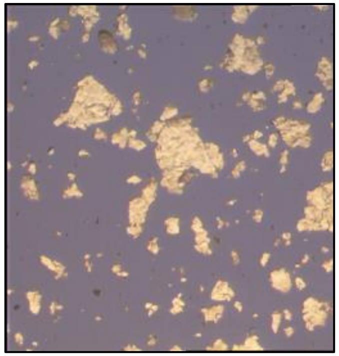
Reflecting



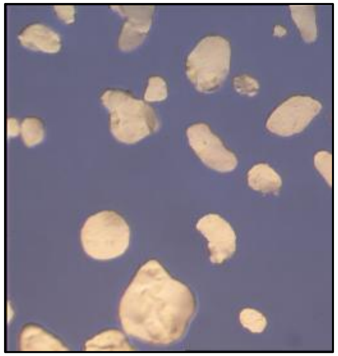


Colorants – *Metallics*

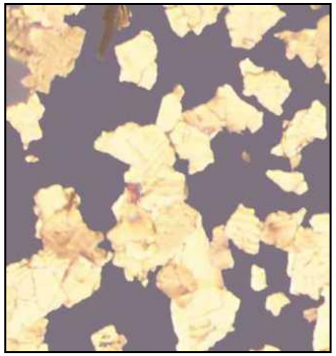
Pigment Type	Examples	Manufacturing Method
Elemental Pigments	Aluminum Zinc Bronze	Controlled combustion, Thermal/Mechanical decomposition, Metallurgical deposition processes



Cornflake



Silver Dollar



VMP

Colorants – *Metallics*

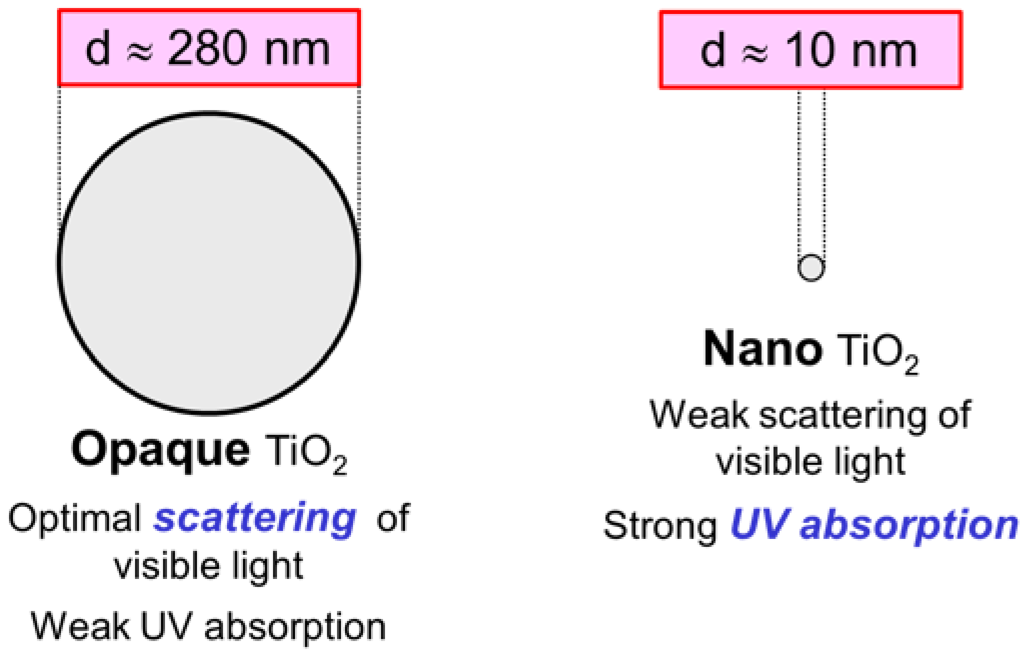
C.I. Pigment Metal 1	**C.I. 77000** Aluminium Al
Hue	Coloured with Basic dyes
Chemical Class	Inorganic
Classical Name	Metallic aluminium
CAS (see note p. vii)	7429-90-5
EU No. (see note p. vii)	231-072-3

C.I. Pigment Metal 2	**C.I. 77400** Copper Cu
Hue	Copper, Bronze
Chemical Class	Inorganic
First known product	Copper, Bronze powder
CAS (see note p. vii)	7440-50-8
EU No. (see note p. vii)	231-159-6

C.I. Pigment Metal 6	**C.I. 77945** Zinc Zn
Hue	Grey
Chemical Class	Inorganic
Classical Name	Zinc
First known product	Zinc, Zinc dust
CAS (see note p. vii)	7440-66-6
EU No. (see note p. vii)	231-175-3

Colorants – *White*

Inorganic

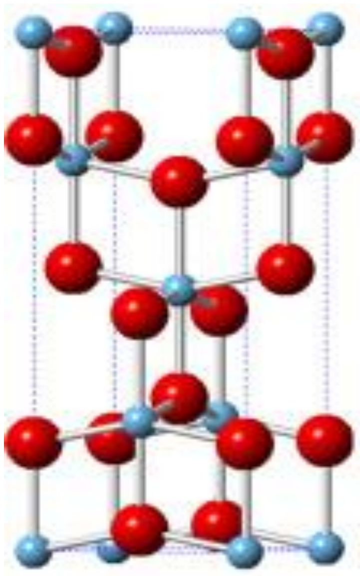


Optical properties of opaque and nano-sized TiO2 particles.

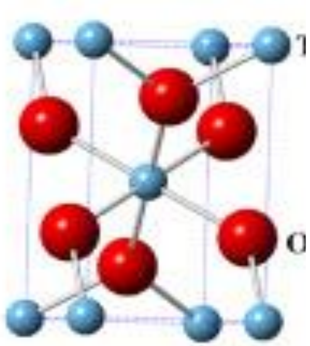
https://knowledge.ulprospector.com/6818/pc-transparent-inorganic-pigments-titanium-dioxide-iron-oxide/

Colorants – *White*

C.I. Pigment White 6	**C.I. 77891** Titanium dioxide TiO_2
Hue	Chalk white
Chemical Class	Inorganic
First known product	Titanium dioxide
CAS (see note p. vii)	13463-67-7
EU No. (see note p. vii)	236-675-5



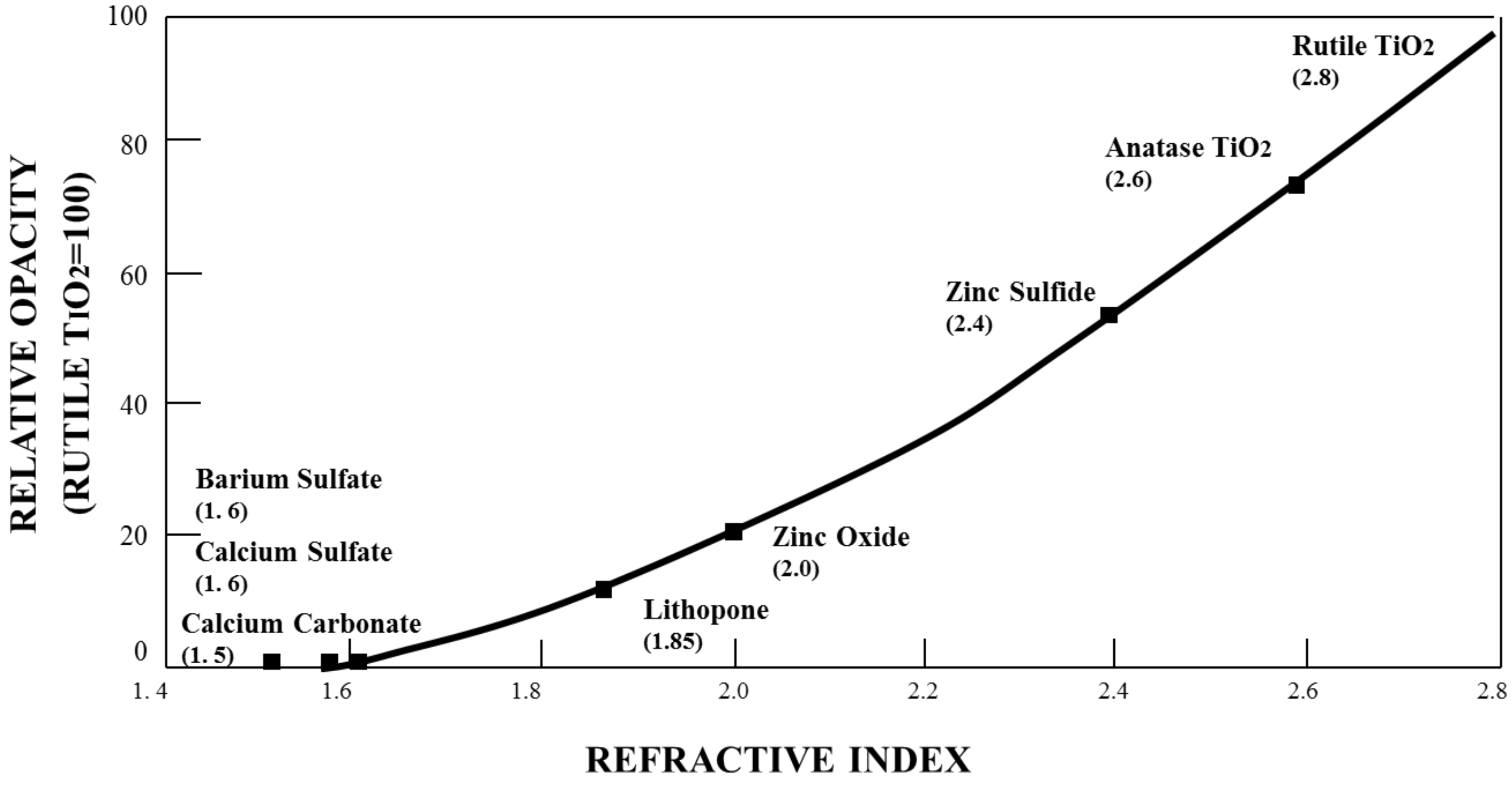
Anatase



Rutile

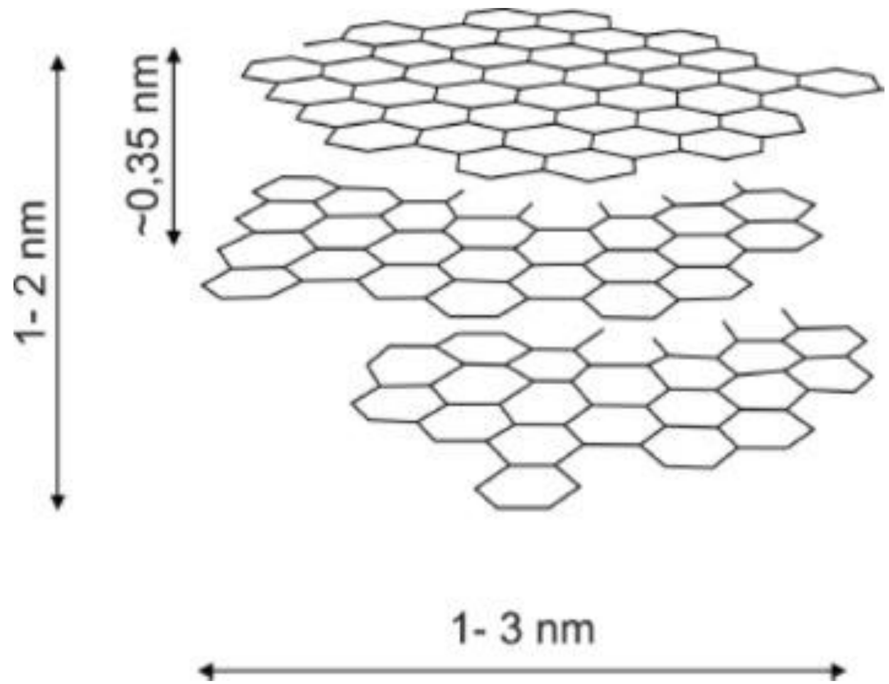
Colorants – *White*

Relative opacity of white pigments in plastics



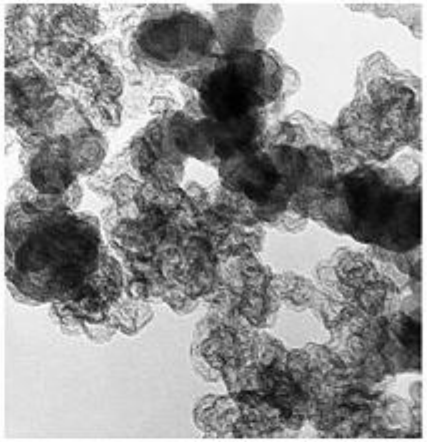
Colorants – *Black*

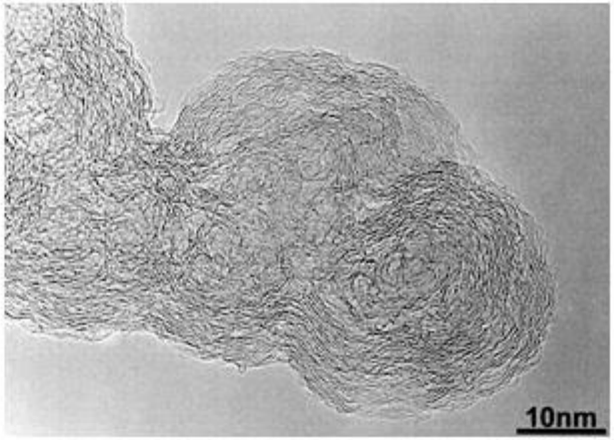
Organic



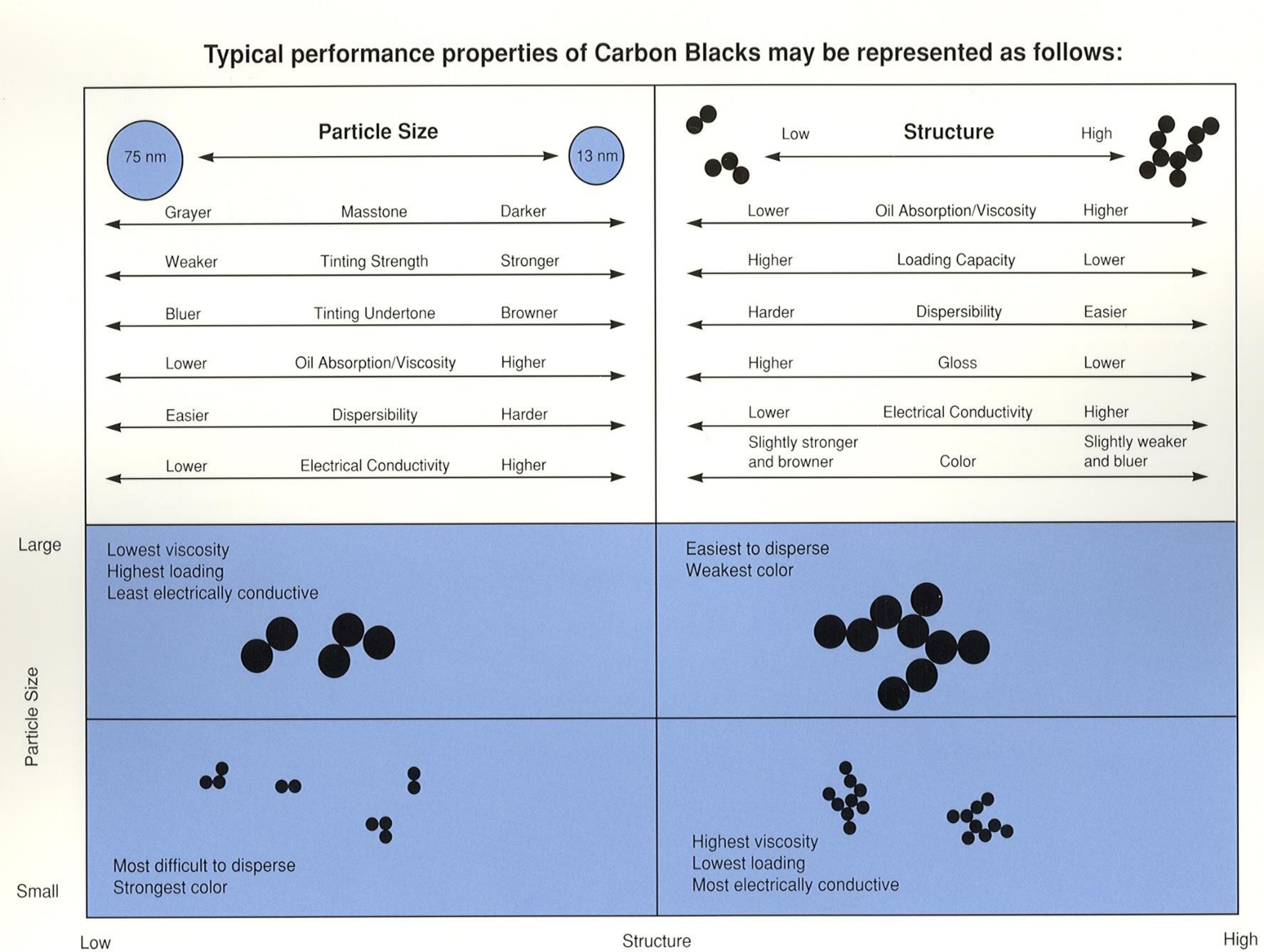
Colorants – *Black*

C.I. Pigment Black 7		**C.I. 77266**
		Almost pure carbon
Hue	Deep Brown/Blue/Grey → Deep black	
Chemical Class	Inorganic	
Classical name	Lamp black	
First known product	Carbon black	
CAS (see note p. vii)	1333-86-4	
EU No. (see note p. vii)	215-609-9	





Colorants – *Black*

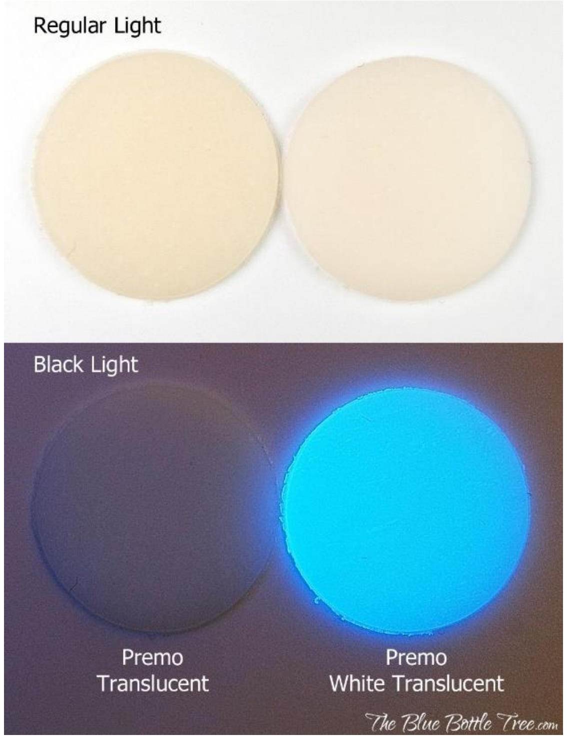


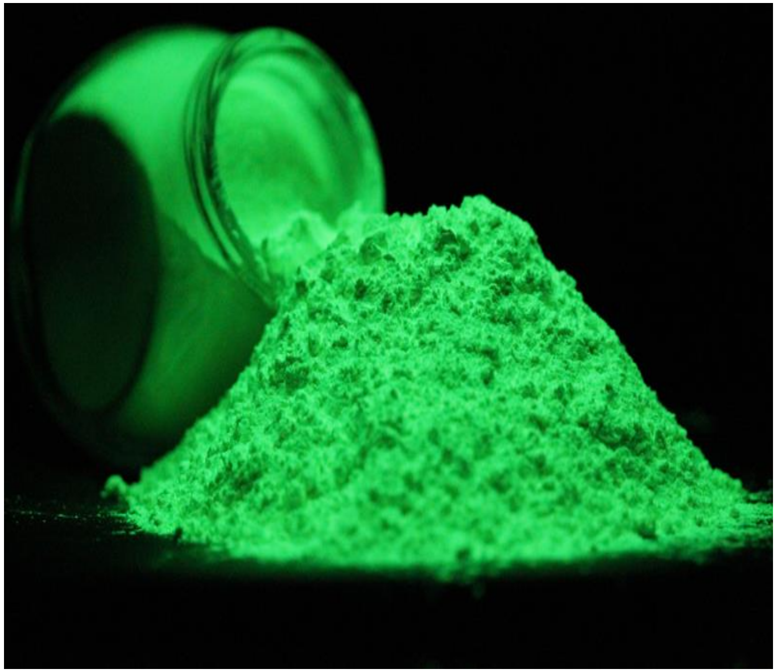
Colorants – *Black*

Inorganic

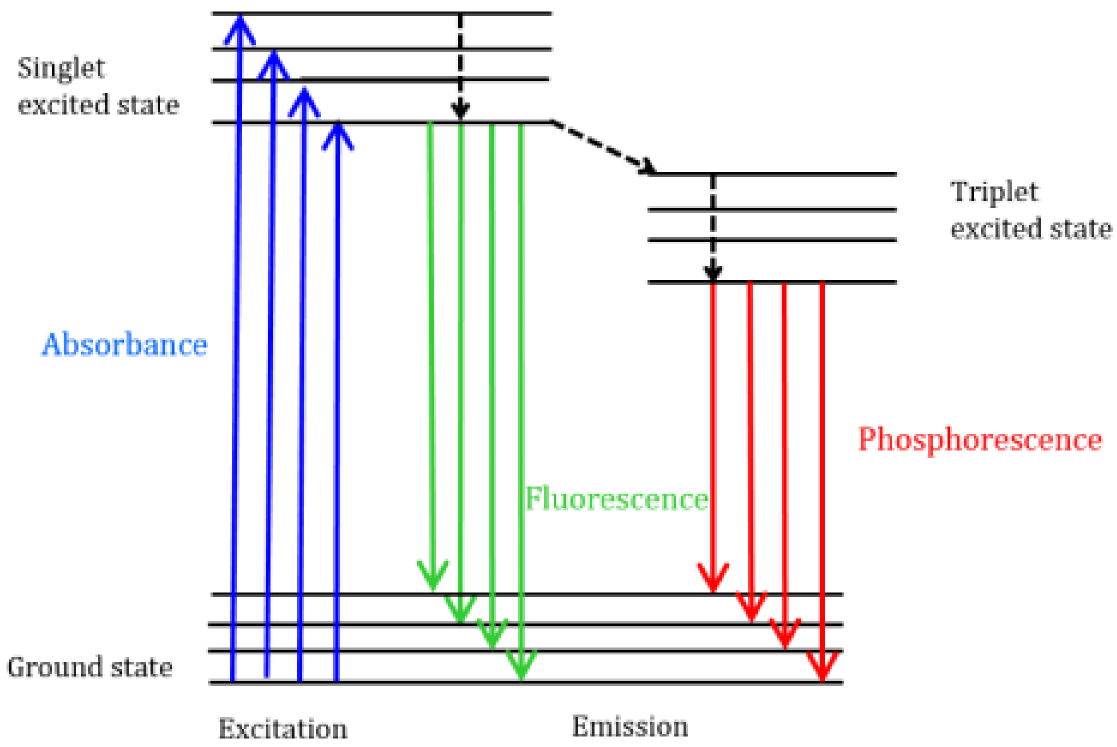
C.I. Pigment Black 26	**C.I. 77494**
	(FeMn), $(FeMn)_2O_4$
Hue	Black
Chemical Class	Inorganic
First known product	Manganese Ferrite Black Spinel FC
CAS (see note p. vii)	68186-94-7
EU No. (see note p. vii)	269-056-3
CPMA No.	13-41-9

Colorants – *Fluorescent*
– Phosphorescent





Colorants - *Emissions*

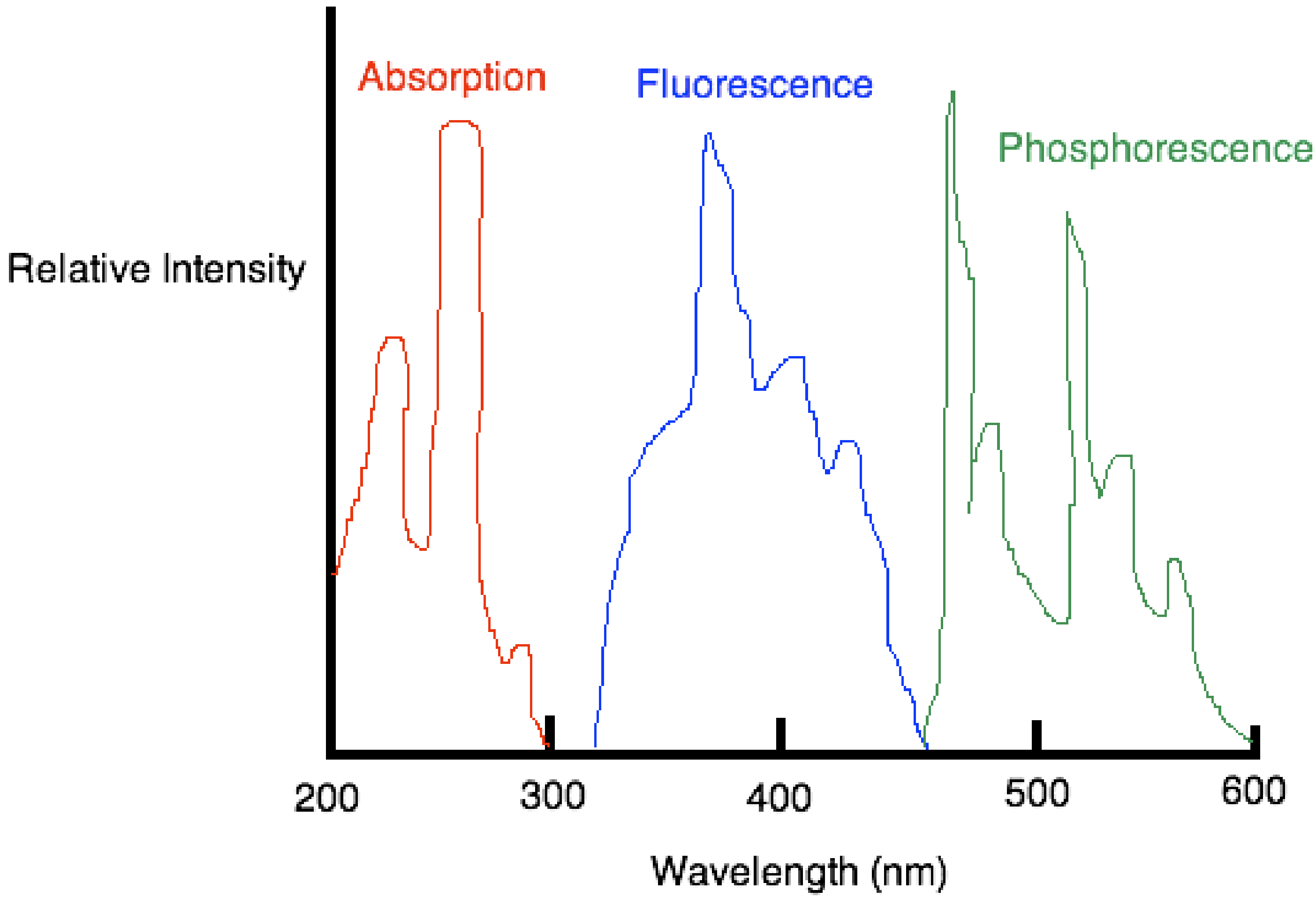


Jablonski diagram illustrating different transitions between a molecule's energy states.

Fluorescence - emissions in nanoseconds

Phosphorescence - emissions in milliseconds and higher

Colorants - *Emissions*

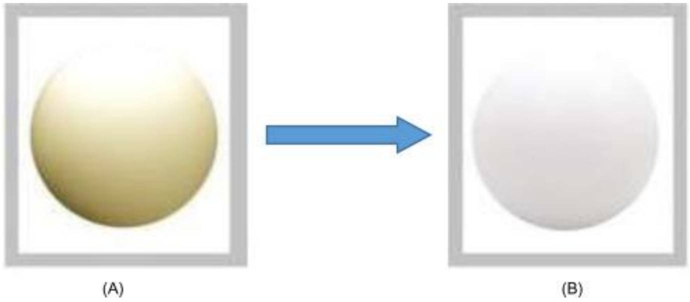


Colorants - *Fluorescent*

Organic

<u>OBA Class types (soluble)</u>

- Triazine- stilbene
- Coumarins
- Imidazolines
- Diazoles
- Triazoles
- Benzoxazolines
- Biphenyl stilbenes



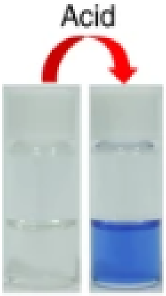
Colorants - *Phosphorescent*

Inorganic

C.I. Pigment White 7	**C.I. 77995**
	Zinc sulfide $ZnS.H_2O$
Hue	White
Chemical Class	Inorganic
Classical name	Zinc Sulphide White
CAS (see note p. vii)	1314-98-3
EU No. (see note p. vii)	215-251-3

Colorants – *Color Changing*

- Thermochromic
- Acidochromic
- Geochromic
- Photochromic



Colorants – *Considerations*

1. Color and Effect
2. Application
    1. Polymer Suitability
    2. Heat Stability
    3. Interactions formulations
    4. Indoor / Outdoor Light / Weather
3. Performance
    1. Migration Resistance
    2. Dispersibility (pressure rise fibers)
    3. Particle size (film transparency)
    4. Distortion (nucleation)
4. Compliance
    1. Food
    2. Toy
    3. Medical

Colorants – *Delivery Forms*

Forms	Comment
Dry Pigment	Most common form
Concentrate (SPD – Single Pigment Dispersion)	Pre-dispersed into a polymer (example – Polyethylene)
Liquid	Pre-dispersed into a fluid (example – mineral oil)
Paste	Surface Pacification (example – aluminums, mineral oil)
Pellet	Surface Pacification (example – aluminums, polyethylene)

End Section IV – Colorants

Return to Index

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Betty Puckerin, Ampacet Corporation

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