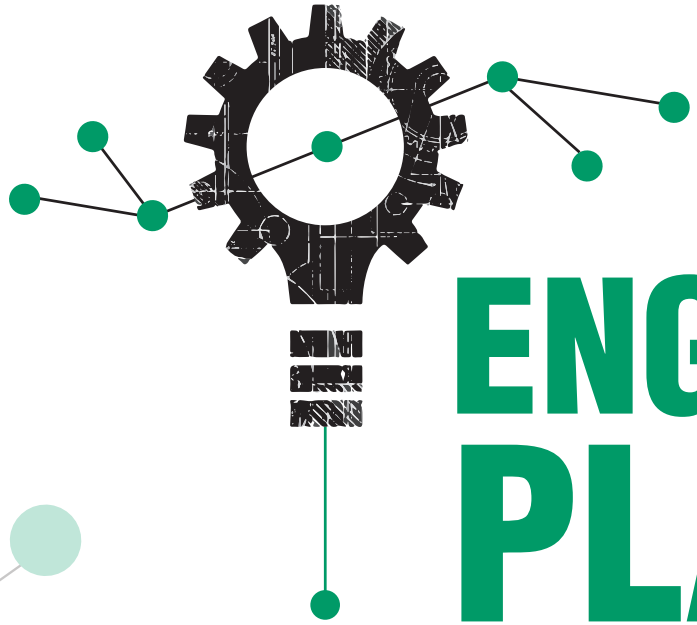


ENGINEERED PLASTICS WORKSHOP

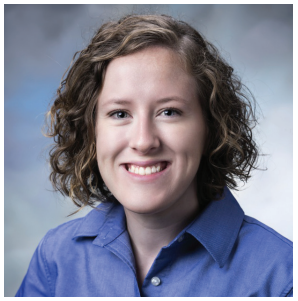
Learn About Thermoplastics I Connect with Experts

2017 **WESTBOROUGH / MASSACHUSETTS**
(BOSTON AREA)

YOUR GLOBAL COMPOUNDER OF
CUSTOM ENGINEERED THERMOPLASTICS

RTP Co.
Imagineering Plastics®

Light and Color:
Create. Control. Communicate.



Hannah Fiore | Color Development Engineer
hfiore@rtpcompany.com
(507) 474-5505

10:15 a.m.

COLOR • CONDUCTIVE • FILM/SHEET • FLAME RETARDANT
STRUCTURAL • THERMOPLASTIC ELASTOMERS • WEAR

Light and Color: Create. Control. Communicate.

Hannah Fiore
Color R&D Engineer

rtpcompany.com • rtp@rtpcompany.com

TOPICS

- Brief introduction to RTP Company Color Division
- Color Fundamentals
  - Three Sciences of Color
  - Evaluation & Control
  - Effective Color Communication
- Beyond the Visible Light
  - Laser Welding
  - Laser Marking
- Questions

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RTP COMPANY COLOR DIVISION

Color virtually all resins

- Engineering resins
- Styrenic resins
- Polyolefin resins

Color in multiple formats

- Masterbatches
- Precolored resins
- Cube blends

Advanced Color Development

- Custom colors
- Multiple light sources
- Regulatory knowledge
  - UL, FDA, USP, RoHS, etc.

GLOBAL COLOR CONSISTENCY

Color Lab Locations

- USA - Winona, MN; Indianapolis, IN; Fort Worth, TX
- Monterrey, Mexico
- Beaune, France
- Shenzhen and Suzhou, China
- Singapore

Color Control

- Consistent raw materials
- Identical hardware and software
- Global database

Speed

- Fast color matching service
- Transfers across regions

COLORING OPTIONS

Masterbatches

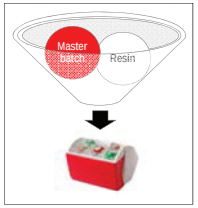
- Concentrated formulation of colorants and/or additives dispersed in a polymer carrier
- Usage defined by let-down ratio or percentage
- Most widely used form to color commodity resins

Precolor

- Colorants are added to the polymer and extruded
- Ready to use as-is

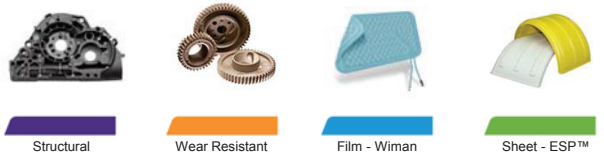
Cube blend

- Masterbatch is blended with resin
  - Two or more pellet solution



PRODUCT FAMILIES

Compounds formulated to meet performance requirements, from one property to multiple technologies



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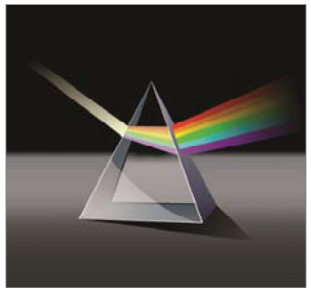
COLOR SCIENCE

Biology
- Color perception

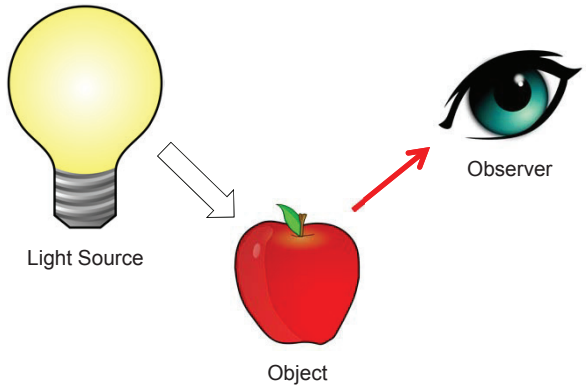
Physics
- Light interactions

Chemistry
- Colorants



BIOLOGY

How do we see color?



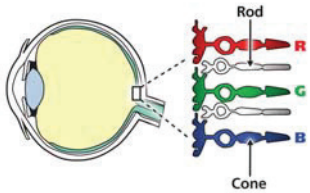
BIOLOGY

Optical nerve sends signal to brain for decoding

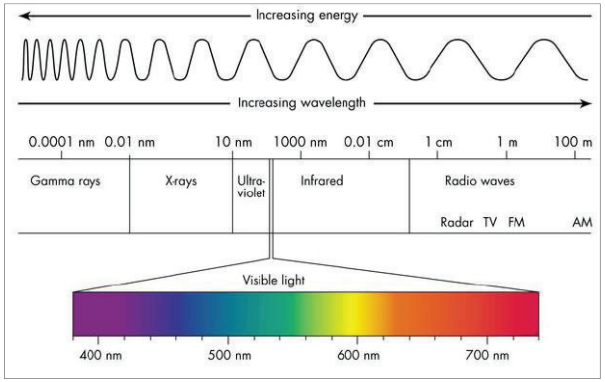
Photoreceptors

Rods
- Vision at low light levels

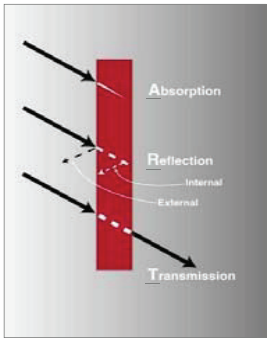
Cones
- Sensitive to three colors



PHYSICS



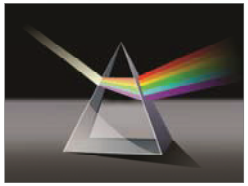
PHYSICS

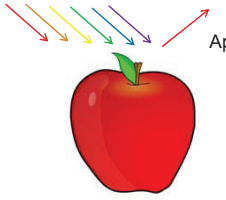


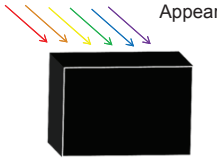
PHYSICS

White light is made up of all wavelengths of visible light.

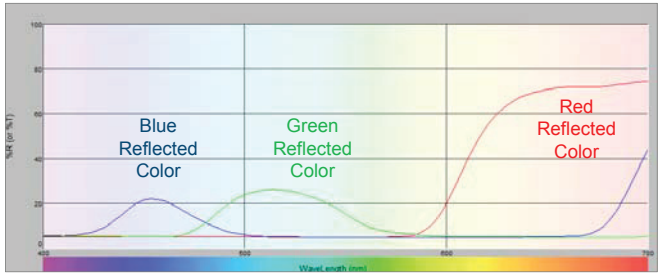
It is separated into individual colors when light passes through a glass prism.







PHYSICS



- Spectral reflectance curves produced by spectrophotometer
- Graph shows light reflected from an object at each wavelength
- Each color has a unique spectral curve

CHEMISTRY

Colorant Types

Pigments

- Particles suspended in matrix
- Inorganic - made from various metals or other materials from nature
- Organic - made synthetically

Dyes

- Soluble in polymer
- Organic

CHEMISTRY

Pigment Types & Limitations

Organic Pigments

- Small particle size
- Difficult to disperse
- Limited heat stability
- High color strength
- Light fastness

Inorganic Pigments

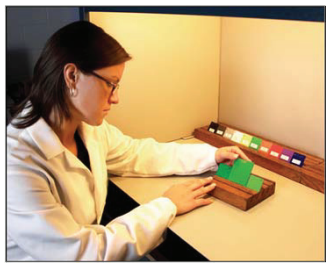
- Large particle size
- Easy to disperse
- Heat stable
- Weak color strength
- Improved light fastness

CHEMISTRY

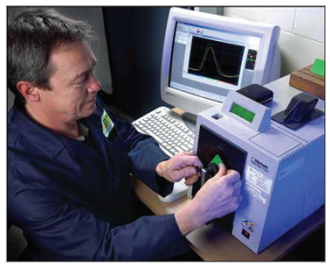
Dyes

- Soluble
  - Migration concerns
- High color strength
- Transparent
- Commonly used in:
  - Styrenic Resins
  - Engineering Resins

COLOR EVALUATION & CONTROL



Visual Color Evaluation



Instrumental Color Evaluation

VISUAL COLOR EVALUATION

Observer
- Each person sees color uniquely

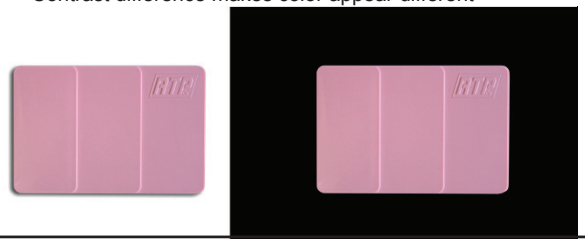
Light Source
- Different spectral distributions (D65, CWF, Incandescent)

VISUAL COLOR EVALUATION

Observer
- Each person sees color uniquely

Light Source
- Different spectral distributions (D65, CWF, Incandescent)

Background
- Contrast difference makes color appear different



VISUAL COLOR EVALUATION

Observer
- Each person sees color uniquely

Light Source
- Different spectral distributions (D65, CWF, Incandescent)

Background
- Contrast difference makes color appear different

Viewing Angle
- Most common 45°

Keep viewing conditions **CONSTANT**

INSTRUMENTAL COLOR EVALUATION

Numeric Color Modeling

Numeric model provides
- 3 dimensional color space
- Quantify colors numerically
- Can be used for specification, identification, comparison, tolerancing

Several Color Spaces
- CIE 1931 Yxy
- CIE L*a*b* 1976
- CIE LCh
  - CMC l:c 1984

COMMON COLOR TERMS

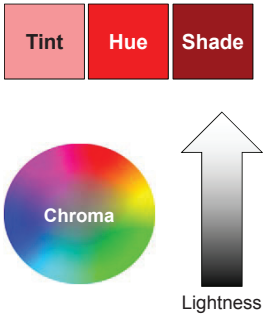
Hue
- Color perceived

Chroma
- Saturation
- Vividness of a color

Lightness
- Measure of brightness
- Luminance

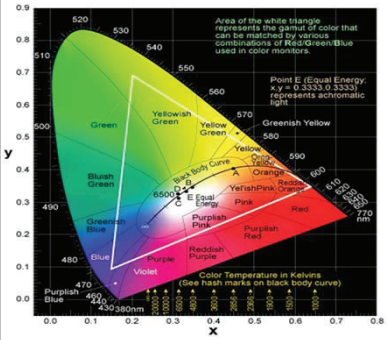
Tint
- Hue has been lightened

Shade
- Hue has been darkened



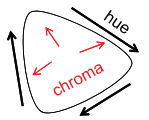
COLOR SPACE

CIE 1931 Yxy



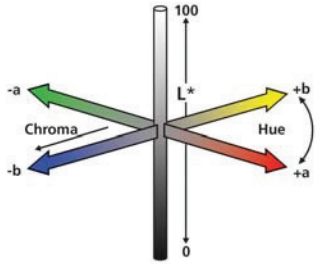
Non-Uniform Color Space

- Numeric values
  - Y = luminance
  - x, y = chromaticity values
- Only chromaticity values shown
- Measures the transmissivity and chromaticity of a color
- Hue changes around color gamut
- Chroma increases from center outward



COLOR SPACE

CIE L*a*b* 1976 Model



$(L_1^*, a_1^*, b_1^*)\ and\ (L_2^*, a_2^*, b_2^*)$

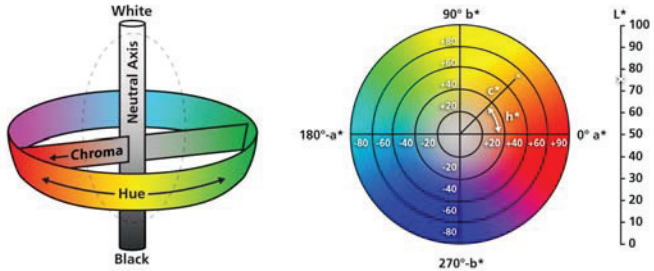
$$\Delta E^* = \sqrt{(L_2^* - L_1^*)^2 + (a_2^* - a_1^*)^2 + (b_2^* - b_1^*)^2}$$

- Numeric values
  - L* = lightness to darkness (100-0)
  - a* = redness to greenness
  - b* = yellowness to blueness
  - ΔE* = total color shift
- Traditional X-Y-Z coordinate system
- Most popular color space
- Uniform color space

COLOR SPACE

CIE LCh Model

cylindrical coordinates r, Φ, z

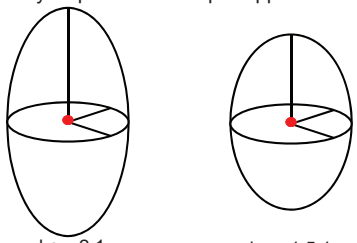


Lightness	Chromaticity	Hue
$L = L$	$C = \sqrt{a^2 + b^2}$	$h° = tan^{-1}(\frac{b}{a})$

COLOR SPACE

CMC l:c (1984)

- Used for tolerancing
- l:c (lightness:chromaticity) values are typically 2:1
- Provides better agreement between visual and instrumental assessment
- Allows user to vary ellipse tolerance per application



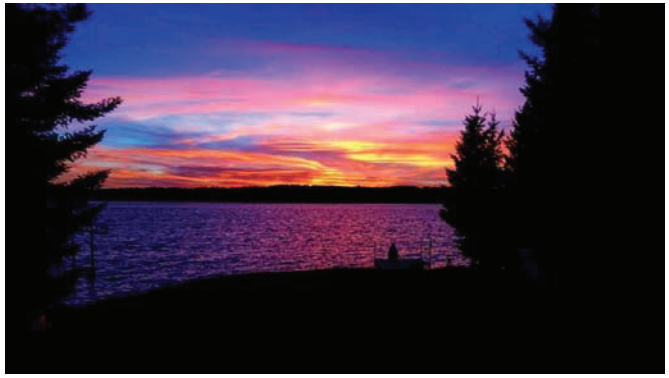
l:c = 2:1

l:c = 1.5:1

TOLERANCES

- Tolerances are developed around variation in raw materials, processing, customer goals for visual appearance
- Asymmetrical color tolerances are perfectly acceptable to use

COLOR COMMUNICATION



It's important to specify all targets through color communication

APPLICATION REQUIREMENTS/TARGET

Application Requirements:

- Resin/compound
- Regulatory restrictions
- Processing method
- Secondary operations

Color Target

Physical Color

Grass Green
Pantone: 347

Color Reference

L* = 43
a* = -22.9
b* = 26.21

Color Space Values

SATISFYING EXPECTATIONS

Color Nomenclature

- Identifies both regulatory and formulation commitment

Lot Control

- Ingredient traceability

Process Control

- Defined manufacturing specifications
- Engineering review during development
- Contributes to consistency

Color Quality Control

- Color meets defined requirements
- Physical properties

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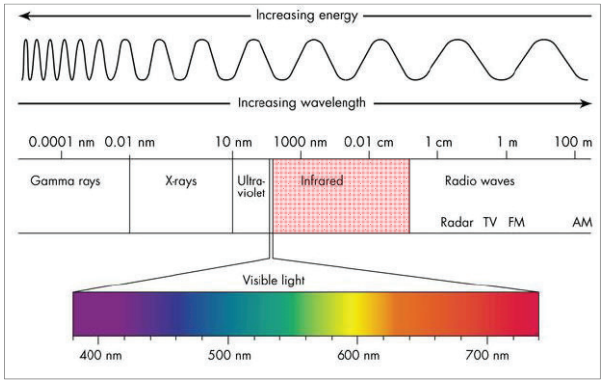
  - Laser Marking
- Questions

LASER WELDING

Beyond Visible Light – IR/NIR

- Utilizes the infrared (IR) and near infrared (NIR) spectrums
  - Active 700 – 2500 nm range
- Combination of light controlling attributes
- Transparent or opaque at specific wavelengths
- Commonly used in:
  - Fiber optics
  - Transmitters/receivers

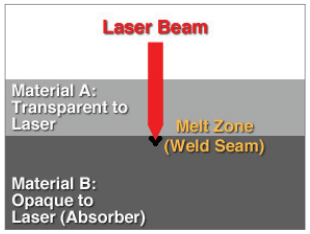
LASER WELDING



LASER WELDING

Requires materials with different NIR behavior

Method for joining thermoplastic parts by using the power of the laser to bond materials



LASER WELDING

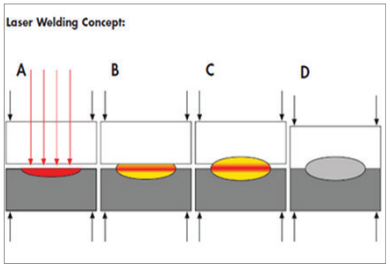
Mechanism

A. Light transmits through upper material and is absorbed by lower material

B. Melting pool is created

C. Heats upper layer

D. Melting pool solidifies under external pressure



LASER WELDING

Resin Types

IR Transparent:

Amorphous Resins
- Require the least amount of energy

Semi-Crystalline
- Require more energy due to scattering

Welding challenges
- PEEK, LCP, PPS, etc.

Highly crystalline materials have significant scatter, therefore require a higher amount of energy

IR Absorbing:

All resins…
- Amorphous
- Semi-Crystalline

Need IR Absorbing colorants

LASER WELDING

Additive Types

IR Reducing:

Glass fibers
Glass beads
Colorants
Various additives
- UV stabilizers, heat stabilizers, etc.

IR Blocking:

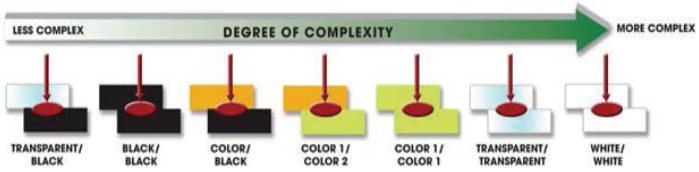
Carbon fiber
Minerals
Metals

Part thickness and laser frequency also determine material transmissivity

LASER WELDING

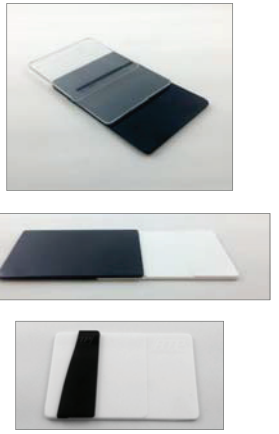
Degree of Complexity

- RTP Company has experience with pigment/filler combinations, and loading levels, to support successful welding using both Diode and Nd:YAG lasers
- Color combinations influence complexity of formulation



LASER WELDING

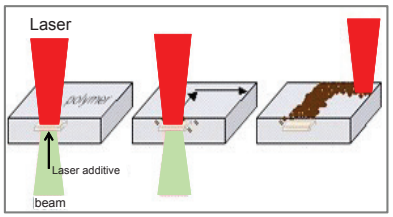
- Weld complex parts
- No flash is produced
- High-precision joints can be produced (Hermetic seals)
- Resins of different compositions can be joined
- No consumables
- No adhesives



LASER MARKING

Basic mechanism

Laser energy absorbed causing a reaction
- Charring (dark mark)
- Foaming (light mark)
- Ablation (removal of layer, ex. Paint)



LASER MARKING

One Light Source

Charring produces dark marks

Foaming produces light marks

No Universal Additives
- Can be combined with other additive technologies
- Unique colors achievable

Marks vary with resin, additive, and color package

LASER MARKING

What gives the highest contrasting mark?

Black resin color with light marks:

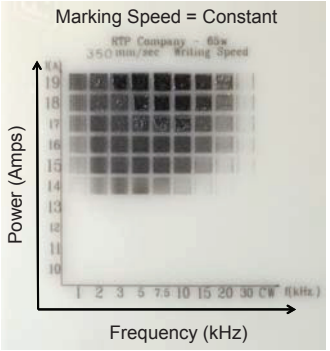
- PP (Olefins)
- Nylon
- ABS (Specific Grades)
- POM
- PMMA
- And more

LASER MARKING

Type of laser and marking parameters will influence quality of mark.

Nd:YAG *(Neodymium doped Yttrium Aluminum Garnet)* is the best compromise of…

- Speed
- Flexibility
- Marking quality



LASER MARKING

- Eliminates the need for pad printing or labeling
- Laser marker has no contact with part
- Most durable

SUMMARY

Create

- RTP Company supplies innovative colors and functional additives to assist you in the creation of your application
- Logos and designs can be created on your part using laser marking

Control

- Our color formulas are controlled by raw materials choices and internal and customer tolerances
- Laser welding of two materials can be done by controlling their IR transmissivity

Communicate

- Effective color communication is crucial for color matching and tolerancing


COLOR • CONDUCTIVE • FILM/SHEET • FLAME RETARDANT
STRUCTURAL • THERMOPLASTIC ELASTOMERS • WEAR
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Hannah Fiore
hfiore@rtpcompany.com
(507) 474-5505
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