

ENGINEERED PLASTICS WORKSHOP

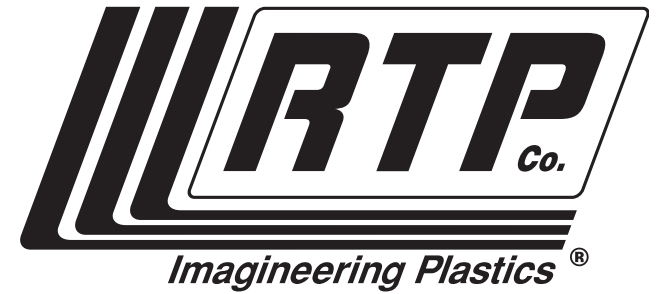
Learn About Thermoplastics | Connect with Experts

2017

**KING OF PRUSSIA / PENNSYLVANIA
(PHILADELPHIA AREA)**

**YOUR GLOBAL COMPOUNDER OF
CUSTOM ENGINEERED THERMOPLASTICS**





○ **Light and Color:
Create. Control. Communicate.**



○ **Hannah Fiore** | Color Development Engineer
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○ **10:15 a.m.**

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

**Light and Color:
Create. Control. Communicate.**

Hannah Fiore
Color R&D Engineer

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RTP 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 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.



RTP 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

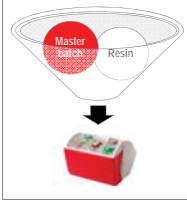
- Fast color matching service
- Transfers across regions




RTP 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




RTP PRODUCT FAMILIES

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

 Color	 Conductive	 Flame Retardant	 Thermoplastic Elastomers
 Structural	 Wear Resistant	 Film - Wiman	 Sheet - ESP™

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RTP COLOR SCIENCE

Biology


- Color perception

Physics

- Light interactions

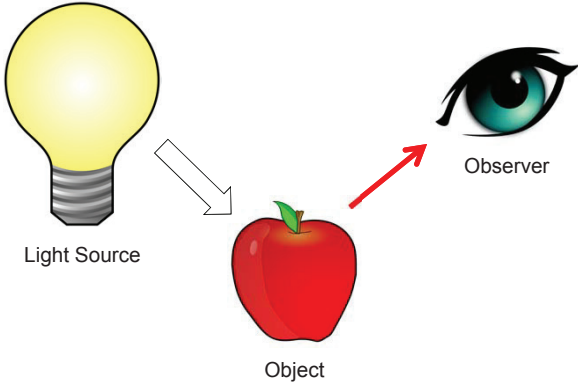
Chemistry

- Colorants



RTP BIOLOGY

How do we see color?



Light Source

Object

Observer

RTP BIOLOGY

Optical nerve sends signal to brain for decoding

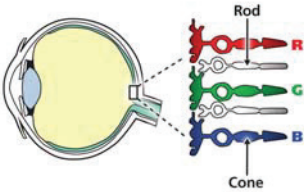
Photoreceptors

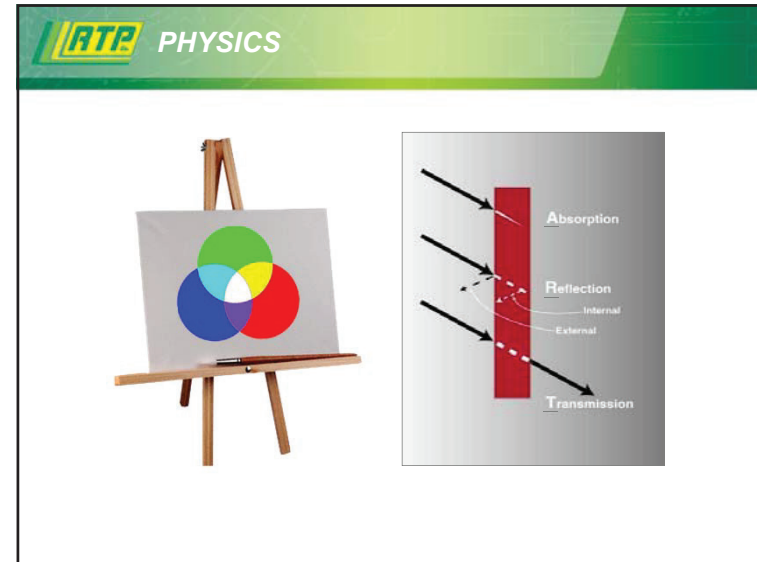
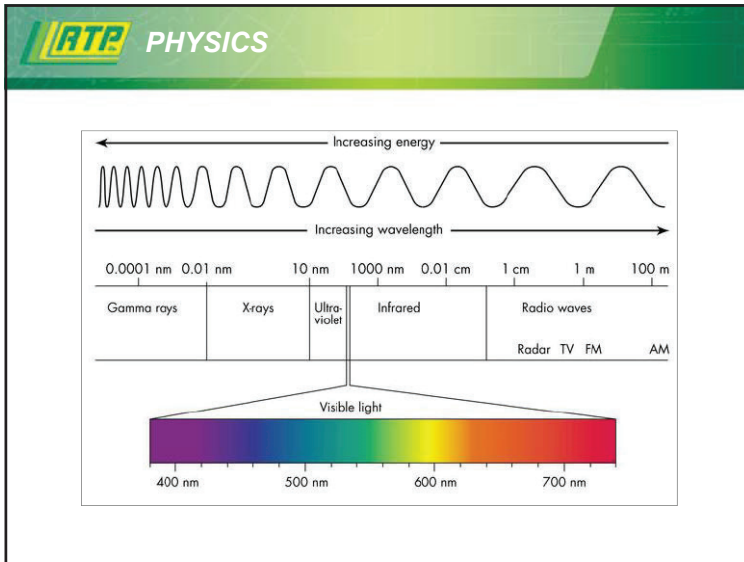
Rods

- Vision at low light levels

Cones

- Sensitive to three colors





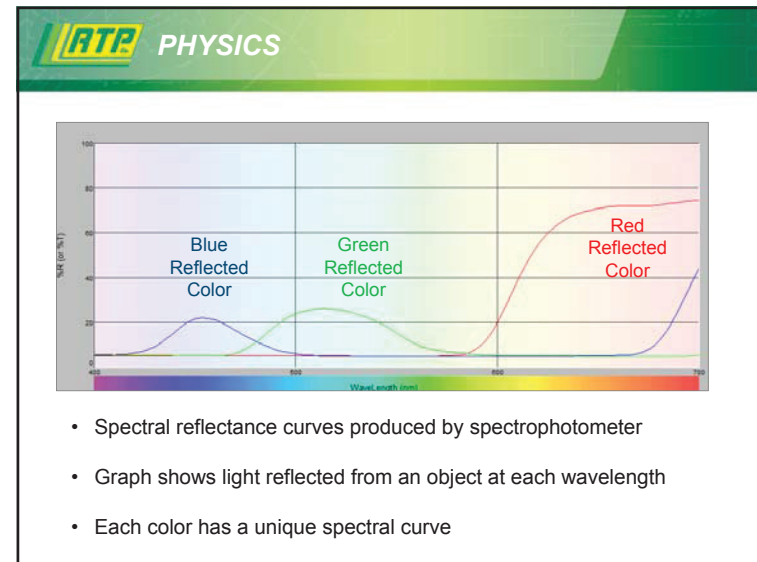
RTP PHYSICS

White light is made up of all wavelengths of visible light. It is separated into individual colors when light passes through a glass prism.

Appears red: A red apple with light rays hitting it.

Appears black: A black object with light rays hitting it.

Black object




RTP 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



RTP CHEMISTRY

Pigment Types & Limitations

Organic Pigments	Inorganic Pigments
<ul style="list-style-type: none"> • Small particle size • Difficult to disperse • Limited heat stability • High color strength • Light fastness 	<ul style="list-style-type: none"> • Large particle size • Easy to disperse • Heat stable • Weak color strength • Improved light fastness

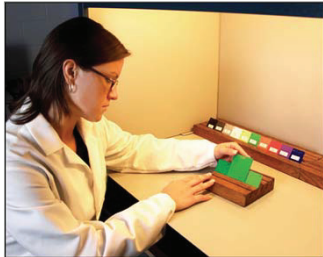
RTP CHEMISTRY

Dyes

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




RTP COLOR EVALUATION & CONTROL



Visual Color Evaluation



Instrumental Color Evaluation

RTP VISUAL COLOR EVALUATION

Observer

- Each person sees color uniquely

Light Source

- Different spectral distributions (D65, CWF, Incandescent)

Daylight Incandescent Horizon Cool White Ultra Violet

RTP VISUAL COLOR EVALUATION

Observer

- Each person sees color uniquely

Light Source

- Different spectral distributions (D65, CWF, Incandescent)

Background

- Contrast difference makes color appear different

RTP 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

RTP 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

RTP 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

RTP COLOR SPACE

CIE 1931 Yxy

Area of the white triangle represents the gamut of color that can be matched by various combinations of Red/Green/Blue used in color monitors.

Point E (Equal Energy; x=y=0.333, 0.333) represents achromatic light.

Color Temperature in Kelvins (See hash marks on black body curve)

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

RTP COLOR SPACE

CIE L*a*b* 1976 Model

- 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

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

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

RTP COLOR SPACE

CIE LCh Model

cylindrical coordinates r, Φ , z

White
Neutral Axis
Black

Lightness
 $L = L$

Chromaticity
 $C = \sqrt{a^2 + b^2}$

Hue
 $h^\circ = \tan^{-1}\left(\frac{b}{a}\right)$

RTP 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

RTP TOLERANCES

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

RTP COLOR COMMUNICATION

It's important to specify all targets through color communication

RTP 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


RTP 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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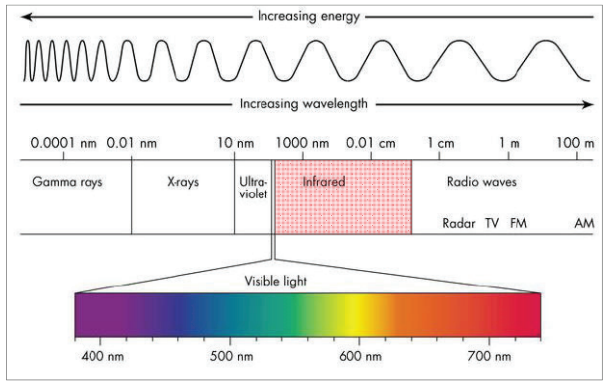


RTP LASER WELDING

- 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



RTP LASER WELDING



The diagram illustrates the electromagnetic spectrum with two scales: 'Increasing energy' (pointing left) and 'Increasing wavelength' (pointing right). The wavelength scale includes 0.0001 nm, 0.01 nm, 10 nm, 1000 nm, 0.01 cm, 1 cm, 1 m, and 100 m. The spectrum is divided into Gamma rays, X-rays, Ultra-violet, Infrared, and Radio waves. The Infrared region is highlighted with a red grid. Below the main spectrum, the 'Visible light' spectrum is expanded, showing colors from 400 nm (violet) to 700 nm (red). Radio waves are further categorized as Radar, TV, FM, and AM.

RTP LASER WELDING

Requires materials with different NIR behavior

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

Laser Beam

Material A: Transparent to Laser

Material B: Opaque to Laser (Absorber)

Melt Zone (Weld Seam)

RTP 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 Concept:

A B C D

RTP LASER WELDING

Resin Types

<p>IR Transparent:</p> <p>Amorphous Resins</p> <ul style="list-style-type: none"> Require the least amount of energy <p>Semi-Crystalline</p> <ul style="list-style-type: none"> Require more energy due to scattering <p>Welding challenges</p> <ul style="list-style-type: none"> PEEK, LCP, PPS, etc. <p>Highly crystalline materials have significant scatter, therefore require a higher amount of energy</p>	<p>IR Absorbing:</p> <p>All resins...</p> <ul style="list-style-type: none"> Amorphous Semi-Crystalline <p>Need IR Absorbing colorants</p>
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RTP LASER WELDING

Additive Types

<p>IR Reducing:</p> <p>Glass fibers</p> <p>Glass beads</p> <p>Colorants</p> <p>Various additives</p> <ul style="list-style-type: none"> UV stabilizers, heat stabilizers, etc. 	<p>IR Blocking:</p> <p>Carbon fiber</p> <p>Minerals</p> <p>Metals</p>
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Part thickness and laser frequency also determine material transmissivity

RTP 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

LESS COMPLEX → DEGREE OF COMPLEXITY → MORE COMPLEX

TRANSPARENT/BLACK, BLACK/BLACK, COLOR/BLACK, COLOR 1/COLOR 2, COLOR 1/COLOR 1, TRANSPARENT/TRANSPARENT, WHITE/WHITE

RTP 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

RTP LASER MARKING

Basic mechanism

→

Laser energy absorbed causing a reaction

- Charring (dark mark)
- Foaming (light mark)
- Ablation (removal of layer, ex. Paint)

Laser, Laser additive, beam

RTP 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

RTP LASER MARKING

What gives the highest contrasting mark?

Black resin color with light marks:

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

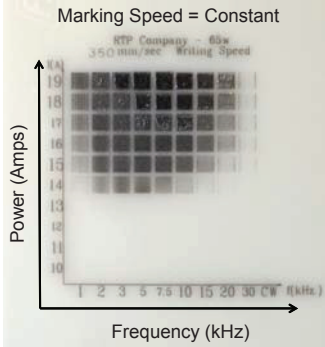


RTP LASER MARKING

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



RTP LASER MARKING

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



RTP 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



Thank You!

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