

Bringing Color to your designs with Masterbatch Advanced Solutions

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Agenda

1. Introduction
2. Color Science
3. Masterbatch
4. Color Effects
5. Coloring of Recyclates
6. Design for Circularity





ADVANCED POLYMER SOLUTIONS

Our diverse portfolio is used to create customizable products including:



Reduced GHG emissions & improved fuel economy



Delivering potable water



Quality healthcare



Agricultural efficiency



Food safety & access



Sustainable & modern living

Catalloy

Polybutene-1

Specialty Powders

Polypropylene Compounds

Engineered Composites

Engineered Polymers

Color Concentrates

Masterbatches

Global Masterbatch Asset Footprint



- Global production network with 20 masterbatch manufacturing sites
- Masterbatch technology centers in each region
- Local color development centers with application

specialty

- Standardized manufacturing and laboratory process providing flexible and consistent service
- Extensive materials expertise, analytical laboratories and pilot process capability to support customer

developments and innovation

- Certified quality standards; supporting global regulatory requirements

Masterbatch & Color Concentrates

Application Areas



Packaging



Building & Construction



Transportation



Agriculture



Consumer Goods



Appliances

Key Properties

Processing Additives	Functional Properties	Optical Appearance & Aesthetics
<ul style="list-style-type: none">▪ Anti-oxidant▪ Processing aid, Lubricant	<ul style="list-style-type: none">▪ Slip, Anti-blocking, De-nesting, Release agent▪ Anti-static, Anti-fog▪ Filler, Nucleating agent, Blowing agent, Flame retardant,▪ UV stabilizer, Anti-oxidant, UV and IR absorber	<ul style="list-style-type: none">▪ White, Black▪ Matt, Synthetic paper, Soft-touch▪ Colors, Pearlescent, Metallic

Core portfolio:

Our Masterbatch portfolio addresses modern customer needs

- *Polybatch* Color Concentrates: Standard Colors, Custom Colors, Special Effects
- *Polyblak* Black
- *Polywhite* White
- *Polybatch* Additives

Advanced Solutions addressing:

Plastic Waste / Climate Change / Thriving Society

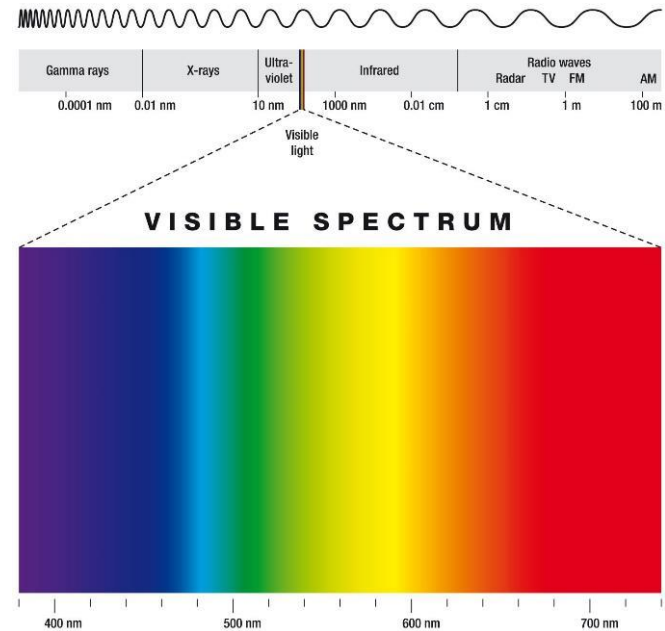
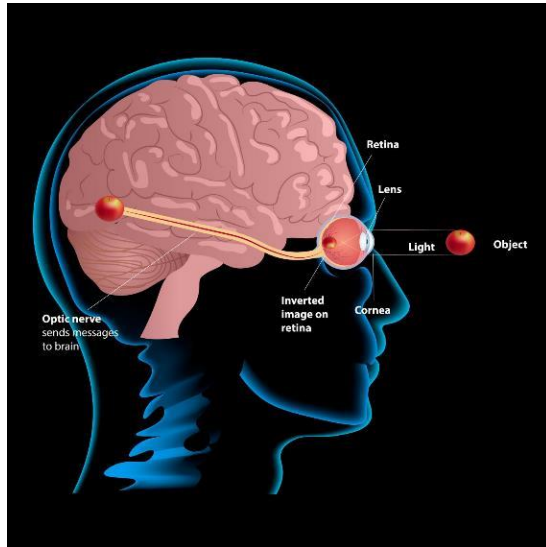
- *Circulen*
 - *CirculenRecover*
 - *CirculenRevive*
 - *CirculenRenew*

Carriers – A variety of different carriers are available

- PP, PE, EVA, Styrenics, PET, PETG, PA, Bio-resins, Technical polymers
- *Sustainable Polymers + Sustainable Ingredients*
- *PCR, PIR, r-PET, Bio-renewable feedstock, Advanced recycling*

Color Science

- Color exists only in our mind and is seen when light waves reflected off an object meet the eye.
- An object appears colored because it absorbs some light wavelengths and reflects back others.



Color Science

The human eye can see more than 1,000,000 different colours and we all experience them differently!

- No physical scale
- Subjective color perception
- We describe colors in different ways, e.g. *'Blue Ocean'*, *'Crimson Red'*



Color Science

Color perception is complex and involves the interaction of several factors:

■ Light source – color can appear differently depending on type of light

- Daylight – sunlight intensity, time of day
- Artificial Light – Incandescent, Fluorescent, Halogen, LED
- Metamerism

■ Object

- Size and shape
- Material – reflection, absorbance, diffraction

■ Observer

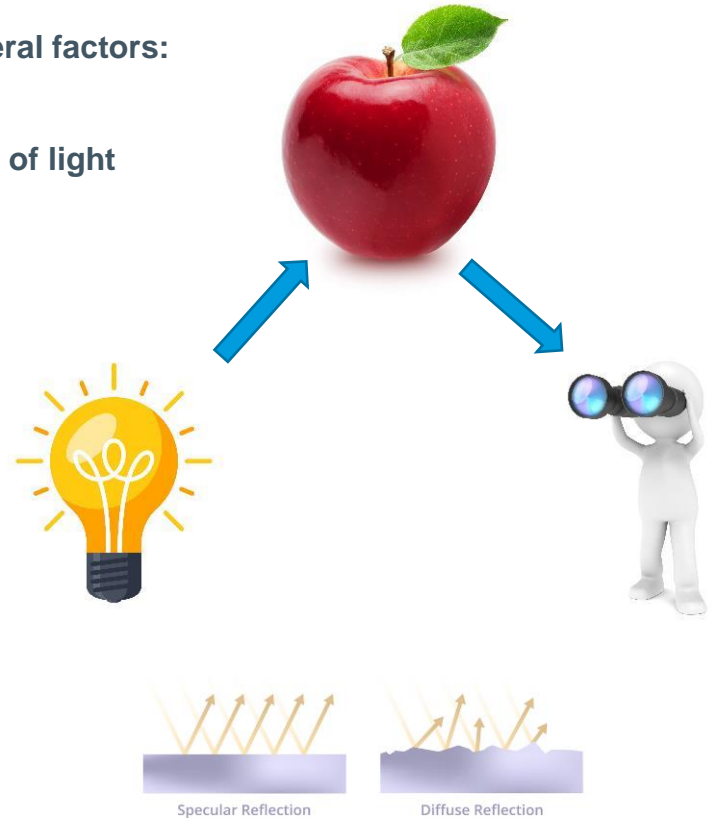
- Human – different people see colors differently
- Digital – type of device

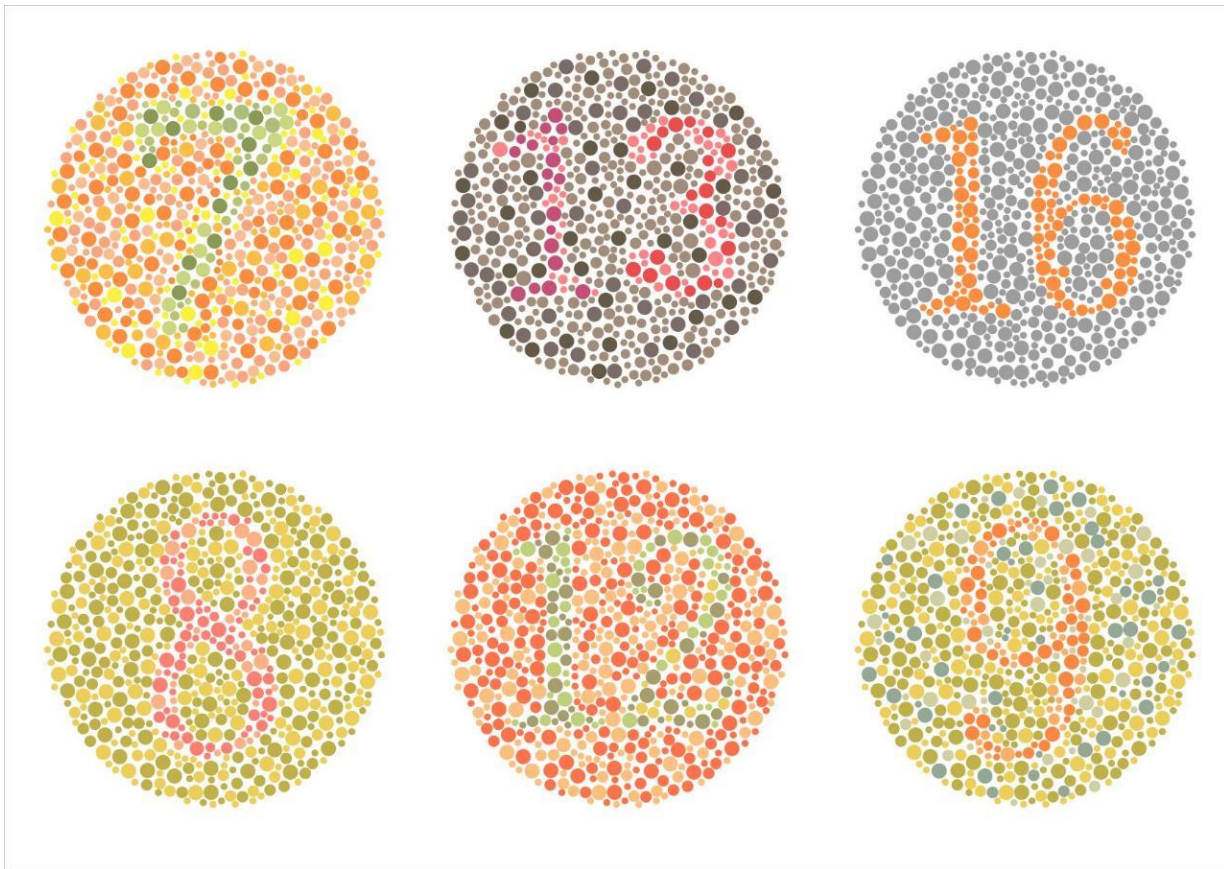
■ Angle of viewing

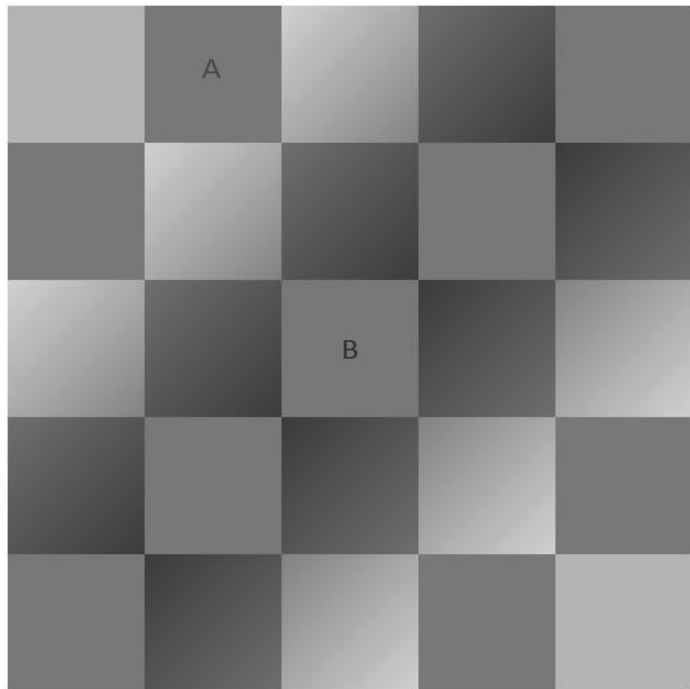
- Amount of reflection and transmission of light

■ Background effect

- Light or dark background changes color perception







Credit: Barton L. Anderson & Jonathan Winawer



Color Science – communication for color

For color design it is important how we communicate color:

■ Define the color master

- Including material and texture
- Master chip with $L^*a^*b^*$ coordinates or RAL, Pantone

■ Define measurement conditions

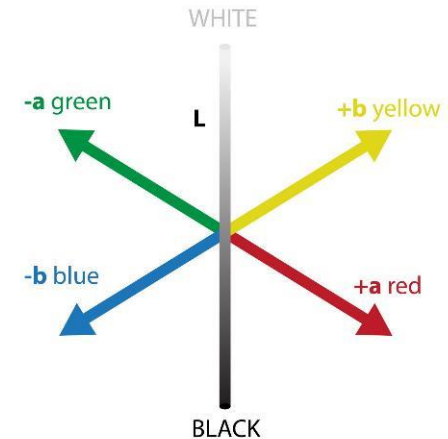
- Measuring equipment
- Light Source e.g. D65, TL84, A
- Measurement angle
- Color calculation model – e.g. CIELAB 1976, dE2000, CMC

■ Specification and tolerances

- Prototype scale up to production
- Batch to batch consistency
 - Use master chip with $L^*a^*b^*$ coordinates

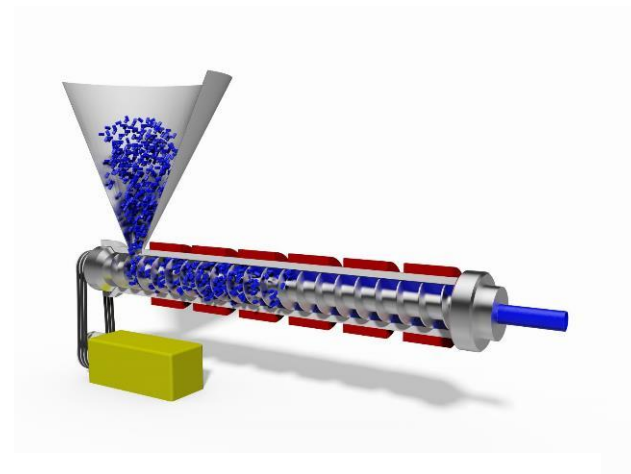
■ Consistency of color across different materials

- Same color in different polymer or materials



Masterbatch Composition

- **Masterbatch is a combination of pigments and additives encapsulated in a polymer matrix.**
- Pigments + Additives are blended and extrusion compounded to provide optimum dispersion of the ingredients in the polymer matrix.
- Recipe is designed to be diluted into the converters polymer to provide the required color and properties when used at the specified dosage (usually between 1% to 5%).
- **Benefits of Masterbatch:**
 - Controlled and clean dosing compared to dry pigments
 - Customised to provide required color and additive properties
 - Economical and flexible



Masterbatch Composition

Masterbatch developer needs to consider many factors for the optimum combination of materials:

■ Polymer

- Compatibility of colorant & carrier for end application
- Optimum dispersion & dilution of colorant

■ Application

- Color – opaque, transparent, special effect?
- Type of article – e.g. rigid or flexible?
- Processing method – temperature and shear sensitivity
- Service Life - how many years does the part need to last & where?
- Additional functionality – does the part need to be UV stabilised, Antistatic
- Interaction of Pigment and Additives to avoid affecting performance or color

■ Regulatory and Sustainability

- Product Safety and Regulations – e.g. RoHS, VOC, Food Contact ...
- Recyclability – NIR detection
- Sustainability



Pigment Selection

- Pigments are typically classified as Inorganic, Organic or Dyes
- Choice of pigment needs to consider the application, polymer and color requirements
- Soluble Dyes are used in specific polymers, e.g. Styrenics, PET, PA, PC and PMMA

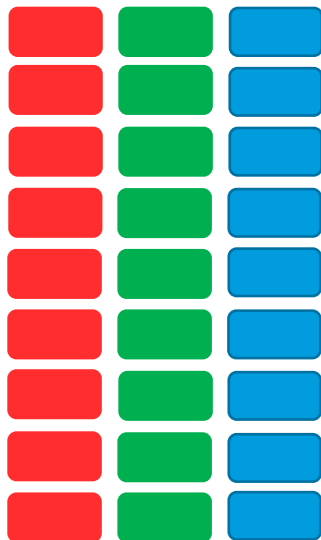
	Inorganic	Organic	Dye
Color Shade	Dull	Medium → Bright	Bright
Tint Strength	Low	Medium → High	High
Opacity	Opaque	Semi-opaque → Transparent	Transparent
Light Fastness	Good → Very Good	Poor → Very Good	Poor → Good
Heat Stability	Good → Very Good	Poor → Very Good	Poor → Very Good
Chemical Stability	Good → Very Good	Poor → Good	Poor → Good



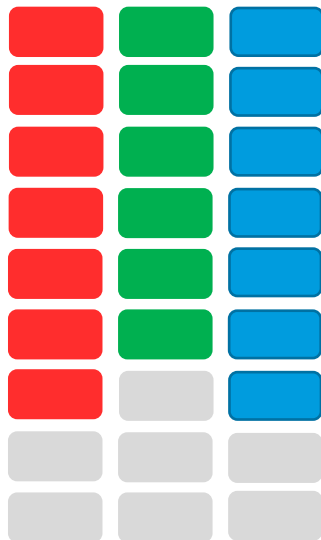
Pigment Selection

- Selection of pigments dependent on polymer and application
- Available pigment palette for the developer reduces as application demands increase

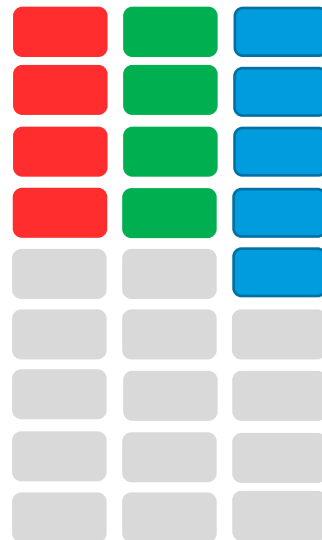
Pigments for Plastics



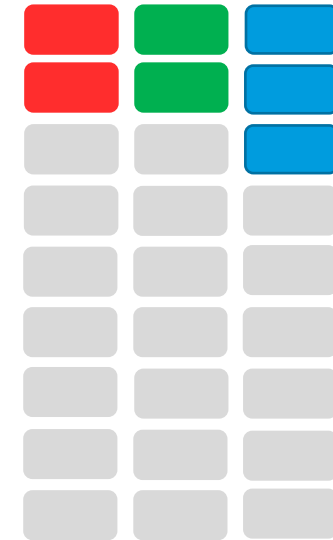
+ Food Contact



+ Outdoor Application

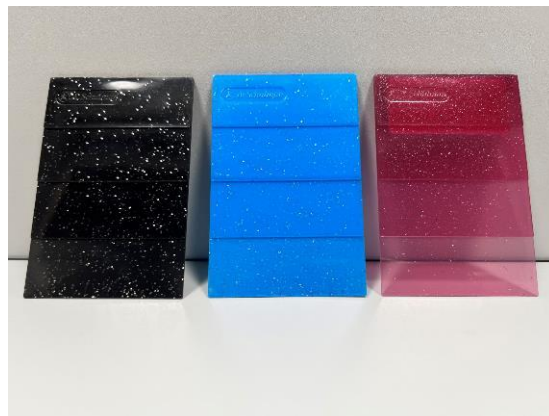
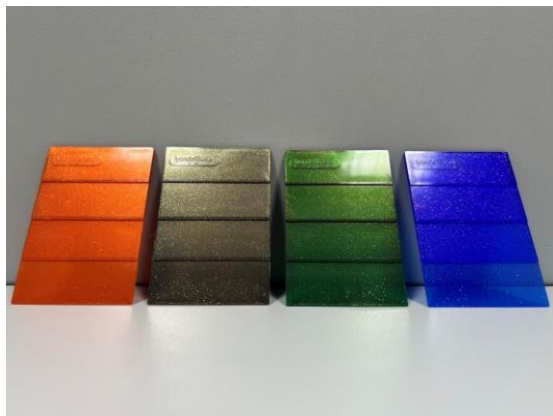
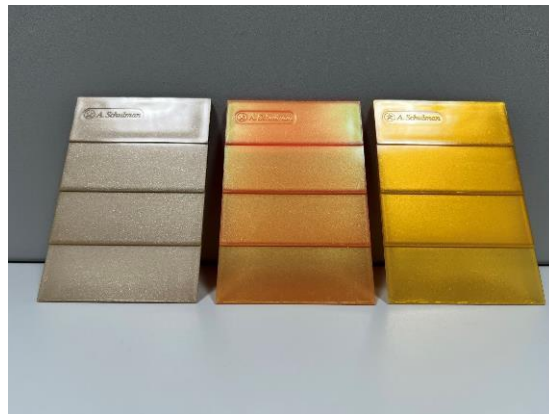
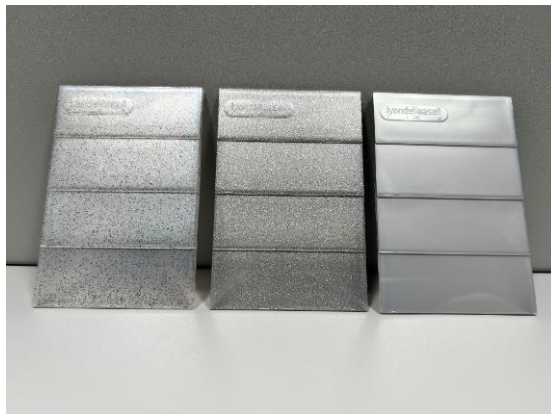


+ Engineering Polymers



Color Effects

- Metallic
- Pearlescent
- Marble
- Glitter



Color Effects

■ Fibre

- Different fibre material types, color, length and diameter

■ Fluorescent

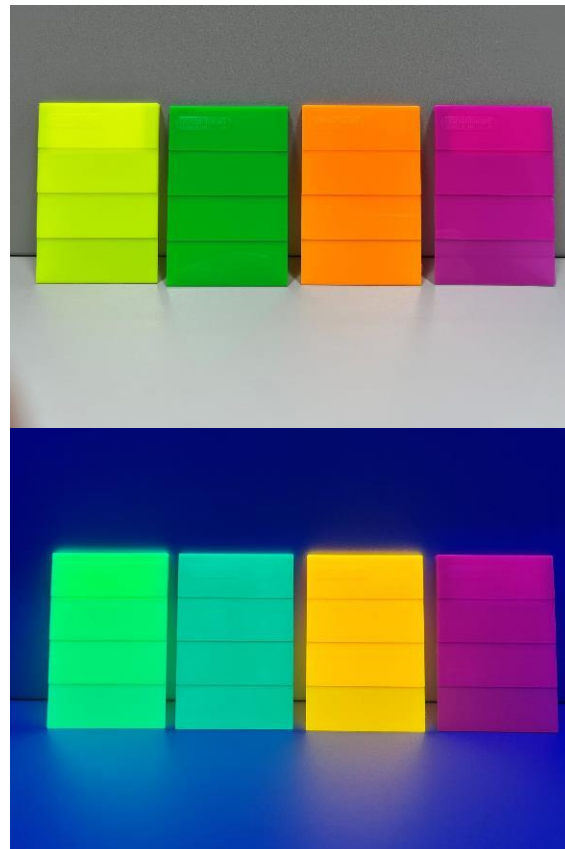
- Bright colors
- High fluorescence under UV light

■ Phosphorescent

- 'Glow in the dark'

■ Thermochromic

- Color change with temperature



Surface Effects

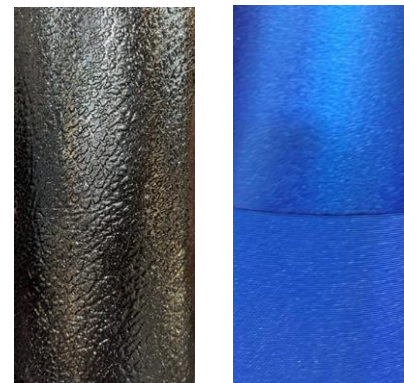
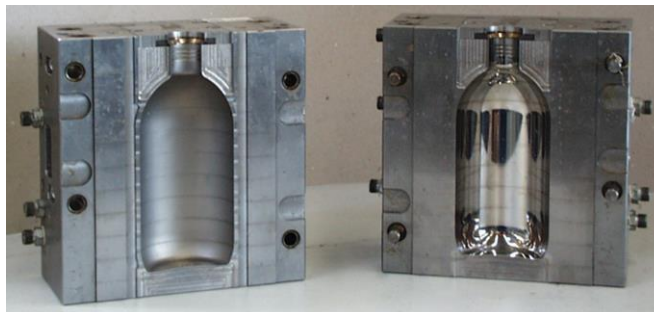
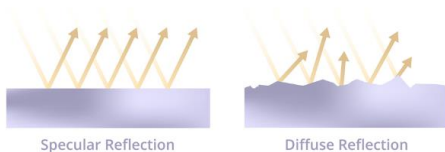
Surface effects can be created by selection of materials or mold design, changing the reflective properties.

■ Material

- Selection of polymers with high gloss or matt appearance
- 'Soft touch' design with **Catalloy** polymer

■ Mold Design

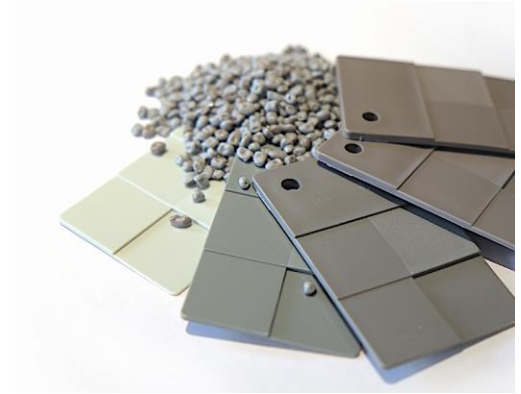
- Mold surface can be polished, matt or engraved to create different textures



Masterbatch solutions for recycle resins

■ Pre-consumer or post-consumer recycle can come in many different colors.

- Ivory to Dark Grey color range
- Color masterbatch needs to be matched depending on the recycle source
- Color shade can be limited by color of the recycle



Masterbatch solutions for recycle resins

- Color travel with increasing content of recycle
- Same masterbatch can give different color with different quality of recycle
 - Color design always needs to consider the recycle material being used



RAL 5012 with PCR Ivory
100% - 75% - 50% recycle



RAL 5012 with PCR Grey
100% - 75% - 50% recycle



RAL 5012 with PCR Ivory (L) and Grey (R)
100% recycle

Masterbatch solutions for recycle resins

- **Metallic and Pearlescent special effects are still possible with recycle resins**
 - Color and quality of recycle needs to be good to avoid losing impact of special effects



RAL 4011 with PCR Ivory
100% - 75% - 50% recycle



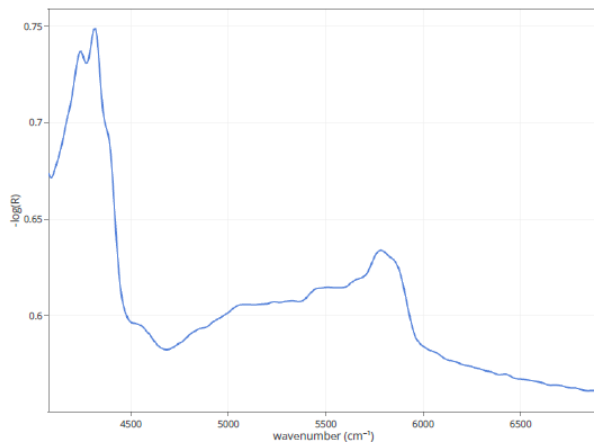
RAL 7048 with PCR Ivory
100% - 75% - 50% recycle



NIR Detectable Colors

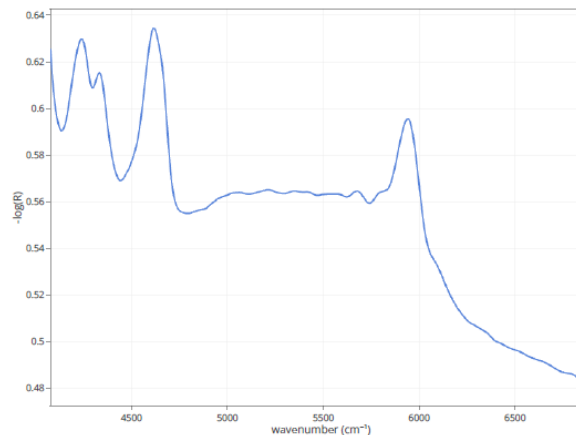
- Parts need to be designed to enable sorting by polymer type using NIR spectroscopy in material recycling centres
- Certain pigments, especially carbon black, can prevent NIR detection and polymer sorting
- Black and dark colors can be designed using alternative NIR detectable pigments
- NIR spectroscopy can be used during masterbatch design

Measurement Graph (1 Spectrum)



PP homopolymer + Color

Measurement Graph (1 Spectrum)



GPPS + Color



Advancing Possible through Design for Circularity

Design for Circularity: Material solutions to address the challenge of designing functional and aesthetic packaging which can be more easily sorted and mechanically recycled.

Mono-material packaging

- Re-design complex and difficult to recycle multi-material packaging to mono-material alternatives while maintaining desired properties and performance.
- *Polybatch* additives for processing of orientated PE films used in food packaging.

Near-infrared (NIR) sortable packaging

- NIR detectable masterbatches for a range of polymers to enable sorting of black and dark colored plastic articles in post-consumer waste streams.
- *Polybatch 73641* NIR with COTREP certification

Masterbatches for Recyclates

- Masterbatch additives for recyclers and converters to improve processing and quality of recycled material.
- Enables recyclates for multiple recycling loops.





Leading global supplier of high-performance plastic compounds, masterbatches and resins



Providing innovative solutions to exactly meet customer application requirements



One-Stop shop for color and additive masterbatches



Raw materials harmonization to ensure consistent quality and supply, worldwide



Specialized color competence and masterbatch technology centers



Sustainability is a core value and a driver

Thank you



WE MAKE *masterbatch solutions* **POSSIBLE**

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Advancing Possible

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