

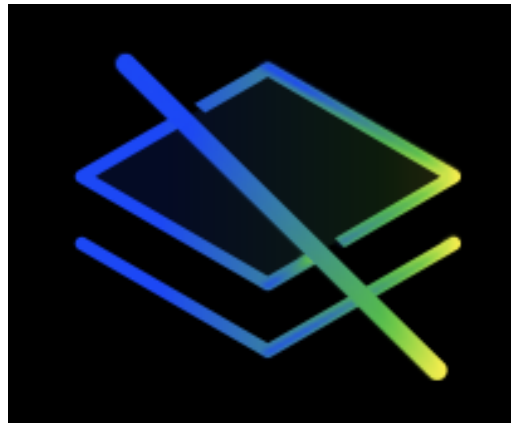


**CYPRIIS**  
Color Inspired By Nature™



## LED Curable Dichroic Coatings Based on Brush Block Copolymers

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September 6, 2024



# INTRODUCTION

## Outline

- Color Today
- Inspiration: Next Generation Color
- Science: Self-Assembly
- Formulation: Practical Considerations



# Coloring Our Everyday Objects is a Complicated Process

Colorants Today are:

**Polluting**



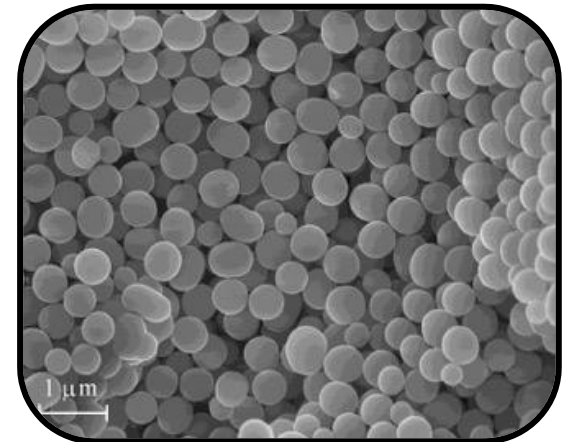
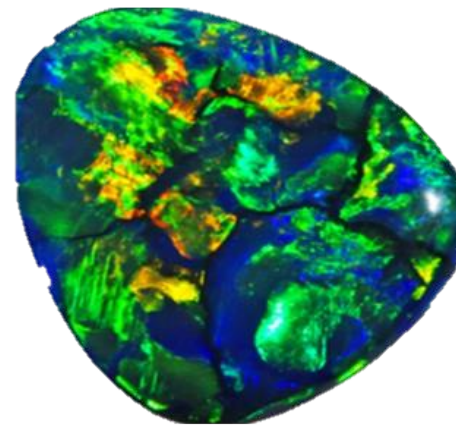
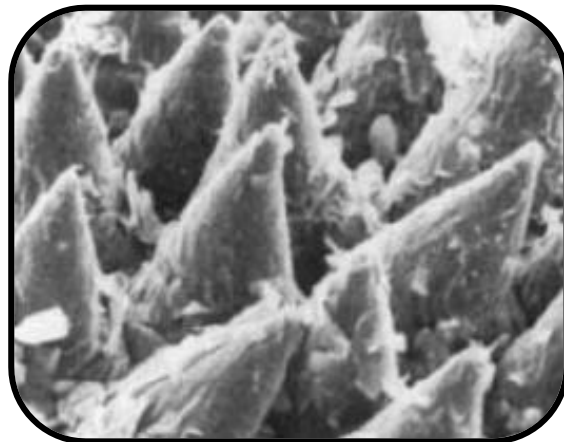
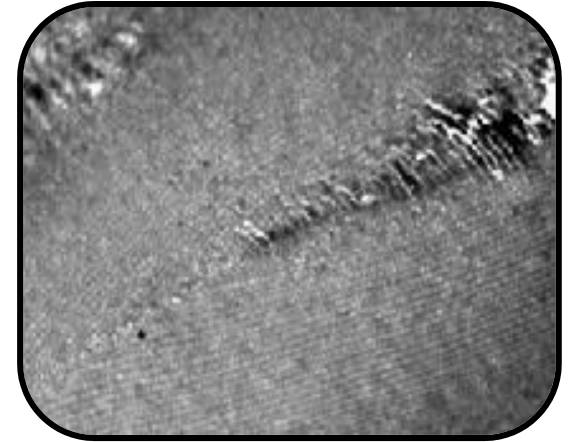
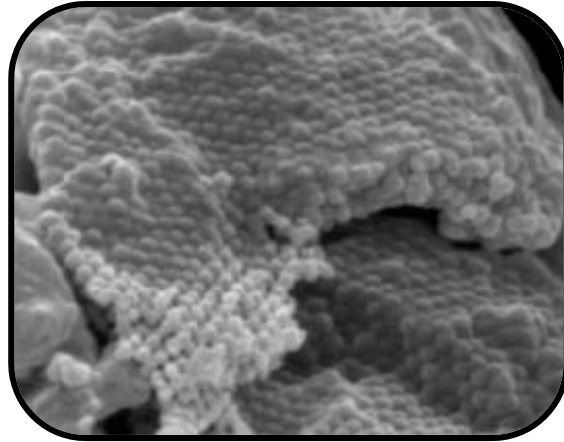
**Complex to Produce**



**Not Differentiated**



# Taking Inspiration From Nature To Build the Next Gen. of Color

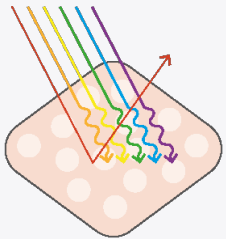


# Producing the Entire Light Spectrum From One Material vs. Several

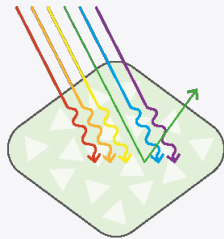
## A Traditional Color (Pigment or Dye)

Made from many different raw materials and unique individual processes that absorb light.

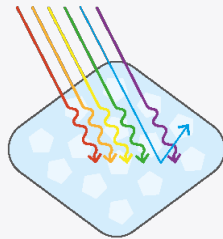
Red



Green



Blue

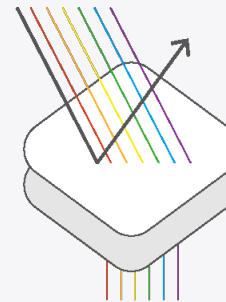


Different Colors ... Different Chemistry

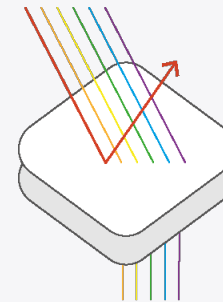
## Structural Color Resin

Made from the same core material and one process that reflects light (visible, UV, infrared).

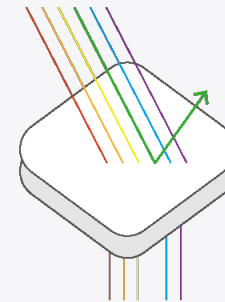
Infrared



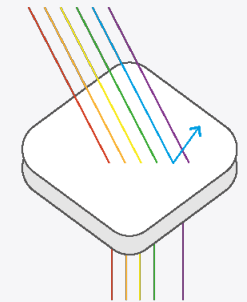
Red



Green



Blue



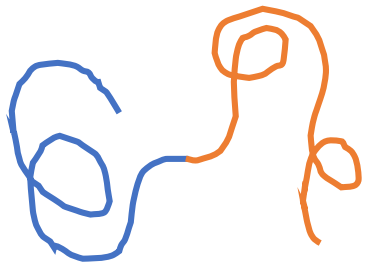
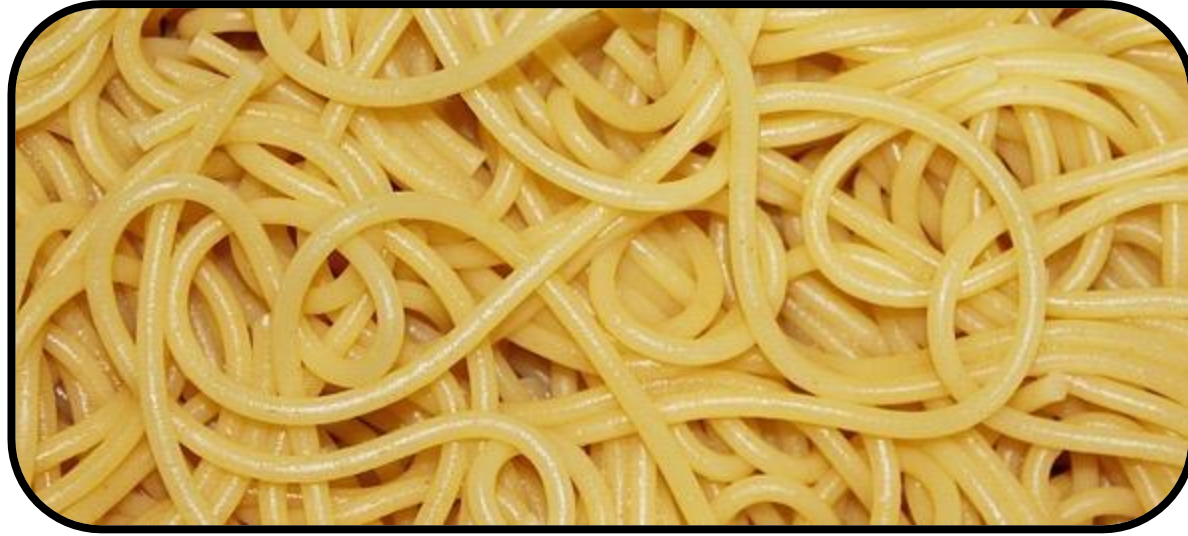
Different Colors ... Same Chemistry



# Self Assembly: A New Paradigm to Commercial Structural Color Coatings

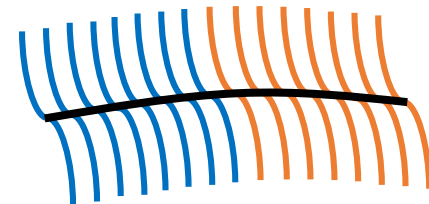


# Enabling Easy to Apply Structural Color Coatings: A Structure-Property Relationship



## Linear Copolymers

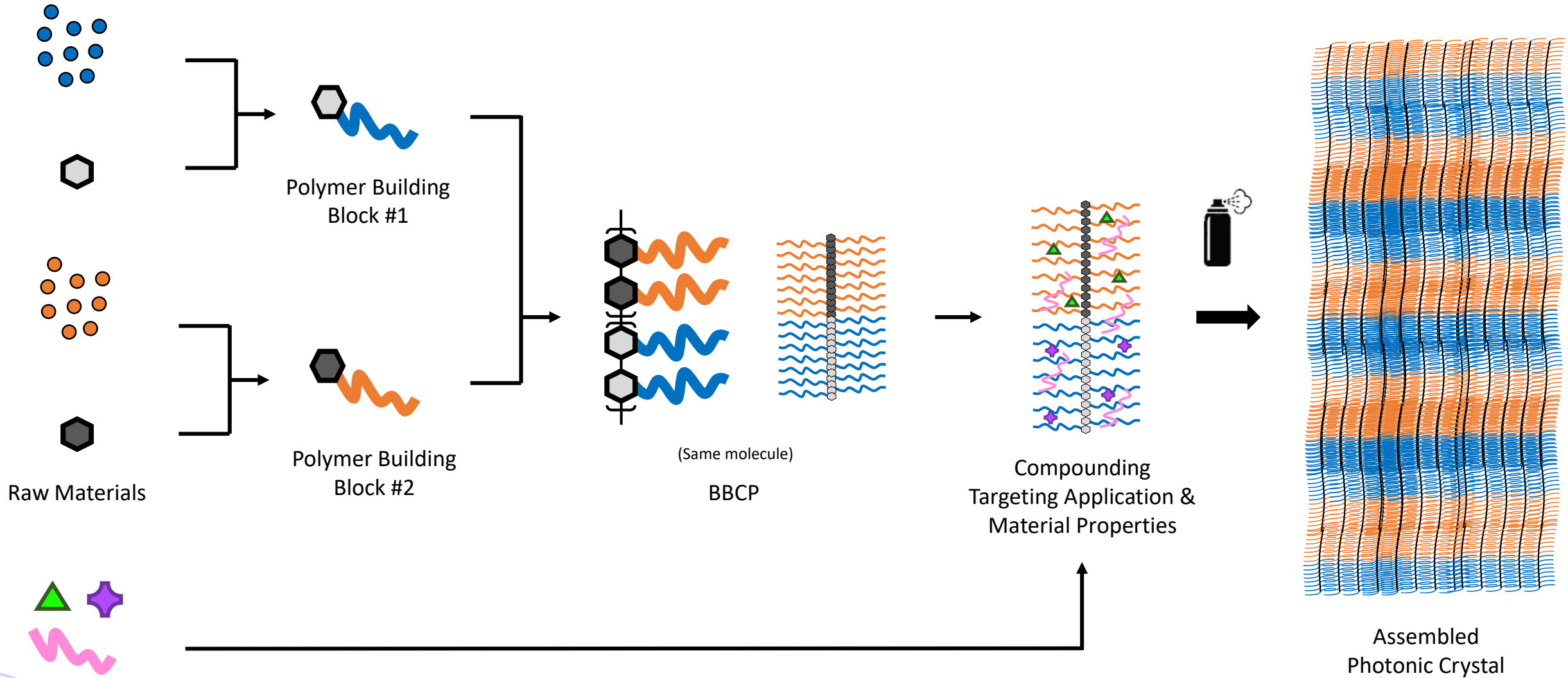
- Highly entangled
- Slow self-assembly
- Small domain sizes



## Brush Block Copolymers

- Low entanglement
- Rapid self-assembly
- Large domain sizes

# Manufacturing of Easy-To-ApPLY Structural Color Coatings



  
Industry Additives  
(small + macromolecules)



# Solvent-Based Self-Assembly



Powdered Form



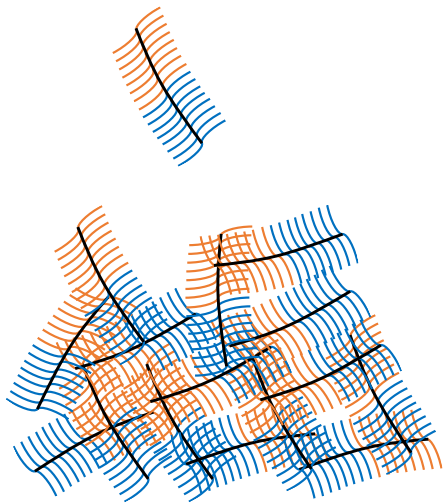
Solvated Form



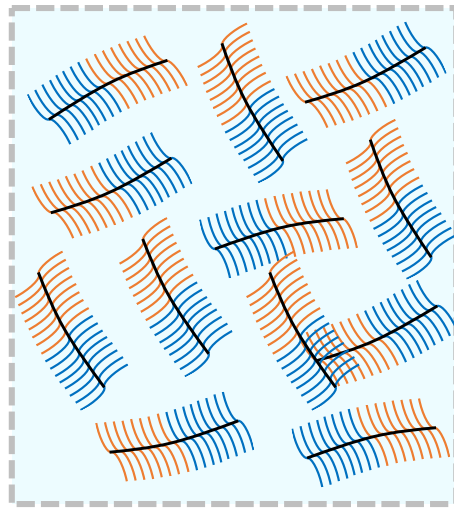
Wet Coating



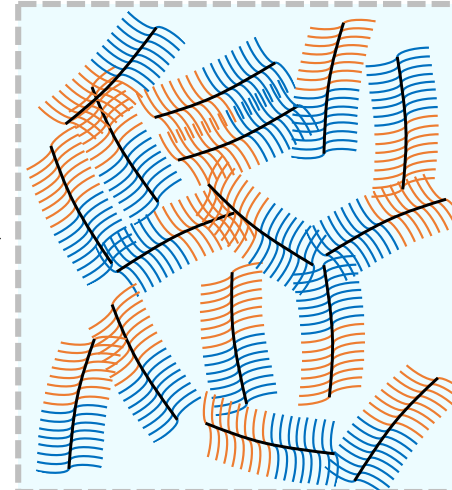
Dried Coating



As Received

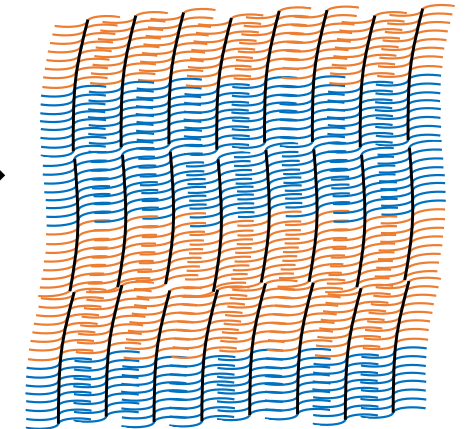


As Formulated



Surface

As Applied



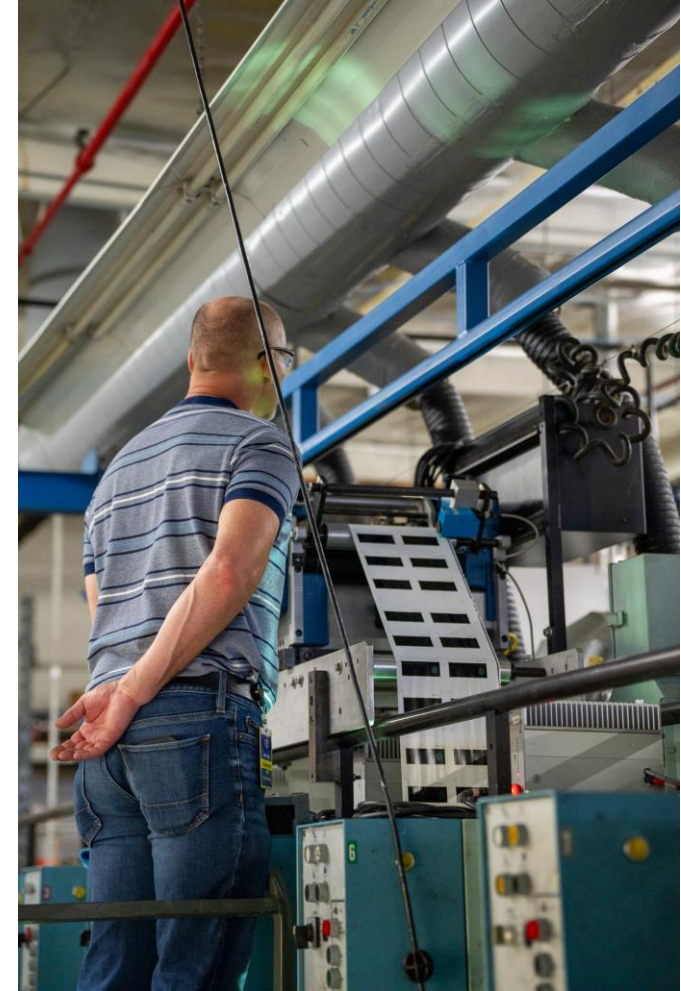
Surface

As Cured

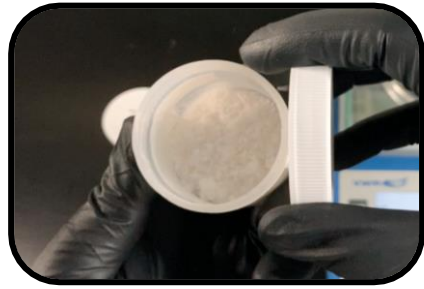


# Transition Away from Annealing: A Fundamentally New Approach to Self Assembling Systems

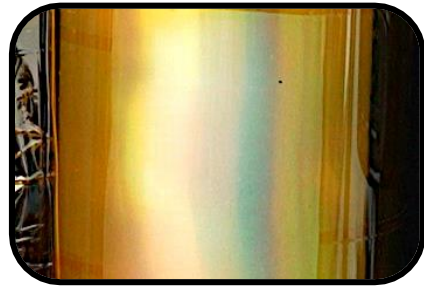
- Major limitations to evaporative / solvent-based annealing system:
  - Time
  - Evaporation / Equipment
  - EH&S considerations
- Approach
  - Replace solvents with industry accepted UV monomers
  - Reduce time to generate vibrant colors from min → sec
  - Eliminate evaporation/drying



# Gen 2: UV Curable Inks



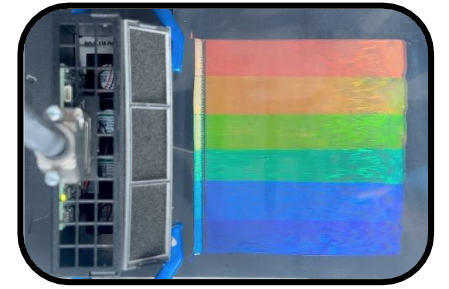
Powdered Form



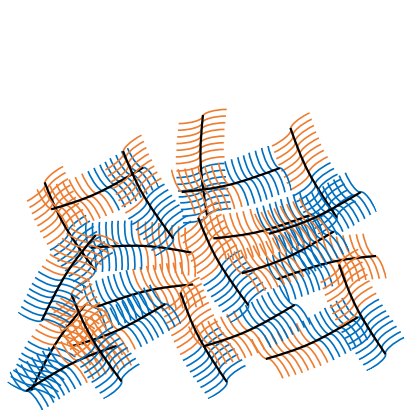
Fully Dissolved



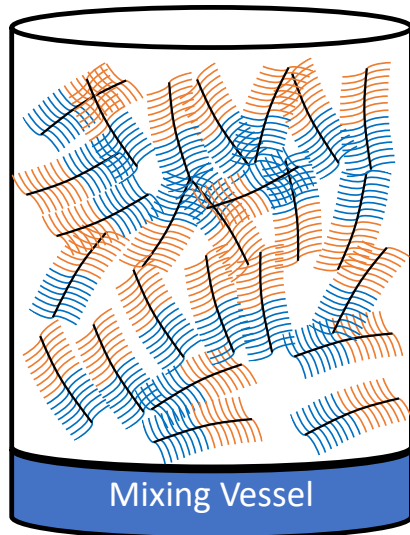
After Application



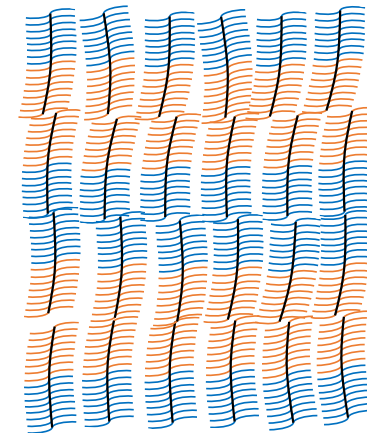
After Curing



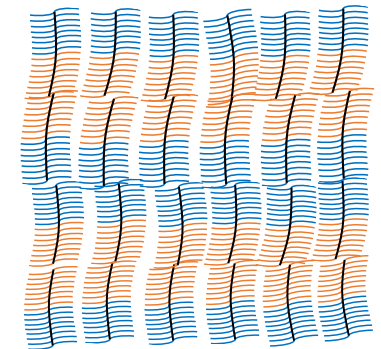
Brush Block Copolymer (BBCP)  
aka Structural Color Copolymer  
(SCC) as Received



A mild to vivid color can be  
observed depending on solids  
loading of SCC due to pre-assembly  
and ordering of the SCC.



Immediately after application,  
the applied ink will be a mild to  
vivid color depending on solids  
loading of SCC.

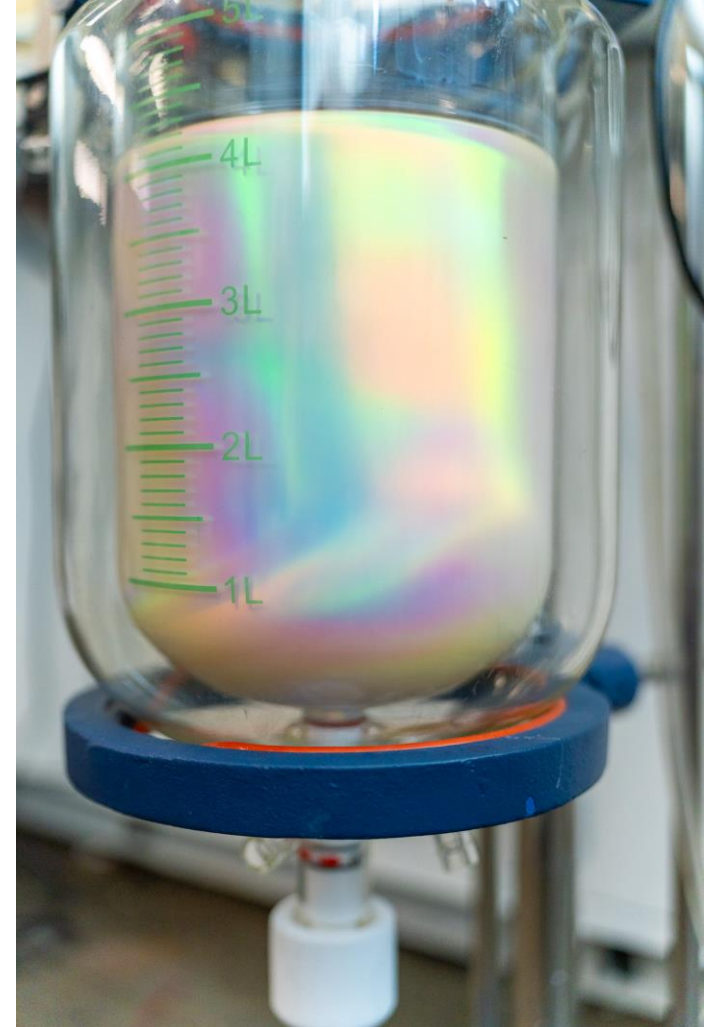


Expected volumetric shrinkage  
with crosslinking/curing. Spectral  
shift to shorter wavelengths.

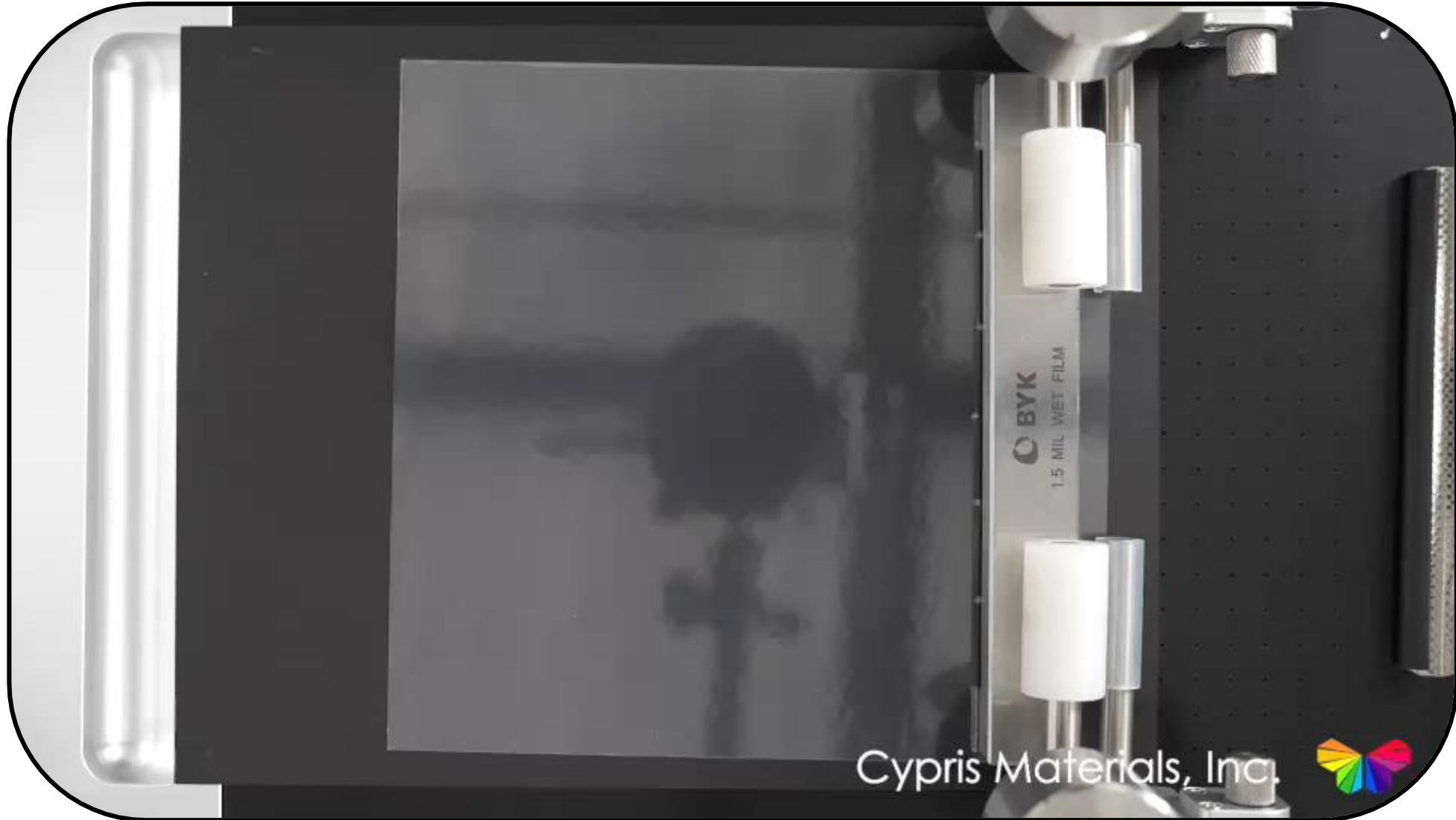


# Practical Formulation Considerations

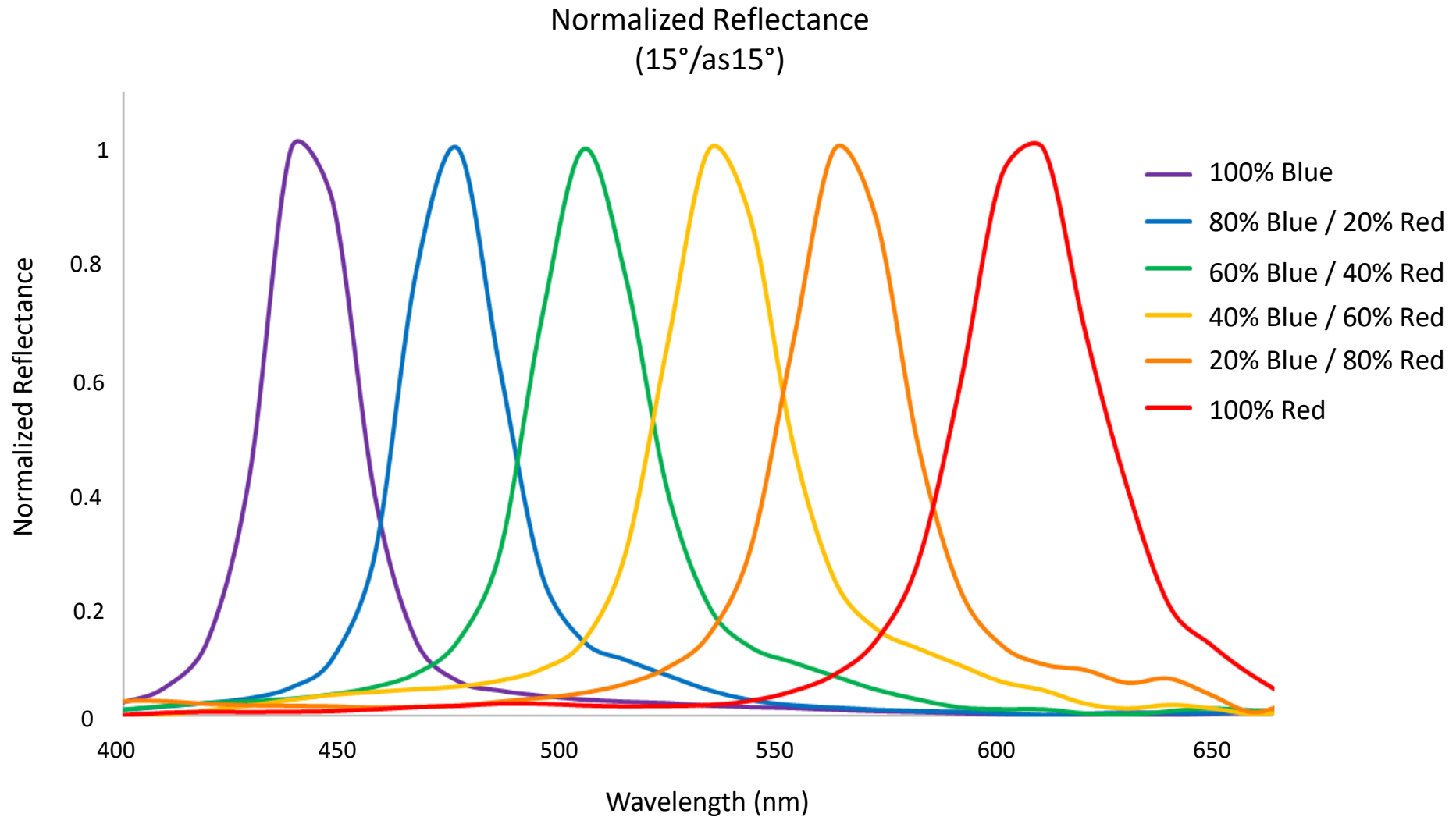
- BBCP must be present in significant loading (~11-25% by wt)
  - High viscosity
- Higher loading of mono-/di-acrylates than typical screen inks
- Recipe modifications across substrates



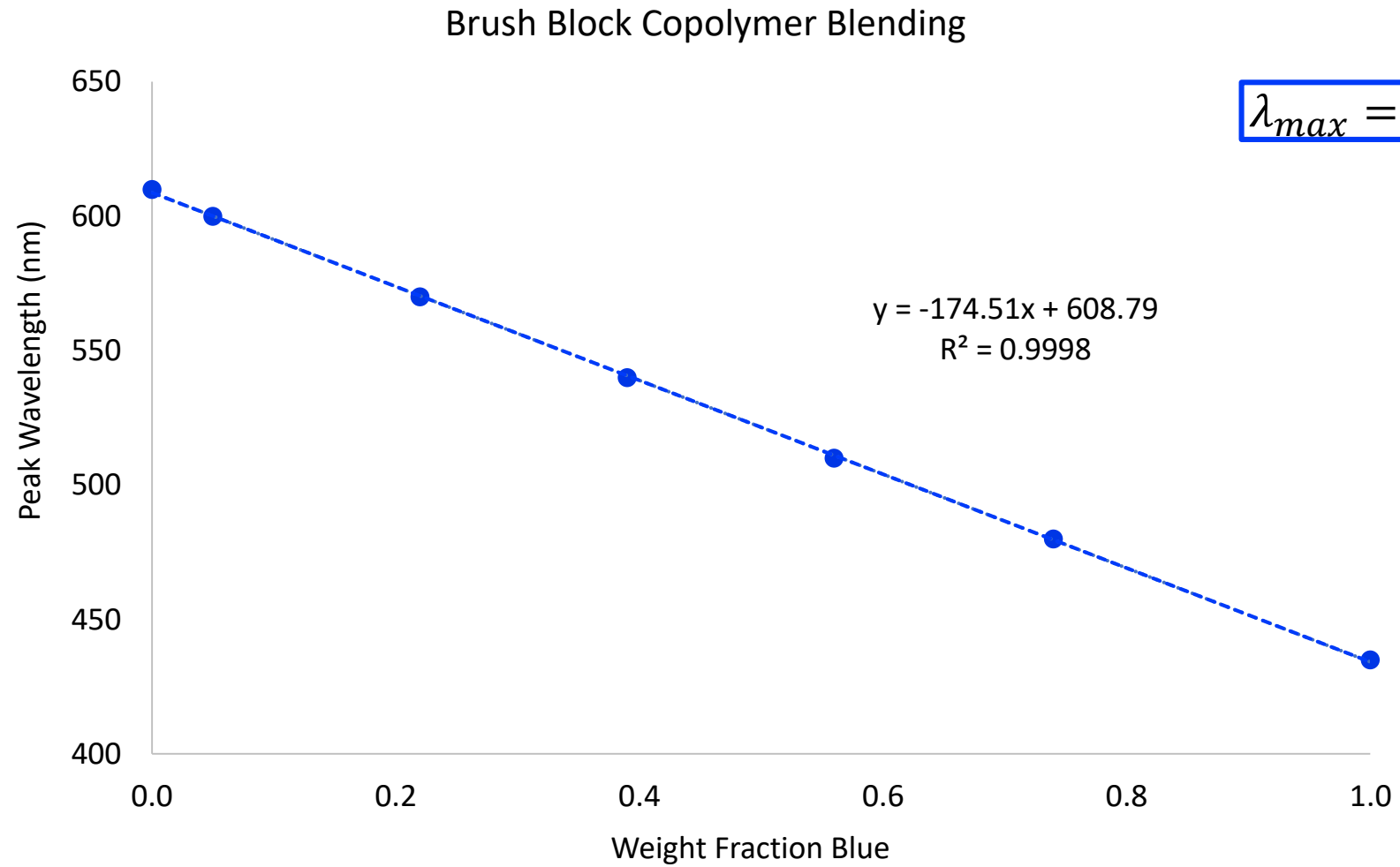
# Wavelength Averaging: Cross-Blending Blue and Red



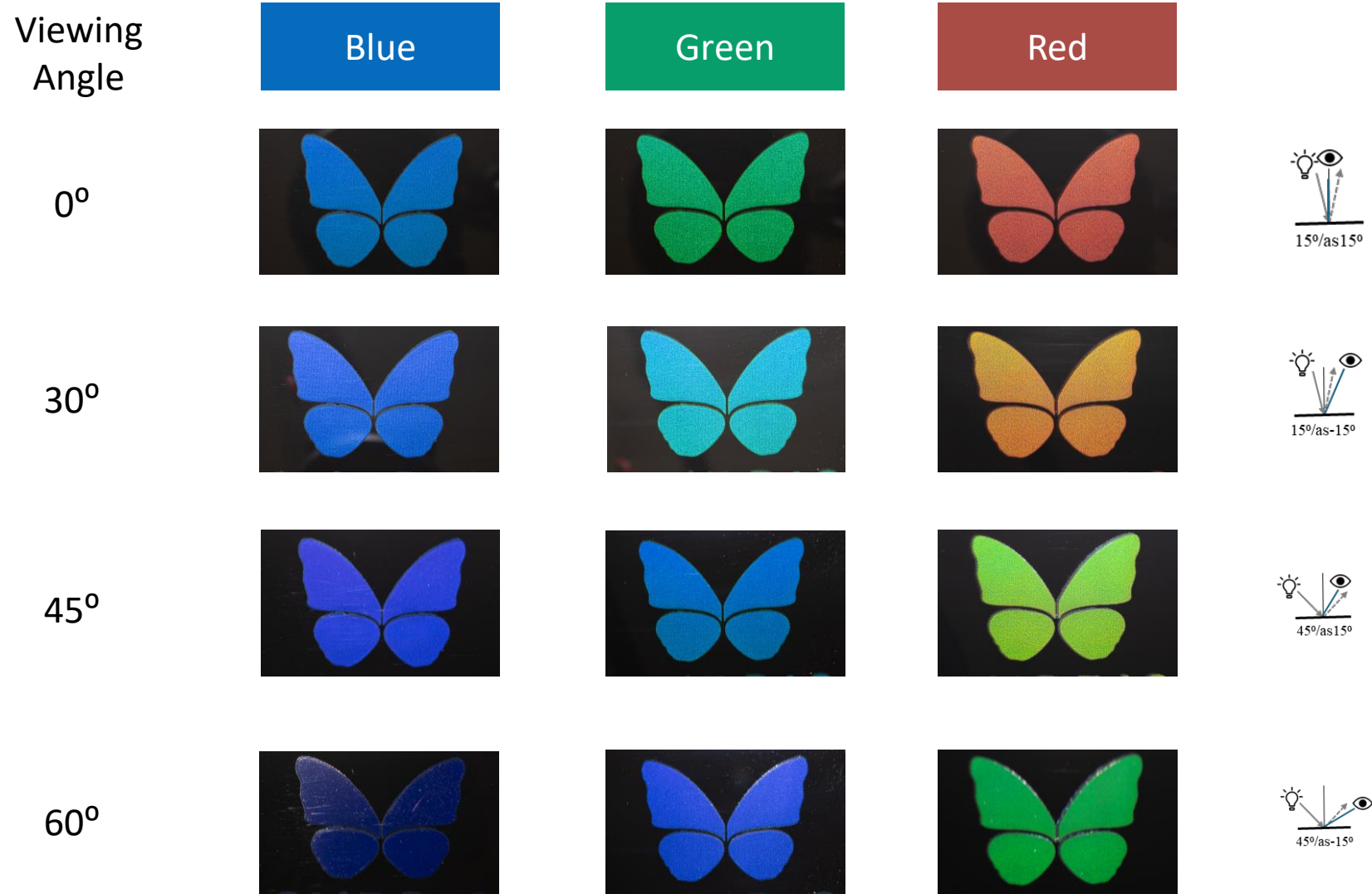
# Wavelength Averaging: Cross-Blending Blue and Red



# Wavelength Averaging – An Analysis

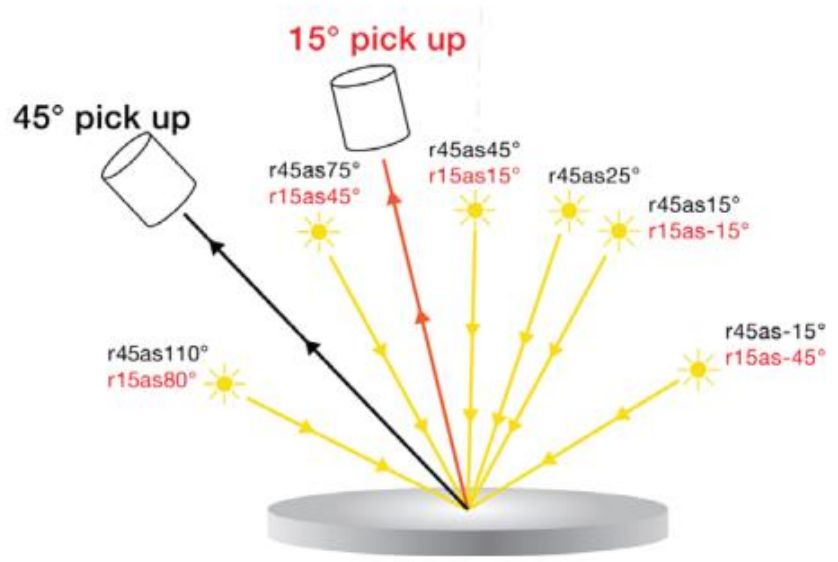


# Visual Assessment of Iridescence

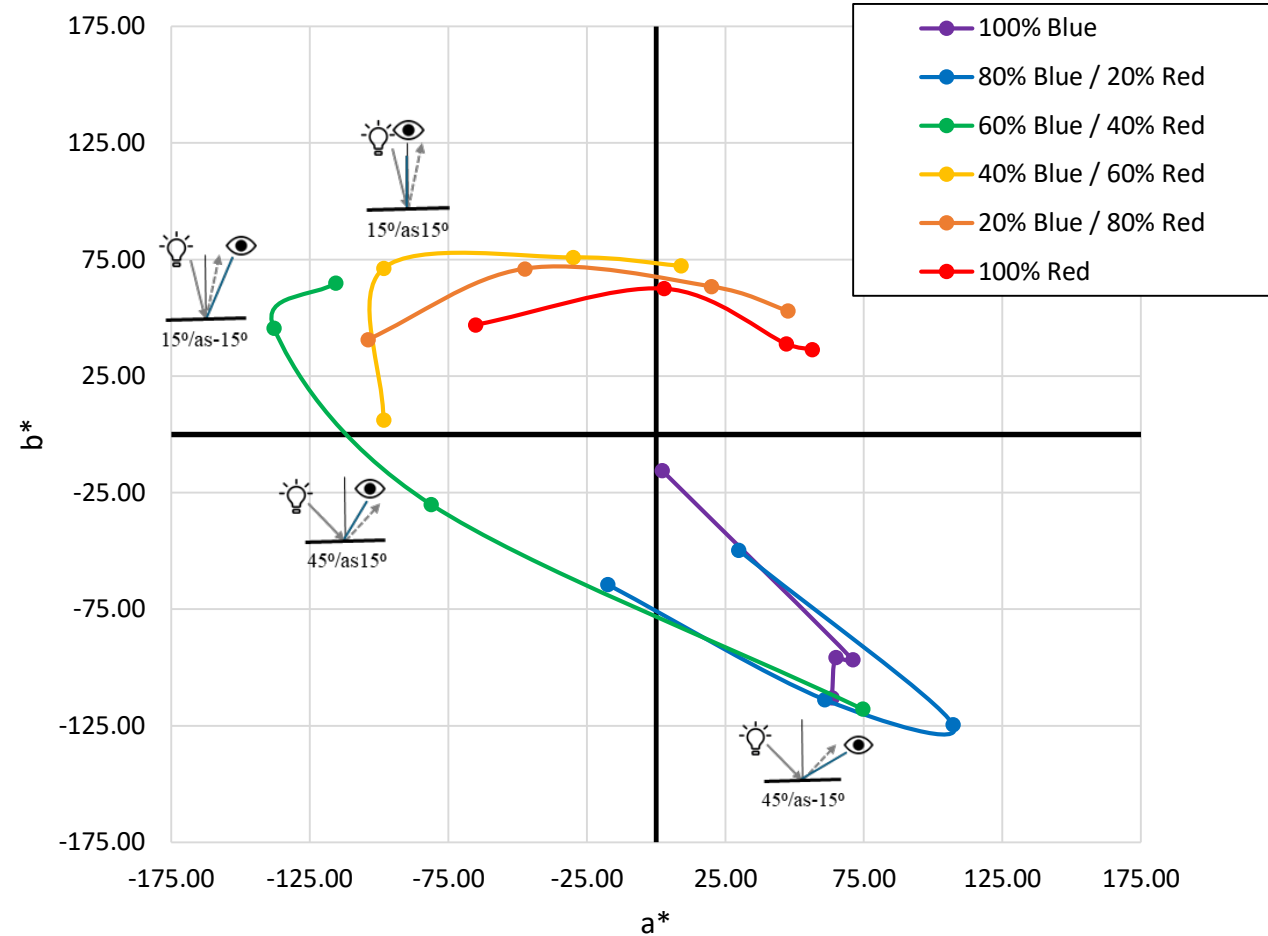




# Goniometric Assessment of Iridescence



Interference Angle Color Performance



# Thank you!

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