RECIPE PREDICTION IN PIGMENTED APPLICATION

UDAY KALE
DATACOLOR
MUMBAI

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Company History

- Since 2009 Datacolor is a stand alone, pure play, publically traded company on the Swiss stock exchange.
- Before 2009, Datacolor was part of the Swiss based Eichhof Holding.
- The sale of 2 of the 3 companies owned by the Holding allowed Datacolor to be well positioned financially to pursue its growth strategy.

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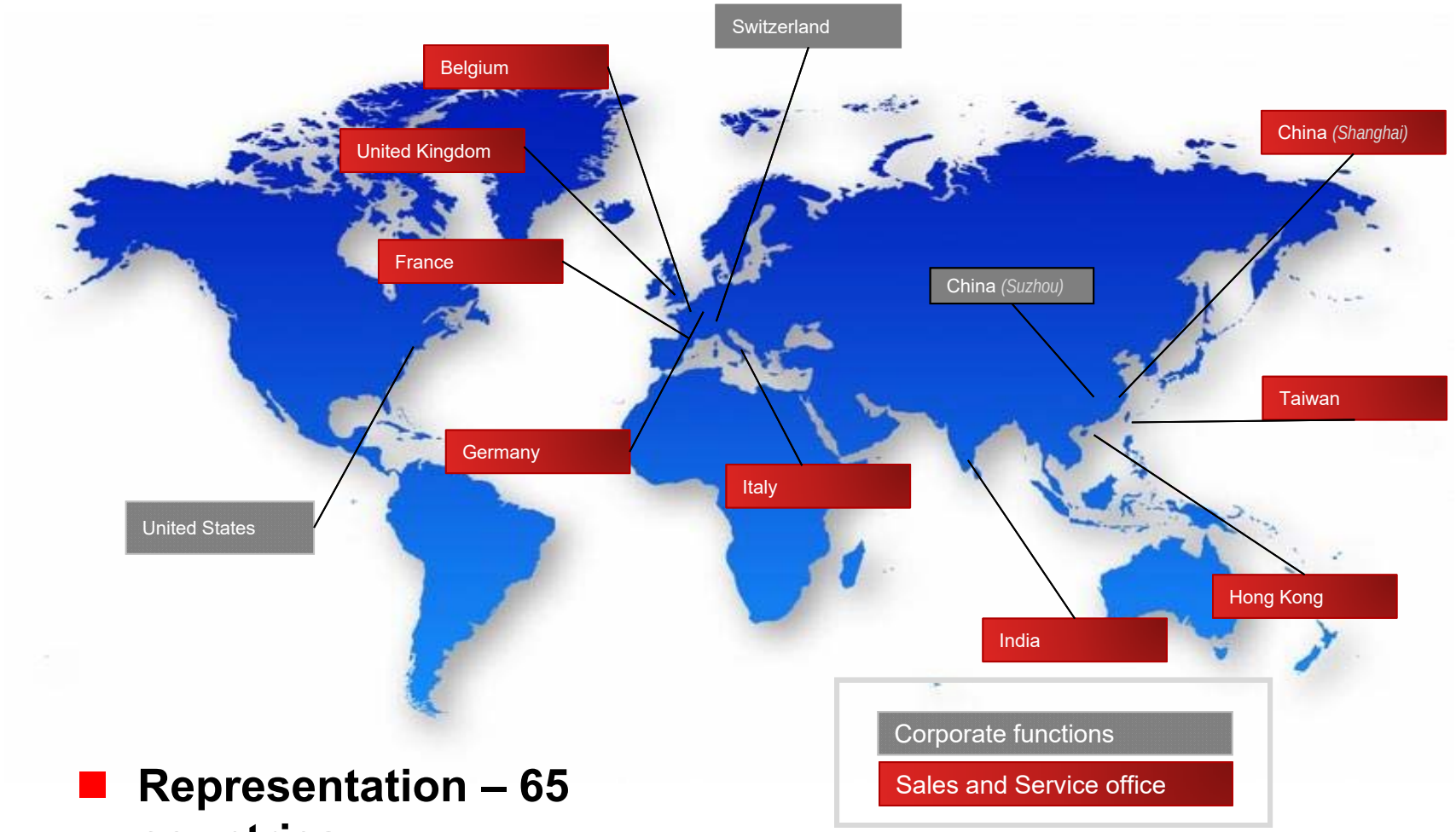
A Global Business



- **Representation – 65 countries**
- **Employees – 300 in 25 counties**

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Brands that rely on Datacolor

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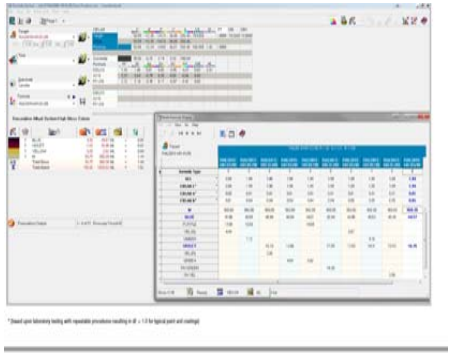
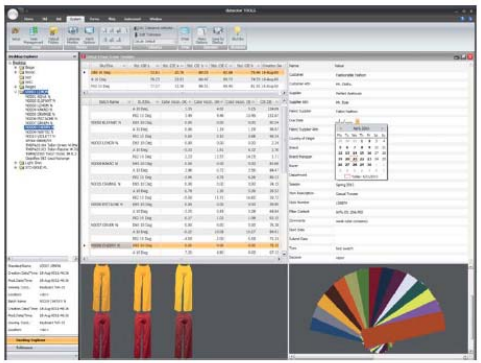
Datacolor Product Portfolio





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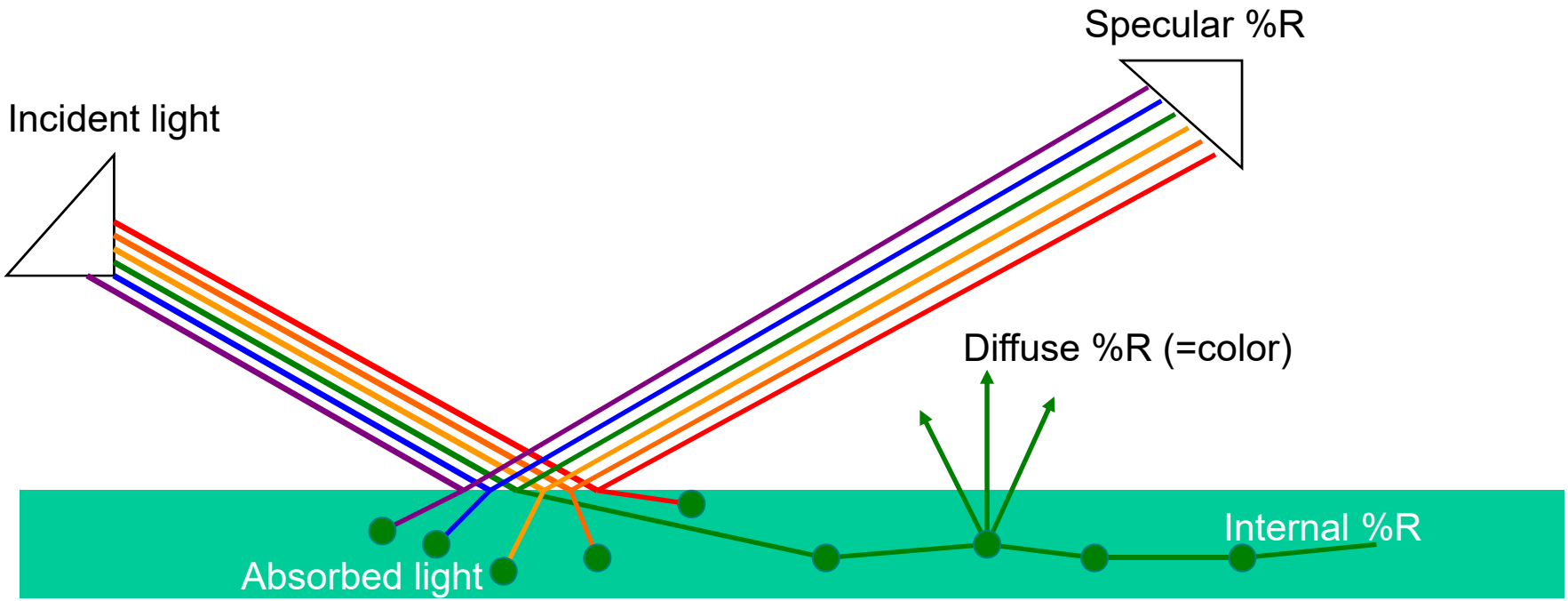
Kubelka - Munk

Behaviour of light



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Complex Subtractive Mixing

Turbid-Media Theory

- Kubelka-Munk
  - K/S is proportional to concentration
  - In the opaque case: $K/S = ((1-r)^2)/2R$

    $K/Smix = (c1K1 + c2K2 + c3K3 ...) / (c1S1 + c2S2 + c3S3 ...)$
  - The full treatment:
- Others

Both Light Absorption and Light Scattering are considered.

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Kubelka Munk Relation

- When light passes through a film (Plastic or Paint) it gets absorbed, Reflected, Scattered or Transmitted.
- The passes of light through such film is very complex and the mathematical description for the phenomenon is known as “ Turbid Medium Theory”.
- Kubelka and Monk simplified the Turbid Media Theory.
- When the light passes through the pigment layer, the changes take place in downward and upward direction (Two fluxes one in downward and other in upward direction)
- This can be calculated using simple mathematical relation from their scattering and absorption coefficients. (K and S)
- Kubelka Monk equation co relates reflectance of an object with Scattering and Absorption coefficients.

$$K/S = (1 - R)^2 / 2R$$

Kubelka Munk Relation

- The most important feature of K M Relation is it is additive. i.e. K/S is additive while Reflectance is non additive.
- K/S function is linearly proportional with concentration of colorants.

  $K/S = \alpha c$ where α is a constant of proportionality.
- Pigments disperse in polymers have both the properties of absorption and scattering hence it is necessary to calculate both the coefficients.
- Such application is termed as Two constant Application.
- In case of Textile dyes particles are in dissolved state hence not capable of scattering. In this case the scattering is contributed by substrate only.
- We need to calculate only absorption coefficient (K) for the colorant
- Such a application is called one constant application.

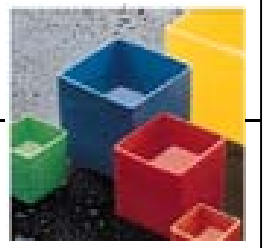
Kubelka - Munk

Kubelka-Munk Function

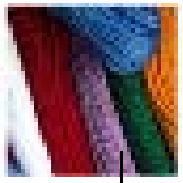
$$K/S = \frac{(1-R)^2}{2R}$$

Matching









Matching colors makes it possible to determine which colorants are needed and which are their optimal quantities to reproduce the color.

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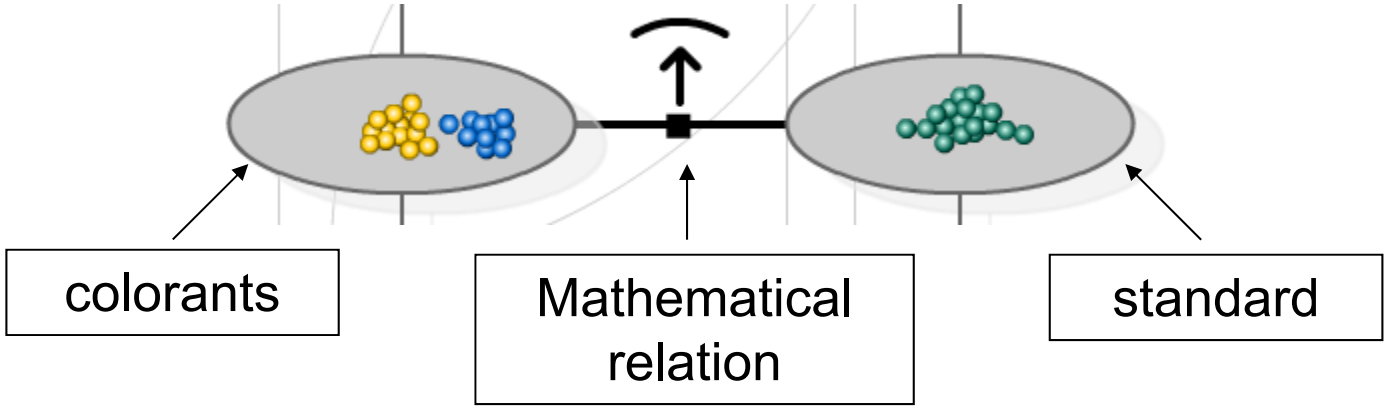
Matching - General

To be able to do a formulation,

we need to define the following things **mathematical**:



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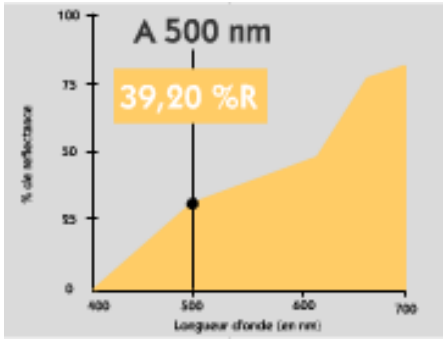
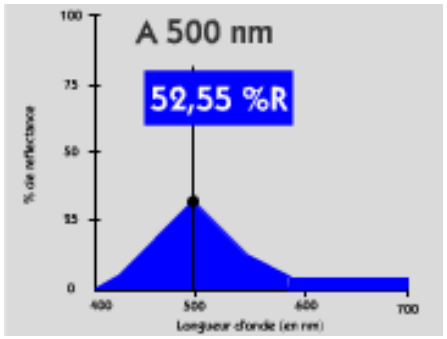
Matching - General



+



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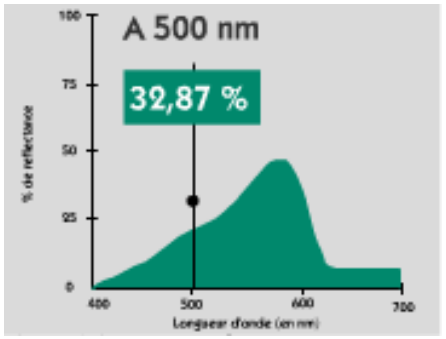

39.20% + 52.55% ≠ 32.87%

Reflection doesn't fit the additive principle

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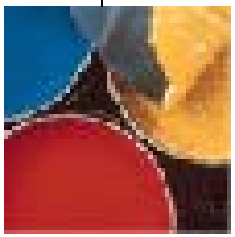
Kubelka - Munk

Solution for the problem:

KUBELKA - MUNK

Function



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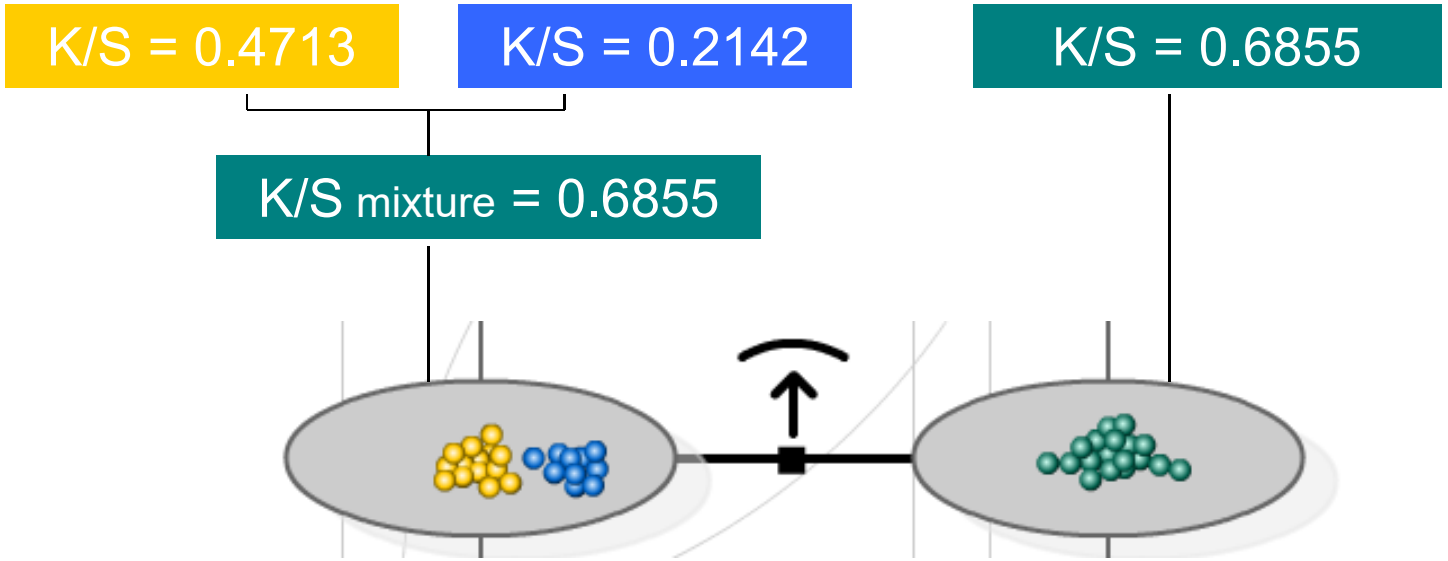
Kubelka - Munk

Application of the Kubelka – Munk function



The K/S function is additive.

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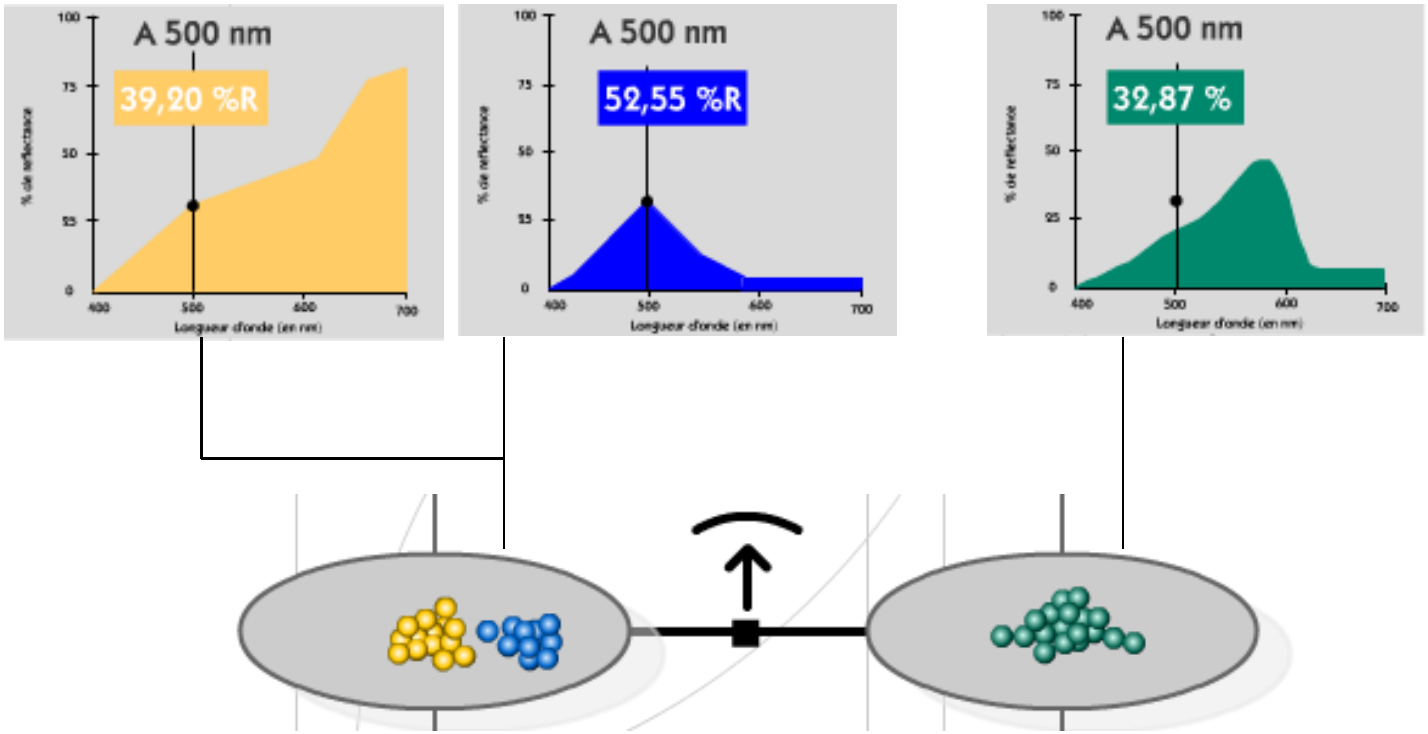
Matching - General



Formulate the color of the standard is the same as reproduce the spectral curve by using a combination of colorants

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Colorant set

Define

the behaviour of the pigments

in a colorant set

so we can match the target.

Matching

The quality of the matches is directly related to the quality of your primary samples!

Colorant set

- **One constant function (transparent)**
- **Two constant function**
  - Relative (opaque)
  - Absolute (translucent)

One constant function

One constant function

Transparent colorant set

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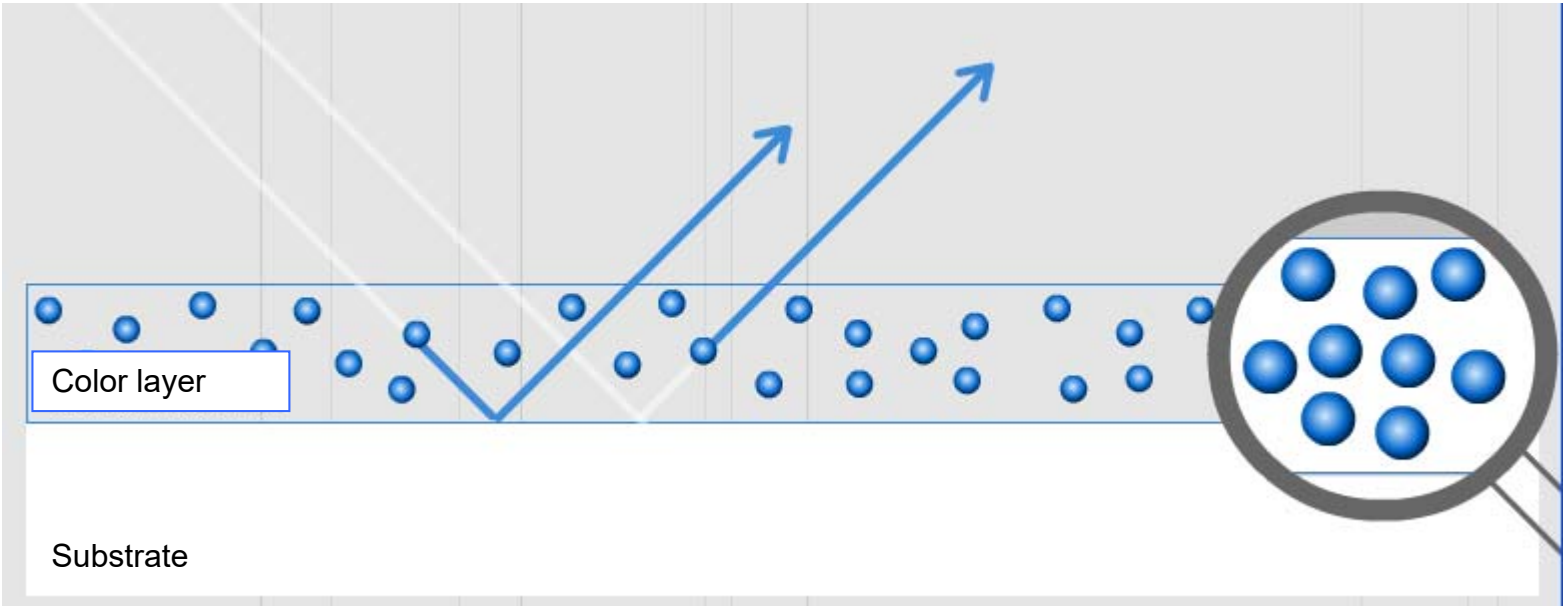
One constant function

Used to match:

- **Transparent or translucent samples that not include a white pigment. If white is used, it is used in a fixed amount.**
- **Example: woodstains, transparent inks, textiles,...**

One constant function

Due to the nature of the colorant, the colorant absorbs but don’t scatter light.



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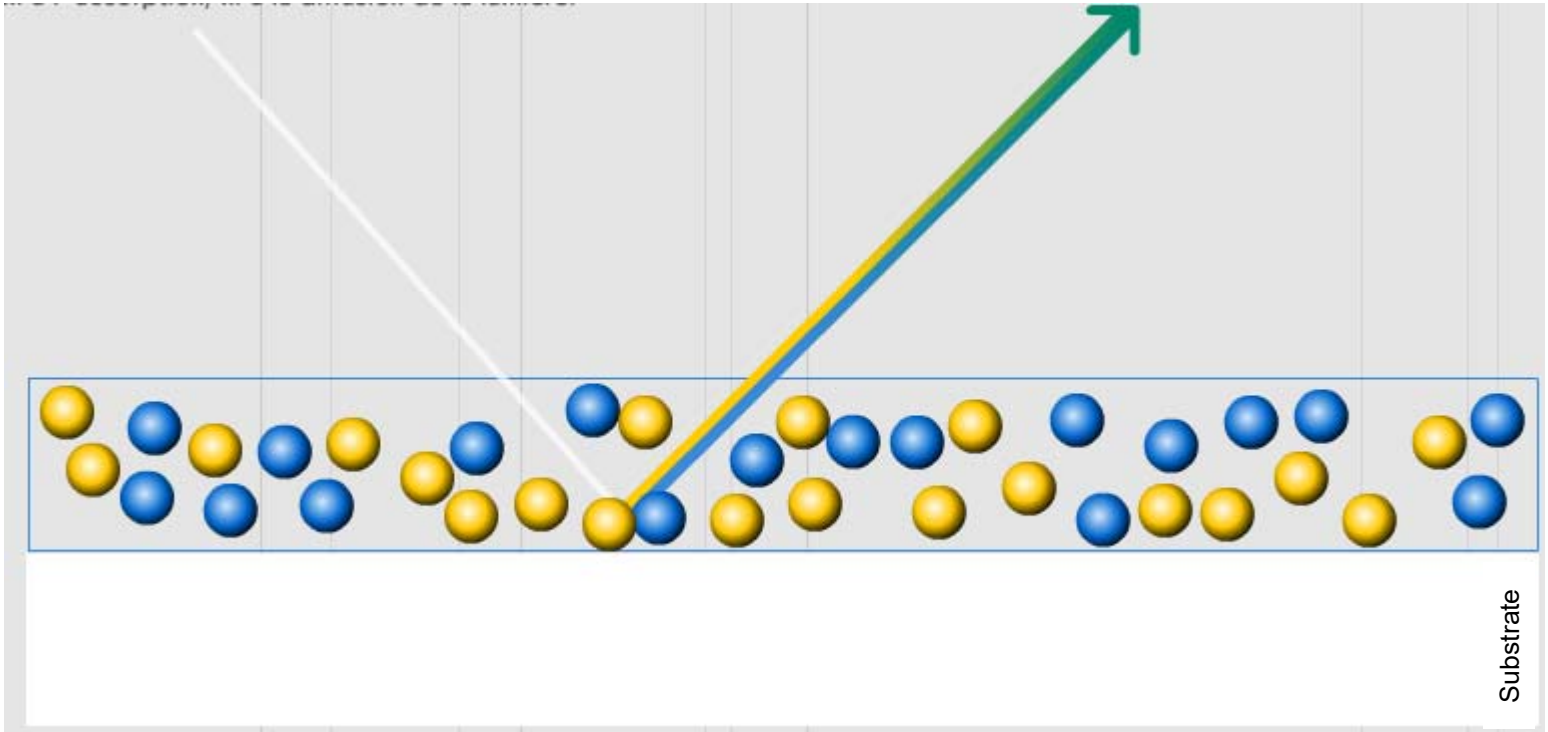
Two constant function

Two constant function

Opaque and translucent colorant set

Two constant function

Due to the nature of the colorant, the colorant selectively absorbs and scatters light.



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Two constant function

Separated K & S values are calculated for the colorant

Two constant relative

- Used for opaque applications
- Substrate is not important
- Film thickness is not important

Two constant absolute

- Used for opaque and non opaque samples
- Substrate is important
- Film thickness is important

Saunderson Correction

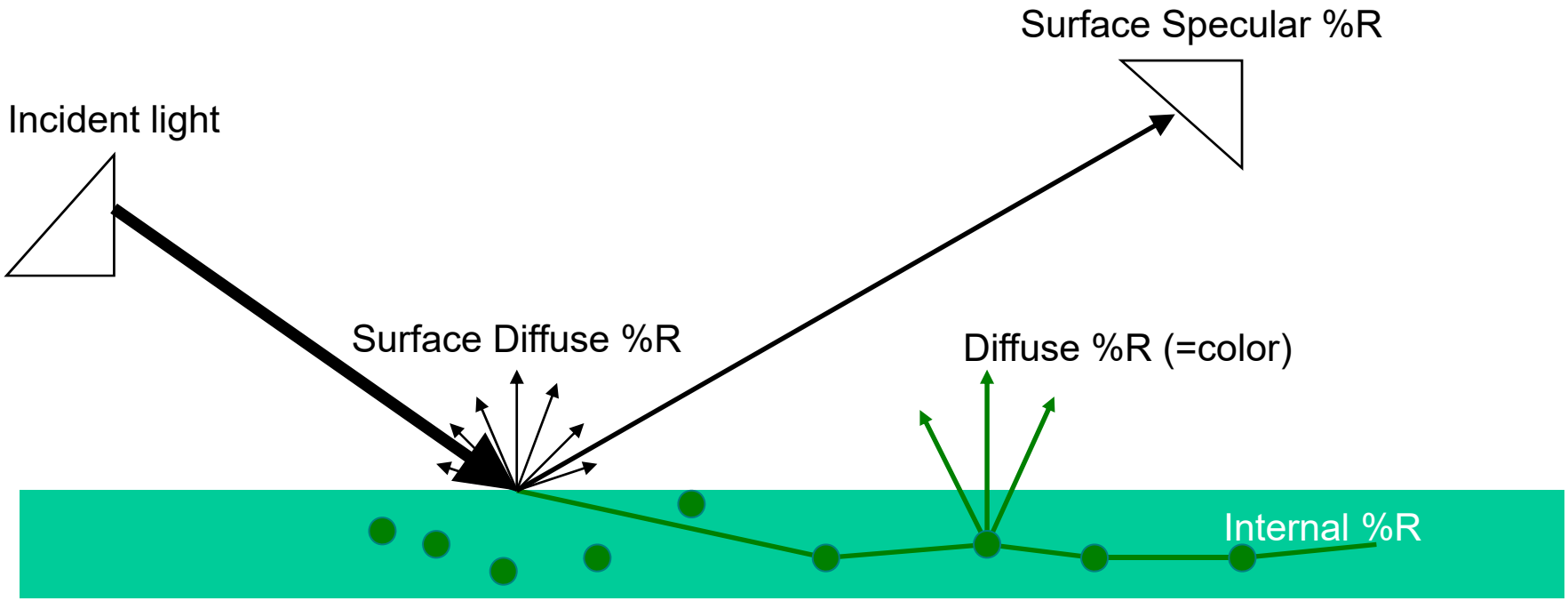
The Kubelka-Munk color model doesn't take into account the reflection losses at the sample boundaries.

There are two losses that Saunderson takes into account:

- **Internal loss (internal %R)**
- **External loss (surface %R – diffuse and specular)**

Saunderson Correction

Behaviour of light



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Saunderson Correction

Note:

When we create a colorant set, we modify the measured reflectance before calculating K and S values of the colorants.

$$R_c = \frac{R_m - k_e}{1 - k_e - k_i * (1 - R_m)}$$

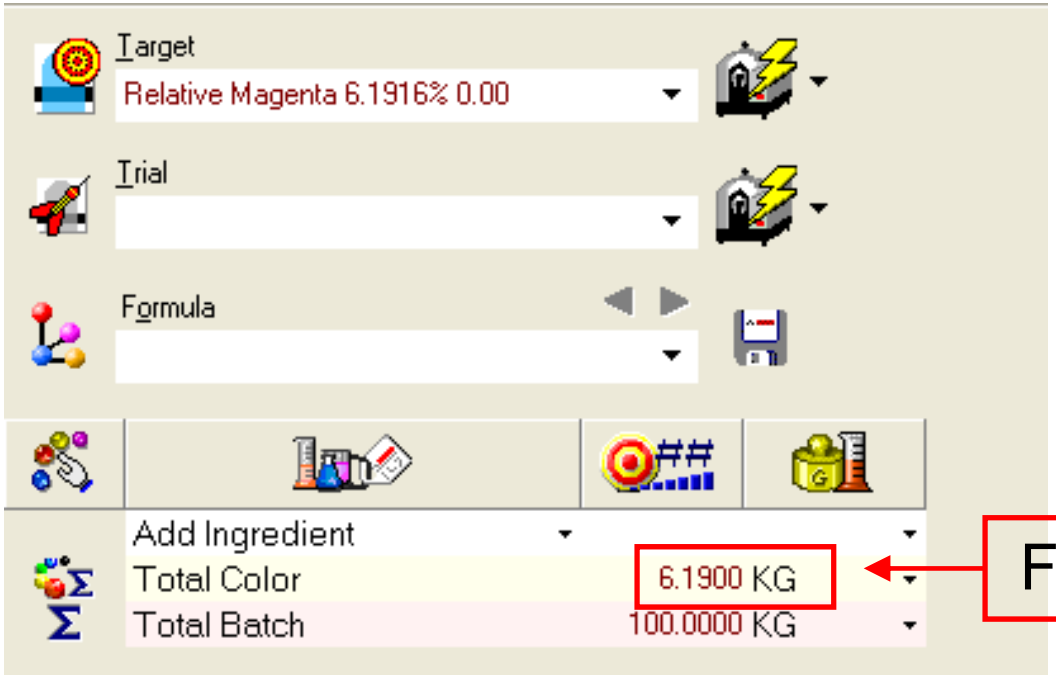
Matching

Opaque Matching

- Substrate isn't important
- Film thickness isn't important
- Will perform an opaque match
- Fix the pigment loading if wanted

Matching

Opaque Matching



Fixed pigment loading

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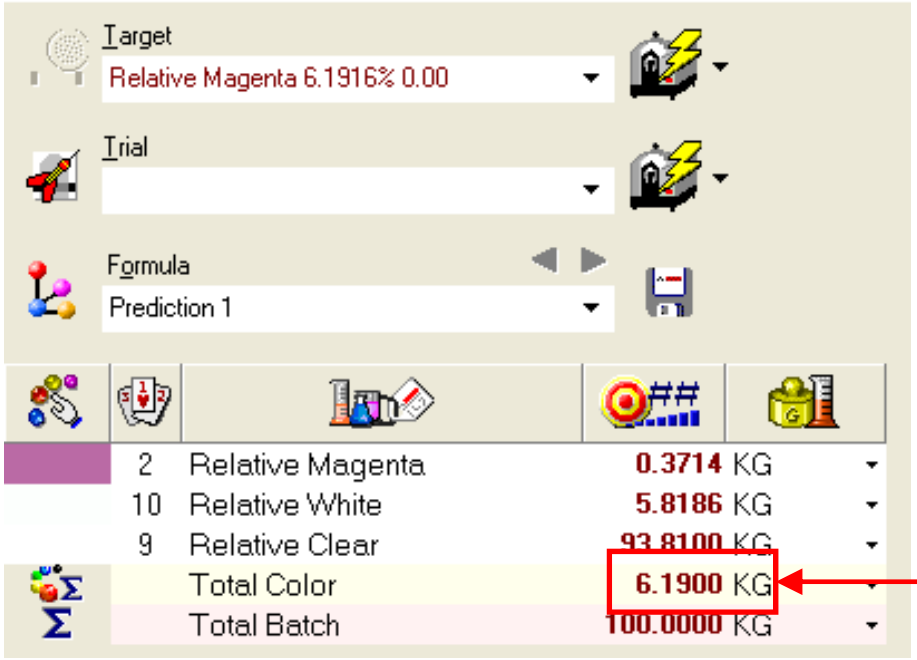
Matching

Opaque Matching



Defined pigment load is reached

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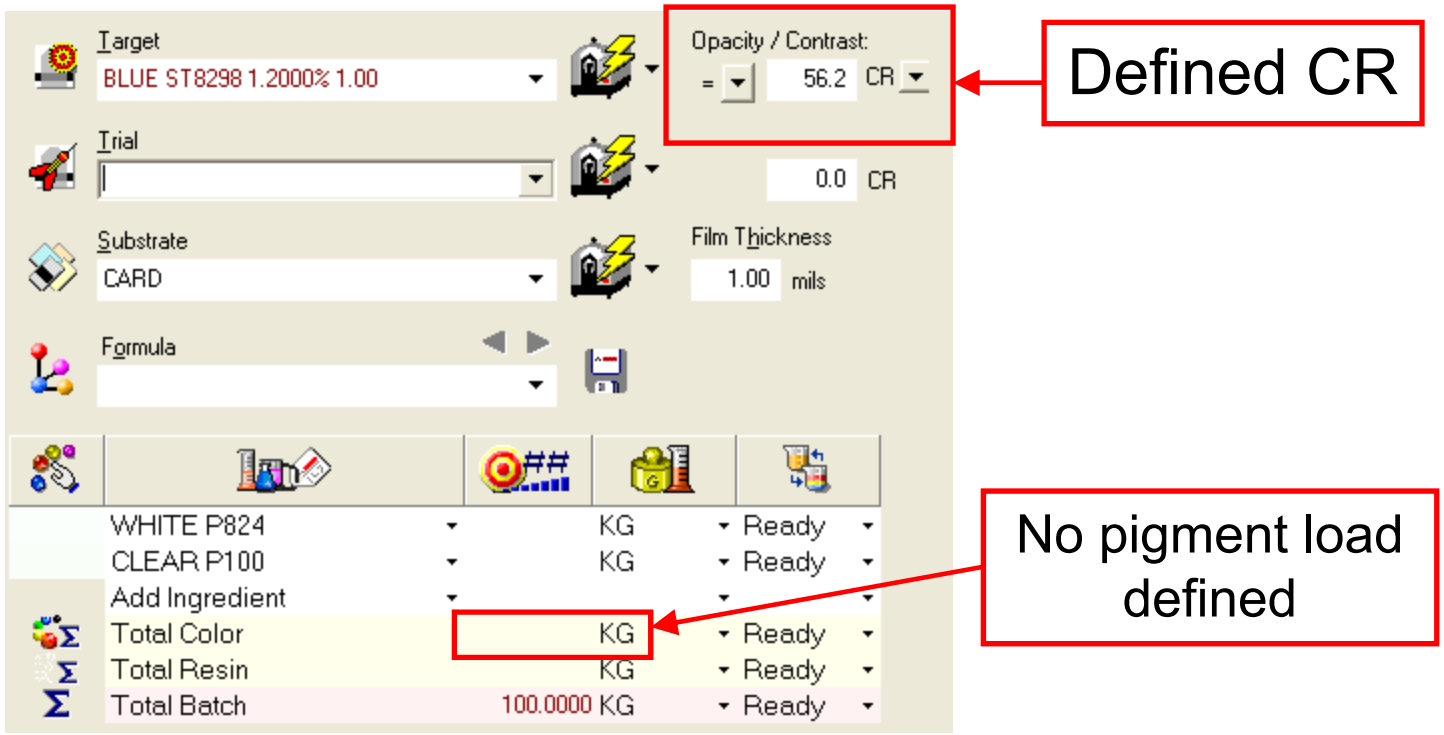
Matching

Translucent Matching

- Substrate is important
- Film thickness is important
- You can do a CR match
- You can do a fixed % load match

Matching

Translucent - CR Match



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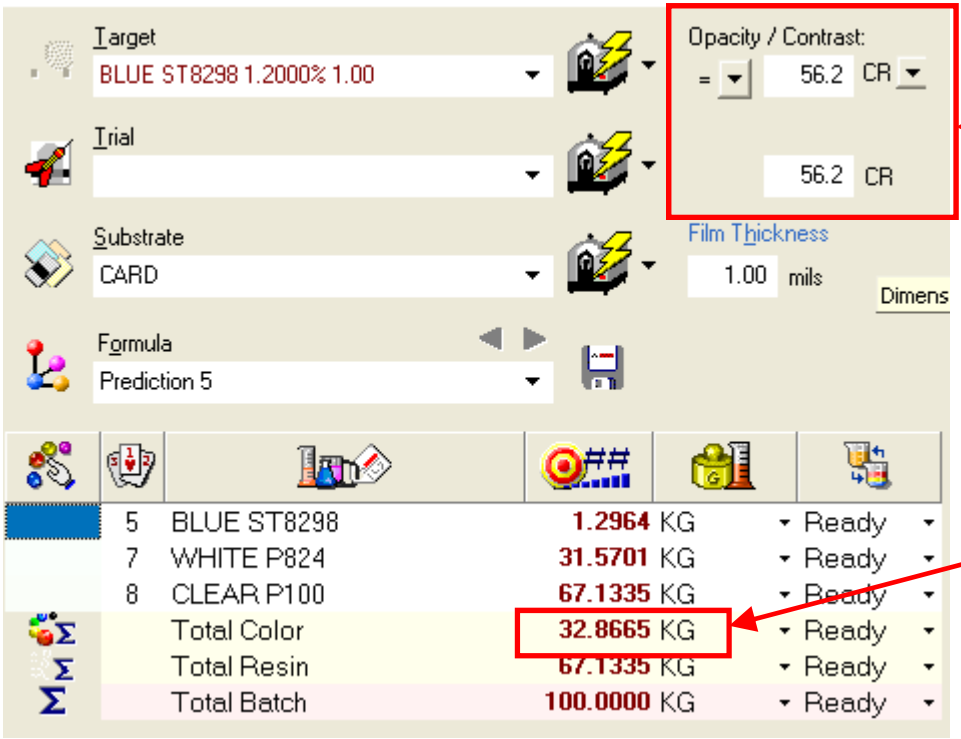
Matching

Translucent - CR Match



Requested CR is achieved

Free pigment loading

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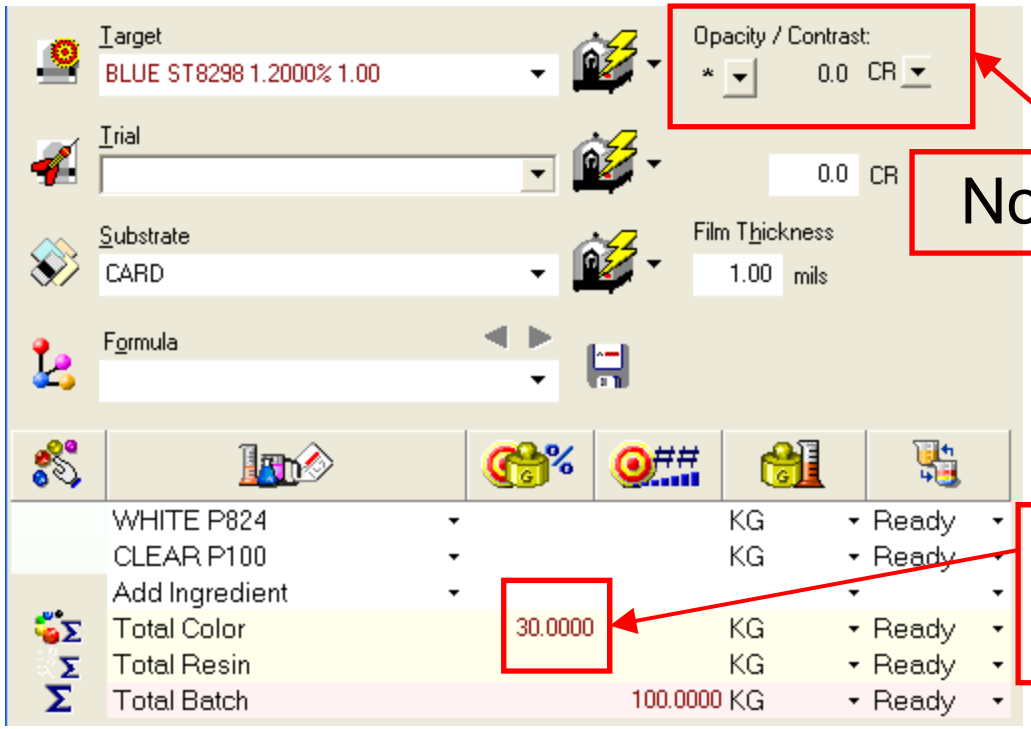
Matching

Translucent - Fixed % Load match



No opacity defined

Fixed pigment loading

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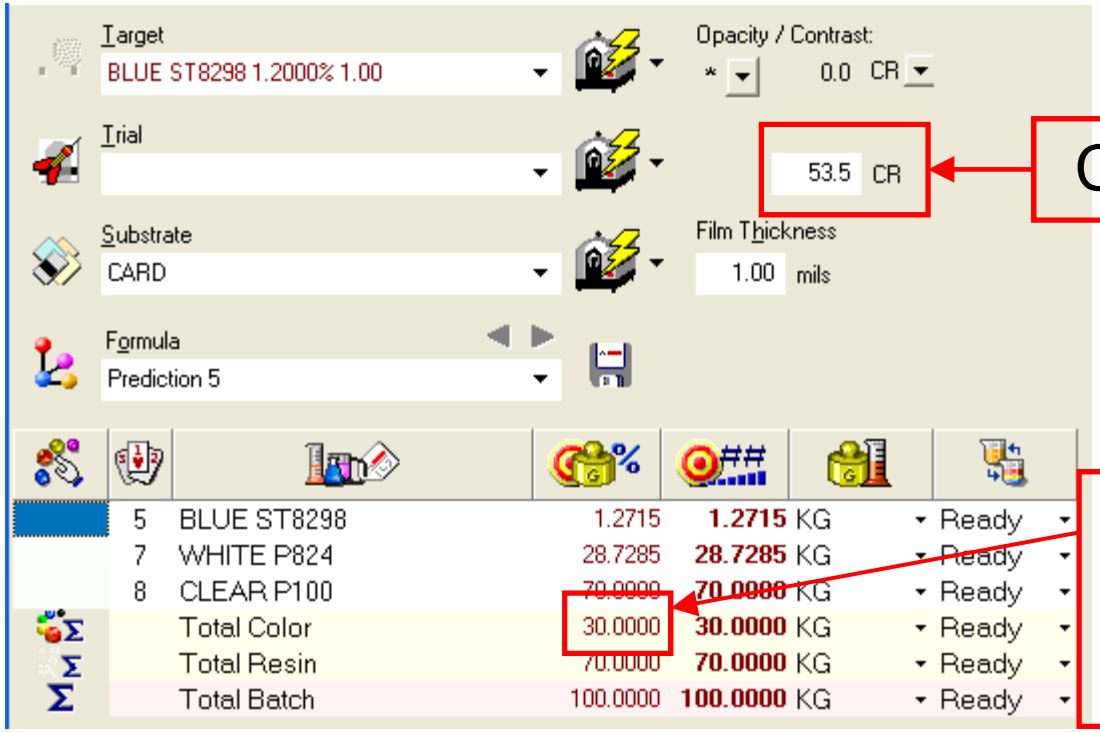
Matching

Translucent - Fixed % Load match



Calculated opacity

Requested pigment loading is reached

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Matching

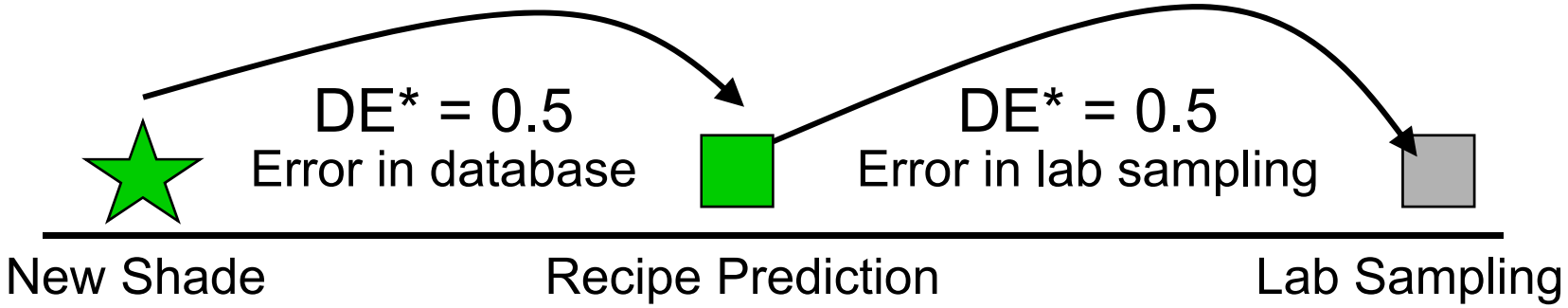
- Matching programs may calculate many recipes for a new shade
- For each recipe the computer gives:
  - Color difference
  - Metamerism
  - Price
  - ...
- The colorist then selects the most suitable recipe considering:
  - Fastness properties
  - Compatibilty
  - ...

Matching

Why don’t my predictions come out right first time?

Matching

1. **Theory assumes colorants behave the same in combination as individually in the database. Does not account for interaction.**
2. **Pigments can differ form the ones used to create the colorant set**
3. **Reproduciability**
4. **Errors in sample preparation**
5. **Appearance**



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What is Smartmatch?

- Smartmatch quantifies the interaction between individual pigments and substrates (Axis Smartmatch)
- Smartmatch is a self learning matchprediction system based on practical experience (Palette Smartmatch)
- Smartmatch is a function to correct matching theory (single constant, two constant or multi constant theory (combined method))

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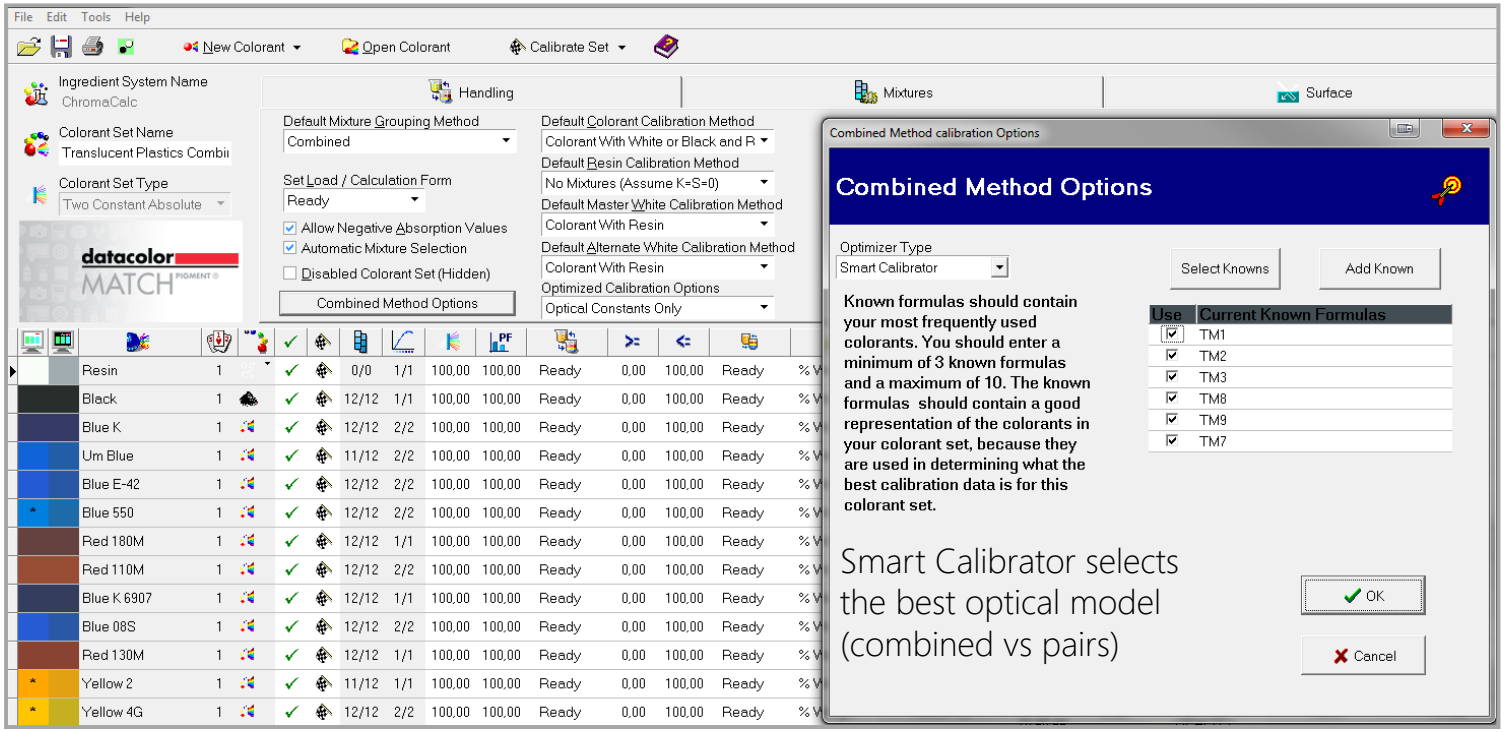
Smart Calibrator



Performance factors

- Eveluate how the colorants perform in the current batch
- Based on a comparison between the amount of colorant you put into the formula and the amount of colorant the system ‘sees’ in the formula.

Performance factors

The colorant can perform 3 ways:

- **PF = 1.0**

  Colorant is performing exactly as expected

- **PF > 1.0**

  Colorant is performing stronger than expected

- **PF < 1.0**

  Colorant is performing weaker than expected

Gloss Compensation

The gloss problem

The lack of agreement between visual and instrumental evaluations (with integrating sphere spectro's) of color samples that have different gloss

Gloss Compensation

When to use gloss compensation?

Batch (or product) gloss

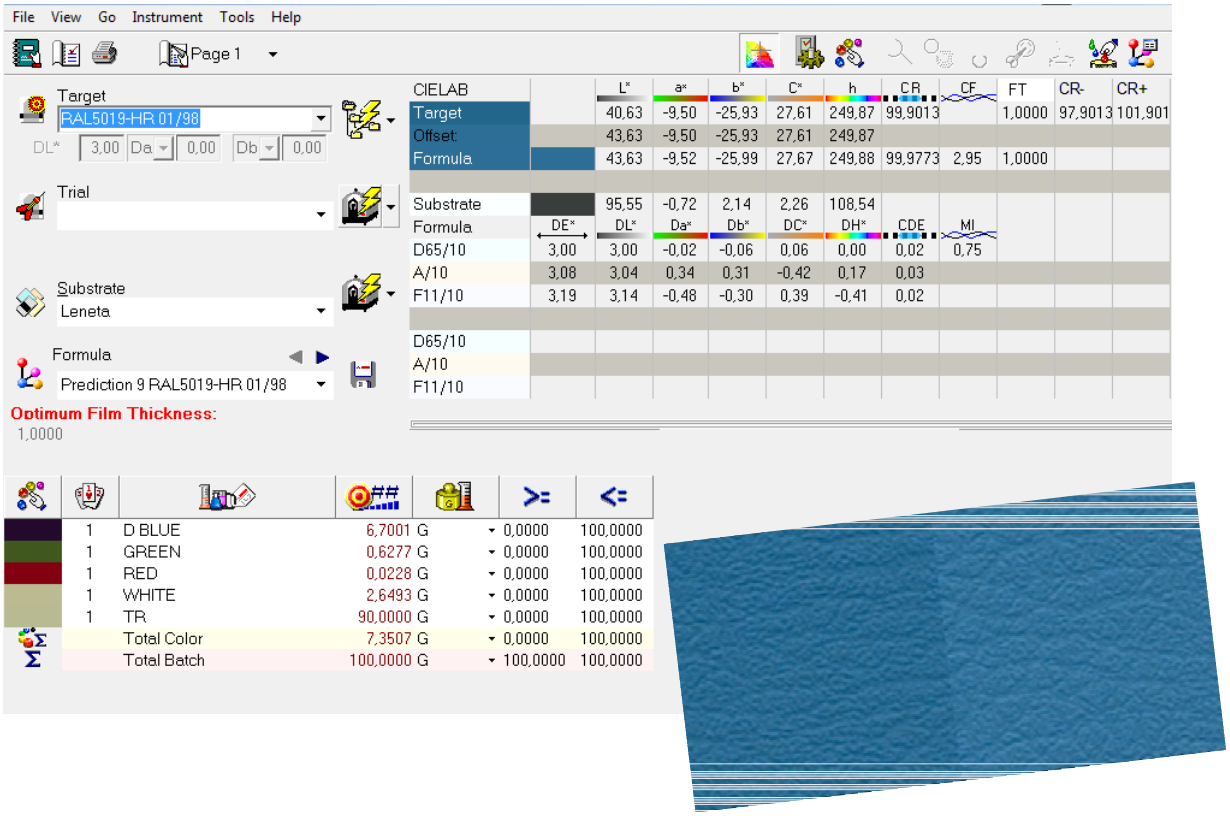
is different than

the gloss of the standard.

Biggest effect for dark colors.

Gloss compensation
offers the ability to more accurately match, correct, and control color, even as the gloss of the standards and the product differ

CIE L*a*b* Offset



- **New Feature**

✓ Match and correct to an offset value of the original target in (CIE L*a*b*, D65)

✓ Utilize common target for color appearance matching of samples with various gloss and texture.

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