
RECIPE PREDICTION IN PIGMENTED APPLICATION

UDAY KALE
DATACOLOR
MUMBAI

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.**

A Global Business



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

Brands that rely on Datacolor



PORSCHE



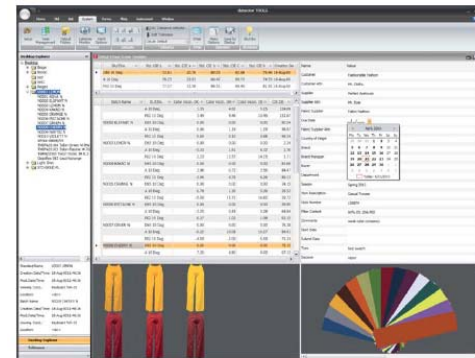
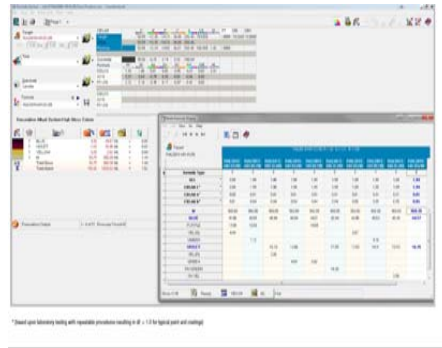
PERRY ELLIS



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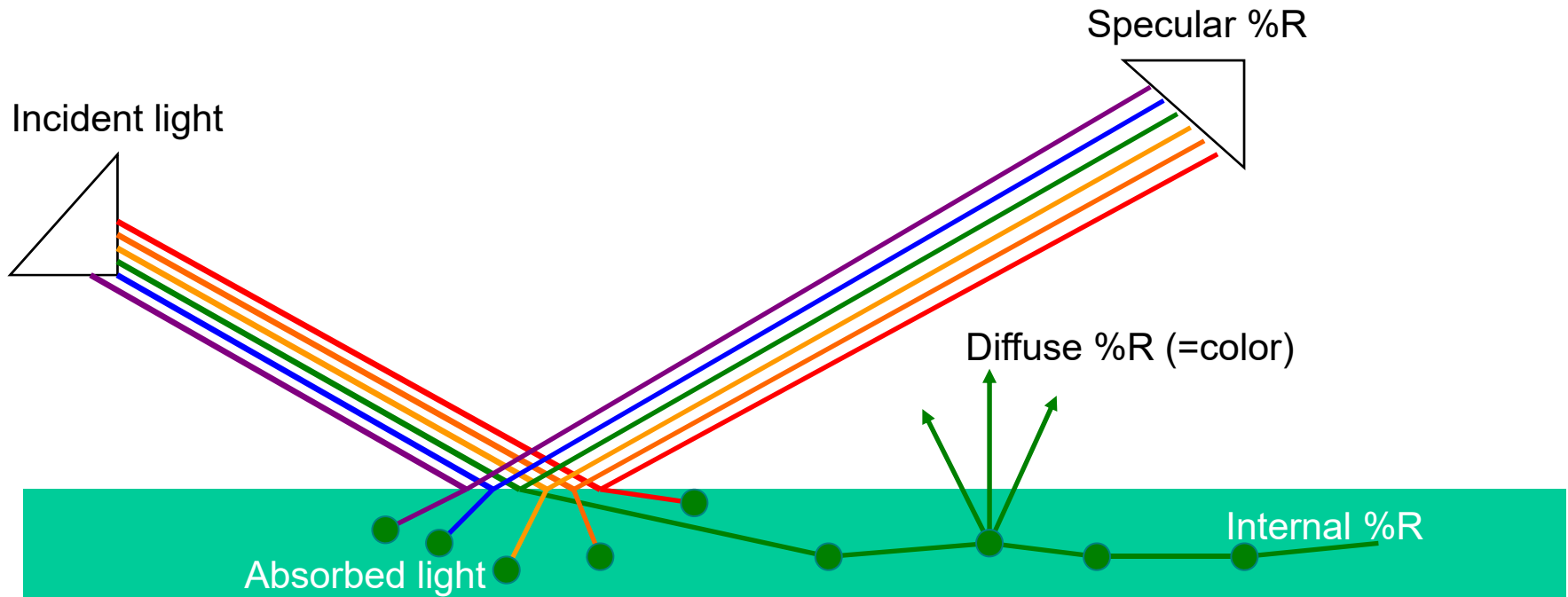
datacolor 

Datacolor Product Portfolio



Kubelka - Munk

Behaviour of light



Complex Subtractive Mixing

■ Turbid-Media Theory

- Kubelka-Munk
 - K/S is proportional to concentration
 - In the opaque case: $K/S = ((1-r)^2)/2R$
 $K/S_{mix} = (c_1K_1 + c_2K_2 + c_3K_3 \dots) / (c_1S_1 + c_2S_2 + c_3S_3 \dots)$
 - The full treatment:
- Others

■ Both Light Absorption and Light Scattering are considered.

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

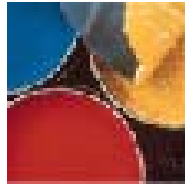
- The most important feature of K M Relation is it is additive. i.e. K/S is additive while Reflectance is non additive.
- K/S function is linearly proportional with concentration of colorants.
 $K/S = \alpha c$ where α is a constant of proportionality.
- Pigments disperse in polymers have both the properties 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

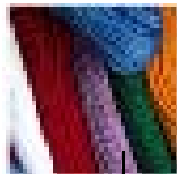
Kubelka-Munk Function

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

Matching

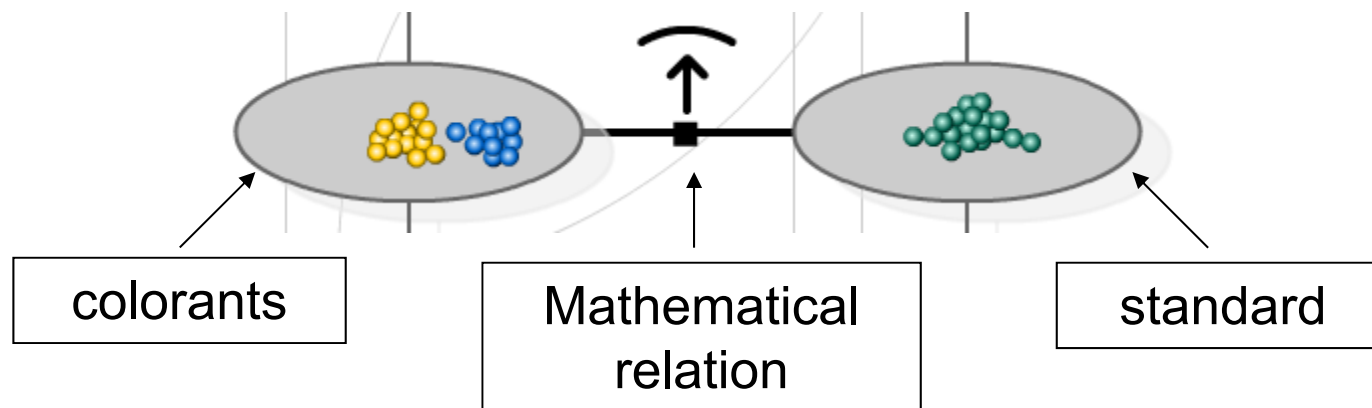


Matching colors makes it possible to determine which colorants are needed and which are their optimal quantities to reproduce the color.

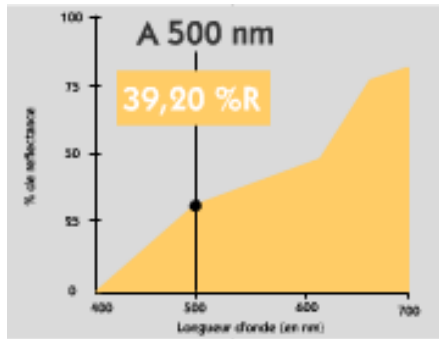


Matching - General

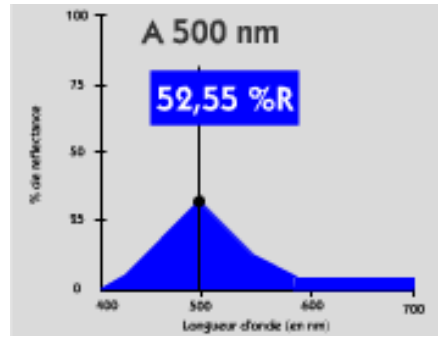
To be able to do a formulation,
we need to define the following things **mathematical**:



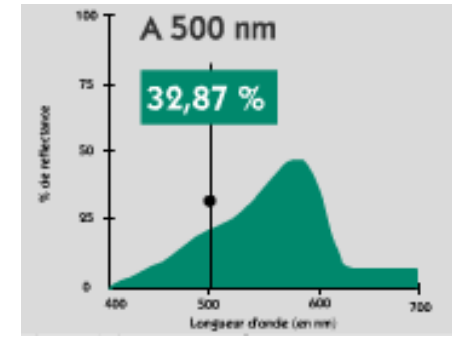
Matching - General



+



≠



39.20%

+

52.55%

≠

32.87%

Reflection doesn't fit the additive principle

Kubelka - Munk

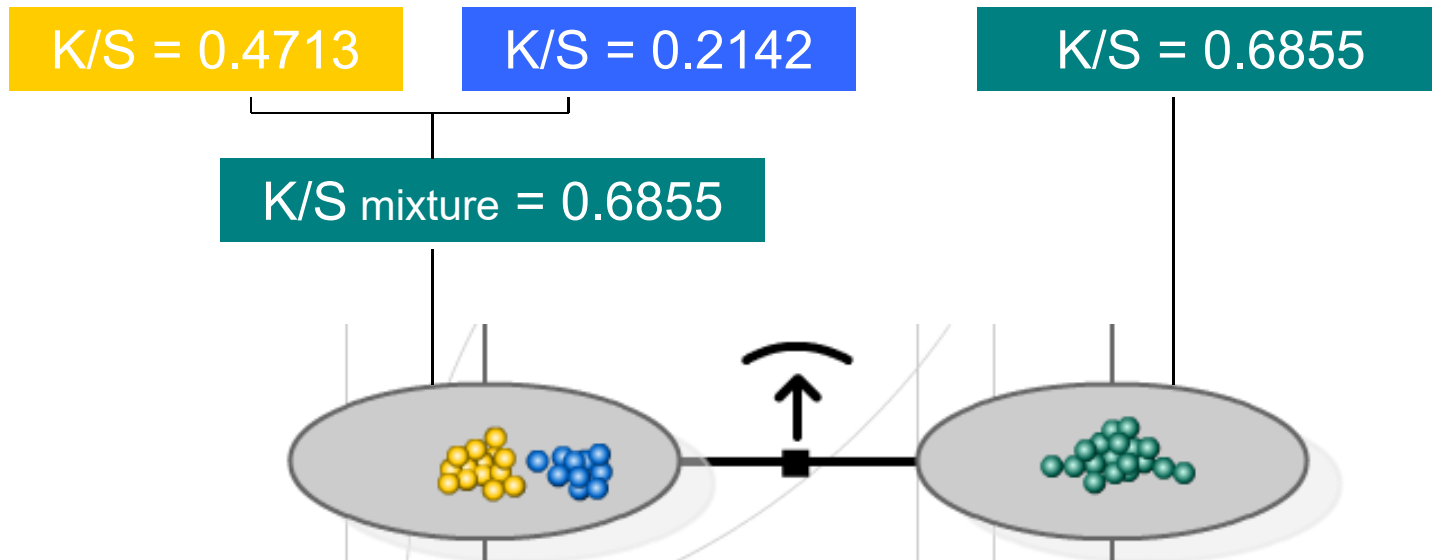
*Solution for the
problem:*

*KUBELKA - MUNK
Function*



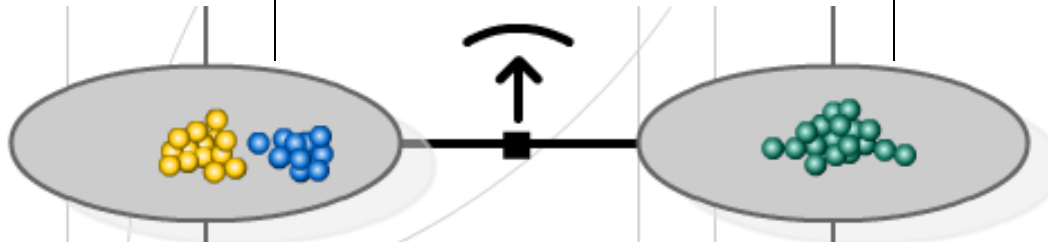
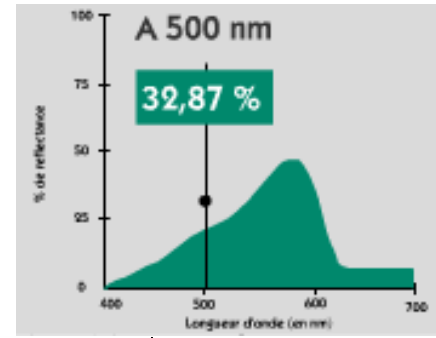
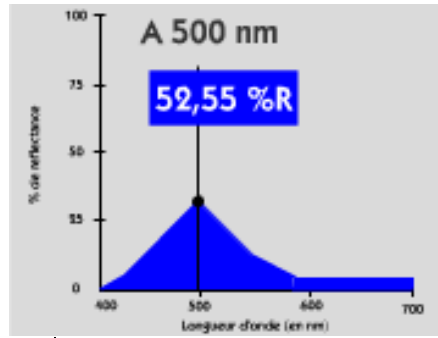
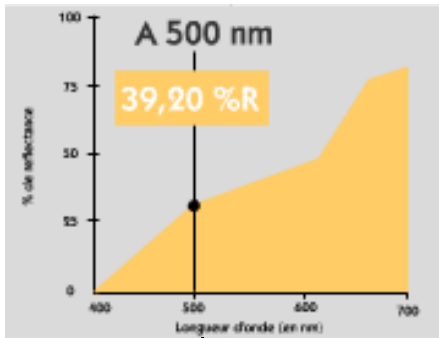
Kubelka - Munk

Application of the Kubelka – Munk function



The K/S function is additive.

Matching - General



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

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

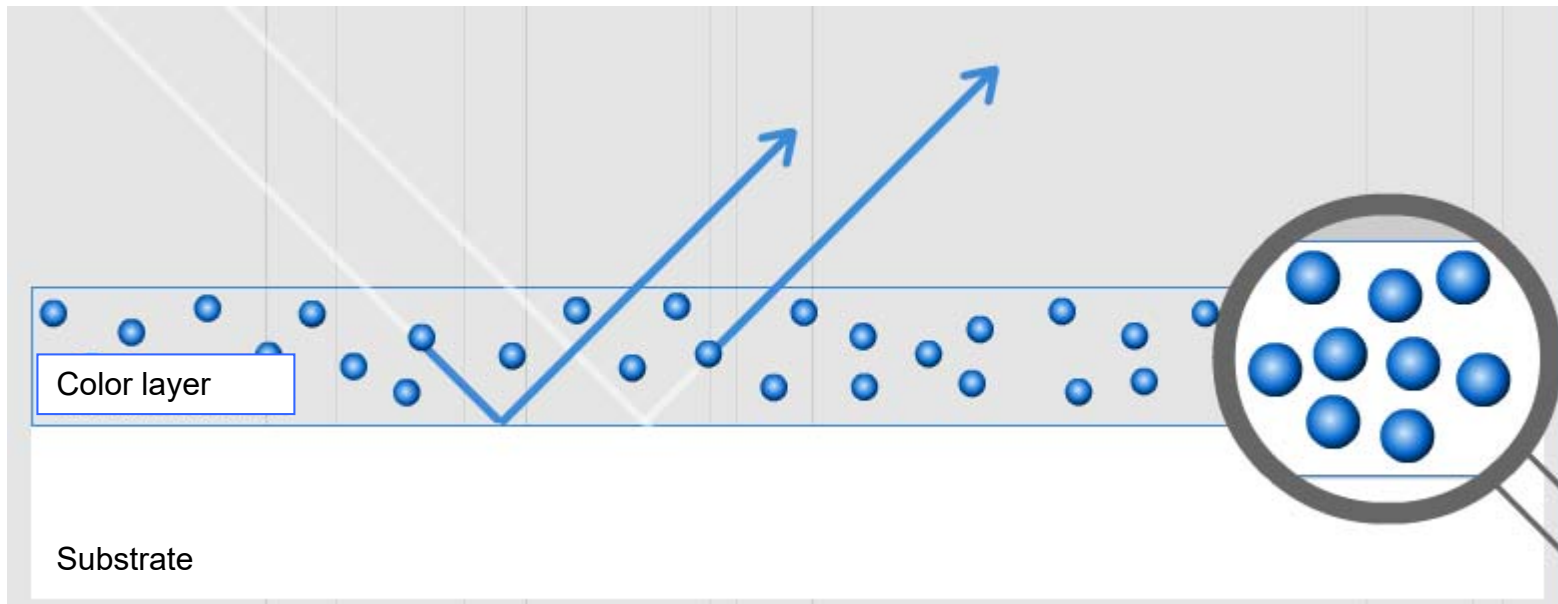
One constant function

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.



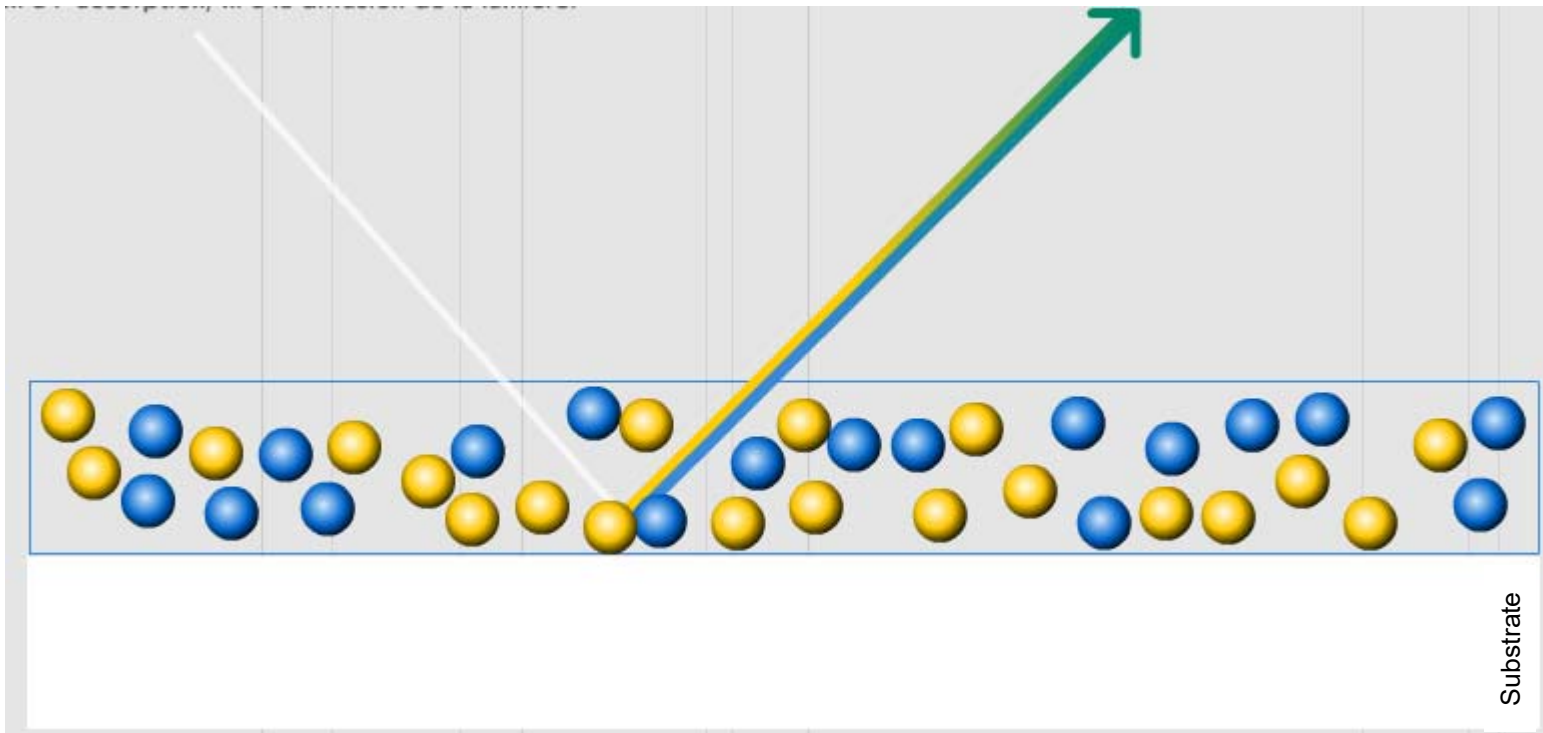
Two constant function

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.



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

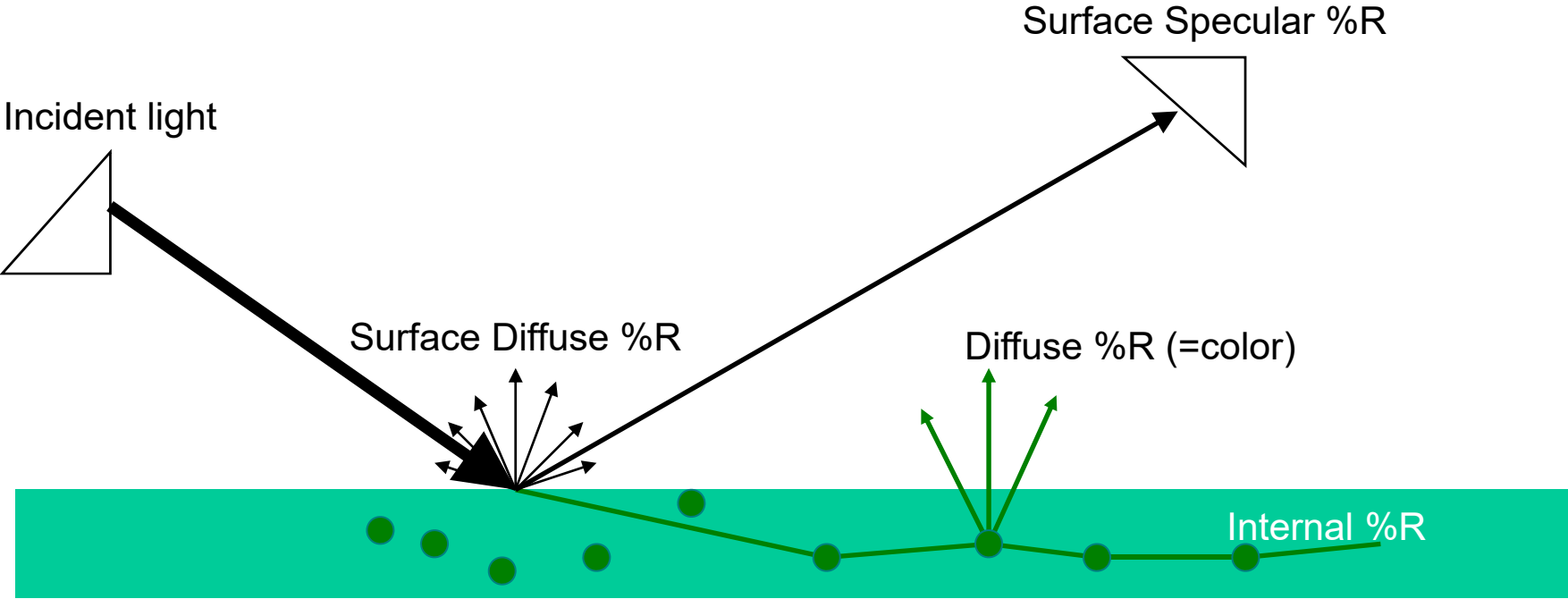
The Kubelka-Munk color model doesn't take into account the reflection losses at the sample boundaries.

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



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

Target	Relative Magenta 6.1916% 0.00
Trial	
Formula	
Add Ingredient	
Total Color	6.1900 KG
Total Batch	100.0000 KG

Fixed pigment loading

Matching

Opaque Matching

Target: Relative Magenta 6.1916% 0.00

Trial: [Empty]

Formula: Prediction 1

2	Relative Magenta	0.3714 KG
10	Relative White	5.8186 KG
9	Relative Clear	93.8100 KG
	Total Color	6.1900 KG
	Total Batch	100.0000 KG

Defined pigment load is reached

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

Target: BLUE ST8298 1.2000% 1.00

Trial: [Empty]

Substrate: CARD

Formula: [Empty]

Opacity / Contrast: = 56.2 CR

Film Thickness: 1.00 mils

WHITE P824	KG	Ready
CLEAR P100	KG	Ready
Add Ingredient		
Total Color	KG	Ready
Total Resin	KG	Ready
Total Batch	100.0000 KG	Ready

Defined CR

No pigment load defined

Matching

Translucent - CR Match

Target: BLUE ST8298 1.2000% 1.00

Trial: [Empty]

Substrate: CARD

Formula: Prediction 5

Opacity / Contrast: = 56.2 CR

Film Thickness: 1.00 mils

5	BLUE ST8298	1.2964 KG	Ready
7	WHITE P824	31.5701 KG	Ready
8	CLEAR P100	67.1335 KG	Ready
	Total Color	32.8665 KG	Ready
	Total Resin	67.1335 KG	Ready
	Total Batch	100.0000 KG	Ready

Requested CR is achieved

Free pigment loading

Matching

Translucent - Fixed % Load match

Target: BLUE ST8298 1.2000% 1.00

Opacity / Contrast: * 0.0 CR

Trial: [Empty]

Substrate: CARD

Film Thickness: 1.00 mils

Formula: [Empty]

WHITE P824	KG	Ready
CLEAR P100	KG	Ready
Add Ingredient		
Total Color	30.0000	KG Ready
Total Resin		KG Ready
Total Batch	100.0000	KG Ready

No opacity defined

Fixed pigment loading

Matching

Translucent - Fixed % Load match

Target: BLUE ST8298 1.2000% 1.00

Opacity / Contrast: * 0.0 CR

Trial: [Empty]

Substrate: CARD

Formula: Prediction 5

Film Thickness: 1.00 mils

Calculated opacity: 53.5 CR

5	BLUE ST8298	1.2715	1.2715 KG	Ready
7	WHITE P824	28.7285	28.7285 KG	Ready
8	CLEAR P100	70.0000	70.0000 KG	Ready
	Total Color	30.0000	30.0000 KG	Ready
	Total Resin	70.0000	70.0000 KG	Ready
	Total Batch	100.0000	100.0000 KG	Ready

Requested pigment loading is reached

Matching

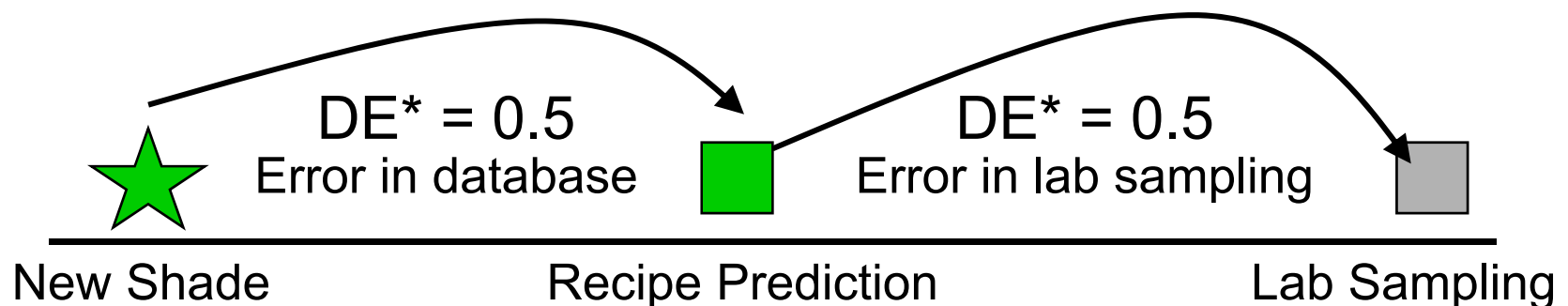
- Matching programs may calculate many recipes for a new shade
- For each recipe the computer gives:
 - Color difference
 - Metamerism
 - Price
 - ...
- The colorist then selects the most suitable recipe considering:
 - Fastness properties
 - Compatibilty
 - ...

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 from the ones used to create the colorant set
3. Reproducibility
4. Errors in sample preparation
5. Appearance



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))**

Smart Calibrator

Combined Method Options

Optimizer Type: Smart Calibrator

Select Knowns | Add Known

Use	Current Known Formulas
<input checked="" type="checkbox"/>	TM1
<input checked="" type="checkbox"/>	TM2
<input checked="" type="checkbox"/>	TM3
<input checked="" type="checkbox"/>	TM8
<input checked="" type="checkbox"/>	TM9
<input checked="" type="checkbox"/>	TM7

Known formulas should contain your most frequently used colorants. You should enter a minimum of 3 known formulas and a maximum of 10. The known formulas should contain a good representation of the colorants in your colorant set, because they are used in determining what the best calibration data is for this colorant set.

Smart Calibrator selects the best optical model (combined vs pairs)

OK | Cancel

Performance factors

- Evaluate 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

The screenshot displays the Datacolor Munsell Color Services software interface. The main window shows the 'Target' section with 'RAL5019-HR 01/98' selected. Below this, the 'Formula' section is set to 'Prediction 9 RAL5019-HR 01/98'. The 'Substrate' is 'Leneta'. The 'Formula' section shows 'Optimum Film Thickness: 1,0000'.

The 'CIELAB' table shows the following values:

	L*	a*	b*	C*	h	CR	CF	FT	CR-	CR+
Target	40.63	-9.50	-25.93	27.61	249.87	99.9013		1.0000	97.9013	101.901
Offset	43.63	-9.50	-25.93	27.61	249.87					
Formula	43.63	-9.52	-25.99	27.67	249.88	99.9773	2.95	1.0000		

The 'Substrate' table shows the following values:

	DE*	DL*	Da*	Db*	DC*	DH*	CDE	MI
D65/10	3.00	3.00	-0.02	-0.06	0.06	0.00	0.02	0.75
A/10	3.08	3.04	0.34	0.31	-0.42	0.17	0.03	
F11/10	3.19	3.14	-0.48	-0.30	0.39	-0.41	0.02	

The 'Formula' table shows the following values:

	DE*	DL*	Da*	Db*	DC*	DH*	CDE	MI
D65/10								
A/10								
F11/10								

The 'Color Targets' table shows the following values:

	Quantity	Value	Unit	Offset	Target
1	D BLUE	6.7001	G	- 0.0000	100.0000
1	GREEN	0.6277	G	- 0.0000	100.0000
1	RED	0.0228	G	- 0.0000	100.0000
1	WHITE	2.6493	G	- 0.0000	100.0000
1	TR	90.0000	G	- 0.0000	100.0000
	Total Color	7.3507	G	- 0.0000	100.0000
	Total Batch	100.0000	G	- 100.0000	100.0000

A blue textured sample is shown in the bottom right corner of the software interface.

■ 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.

