School of Chemistry
FACULTY OF MATHS AND PHYSICAL SCIENCES

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Colour Theory & Applications

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Clever Characterisation for Smarter Formulation II
10.11.2017

Colour Communications

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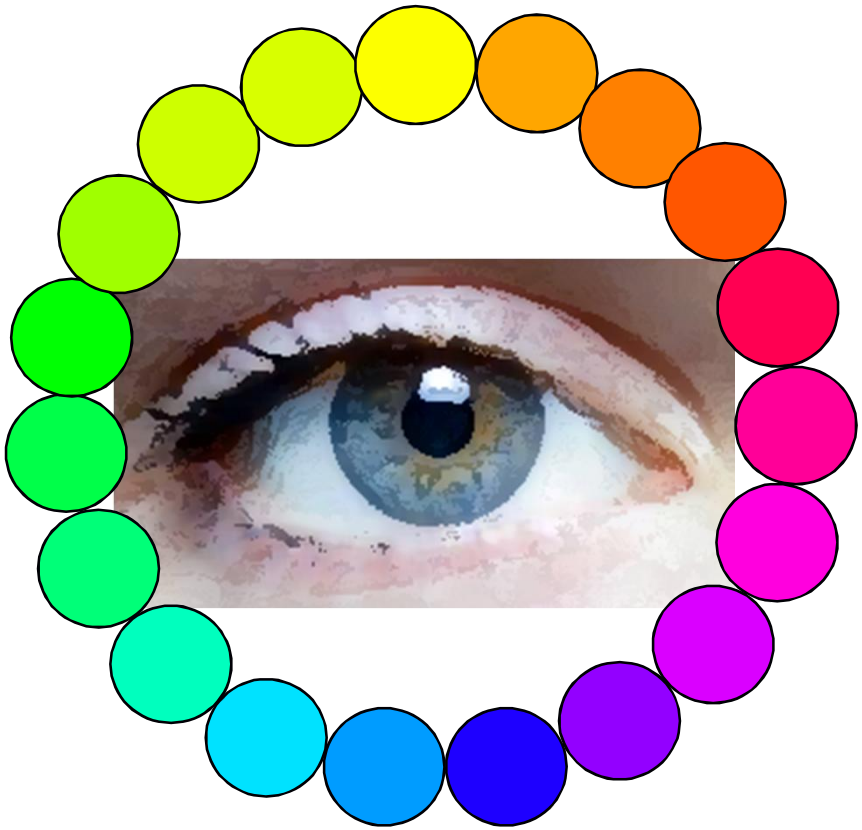

Radiometric Terms

wavelength, flux and intensity

Photometric Terms

luminosity

(to describe the visual brightness of a beam or source of light)

Colorimetric Terms

lightness, hue, chroma (or intensity)

Requirements for Numerical Methods of Specifying Colour

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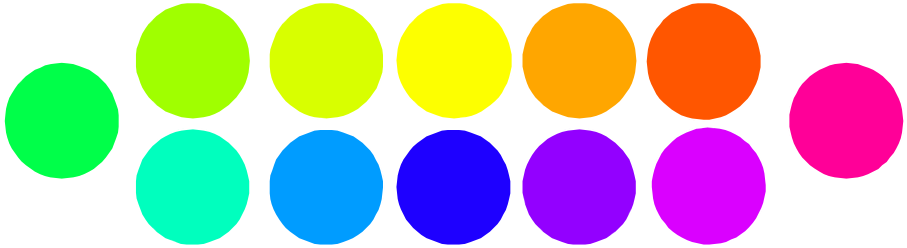
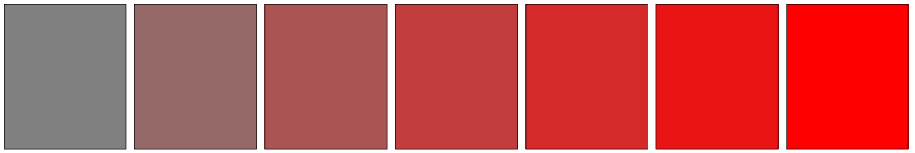
- Numerical methods of describing colour are used to communicate colour information without the need for physical samples.
- Ideally the numbers should by easily interpreted in terms of the attributes

lightness

hue



chroma or intensity



CIE Colour Spaces & Spectral Locus

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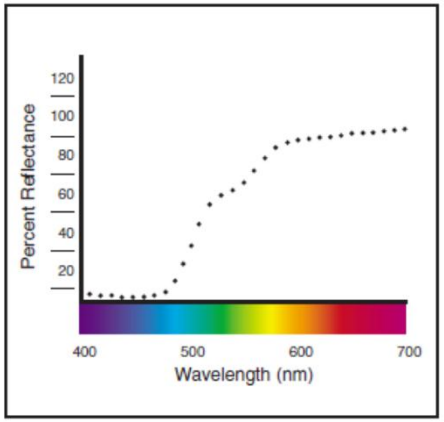
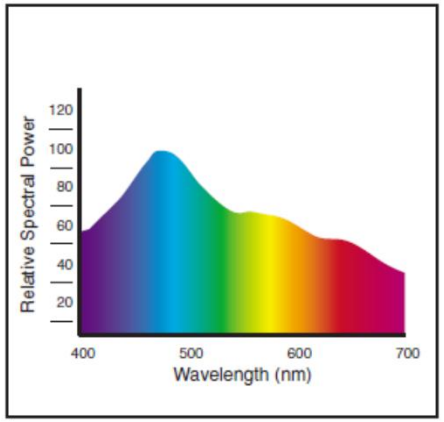


X



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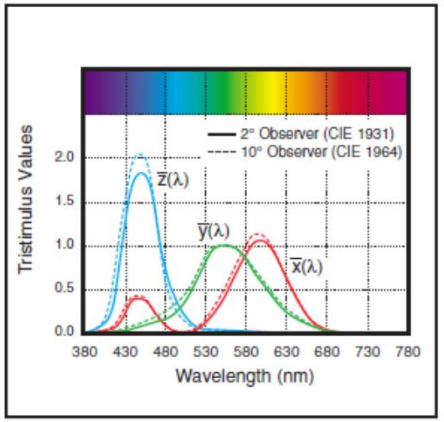
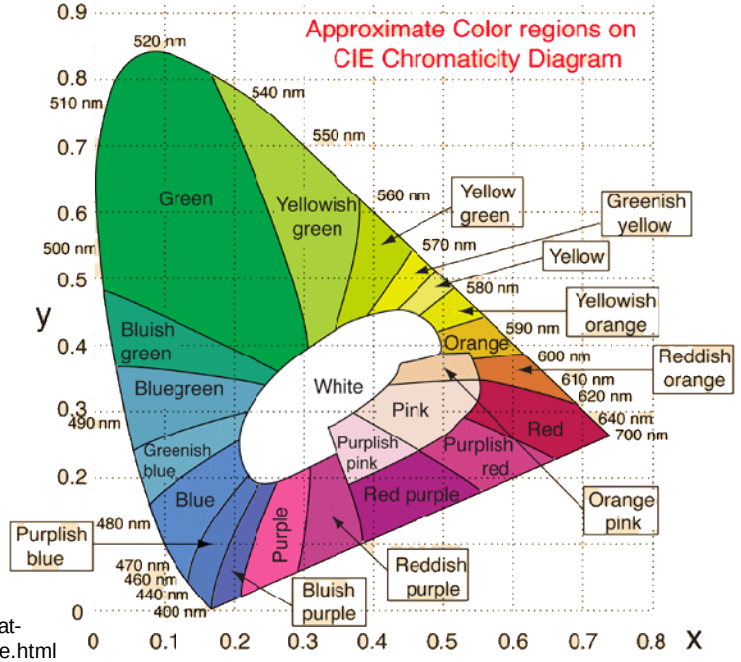


Spectral Curve D65 Illuminant Standard Observer

X = 62.04
Y = 69.72
Z = 7.34

Tristimulus Values



http://www.avsforum.com/forum/166-lcd-flat-panel-displays/2812161-what-color-volume.html

Chromaticity Chart & OLED

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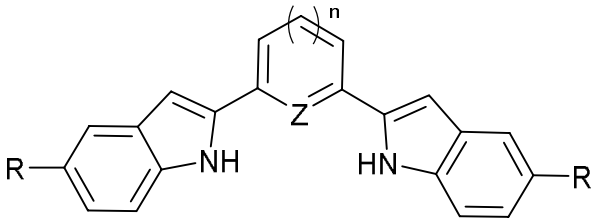
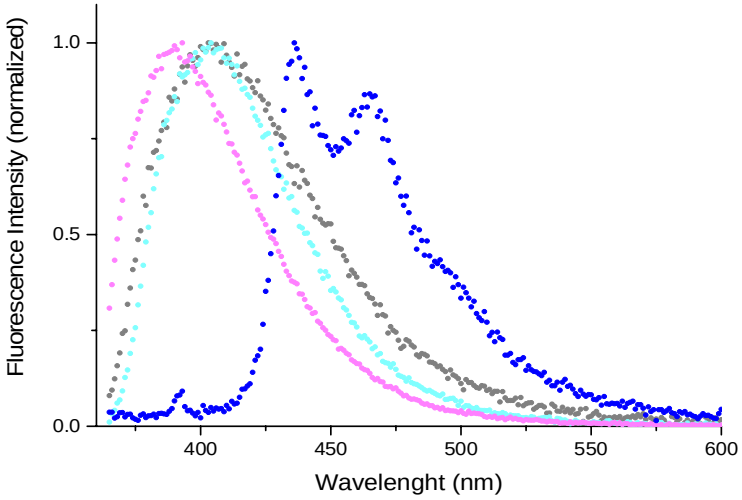
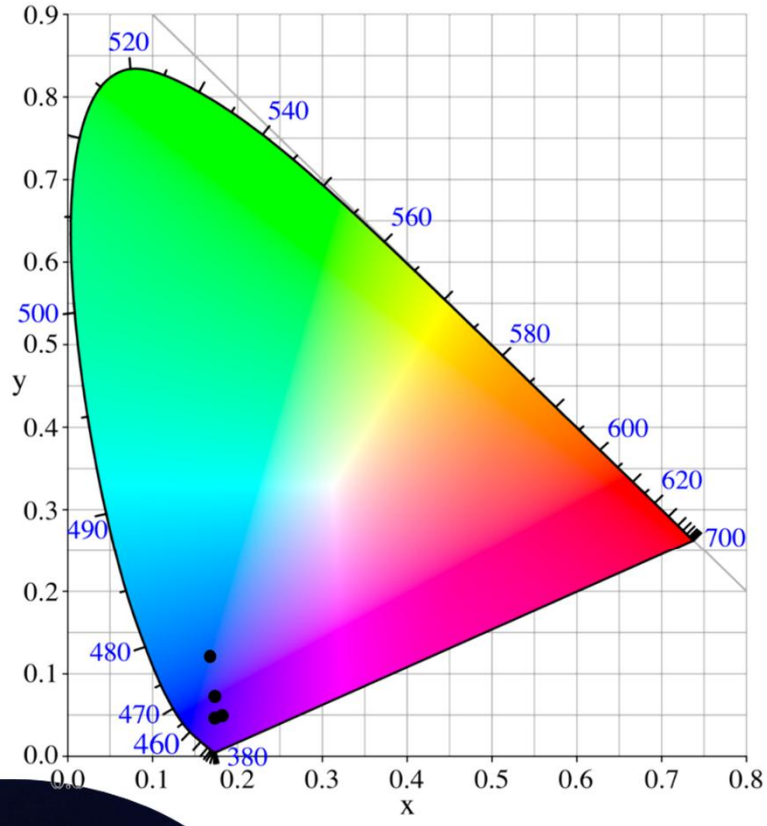
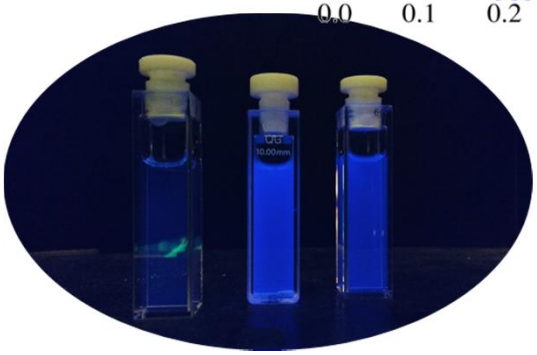


Z = N (n=1), CH (n=1), S (n=0)
R = H; OCF_3; OMe







Canas AMG; Martsinovich N; Sergeeva NN
CHEMISTRYSELECT, 2017, **2**, 2433-2438

Drawbacks of the XYZ Systems

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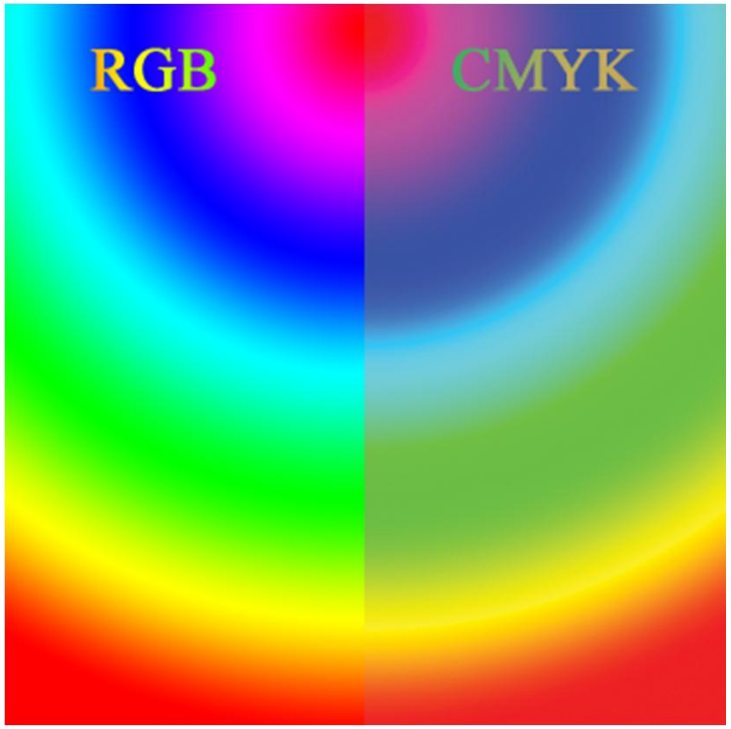
It is difficult the interpret the X, Y and Z numbers in terms of

- hue
- lightness and
- chroma



CIE recommended two alternate uniform colour scales:
CIE 1976(L*a*b*) or CIELAB and CIELCH(L*C*h°).

CIE Lab & CIELch Colour Spaces

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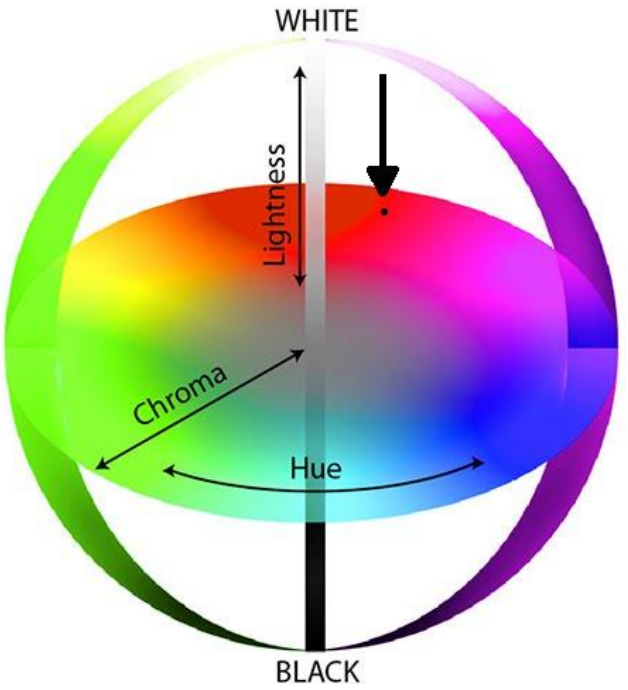
The CIE Lab and Lch systems

- A three dimensional space in which all surface colours can be represented.

- The colour parameters are easily interpreted in terms of the lightness, hue and depth of a colour.

- The axes are scaled so that a just perceptible colour difference is approximately unit distance.



CIE Lab & CIELch Colour Spaces

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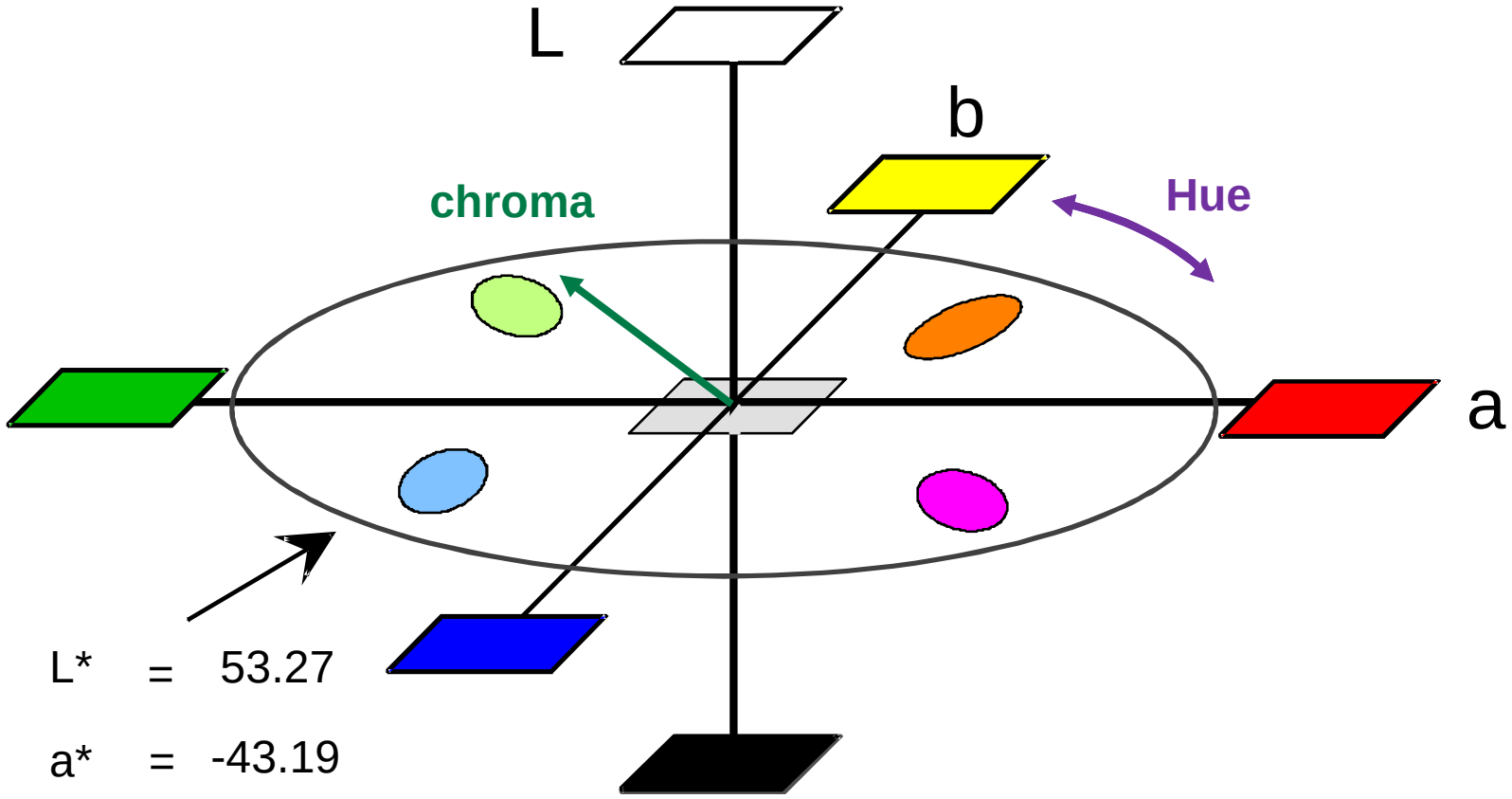

L* = 53.27

a* = -43.19

b* = -36.81

Example - Formulation

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Cleaning and restoration of building facades.

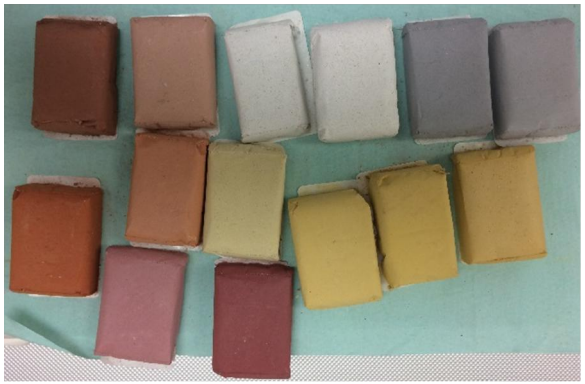
Douglas Mill, Bradford

Before After

Previously work has been carried out by visual inspection to match existing masonry in an *ad hoc* fashion.

WGL have collaborated with UoL Colour Science to improve their processes:

- Improve accuracy
- Reduce waste
- Streamline procedures



Prof Long Lin & Dr Daniel Hall in collaboration with WGL

Example – Thermal stability

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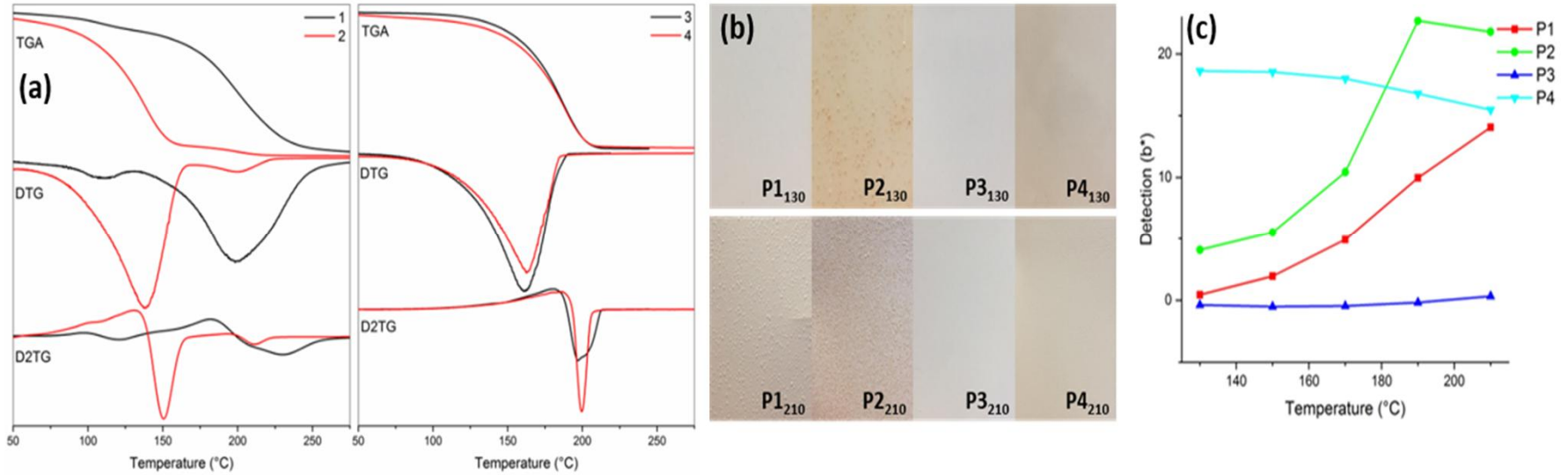

Figure: (a) TGA, DTG and D2TG graphs of compounds 1-4. (b) Photographs of the surface of the formulation coatings (c) Graph of b* values for $P1_{130\text{-}210}$, $P2_{130\text{-}210}$, $P3_{130\text{-}210}$ and $P4_{130\text{-}210}$.

	130 °C			ΔE			
Entry	L*	a*	b*	150 °C	170 °C	190 °C	210 °C
P1	93.95	-0.27	0.43	1.61	4.55	10.01	22.19
P2	93.75	-0.68	4.07	1.44	6.76	22.87	27.70
P3	94.43	-0.08	-0.39	0.40	0.33	0.31	0.74
P4	89.39	1.45	18.62	0.46	0.40	2.38	3.77

Table: L*a*b* and ΔE values for compounds 1-4 in thermally treated plastisol formulations P1-P4 at different curing temperatures.

Acknowledgment

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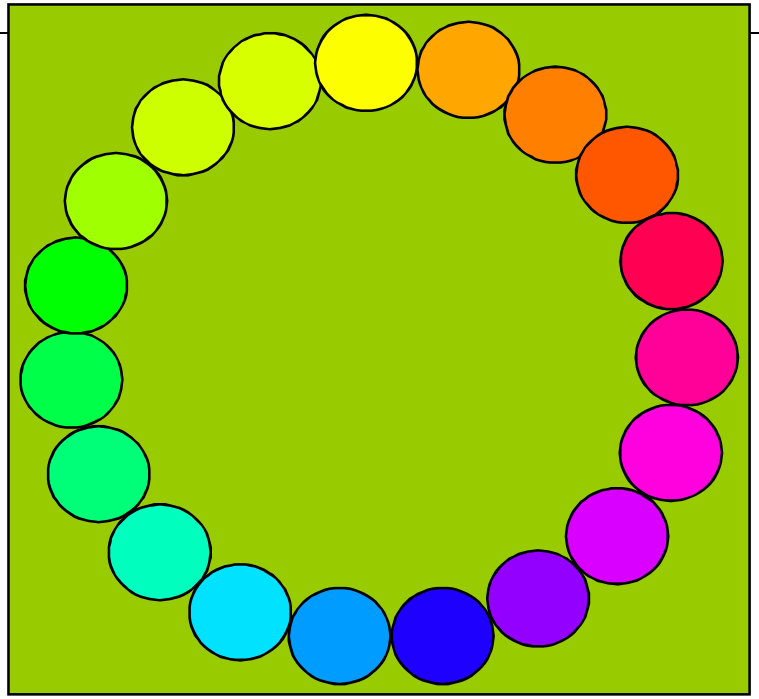
Hue



We assume that for white, grey and black:

$$\rho = \gamma = \beta$$

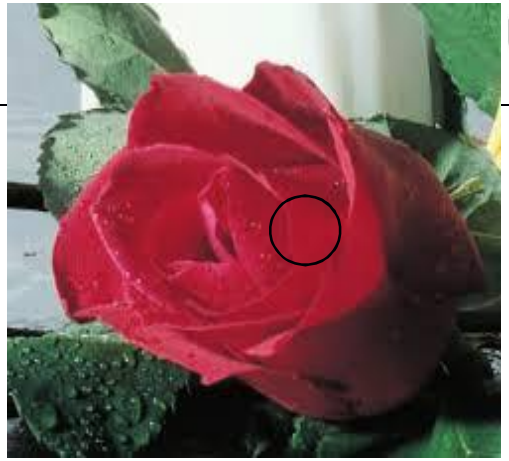
Colour differences from them is 0.

The hues of colours can be indicted, thus:

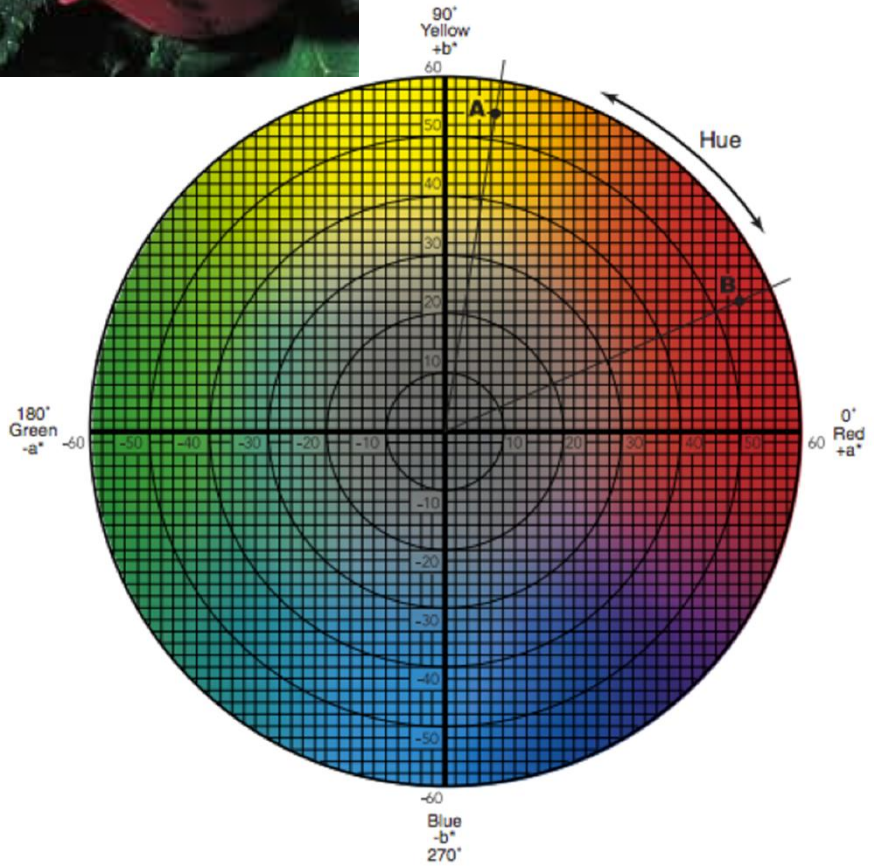
C1 – positive –
C1 – negative –
(C2-C3) – positive –
(C2-C3)- negative –

Examples

Flower A:
L = 52.99*
a = 8.82*
b = 54.53*



Flower B:
L = 29.00*
a = 52.48*
b = 22.23*



These points specify each flower's hue (color) and chroma (vividness/dullness).

When their L* values (degree of lightness) are added in, the final colour of each flower is obtained.

Radiometric Terms

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wavelength, flux and intensity

	Unit	Description
Wavelength	nm, 10^{-9} m	Visible range is 360 nm to 830 nm
Flux	Watts	Energy emitted by an object per unit time.
Intensity	Watts/m^2	Energy per unit time crossing a unit area oriented normal to the beam direction

Photometric Terms

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to describe the visual brightness (luminosity) of a beam or source of light

	Unit	Description
Luminous flux	Lumen	Visual energy emitted by an object in unit time
Luminance	Lux , Lx 1 Lux = 1 Lumen/m^2	Visual energy per unit time crossing a unit area oriented normal to the beam direction

Colorimetric Terms

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Attribute	Description	Example
Brightness (absolute)	Response from light sensitive cells	bright, dim
Hue (absolute)	Similarity between colour and the primary sensations (red, yellow, green, blue)	reddish, greenish-blue
Colourfulness (absolute)	Measure of the concentration of the hue sensation	neutral, colourful
Saturation (relative)	Relative proportion of colourfulness to brightness	
Lightness (relative)	Brightness compared to that of a white viewed under the same conditions	light, dark
Chroma (relative)	Colourfulness compared to the brightness of a white viewed under the same conditions	strong, weak