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What is the Colour Rendering Index?



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Colour are „actions“ of the light

The property of the light source that influences the appearance of objects in terms of colour is called „Colour Rendering“

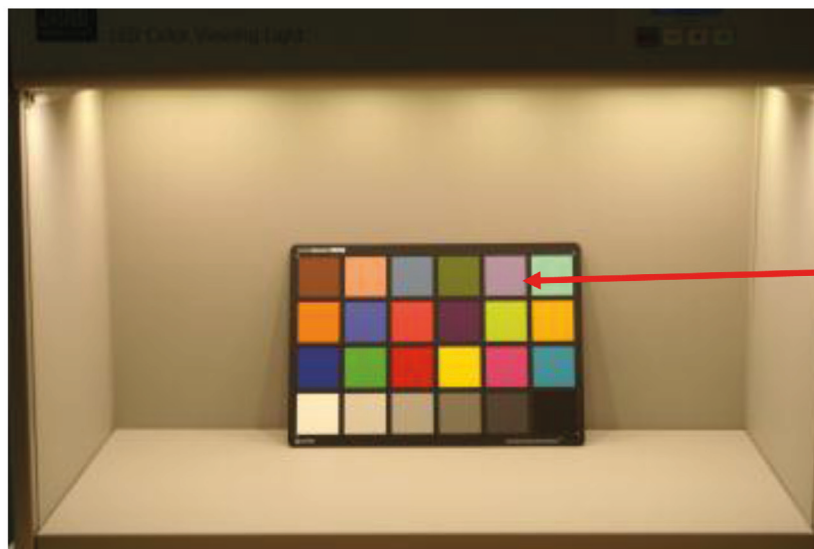




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Colour Rendering

The result of the colour rendering can be measured with a Spectroradiometer.



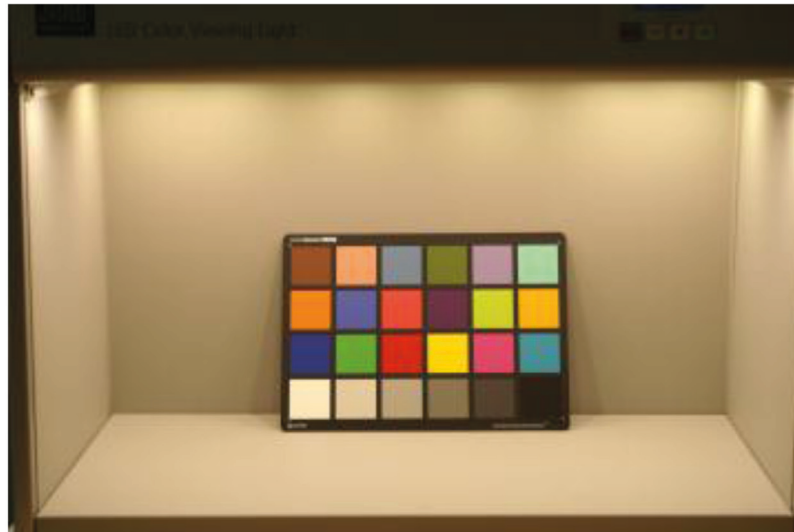
Fluorescent Light

$L^* = 56.84$
 $a^* = 6.76$
 $b^* = -23.14$



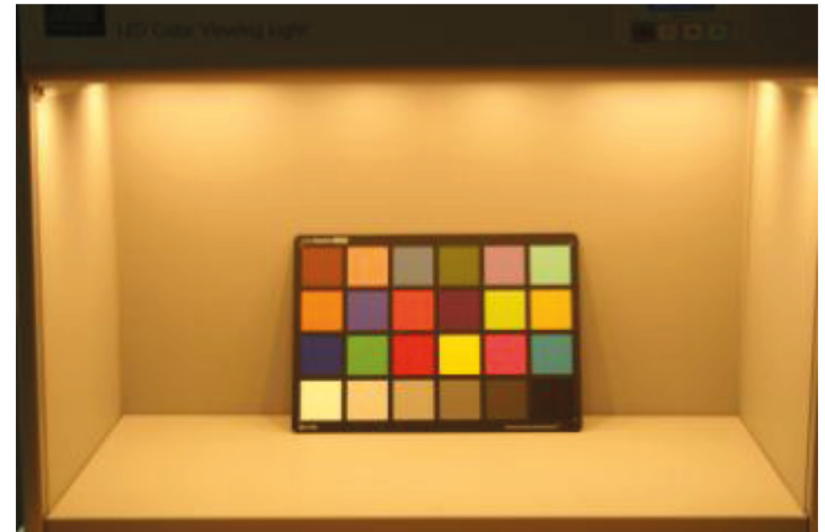
Colour Rendering

Fluorescent Light



$L^* = 56.84$
 $a^* = 6.76$
 $b^* = -23.14$

Incandescent Light

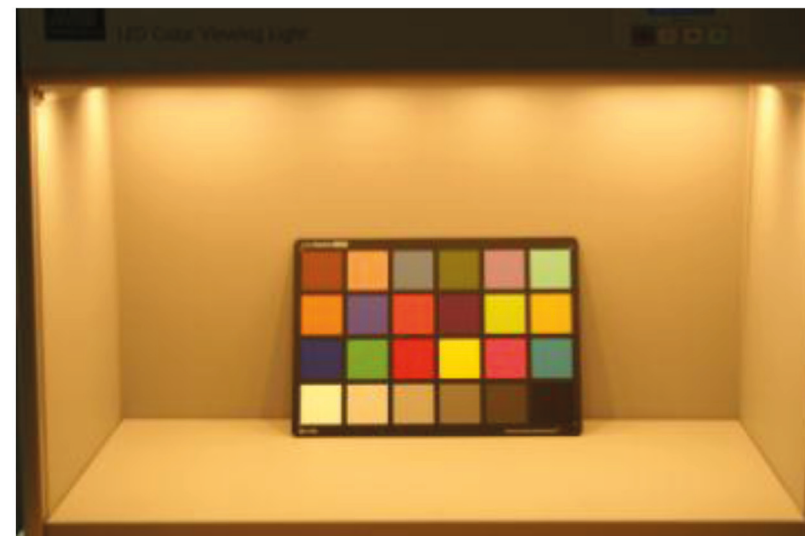
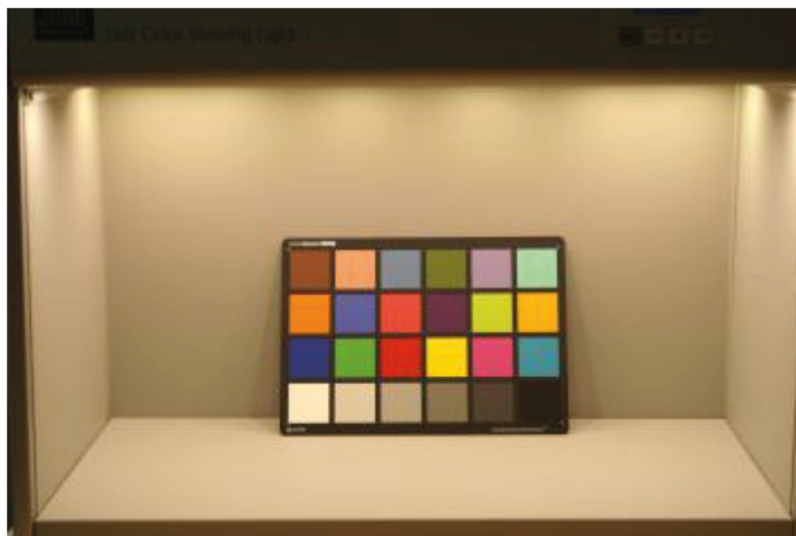


$L^* = 55.68$
 $a^* = 4.79$
 $b^* = -24.01$

Appearance of object colours

Fact:

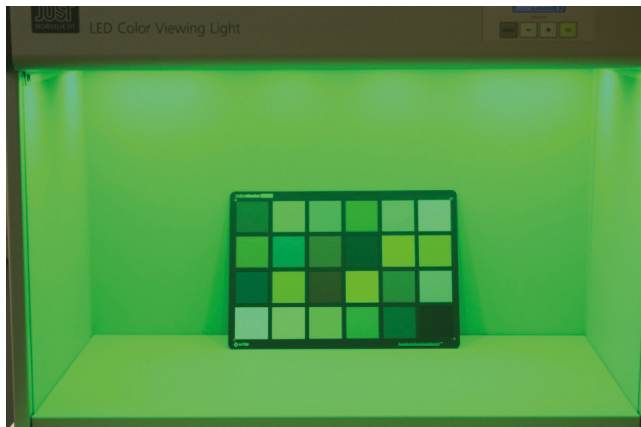
The observed colour of an object changes* if the spectral distribution of the Light Source is changed.



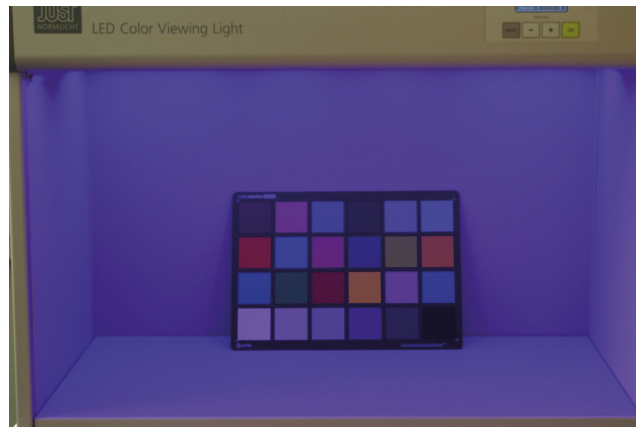
*only black objects have a perfect colour constancy

Extreme Examples

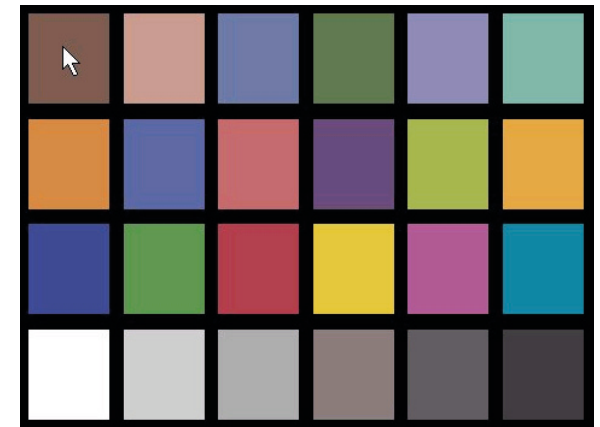
Green LED



Blue LED



Reference: Daylight



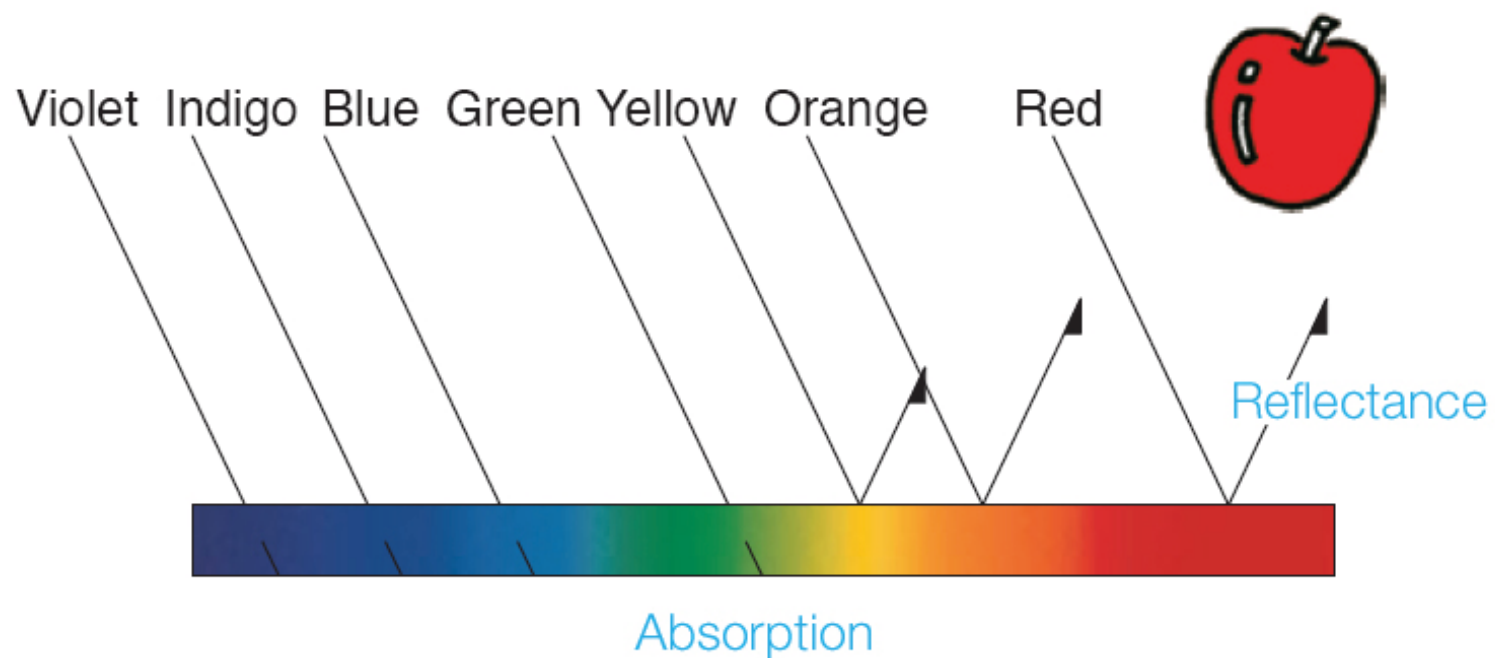


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Reflection

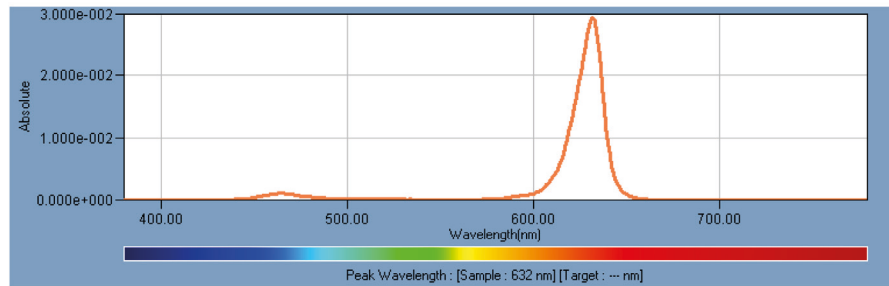
Fact:

The colour of an Object depends on the spectral distribution of the Light Source.



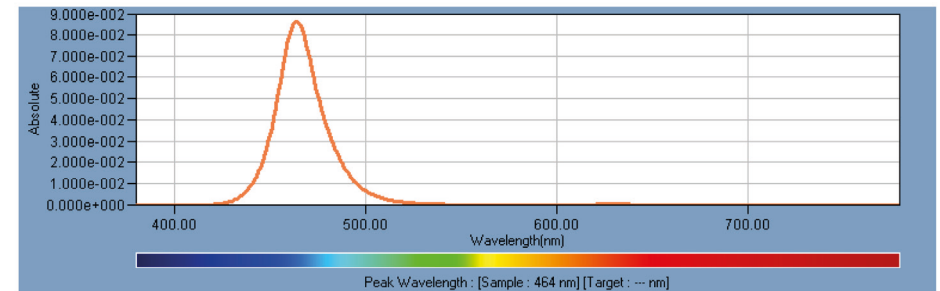
Extreme example

Illumination by Red LED

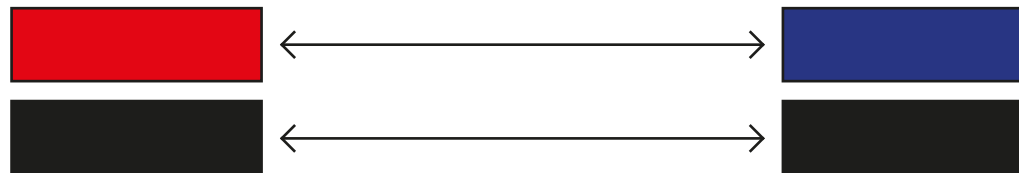


Give good reproduction of Red Object
 Give bad reproduction of object colour in Blue and Green Area

Illumination by Blue LED

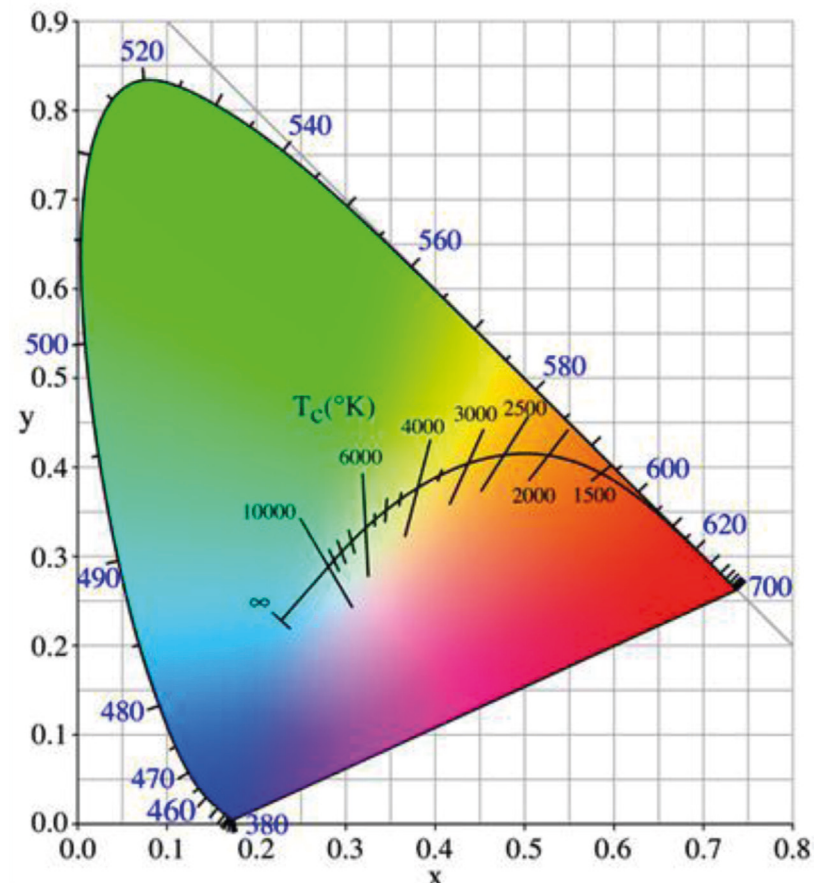


Give good reproduction of Blue Object
 Give bad reproduction of object colour in Red and Green Area



Characterization of a light source

A light source can be expressed in xy coordinates of the CIE31 colour diagram or in correlated color temperature (T).
The brightness is given in Lux (Lv).



Lv	194.67
x	0.4164
y	0.3727
T	3098
duv	-0.0101

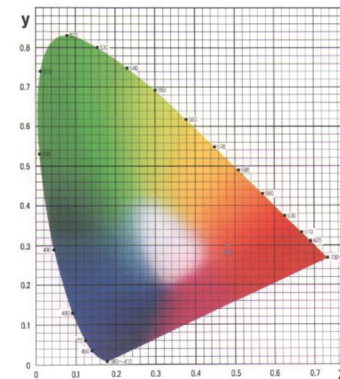
Colour temperature is not enough

It's possible to obtain the same colour temperature or chromaticity coordinates for light sources having different spectral distribution.

Light source 1



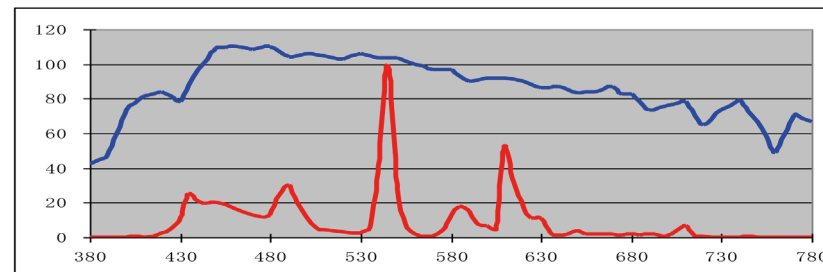
Tc:6184K



Light source 2



Tc:6184K



Both light sources can have the same colour coordinates and colour temperature but different spectral distribution and therefore produce different colour appearance of objects > their colour rendering is different

Light sources

Many different light sources are available. But which light source give the “right” colour appearance?



Sunlight



Tungsten



Halogen



Fluorescent



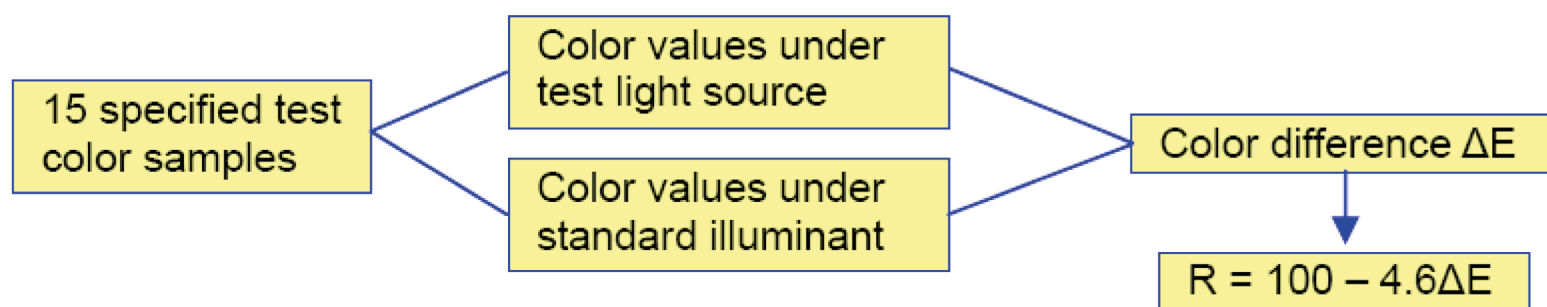
LED



OLED

Colour Rendering Index (CRI) is the method to measure and specify Colour Rendering Properties of light sources compared to natural light or a specifically chosen reference illuminant.

Determining Colour Rendering Indices



The standard illuminant to be used should be selected according to the colour temperature of the test light source:

When test light source colour temperature is $>5000\text{K}$:

CIE daylight illuminant having the same colour temperature as the test light source.

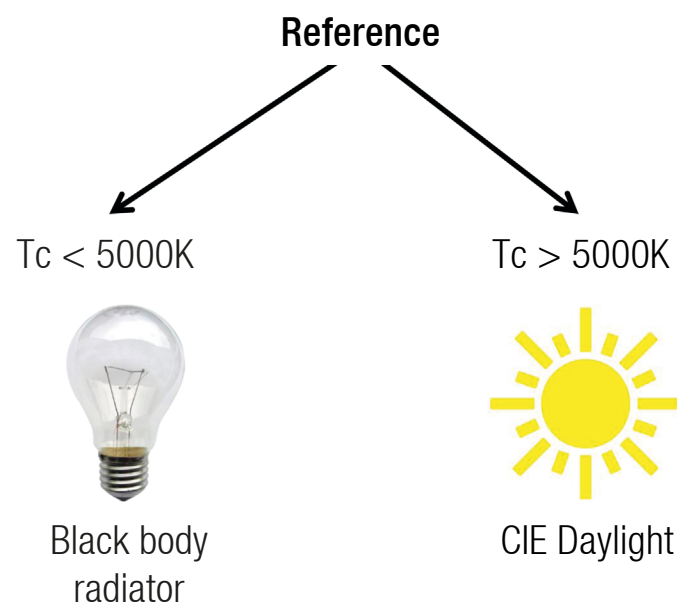
When test light source colour temperature is $<5000\text{K}$:

Perfect radiator at the same colour temperature as the test light source.

Note: The standard illuminant can also be set to a fixed reference illuminant if it is specified in a standard (e.g. ISO 3664 uses D50 as fixed standard illuminant)

Compare colour appearance with reference

CRI indicates how well the colour appearance matches between the reference light source and sample light source for various object.



Evaluating

Determine correlated colour temperature of test light source > Calculate CRI



For general colour rendering evaluation, the correlated colour temperature of reference light source must match with the evaluating light source

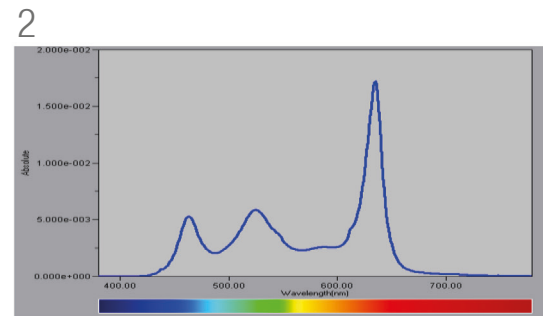
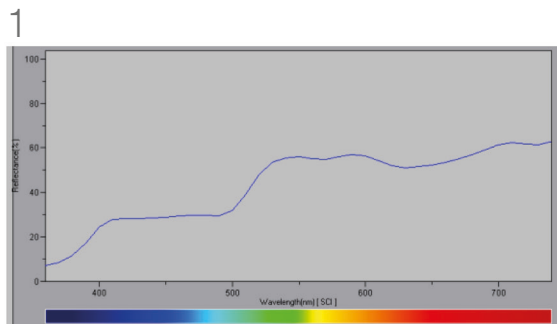
Conditions to determine CRI

To determine the CRI, the following three data sets are necessary:

1. Spectral reflectance of test colour > known
2. Spectral distribution of standard illuminant > known
3. Spectral distribution of test light source

1. and 2. are values that can be obtained from standard references.

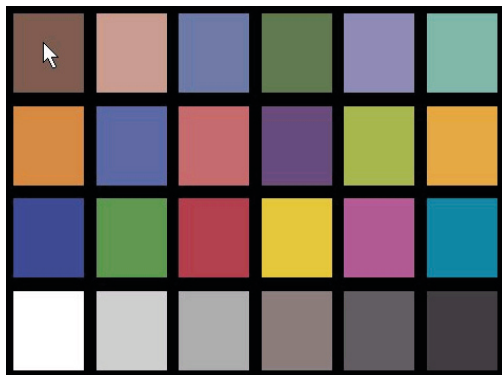
If 3. can be determined, the colour rendering index of the test light source can be calculated.



Conditions to determine CRI

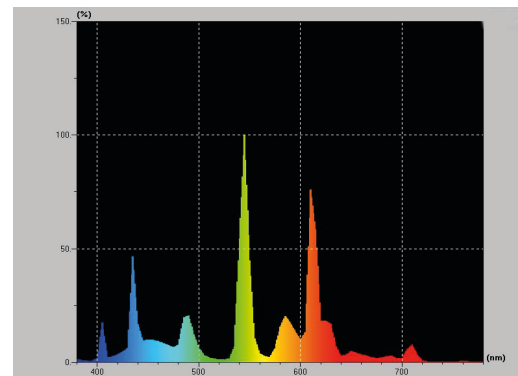
1. Reference

Spectral reflectance is known.



2. Reference illuminant

Spectral distribution is known.



3. CRI

of the test light source can be calculated when spectral distribution is measured.



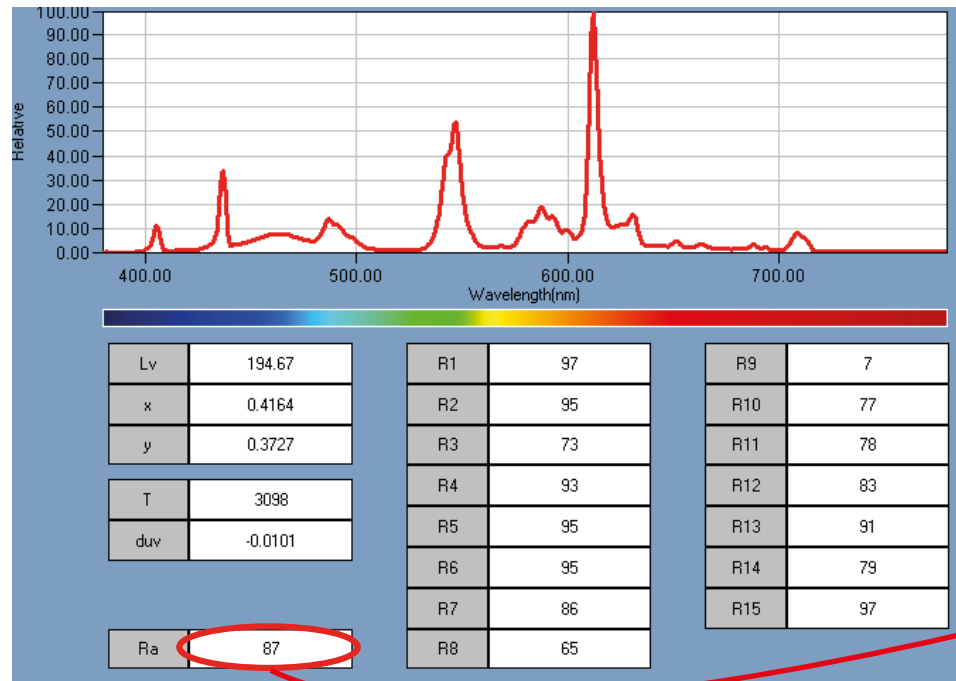
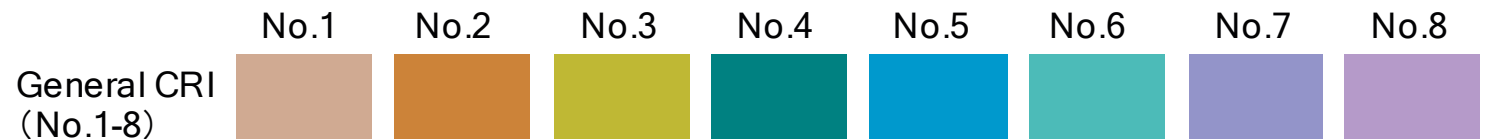
Eight selected Munsell test colours

How well does a light source reproduce a colour?
Score of 100 is reference light source.



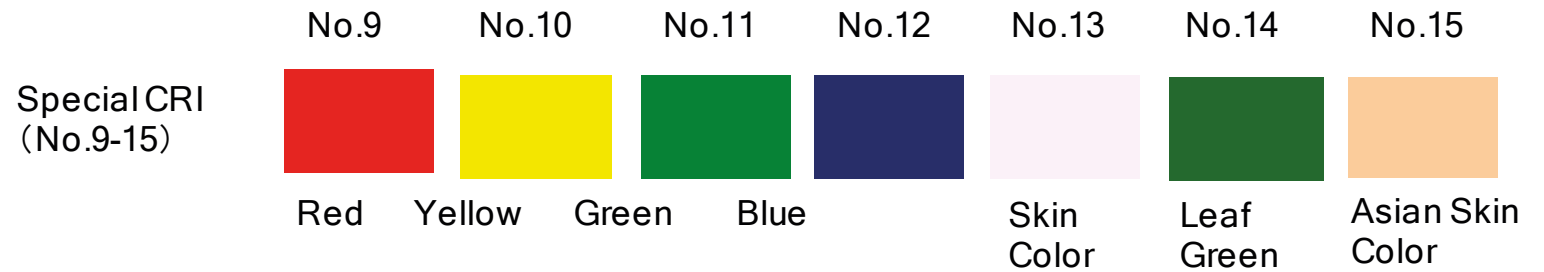
Six additional colours were selected by CIE no. 9 -14

Rendering Index Average (R_a)



Average Rendering Index (R_a) of all 8 colour is calculated and displayed using CS-2000 and CS-S10w software

CRI Evaluation of samples Nr. 9-15



Lv	194.67	R1	97
x	0.4164	R2	95
y	0.3727	R3	73
T	3098	R4	93
duv	-0.0101	R5	95
		R6	95
		R7	86
		R8	65
Ra	87	R9	7
		R10	77
		R11	78
		R12	83
		R13	91
		R14	79
		R15	97

R9 = 7 means that this light source does not produce the same colour as the reference in red.

Ra of 87 expresses that this Light source gives good colour appearance compared with reference Light source (Max. = 100)



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Definition

The Colour Rendering Index is a quantification of the faithfulness of colour appearance under the test light source compared to the colour appearance under the standard illuminant.

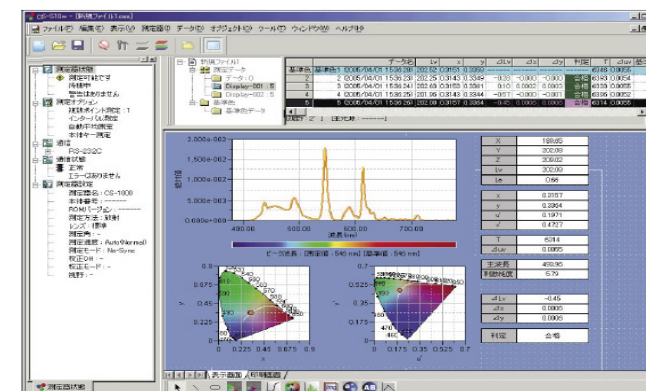
It is not an index for indicating how preferable colours appear.



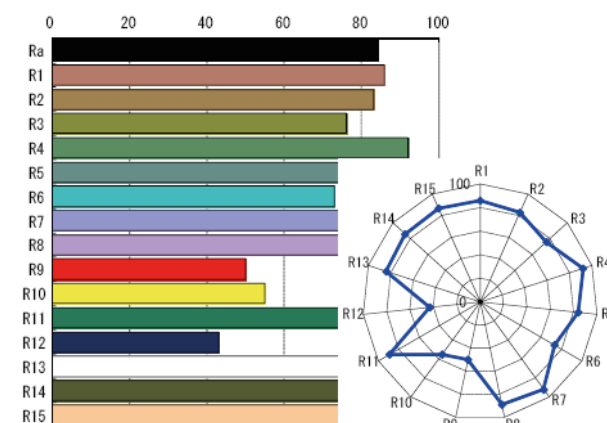
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Instruments to calculate CRI

Option 1:
Spectroradiometer CS-2000 with
Software CS-S10w



Option 2:
Portable Spectrophotometer CL-500A
on Display or with Software CL-S10w



Limitations of CRI

With some light sources, the CRI does not perfectly correlate with the visual judgment.

The reasons are very unnatural spectrums (e.g. from RGB LED's) in combination with the used test colours which do not reflect all object colours that can be found.

Anyhow, the CRI is a well established and widely used method to judge the colour rendering properties of light sources.



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Thank you