Does Higher Luminous Efficiency Mean Lower CRI?

First, let's start with a few concepts:

CRI/Ra (Color Rendering Index): Is a quantitative measure of the ability of a light source to reveal the colors of various objects accurately in comparison with an ideal or natural light source. The lower the CRI is, the more distorted the color will be.

Luminous Efficiency: luminous flux emitted by the LED light source(lm)/Power(W)=LED Luminous Efficiency, unit: lm/W. And the effect of light is the effect of the vision, so luminous efficiency≠light effect.

CCT(Color Temperature): In simple terms when the color temperature is below 3300K, the color turns to red which gives us the warm feeling; between 3000-6000K, people have no obvious visual and psychological effect in this tone; exceeding 6000K ,the color appears to be blue.

For LED chips, generally speaking, only by adjusting the phosphor will you obtain different color temperatures, the higher the CRI is, the lower the Luminous Efficiency will be.

But Omni-Ray Lighting understands this is not totally accurate. It's not because of low luminous efficiency that CRI shows high, but to improve the CRI, some luminous efficiencies are sacrificed. However, many people still have some misconceptions about the perception of luminous efficiency.

Factors affecting the CRI (color rendering index)

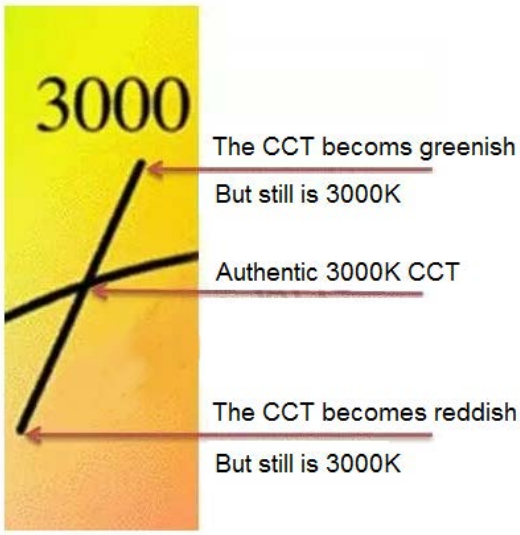
Most LED chips of commercial LED lighting is a blue LED chip coated with blue light (YAG) excited yellow phosphor, usually, we called it "bloom". The blue light emitted by the chip complements the yellow light emitted by the phosphor to form white light.

If we want to improve the color rendering of LED, we need to involve the calculation of the color index. Normally, the calculation of CRI is R1—R8, the chromatography is relatively narrow. But it also lacks a very important spectrum, which is a special CRI R9. Red R9 (saturated red) is an index to evaluate the quality of red appearance. For their application, like Halls, Photographic Workshop, etc., it helps to accentuate the color of the skin. Therefore, the current color index Ra evaluation using R1—R8 as the standard is far from convincing. In real life, International Commission on Illumination sets the color index of sun light as 100, and specify 15 test colors. The CRI of these 15 colors are represented by R1-R15.

To estimate if the CRI of the light source is good or not, we see the value of it at the 15 points. When comparing a light source with a specified reference source, the index value of 100 is the best. Generally, the color rendering properties of light sources are roughly divided into four categories by CRI: Below 50 is "poor", 50 to 70 is "average", 70-80 is "good", and above 80 is "excellent".

If the original color index of an LED is 70, and you want to increase the color index to 80, you might just add a little bit of red phosphor. However, you need to increase the concentration of red phosphor twice to reach the color index to 90.

This is not without cost, if the concentration of red phosphor is too high, the color point of the LED will deviate from the Planck curve, causing a serious color cast.



“Correlated Color Temperature(CCT)”3000K

3265 K	CCT	3282 K
68	CRI(Ra)	63
58	Re(R1-R15)	51

▲We can see from the above image, they're the same color temperature of about 3200K, but our naked eye can see the obvious difference.

Therefore, the proportion of red phosphor formula is different, and the effect on color index and color temperature is different.

In addition, the red phosphor has a characteristic: The optical conversion efficiency is low when excited, so it can pull down the overall light performance of the LED. Many now call this "Pupil Lumens" because of your eyes reaction to CRI and perceived brightness or lumens.

So the effect of red phosphor on CRI and luminous efficiency is obvious:

1. Over high concentration of red phosphor will result in serious color cast of LED.
2. The optical conversion efficiency is low when red phosphor excited, which will pull down the overall light performance of the LED.

To ensure luminous efficiency when improving the CRI of LED's, and ensure it won't result in serious color cast at the same time, each LED chip factory has their own formula for fluorescent powder. This is also the core secret of these factories, and brand managers. Omni-Ray Lighting, Inc. specifies Cree, and Philips LED chips for nearly all of the products offer. We use SAN'AN, and Nichia chips which are more economically applicable for high volume applications like T8 tubes, where several thousand units can reside in one location, and ROI is calculated at its maximum benefit.

Therefore, there is no necessary connection between the calculation principle and the physics principle of luminous efficiency and CRI.