Study on full color RGB LED source lighting for general lighting and Improvement of CRI (Color Rendering Index)

YungKyung Park†
*Department of Color Design, Ewha Womans University

Abstract

The purpose of this study is to check if LED lighting can be used as general lighting and examine the color rendering property of full color RGB LED lighting. CRI is one of the important properties of evaluating lighting. However the present CRI does not fully evaluate LED lightings. Firstly, the performance of a simple task was compared other than comparing CRI values for different lighting. For experimental preparation three types of lightings were used; standard D65 fluorescent tube, general household fluorescent tube, and RGB LED lighting. All three lightings show high error for Purple-Red. All three lightings show similar error for all hues and prove that color discrimination is not affected by the lighting. This proves that LED could be used as general lighting. Secondly, problems of the conventional CIE CRI method are considered and new models are suggested for the new lighting source. Each of the models was evaluated with visual experiment results obtained by the white light matching experiment. The suggested model is based on the CIE CRI method but replaces the color space model by CIELAB, color difference model by CIEDE2000, and chromatic adaptation model by CAT02.

Key words: LED, Color rendering index, Lighting, CIEDE2000, CAT02

1. Introduction

Lighting has developed in various types by aid of material and chemistry over these few years. Especially LED(Light-Emitting-Diode) has been replacing not only the special spot lights but also general home lighting. Although the CCT(correlated color temperature) is similarly matched to the contemporary lighting sources such as fluorescent lighting the spectrum differs and that can effect hue discrimination. We are often misled to consider RGB LED lighting to be insufficient for white general lighting due to the narrow peaks of the spectrum. Color rendering is an important criterion for quality of light source and is defined by CIE(Commission Internationale de l’Eclairage) as the “effect of an illuminant on the color appearance of objects by conscious or subconscious comparison with their color appearance under a reference illuminant”(CIE,1987). White RGB LED light sources have spectral power distributions with three significant peaks corresponding to their R, G and B components. Therefore, they can cause large color differences compared to the reference illuminant which has broad spectral power distribution curves. The problem is that the CRI does not fully match for LED lightings. Therefore other than comparing CRI values for each lighting, the performance of a simple task was compared.

The next step is to characterize the color rendering properties of light sources, which the CIE decided to regard the ‘test-color method’(CIE, 1995), and this assesses the magnitude of the color shift of a number of

† Corresponding Author : YungKyung Park (Color Design, Ewha Womans University)
E-mail : yungkyung.park@ewha.ac.kr
TEL : 02-3277-2512
test objects illuminated first under a test source and then under a reference illuminant as the fundamental method for color rendering appraisal. A color rendering index (CRI), which is based on this principle, was recommended by CIE in 1974 as the standard method to evaluate the color rendering properties of light sources. Thus since 1974, the CIE color rendering index has been used ever since. However, a large number of papers have been published to criticize it for its outdated colorimetric techniques and its breaking down when compared with visual observations (CIE, 2002, Sándor et al., 2003).

Moreover, the CIE test-color method has been found extremely problematic when LED-based light sources have been evaluated together with other traditional light sources. White RGB LED light sources have spectral power distributions with three significant peaks corresponding to their R, G, and B components. Therefore, they can cause large color differences compared to the reference illuminant which has broad spectral power distribution curves.

In this paper, the general lightings were compared by a simple task and the weaknesses of the CIE test-color method, such as the chromatic adaptation, uniform color space and the test color samples, are discussed respectively.

2. Hue discrimination under various lighting

2.1. Experimental

For experimental preparation three types of lightings were used; standard D65 fluorescent tube, general household fluorescent tube, and RGB LED lighting. The LED lighting consists of Red, Green, and Blue LEDs that can operate independently and the RGB levels are controlled to match CCT of 6500K. The ‘Hue 100 Test’ was used as the tool and participants were highly trained 20 females in their 20-30s’. They were asked to complete the task within four minutes under three lightings having 550lx. Fig. 1 shows the color discrimination experiment.

Figure 1. Color discrimination experiment

2.2. Results

Each participant’s error data was recorded for 100 hues. The error data is a score of the incorrect order lining of the continuous hue. This shows discrimination level of the hue. The average of the error data is plotted against each hue. The error data shows the discrimination level of each hue.

The D65 lighting used in the experiment has a relevantly broad spectrum while LED and fluorescent has narrow bands at R, G, and B wavelengths. However, in spite of the thought that broadband would be more precise for color discrimination, all three lighting shows similar error for the hue test.