Kanagawa Institute of Technology

Investigation of controllable-tone lighting systems using phosphor and UV LEDs with different peak wavelengths

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◆ Introduction

Background: White LED in recent years has improved color rendering, and the average color rendering index Ra is 97 for solar LEDs[1]. Solar LEDs allows for the tuning of the emission spectrum, but its emission color cannot be adjusted after purchase[1]. Studies have been conducted to reduce the color temperature of white light by adding the warm white of an orange LED to a white LED. Based on this technology, a change in color temperature similar to the halogen bulb has been reproduced by LEDs[2]. Furthermore, we aimed to develop a remote phosphor type LED light source that can change the correlated color temperature and color rendering of white LEDs, and investigated the emission spectrum for the same phosphor using excitation sources with different wavelengths and approximately equal emission intensities[3].

Objective: In this study, we aimed to develop a remote phosphor type LED light source that can change the correlated color temperature and color rendering of white LEDs. We tested excitation sources with different wavelengths for the same phosphor sample to see how its emission spectrum changes with wavelength.

◆ Experimental

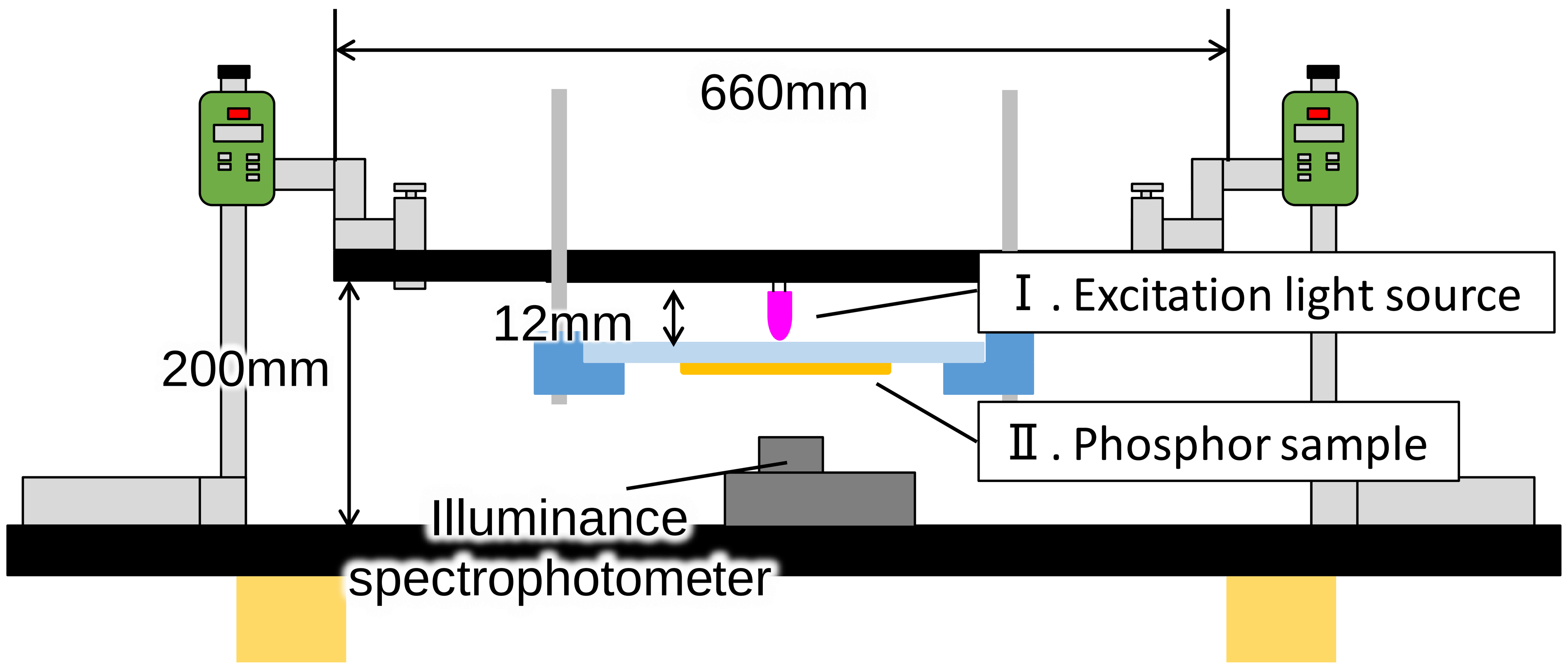


Figure 1. Schematic of the emission spectrum experimental setup

Ⅰ. Excitation light source

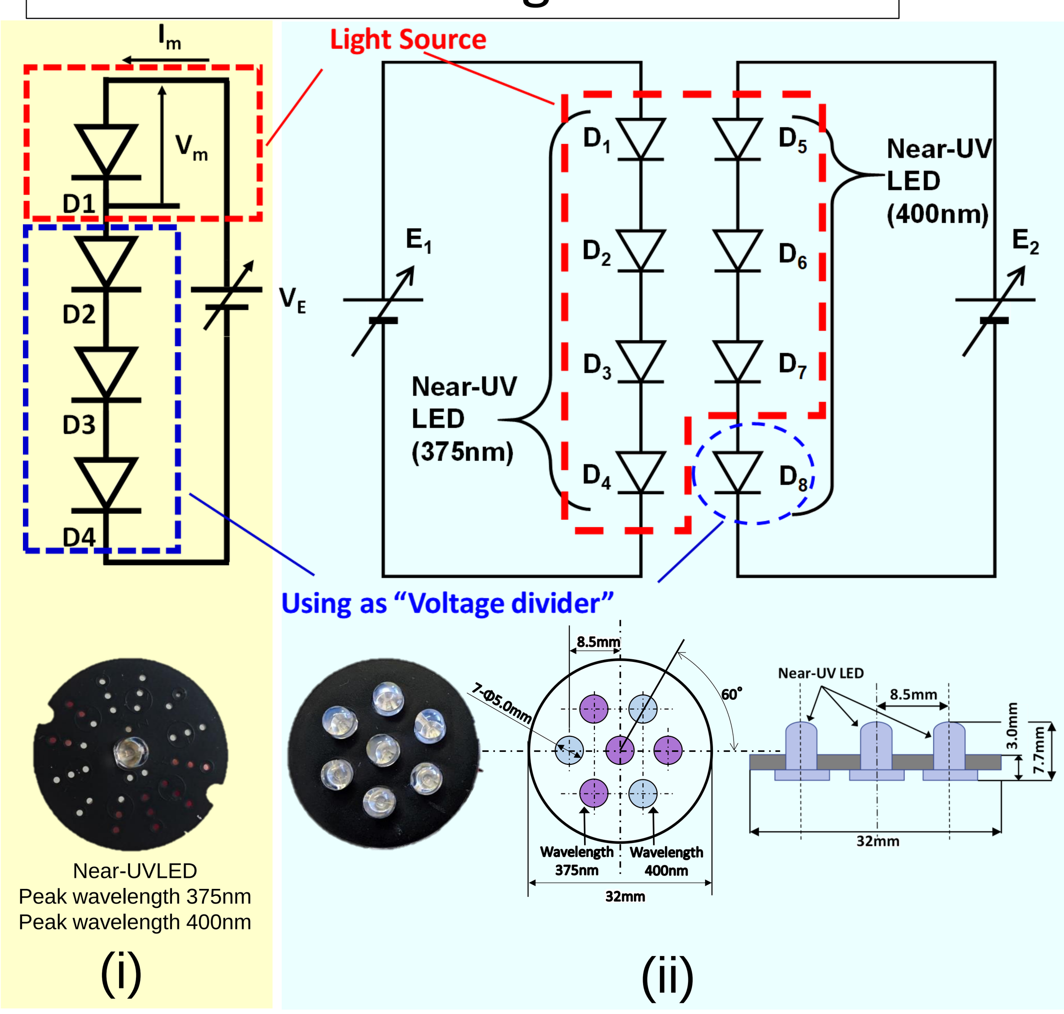


Figure 2. LED light source circuit

Table 1. Five excitation conditions of phosphor sample and emission intensity of excitation source

	Condition patern	Intensity (arb. units) 375nm	400nm
(i)	A	0.1	-
	B	-	0.1
(ii)	C	0.5	0.5
	D	0.5	0.2
	E	0.2	0.5

(i) By connecting four LEDs in series, the IV characteristics were improved and the emission intensity of the LEDs was fine-tuned.

(ii) The 375nm-LED has four lamps connected in series. The 400nm-LED also has four lamps connected in series, in which three lamps are inside the light source and one lamp is outside the dark room.

Ⅱ. Phosphor sample

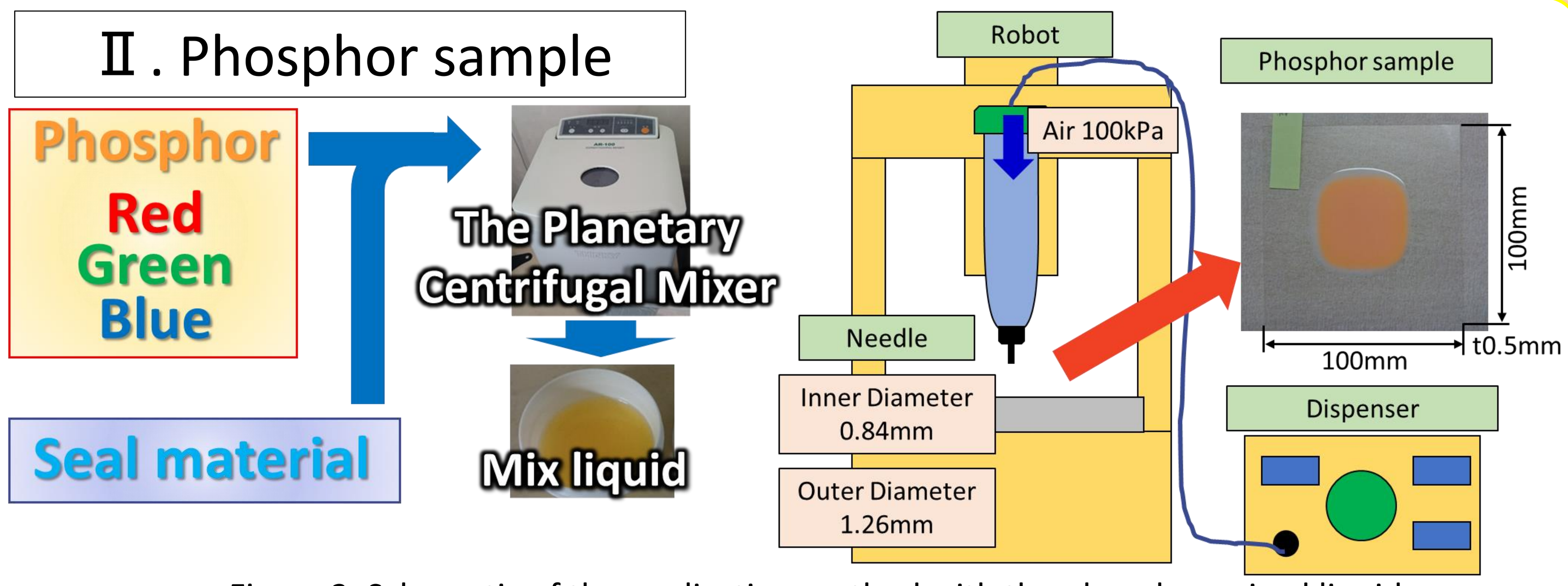


Figure 3. Schematic of the application method with the phosphor-mixed liquid

Table 2. The properties of phosphors

Phosphor	Peak emission wave length[nm]	Peak excitation wave length[nm]
Red Phosphor（CASN）	652	328
Narrowband Green Phosphor（βSiAlON）	538	302
Broadband Blue Phosphor（JEM）	480	380

- Mixing and stirring of the phosphor were carried out at 700 rpm for 3 minutes by the planetary centrifugal mixer. It moved to the barrel of the dispenser application container and defoamed at 700 rpm for 1 minute.
- The mixed liquid of the phosphor and the sealing material was applied to the glass substrate by a dispenser and an application robot.

Ⅲ. Emission spectrum for LED under five excitation conditions

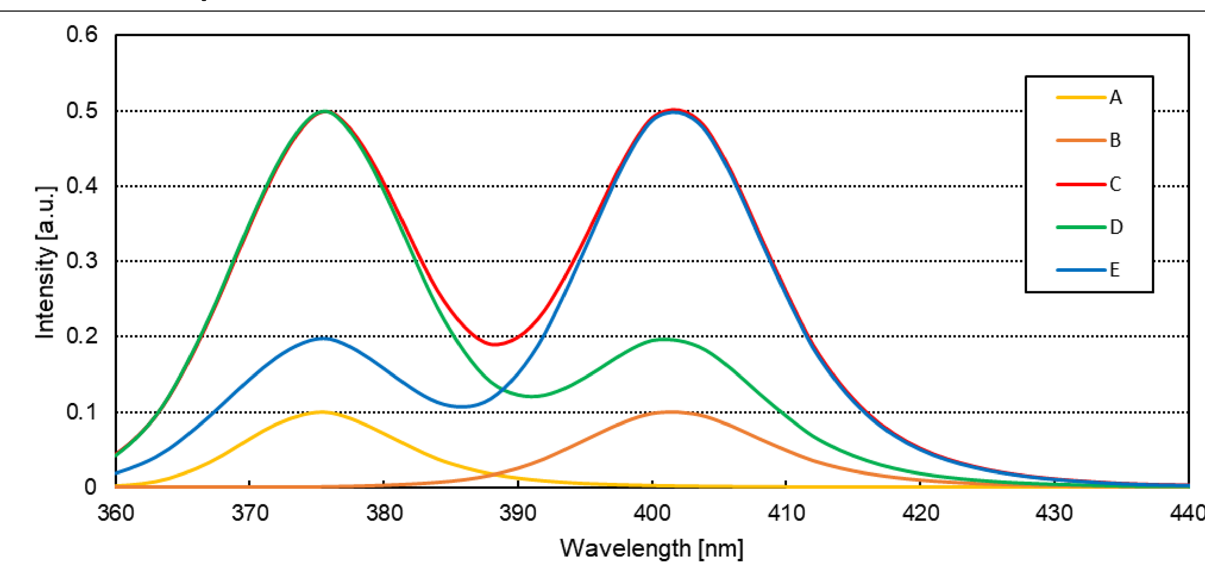


Figure 4. Emission spectrum for LED under five excitation conditions

◆ Results and Discussion

Table 3. Approximate luminous flux value Φm [4], correlated color temperature and color rendering of phosphor sample under five excitation conditions

	A	D	C	E	B
Φm [lm]	8.32	2.48	7.16	6.20	14.37
Tcp [K]	2329.69	2296.92	2261.98	2231.61	2199.91
ΔTcp [K]	C-A	C-D	C-C	C-E	C-B
	-67.72	-34.94	0.00	30.36	62.07
Ra	89.27	90.85	91.65	91.37	90.97
R9	78.12	84.57	89.16	92.84	97.13
R10	95.45	97.09	92.76	88.34	83.85
R11	79.28	82.18	83.93	85.39	87.22
R12	89.38	91.64	86.43	79.35	71.00
R13	87.34	90.32	92.27	93.93	95.72
R14	90.77	89.01	87.70	86.26	85.01
R15	87.62	90.28	91.97	93.21	94.51

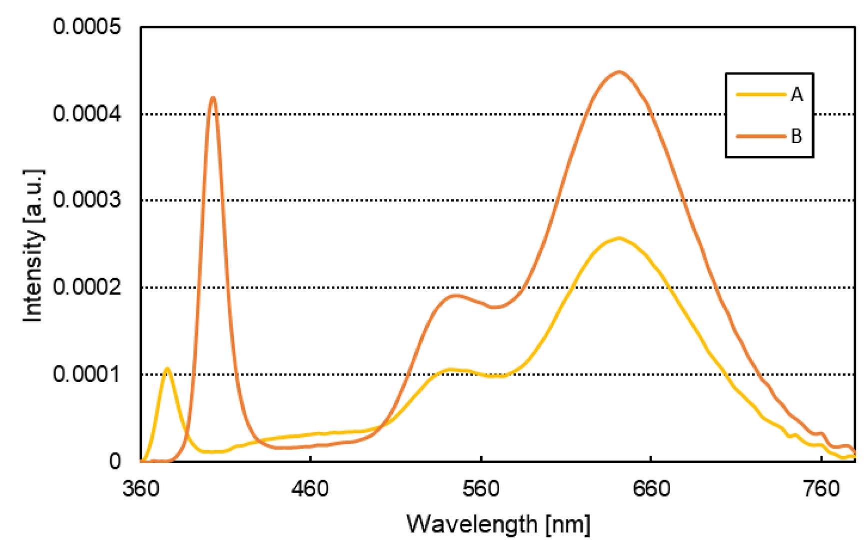


Figure 5. The spectrum of phosphors in lighting conditions A and B

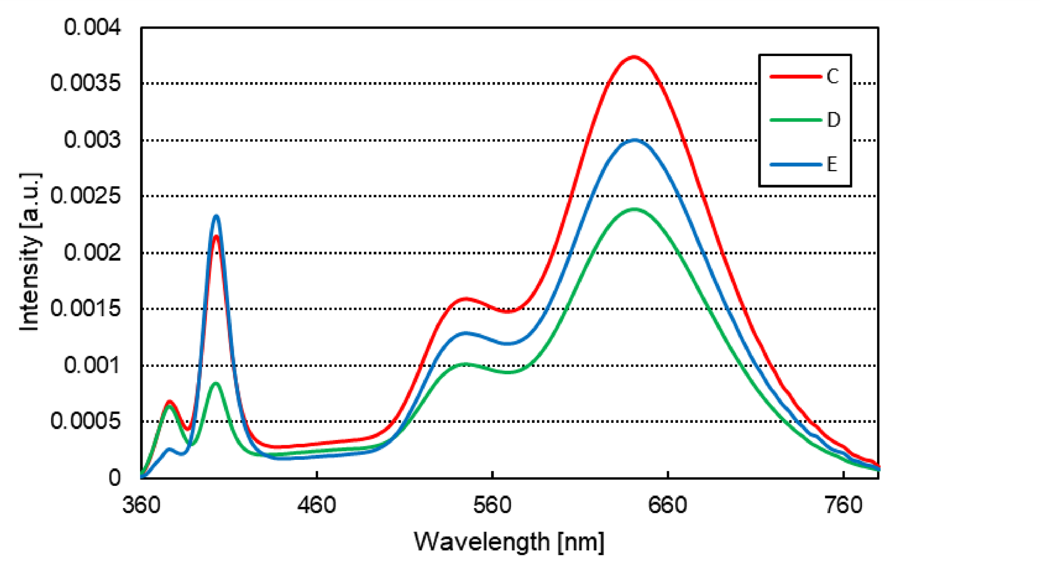
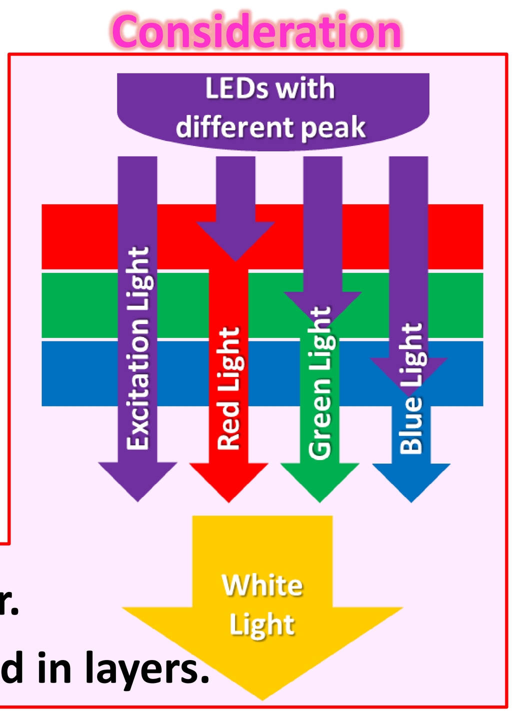


Figure 6. The spectrum of phosphors in lighting conditions C, D and B

- The correlated color temperature changed by approximately 30 [K] in the order of LED lighting conditions A, D, C, E, and B.
- By changing the wavelength of the excitation light, a change in the correlated color temperature of 130 [K] was obtained at 375 nm and 400 nm.
- Compared to commonly used incandescent bulbs whose color temperature is 3000 [K], the color temperature of the experimental sample in this study is low.
- The red phosphor and the green phosphor may have secondary excitation that fluoresces even with the blue light of the blue phosphor.

Consideration



- **It is necessary to suppress the secondary excitation and increase the emission intensity of the blue phosphor.**
- **A multi-layer method is being studied in which the surfaces coated with the respective phosphors are formed in layers.**

◆ Conclusion

- **Using two LEDs with different peak wavelengths (375nm and 400nm) as the excitation source, the correlated color temperature of the fluorescence sample light could be changed in steps of about 30K by changing the ratio of the emission intensity of the excitation source.**
- **The prepared fluorescent sample had a maximum correlated color temperature of 2329K(as 375nm-LED) and a minimum correlated color temperature of 2199K (as 400nm-LED).**

Future Task: To enable dimming at a correlated color temperature of 3000K or higher similar to a commercially available illumination light source.

REFERENCE

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