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Ultraviolet ray wavelength in Gafchromic XR-RV3 and XR-SP2 films

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Introduction

When using Gafchromic films, a double exposure technique is used as a correction method for the nonuniformity error of the active layer in therapeutic radiology. (1)

Therefore, ultraviolet (UV) irradiation is considered as an X-ray substitute in the double exposure technique. (2) It is one of the correction methods for the nonuniformity error of Gafchromic XR-RV3 and XR-SP2.

(1): Lewise 2014 *(2): Katsuda et al. 2009*

“Ultraviolet ray wavelength in Gafchromic XR-RV3 and XR-SP2 films”

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Purpose

The purpose of this study is to determine the UV-A suitable wavelength of UV-LED that is used as a substitute for X-rays in the double exposure technique for the Gafchromic XR-RV3 and XR-SP2.

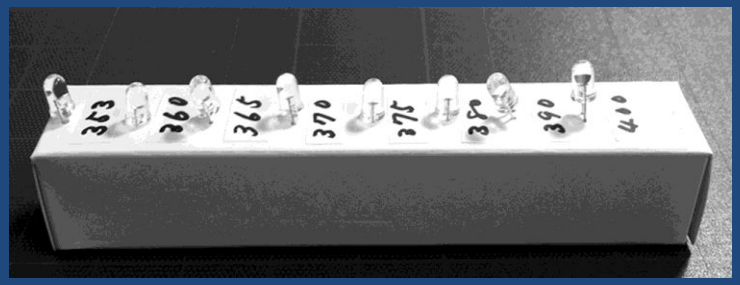

Fig. 1. The UV-LEDs. Output peak wavelengths were from 353 to 400 nm.

Table 1. Main characteristics of UV-LED lamps.

LED-Name	I_F(mA)	λρ(nm)	V_F(V)	P_O.(mW)
NS355L-5RLO	20	353	3.2	1.2
NS360L-5RLO	20	360	3.2	1.8
NS365L-5RLO	20	365	3.2	2.4
NS370L-5RLO	20	370	3.2	4.0
NS375L-5RLO	20	375	3.2	11.0
NS385L-ERLO	20	380	3.2	17.4
	20	385	(Int.)3.6	19.2
NS395L-ERLO	20	390	3.0	21.0
	20	395	(Int.)3.2	25.2
NS400L-ERLO	20	400	3.0	21.0

I_F(mA): Direct current order direction of electric current.

λρ(nm): Peak wavelength. Int.: Interpolate value.

V_F(V): Direct current forward voltage. P_O.(mW): Photo output.

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Materials and Methods

1.UV-LED

In this study, UV-LED that UV rays from wavelength 353 to 400 nm were used. (Table 1 and Fig.1)

2. Gafchromic films

Gafchromic XR-RV3 (Lot #05221402) and XR-SP2 (lot #001311401) were used for this study.

The Gafchromic XR-RV3 or XR-SP2 was fixed onto acrylic plates of 3-mm thickness for the improvement of reproducible the film position at the time of the scanning.

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3. Irradiation device

The UV cut acrylic plate for fixing the irradiation position contained 20 holes with 30-mm diameters (Comogras, 3-mm thickness; Kuraray) for irradiation of Gafchromic XR-RV3 or XR-SP2 (Fig. 2). The each UV-LED was attached acrylic box that made of UV cut acrylic plate (Fig. 3). Actual placements of the measurement are shown in Fig. 4.

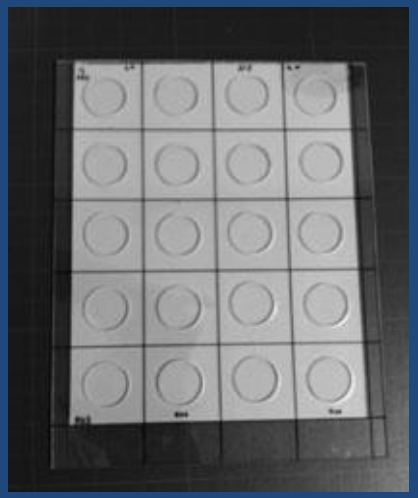

Fig. 2. The UV cut acrylic plate for fixing the irradiation position Contained 20 holes with 30-mm diameters.

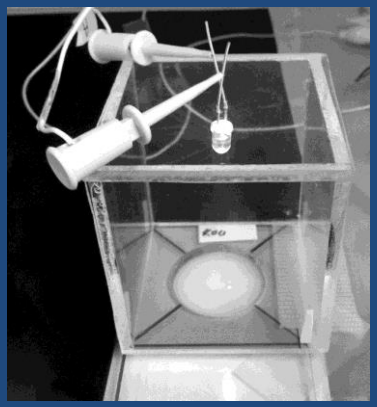

Fig. 3. The each UV-LED was acrylic box that made of UV cut acrylic plate .

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4. Irradiation method

Gafchromic XR-RV3 or XR-SP2 was irradiated with UV-A of different wavelengths through the 30 mm diameter of irradiation hole for 2 and 4 hours, respectively.

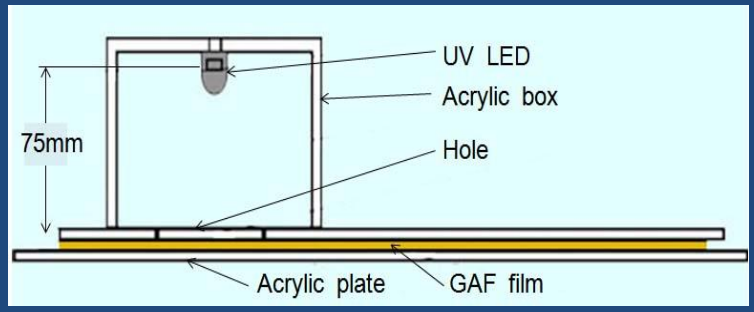

Fig. 4. Exposure arrangement of the UV-LED and Gafchromic (GAF) XR-RV3 or XR-SP2.

5. Scanning method

The films were scanned after every irradiation by a flatbed scanner ES-10000G (Seiko Epson) and images using Photoshop CS2 (Adobe Systems Incorporated) were acquired.

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The images were read with 48-bit, 100 dpi resolution, in the RGB mode with the PPC film (3M Company) with a protection film of liquid crystal (Sanwa Supply Inc.) for the removal of moire artifacts (Newton's rings) .

The Gafchromic films were always scanned in the same orientation. A series of procedures was performed the room temperature within 25℃ to 21℃.

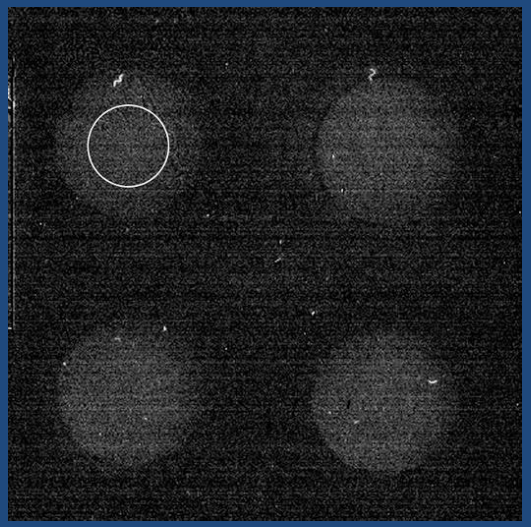

Fig. 5. Subtraction images of the Gachromic XR-RV3 with region of interest.

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6. Analysis

Red channel image was use for analysis . A circular ROI of 0.5 inch was set in the center of the UV irradiation region (Fig. 5). The pixel values of Gafchromic XR-RV3 and XR-SP2 for different wavelengths UV irradiation were measured with Image J, as a histogram in ROI.

Table 2. Pixel value of subtracted image of Gafchromic XR-RV3 and XR-SP2.

λρ(nm)	Pixel value(Mean±SD) XR-RV3	XR-SP2
353	NA±NA	122.78±160.39
360	NA±NA	98.81±149.89
365	171.48±196.46	174.53±185.45
370	235.12±199.86	191.96±186.79
375	669.16±290.04	351.34±211.39
380	1084.78±240.88	467.38±217.80
385	1199.83±282.39	446.15±214.06
390	1259.30±262.60	565.36±214.32
395	1276.81±254.30	557.12±219.81
400	836.02±274.48	576.46±219.75

λρ(nm): Peak wavelength

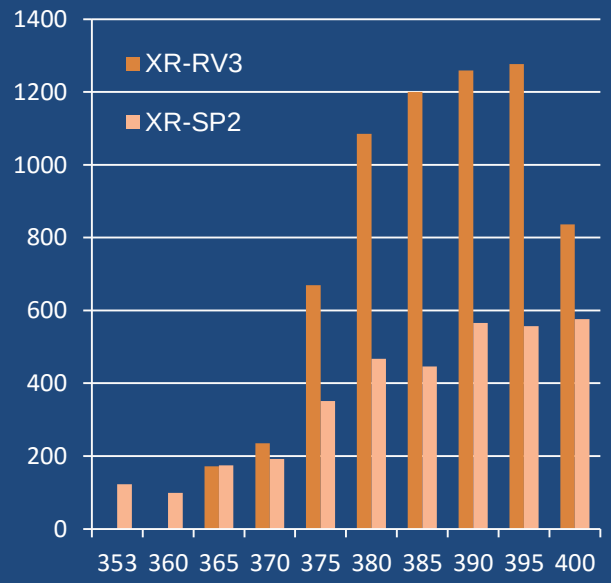

Fig. 6. The graph shows the pixel values of subtraction image before and after the UV-A irradiation in Gafchromic XR-RV3 and XR-SP2.

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Results

Fig. 6 shows the pixel values of Gafchromic XR-RV3 and XR-SP2 (Table 2). Most high pixel value was shown in Gafchromic XR-RV3 when UV-LED of 395 nm of wavelengths UV was irradiated. The mean ± SD was 1276.81 ± 254.30. In addition, most high pixel value was shown in Gafchromic XR-SP2 when UV-LED of 400 nm of wavelen UV was irradiated. The mean ± SD was 576.46 ± 219.75.

Irradiation UV strengths are shown in Table 3.

Table 3. UV strength of each UV-LED wavelength

λρ(nm)	UV strength (μW/cm^2)
353	187.07
360	220.36
365	507.10
370	653.70
375	1423.90
380	536.20
385	656.90
390	85.29
395	91.85
400	13.90

λρ(nm): Peak wavelength

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Conclusions

Gafchromic XR-RV3 and XR-SP2 was reacted effectively to UV-A LED irradiation of 395 and 400 nm when substituted for X-rays in the double exposure technique.

Therefore, the irradiation of Gafchromic XR-RV3 and XR-SP2 with homogeneous UV rays by the UV-LED wavelengths of 395 or 400 nm can correct the nonuniformity error of the active layer efficiently.

When high strength UV-LED is used, the UV ray is available as a substituted X-rays.