J. Basic. Appl. Sci. Res., 4(6)145-150, 2014
© 2014, TextRoad Publication
ISSN 2090-4304
Journal of Basic and Applied Scientific Research
www.textroad.com

Radiometric Comparison of Conventional and Phototherapy Lamps

Sameh M. Reda

Radiometry lab., National Institute for Standards (NIS), Egypt.

Received: April 2, 2014
Accepted: May 4, 2014

ABSTRACT

Phototherapy results in the conversion of bilirubin to more water-soluble isomers. Fluorescent lamps are commonly used as indoor lighting and phototherapy sources in Egypt. Seven fluorescent lamps with different emission spectra have been compared. This study focused on the fluorescent phototherapy lamps for treatment of hyperbilirubinemia. All the lamps were aged for 10 hours at room temperature (23±2) and their spectral power distribution were obtained using a CCD spectrophotometer .It is found that the special blue phototherapy lamp has the closest requirement spectrum of the standard phototherapy spectrum. Special green is not commonly used for phototherapy and its output spectrum does not fully cover the standard phototherapy requirements same as commercial green. The output spectrum of commercial blue also covers the standard phototherapy, with broader spectrum and lower power compared to the special blue phototherapy lamp.
The compatibility of the studded lamps to produce phototherapy spectrum band as defined by Egyptian standards 5807/2007 & International Electro Technical standards IEC 60601-2-50/ 2000 can be arranged as: Special blue, bluish white, commercial whit (daylight lamps), and green lamps (special and commercial).

KEY WORDS: Phototherapy, Fluorescent lamps, hyperbilirubinemia, spectral power distribution, light applications.

1.INTRODUCTION

Fluorescence is the absorption of radiation at one wavelength and emission at a different wavelength. In many cases it is used to convert ultraviolet (UV) emissions into useful visible light, as in the case of fluorescent tube [1].

Fluorescent tubes, figure (1), contain an inert gas with a small amount of mercury in a glass tube. At low pressure; the inert gas (such as argon) allows an electrical discharge, which started with the help of a glowing filament, emitting electrons to be sustained through the tube. In order to excite the mercury atoms found in the tube by electron collisions. Mercury then emits light mostly at the ultraviolet (UV) region. The phosphor, coating the inner wall of the tube absorbs most of UV radiation and re-emits this energy in longer wavelength light band [1].

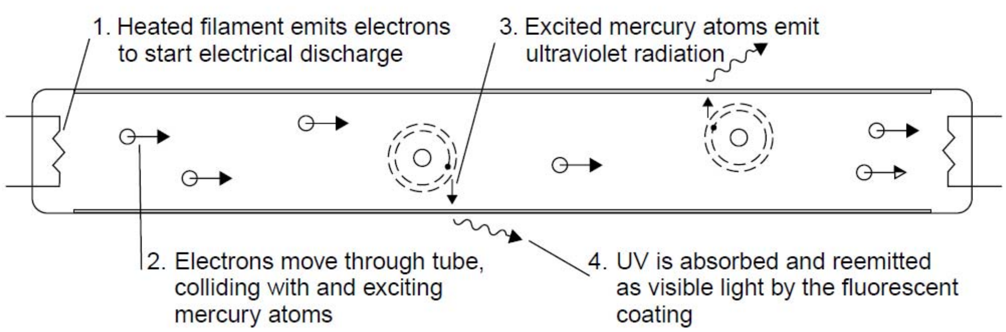

Figure 1: Sketch diagram of Fluorescent lamp and its contents.[1]

Different phosphor materials emit dissimilar spectra which can be used at many applications. Conventional phototherapy lamps are widely used and accepted for the treatment of neonatal hyperbilirubinemia. Effective phototherapy depends on three important criteria identified as: effective spectrum, sufficiently high irradiance and large effective treatment area [2,9].

Hyperbilirubinemia results from the accumulation of unbound bilirubin in the infant's serum, which is normally a breakdown product of heme generated by red blood cells turnover. Another cause is the non-pathologic hyperbilirubinemia resulting from the delayed development of liver enzymes that

***Corresponding Author:** Sameh M. Reda, Radiometry lab., National Institute for Standards (NIS), Egypt. Email:egyreda@hotmail.com

conjugate bilirubin with albumin and permit their elimination. The phototherapy is a mechanism of photochemical conversion of bilirubin to a different molecular shape that is easier to be eliminated. Different types of fluorescent lamps have been used in phototherapy units (luminaire) ; most of which have appreciable output from 420 to 470 nm, and the peak approximately 455 nm figure (2). [3].

Literatures noted that special blue tubes provide (10–15 $\mu W/cm^2/nm$) which is much greater irradiance than regular (commercial) blue tubes. Special blue tubes are more effective because they provide light in the blue-green spectrum. At this range of wavelengths, light penetrates skin well and is maximally absorbed by bilirubin. There is a common misconception that ultraviolet light is used for phototherapy. The phototherapy luminaries must emit insignificant ultraviolet radiation, and the small amount of ultraviolet light that is emitted in longer wavelengths range than that cause erythema. In addition, almost all ultraviolet light is absorbed by the glass wall, and the fluorescent materials of the fluorescent tube and the Plexiglas cover of the phototherapy luminaries [4,10].

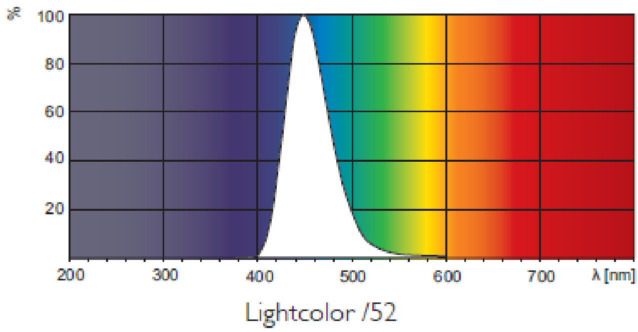

Figure 2: The absorption spectrum of unbound serum bilirubin (BR). [5]

To evaluate and control the optical radiation hazards which are emitted from the broad-band optical sources and lamp systems. It is necessary to determine first the spectral power distribution of optical radiation emitted from the source. [6]

There are well known optical radiation hazards associated with some lamps as retinal injury resulting from blue light exposure. This hazard is defined as the photochemical potential induced from radiation at wavelengths primarily between 400 nm and 500 nm. This damage mechanism dominates over the thermal damage mechanism for times exceeding 10 seconds. [6]

This work studies seven lamps different in their spectral emission compared with each other and referring to the requirements of the Egyptian standards 5807/2007 & International Electro Technical standards IEC 60601-2-50/ 2000 to define their compatibility with the standers requirements.

2.MATERIALS AND METHODS

1- Different lamps are found in the Egyptian market. Some are currently used in hospitals for hyperbilirubinemia treatment. These are listed by codes, spectral range, and current application in Table 1.

Table 1: list of the studied lamps with their codes, spectral range, and current application

Lamp code	Spectral range	Current application
S1	White (Visible)	Indoor lighting and Jaundice phototherapy
S2	Special Blue 1	Jaundice phototherapy
S3	Blue	Indoor lighting
S4	Green	Indoor lighting
S5	Special Blue 2	Jaundice phototherapy
S6	Special Green	Jaundice phototherapy
S7	Bluish White	Jaundice phototherapy

2- Spectral power distribtion system shown in figure 3 based on Hamamatsu mini spectrometer with CCD of spectral response 200- 800nm image sensor.

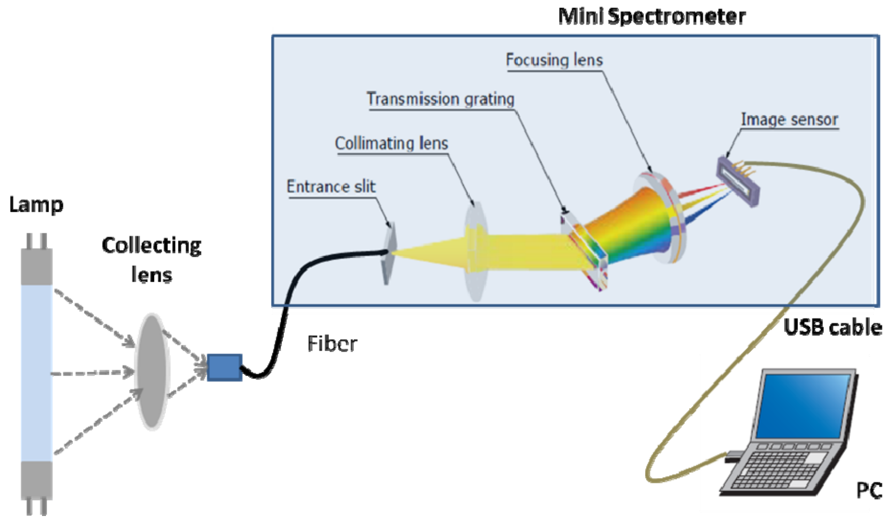

Figure 3: Experiment setup for spectral power distribtion.

The lamps were aged for ten hours [7]. They were given enough time to worm up prior collecting data. The spectral power distribution of the lamps obtained through analyzing the output of the lamps with the mini spectrometer, figure (3). The output is recorded on the computer as two columns, wavelengths versus count. All the data were normalized to the maximum.

3.RESULTS AND DISCUSSION

The relation between the wavelengths versus output power for each lamp is illustrated in the following figures 4, 5, 6, 7, 8, and 9. These figures show comparisons of the output power of the lamps.

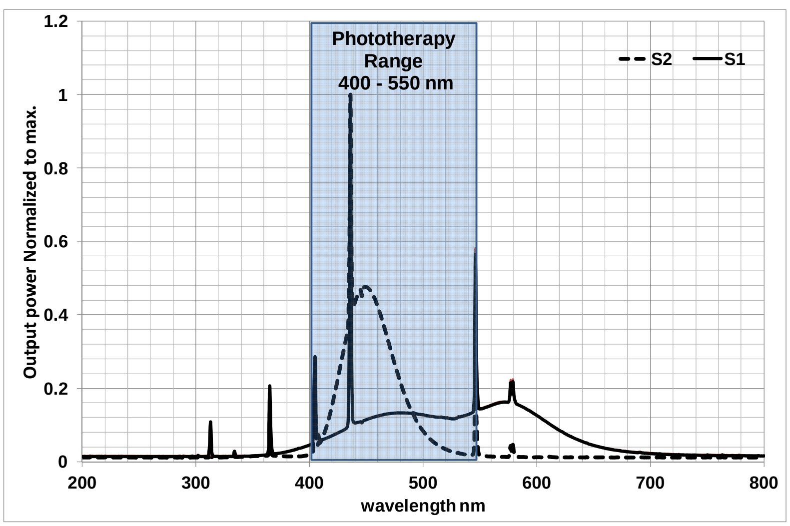

Figure 4: Comparison between the outputs of two **S1** and **S2** lamps.

The relations between the wavelength and the output power for the lamps describe how the output depends on wavelength for different lamps. These relations give information about the lamp characters, and help in selecting a lamp for special application. Figures 4 to 9 show comparisons between output spectra of 7 lamps coded **S1** to **S7**. The comparison based on S2 spectrum which is thought to have the best fit agreed with recommendation mentioned at the "particular requirements for the Safety of the infant Phototherapy equipment standard, IEC 60601-2-50-2000 "[8]. Compering figure 4 and figure 5, it is found that both white phototherapy S1 and bluish white phototherapy S7 have broad spectra unlike special blue S2. In figure 6 the spectrum of the commercial blue S3 is the actually the same as that of S2 with low power in all the range. At figure 7, the special blue spectrum of S2 and S5 is nearly the same even they of different manufacture.

It is noticed also that there is no any difference between **S1** used for phototherapy and commercial day light fluorescent lamps.

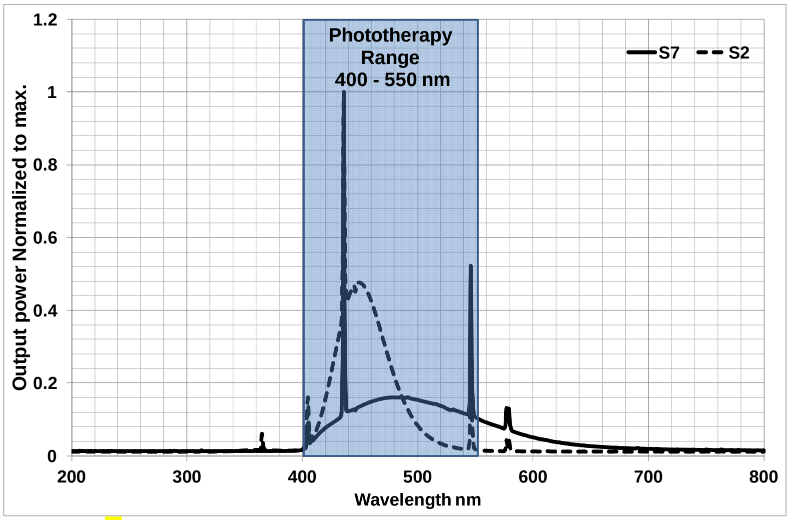

Figure 5: Comparison between the outputs of S2 and S7 Phototherapy lamps.

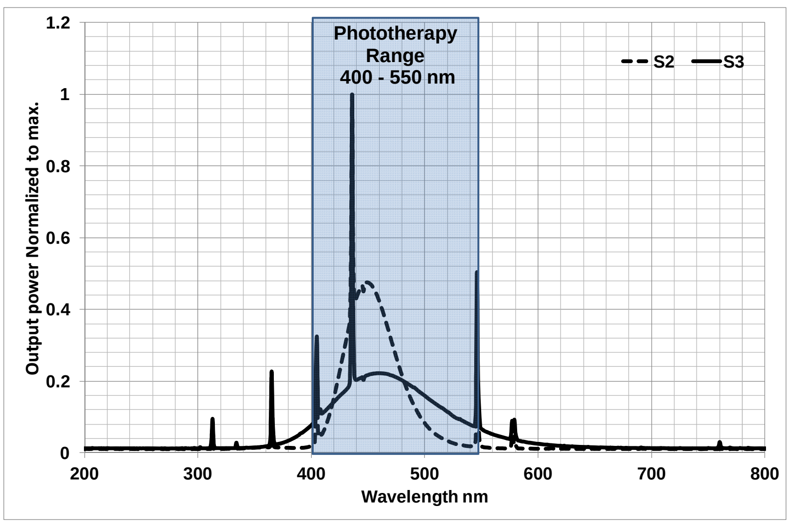

Figure 6: Comparison between the outputs of **S2** Phototherapy and **S3** Blue lamp.

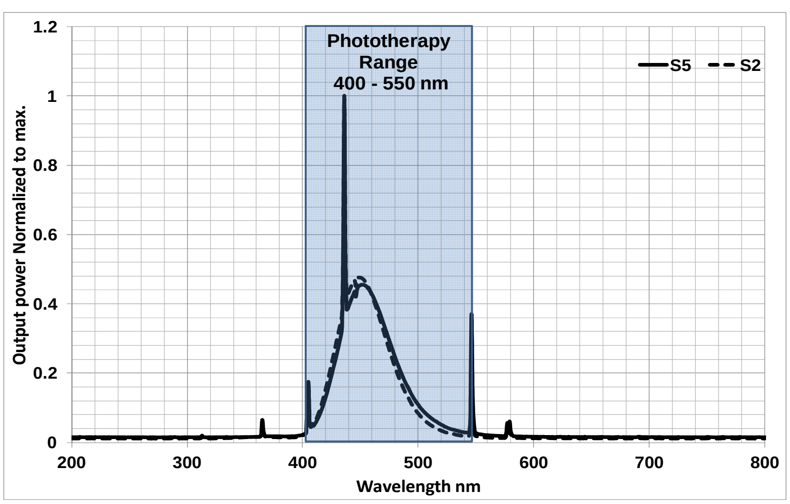

Figure 7: Comparison between the outputs of **S2** and **S5** Phototherapy lamps.

Some lamps with special green spectrum **S6** are used in Jaundice phototherapy compared with Blue phototherapy **S2,** figure 8, shows their different spectra and their maximum emission bands which are located at the same band of phototherapy (400 - 550nm). The spectrum of the commercial Green **S4** in figure 9 is nearly the same as Green phototherapy **S6** but with slight shift in the peak.

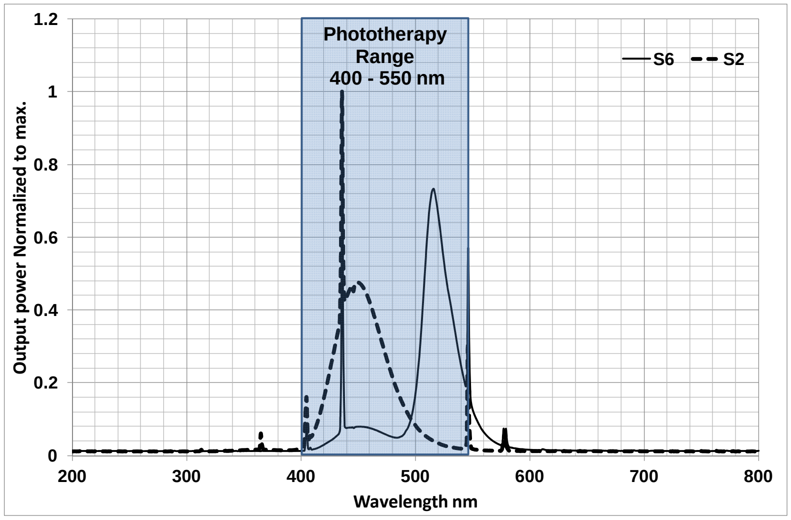

Figure 8: Comparison between the outputs of S2 Blue phototherapy and **S6** Green phototherapy.

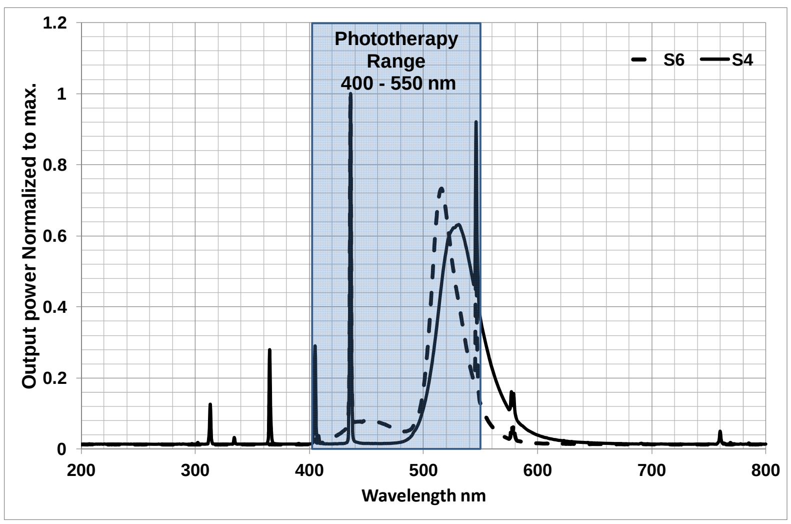

Figure 9: Comparison between the outputs of **S6** Green phototherapy and commercial **S4** Green lamps.

4.CONCLUSION

Fluorescent lamps are still commonly used as indoors lighting and phototherapy sources in Egypt. This study is focused on the fluorescent phototherapy lamps. The spectral power distribution emissions from seven types of fluorescent lamps were studied. The spectral output of the lamps were normalized to their maximum and compared with each other. The special blue phototherapy lamp was found to be the closest lamp to the requirement of the standard phototherapy spectrum. Special green is not commonly used for phototherapy and its output spectrum cover part of the standard phototherapy requirements like commercial green. Also the output spectrum of commercial blue cover the standard phototherapy with broad spectrum and lower power compared with special blue phototherapy lamp.

Broad spectrums of the white commercial and bluish white phototherapy lamps are covering the standard phototherapy spectrum with lower power in the recommended spectrum range.

REFERENCES

1- Mark Csele, 2004. Fundamentals of Light Sources and Lasers, A John Willey & Sons ,Ch.2, INC,

2- Stephanie D.P. Wentworth, 2005. Neonatal phototherapy – today's lights, lamps and devices , volume 1, issue 1.

3- Leonard I. Grossweiner, Linda R. Jones, James B. Grossweiner, B.H. Gerald Rogers, The Science of Phototherapy: An Introduction, 2005 Springer.

4- Pediatrics 2004. Management of Hyperbilirubinemia in the Newborn Infant 35 or More Weeks of Gestation,;114;297.

5- Philips, 2009. Light sources for phototherapy, Philips, 4th edition .

6- CIE S 009/E:2002. Photobiological Safety of Lamps and Lamp Systems

7- Egyptian standards 5807/2007, 2007. Particular Requirements For The Safety Of The Infant Phototherapy Equipment, Egyptian Organization for Standardization and quality.

8- IEC 60601-2-50-2000, 2000. Particular Requirements For Safety Of Infant Phototherapy Equipment.

9- National Institute For Health And Care Excellence, 2010. Neonatal jaundice, NICE clinical guideline 98.

10- Ozge Aydemir, Emel Soysaldı, Yusuf Kale, Sumru Kavurt, Ahmet Yagmur Bas, Nihal Demirel, 2013. Body Temperature Changes of Newborns Under Fluorescent Versus LED Phototherapy, The Indian Journal of Pediatrics, September 2013