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(54) **Spectrum for mesopic vision**

(57) The present invention proposes a lighting arrangement comprising a supporting element (2) having at least one blue LED light source (3a) being at least partially covered with colour conversion layer (5a) and designed to emit a light of at least a first wavelength region, and at least one red LED based light source (3b) being designed to emit light of at least a second wavelength region, said blue and red LED light sources (3a, 3b) being adapted to mimic a predefined mesopic spectrum, the spectrum having a first intensity peak (11) at a wavelength of 440 to 480nm and a second intensity peak (12) at a wavelength of 600 to 650nm.

Fig 1a)

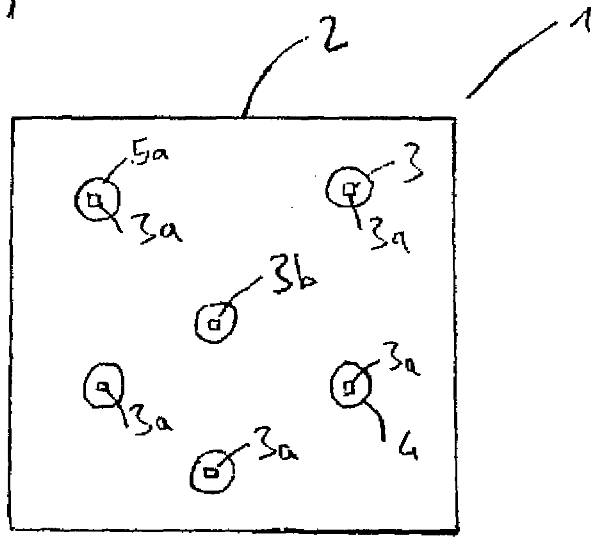

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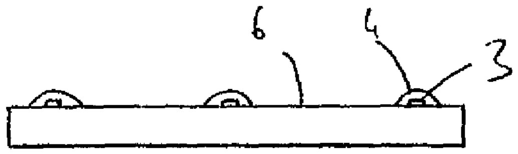
Fig 1b)



Description

Field of the invention

[0001] The present invention relates to a lighting arrangement emitting light of a predefined spectrum, in particular to a lighting arrangement emitting light of an enhanced spectrum for mesopic vision.

Background of the invention

[0002] In the field of street lighting, traditional light sources, like incandescent lamps, fluorescent lamps, HID lamps or others are well known.

[0003] In recent development, LED lighting arrangements have been developed which enable the minimization of the electrical power consumption compared to the above-mentioned illumination devices. Moreover, the luminance of these LED lighting arrangements is considerably higher. Thereby, it is known to provide blue LEDs coated with a suitable phosphor in order to convert at least a portion of the emitted blue light into light of a longer wavelength, thus enabling the provision of a white light source.

[0004] At reduced light levels, i.e. under mesopic conditions, both, the conventional and the known LED light sources are however not optimally designed with respect to the sensitivity of the human eye.

[0005] Light provided by a lighting device having a pedefined spectral distribution hits photoreceptors in the retina of the human eye, namely the "rods" and the "cones". Thereby, the rods are used for vision at reduced light levels, i.e. at so-called scotopic levels. The rods are extremely sensitive to light, but provide achromatic vision. The other type of photoreceptors of the human eye, the cones provide colour vision at photopic levels of illumination, but are less sensitive. In general, the light level during daytime corresponds to photopic levels such that the cones suppress the rods. Howevoer, in case of reduced levels of illumination and thus, at mesopic levels, the rods become more dominant. Thereby, the rods are most sensitive for light having a relative short wavelength, i.e. about 505nm, whereas the cones are most sensitive for light having a wavelength of about 555nm.

[0006] Furthermore, besides the conventional rod-cone system, a melanopsin-associated photoreceptive system exists in the retina that conveys information for accessory visual functions such as for example the pupillary light reflex.

[0007] It is thus to be understood that the human eye comprises spectral sensitivity characteristics which change with the provided illumination intensity respectively the provided light level. Thereby, different ranges of wavelength of light lead to specific reactions within the human eye.

[0008] Hence, for providing an ideal vision of the human eye particularly at mesopic conditions, it is desired to provide a light source emitting light of a specific spectral distribution, said spectral distribution being adapted to ideally match the spectral sensitivity of the human eye at the particular level of illumination. WO2006/132533 A2 relates to a lighting arrangement which provides an improved visibility compared with conventional utility lighting. The lighting arrangement is designed to emit light in a first wavelength region and light in a second wavelength region. The first wavelength region comprises wavelengths of 500-550 nm. The second wavelength region comprises wavelengths of 560-610 nm. The lighting unit is designed to generate light having a dominant wavelength from the first wavelength region in such a way that the eye sensitivity of the human eye is dominated by rods.

[0009] WO 2009/013317 A1 relates to a lighting arrangement for illuminating an area under mesopic conditions. The lighting arrangement has one or more LEDs emitting substantially monochromatic light in a first wavelength region. The lighting arrangement further has one or more LEDs emitting substantially monochromatic light in a second wavelength region. Thereby, the combination of LEDs is such that, in use, the light provided by the lighting arrangement has a ratio of scotopic to photopic light (S/P-ratio) greater than 2.

[0010] Although, the lighting arrangement described in the prior art can improve vision at low illumination levels, further improvement is desired.

[0011] Therefore, the present invention particularly aims at providing a lighting arrangement emitting light of a particularly desired spectral distribution which helps the human eye to achieve an improved ability to see at mesopic conditions.

[0012] The present invention seeks to address the above-described problems. The invention also aims at other objects and particularly the solution of other problems as will appear in the rest of the present description.

Object and summary of the invention

[0013] In a first aspect, the present invention proposes a lighting arrangement comprising a supporting element having at least one blue LED light source being at least partially covered with colour conversion layer and designed to emit a light of at least a first wavelength region, and at least one red LED based light source being designed to emit light of at least a second wavelength region. The spectrum of the emitted light by the lighting arrangement is adapted to a predefined spectrum for mesopic vision, the spectrum having a first intensity peak at a wavelength of 440 to 480nm and a second intensity peak at a wavelength of 600 to 650nm.

[0014] According to the invention, white light of a particularly desired spectral distribution is provided by the lighting arrangement. Thereby, the spectrum comprises an intensity peak at about 440 to 480nm. Moreover, the emitted spectrum comprises a further intensity peak at about 600 to 650nm.

[0015] It is to be understood that by the term 'mimic', the adaption of the spectral distribution of the light emitted by the at least one blue and red LED source is meant, in order to match the spectral sensitivity of the human eye at a mesopic level of illumination.

[0016] In a preferred embodiment, the lighting arrangement comprises a plurality of blue LED light sources. Thereby, the ratio of the number of the blue and red LED light sources respectively is between 3.5 to 1 and 5 to 1. In a particular preferred embodiment, the ratio of the number of the blue and red LED light sources respectively is 5 to 1.

[0017] In the lighting arrangement according to the invention, the blue LED light sources are preferably blue LED dice. Thereby, the blue LED dice preferably emit light of a wavelength between 440 and 480nm.

[0018] In a preferred embodiment, the blue LED dice are at least partially covered with a LuAG: Ce^{3+} phosphor. Accordingly, at least a portion of the emitted monochromatic light of the blue LED dice is converted to light of a longer wavelength. In particular, the light emitted by the blue LED dice is at least partially converted to light of greenish colour, i.e. to a wavelength of about 520 to 570nm.

[0019] A Cerium (Ce^{3+}) doped LuAG phosphor is available e.g. from Merck Chemicals, Darmstadt, Germany.

[0020] In a preferred embodiment, the blue LED dice may as well be at least partially covered by any green, greenish-yellow, or yellow colored light emitting phosphor(s) like garnets such as YAG (doped with Ce^{3+}), orthosilicates such as BOSE (doped with Eu^{2+}) or $CaSr_2O_4$ (doped with Ce^{3+}) . Accordingly, at least a portion of the emitted monochromatic light of the blue LED dice is converted to light of a longer wavelength, in particular to light of green, greenish-yellow, or yellow colour and thus, to a wavelength of about 550 to 590nm.

[0021] In a preferred embodiment, the red LED light source is constituted by a red LED die. Accordingly, a monochromatic light source is provided which is designed to emit a light of a predefined wavelength that preferably lies between 605 and 635nm.

[0022] In another preferred embodiment the red LED light source is constituted by a blue LED die being covered with a colour conversion layer that converts the light emitted by the blue LED die at least partially to light of a wavelength between 610 and 700nm. Thereby, the colour conversion layer preferably comprises a nitride comprising phosphor like SiONs, SiAlNs (e.g. $CaAlSiN_3:Eu^{2+}$ as most widely spread red nitride compound nowadays) SiAlONs, Silicon oxynitrides, and carbonitrides.

[0023] The colour conversion layer is preferably applied to the respective LEDs by means of generally known methods such as for example a dispensing process. Thereby, the colour conversion layer is preferably provided as an encapsulant to the respective LED. The colour conversion layer may as well be provided as a globe top to the respective LED. Further the phosphor layer could be directly deposited onto the surface of the LED die as a thin film. Thereby, a colour conversion agent may be present within a provide epoxy, silicone or epoxy-silicone resin material.

[0024] The lighting arrangement according to the present invention preferably emits a light having a resulting temperature between 4200 and 4800 Kelvin. More preferably, the resulting temperature lies between 4300 and 4700 Kelvin.

[0025] The colour rendering index R_A of the lighting arrangement is preferably greater than 70, more preferably, the colour rendering index R_A is greater than 73.

[0026] The lighting arrangement is designed to emit light of a predefined spectral distribution. Thereby, the at least one blue and red LED light source are preferably arranged on the same supporting element.

[0027] Preferably, a mesopic spectrum of light is provided such that the mesopic responsiveness of the human eye is enhanced. At the same time, an improved quality of the light perceived by the human eye is provided. Moreover, a relatively high scotopic to photopic light ratio (S/P-ratio) higher than 2 of the lighting arrangement is obtained.

[0028] It is to be understood that the aim of such a spectrum to be provided is to stimulate the rods of the human eye in such a way that a specifically desired ratio between scotopic and photopic vision is obtained. It is further an aim to provide a particular amount of red light in the spectrum, since red light enables the provision of contrast in the foveal area of the human eye. Furthermore, the pupil size of the human eye has an influence on the mesopic vision of the human observer, which thus has to be considered.

[0029] The spectral distribution of the light emitted by the lighting arrangement preferably comprises an intensity peak at a wavelength of 440 to 480nm, preferably 440 to 460nm.

[0030] In the range of a wavelength between 440 to 480nm, the scotopic cones and rods of the human eye are particularly stimulated. Hence, by providing an intensity peak of the emitted spectrum within this wavelength region, the mesopic vision of the human observer is enhanced.

[0031] Furthermore, the spectral distribution of the emitted light preferably comprises an intensity peak at a wavelength of 600 to 650nm, preferably at 620nm.

[0032] According to the provided intensity peak within this wavelength region, the ability of the human eye to perceive a sharp image and to see contrast is particularly enhanced.

[0033] In a preferred embodiment, the intensity of the emitted light at a wavelength of 470 to 490nm is about 1.5 to 6 times smaller compared to the intensity in the area of 440 to 480nm.

[0034] It is to be understood that this particular wavelength region is referred to as Melanopsin area that has influence on the pupil size of the human eye. Thereby, it is desired to minimize the intensity of the provided light within this wavelength region in order to positively influence the pupil size of the human eye for mesopic vision.

[0035] Preferably, within the wavelength region of 500 to 530nm, the intensity of the emitted light lies between 50 and 85% of the light emitted in the wavelength region of 440 to 480nm.
[0036] Within this wavelength region, the mesopic cones and rods are particularly stimulated.
[0037] Moreover, the intensity of the emitted light at a wavelength of 530 to 600nm is preferably 30 to 65% of the light intensity in the area of 440nm to 480nm.
[0038] In this particular wavelength region between 530 to 600nm, a high intensity is positively influencing the light output and thus, for increasing the lumen of the provided light arrangement. However, a colour oversaturation effect needs to be prevented for providing a particular enhanced mesopic vision.
[0039] Accordingly, the invention enables to increase the light output of the lighting arrangement, whereby at the same time, the colour oversaturation effect is decreased.
[0040] Hence, by means of the lighting arrangement according to the present invention, an enhanced and almost ideal mesopic spectrum of the emitted white light is provided by preferably using blue LED dice with particularly chosen colour conversion layers and a smaller amount of red light. Thereby, in particular due to the preferred ratio of the provided blue and red LED light sources, the ability of the human eye to see at mesopic vision is enhanced.
[0041] The lighting arrangement may further comprise an electricity supply that is connectable to the lighting unit thereof. Thereby, the LEDs of the lighting unit are preferably electrically connected in series.
[0042] However, the LEDs may as well be connected in parallel strings. Thereby, each string preferably comprises a predefined mixture of blue and red LED sources. In a particular preferred embodiment, three parallel strings are provided. "Mono-colored" LED strings comprising only one color could be applied as well.
[0043] The lighting arrangement of the invention may further comprise a processing device for regulating the intensity and/or the direction of light emitted by the lighting arrangement.
[0044] The lighting arrangement of the invention may comprise a plurality of lighting units according to the invention.
[0045] In a second aspect, the invention relates to a method for mimic a predefined mesopic spectrum by means of a lighting arrangement comprising at least a blue LED light source and a red LED based light source, the method comprising the steps of:

- emitting light of a first wavelength region,
- converting said light at least partially from said first wavelength region to light of a higher wavelength,
- emitting light of a second wavelength region, the resulting spectral distribution of the emitted light having a first intensity peak at a wavelength of 440 to 480nm and a second intensity peak at a wavelength of 600 to 650nm.

Brief description of the drawings

[0046] Further features, advantages and objects of the present invention will become apparent for the skilled person when reading the following detailed description of embodiments of the present invention, when taken in conjunction with the figures of the enclosed drawings.

Fig. 1a refers to a schematic top view of a preferred embodiment of a lighting arrangement according to the present invention.

Fig. 1b refers to a schematic side view of the embodiment of the lighting arrangement according to figure 1a.

Fig. 2a refers to a spectral distribution of the light emitted by a preferred embodiment of the lighting unit according to the present invention, in which blue LEDs covered with a greenish-yellow light emitting phosphor and red LEDs are provided.

Fig. 2b refers to a graph showing the MacAdam ellipse according to CIE1931 of the light emitted by the preferred embodiment according to figure 2a.

Fig. 3 shows measured CCT vs. observation angle curve relating to another preferred embodiment according to the present invention, in which only blue LEDs that are covered by a yellow and red light emitting phosphor are provided.

Fig. 4 refers to a spectral distribution of light emitted by a further preferred embodiment of the present invention, in which blue LEDs covered with a green light emitting phosphor and red LEDs are provided.

Detailed description of the drawings

[0047] Figure 1 shows a schematic top view of a preferred embodiment of a lighting arrangement according to the present invention.
[0048] The lighting arrangement comprises a supporting element 2 supporting a lighting array respectively a lighting unit 1 which comprises of a predefined number of diodes 3.
[0049] In a preferred embodiment, the lighting unit 1 comprises a number of 5 blue LEDs 3a and at least one red LED 3b. The respective LEDs are conventional LEDs that emit substantially monochromatic light in a first and second wavelength region, respectively.
[0050] It is to be understood that the total number of the LEDs 3 may however vary in order to provide a predefined spectral distribution of the emitted light.
[0051] In a preferred embodiment, the ratio of the number of blue and red LEDs 3a, 3b lies between 3,5 to

1 and 5 to 1, more preferably between 4 to 1 and 5 to 1.

[0052] The LEDs 3a, 3b are preferably covered by an encapsulant such as for example silicone resin material 4.

[0053] The blue LEDs 3a are preferably covered by encapsulant 4 comprising a predefined amount of colour conversion particles 5a. Thereby, the colour conversion particles 5a are preferably garnet phosphor particles such as e.g. YAG. Hence, at least a portion of the blue light emitted by the blue LED dice 3a is converted to a yellow light. Accordingly, the lighting unit 1 provides a white light source.

[0054] In another preferred embodiment, the blue LEDs 3a are preferably covered by encapsulant 4 comprising phosphor particles that at least partially convert the emitted light of the blue LEDs to green and/or greenish-yellow light. Preferably, the phosphor particles are LuAG (doped with Ce^{3+}) phosphor particles.

[0055] In another preferred embodiment, instead of the at least one red LED 3b, another blue LED 3a is provided, said particular LED being covered by an encapsulant 4 comprising phosphor particles which at least partially convert the emitted light of the blue LED to red light. Thereby, the phosphor particles are preferably nitride comprising phosphor particles.

[0056] The amount of colour conversion particles 5a within the provided silicone resin 4 and the amount of the provided LEDs 3a, 3b is preferably selected such that a predefined spectrum of the emitted light is obtained, said spectrum being designed to support the human eye to achieve an improved to visualization ability under mesopic conditions. The spectral distribution of the emitted light will be discussed in greater details with reference to figures 2a and 4.

[0057] Figure 1b schematically shows a side view of lighting arrangement according to figure 1a. As can be seen in figure 1b, the LEDs 3 are covered by the encapsulation 4 which is preferably arranged hemispherical. Said hemispherical or dome-shaped encapsulations could be globe-tops. Accordingly, light emitted by the LEDs 3 is emitted in a planar distribution pattern perpendicular to the surface 6 of the supporting element 2. Thereby, the light emitted by the LEDs 3 produces a generally uniform conical pattern of predefined angle, e.g. 150 to 160°.

[0058] Figures 2a and 2b relate to a preferred embodiment of the invention according to which the lighting unit 1 as shown in figure 1a and 1b comprises a number of 15 blue LEDs 3a that are covered by a silicone encapsulant comprising YAG phosphor particles, and three red LEDs 3b.

[0059] Thereby, the blue LEDs 3a and the red LEDs 3b and the provided colour conversion agent 5a are arranged to produce a particular spectral power distribution of the emitted light as shown in figure 2a.

[0060] As can be derived from figure 2a, the produced spectrum 10 of the lighting arrangement has a first peak 11 within the wavelength region of between 440 to 460nm.

[0061] Within the wavelength region of 480 to 500 nm, the intensity (or spectral power distribution) of the emitted light is preferably at a minimum 13. Preferably, the light intensity of said minimum in this wavelength region is about 1.5 to 6 times, more preferably, 2 to 4 times smaller compared to the intensity in the first peak located between 440 to 480nm of the emitted light spectrum 10. Accordingly, the pupil size of the human eye is prevented from negatively influencing the mesopic vision of the observer.

[0062] In the wavelength region of 500 to 580nm, the intensity of the emitted light shows a maximum 14 as an intermediate peak at about 530nm.

[0063] In the wavelength region between 540 and 600nm, the balance between brightness of the light and colour oversaturation is adjusted. Thereby, the intensity of the emitted light within this region is preferably between 50 to 90%, more preferably between 60 and 70%, of the light intensity in the wavelength region of 440nm to 480nm.

[0064] In the wavelength region between 580 to 610 nm, the spectrum preferably comprises an intermediate minimum 15. The minimum 15 is preferably has an intensity which is about 70 to 90%, more preferably between 75 to 85% of the intensity of the intermediate peak 14.

[0065] Furthermore, the spectrum preferably comprises a peak 12 at around 620 nm. Thereby, the light intensity of this peak is preferably 110 to 150%, more preferably between 120 and 140% of the light intensity of the peak 11 in the wavelength region between 440 to 480nm.

[0066] Figure 2b relates to a graph showing the MacAdam ellipse according to CIE1931 of the light emitted by the preferred embodiment as outlined above.

[0067] As can be seen in figure 2b, the emitted light is light with chromaticity x-coordinates between 0.3600 and 0.3850, and with chromaticity y-coordinates between 0.3760 and 0.4000.

[0068] The colour temperature of the emitted light is preferably 4500K. The light flux of the emitted light is preferably between 2120 and 2170 lumen.

[0069] Figures 3 relate to another preferred embodiment according to the present invention, in which the lighting unit 1 as shown in figure 1a and 1b comprises a number of 18 blue LEDs 3a that are covered with a silicone encapsulant comprising phosphor particles. Thereby, a number of 15 blue LEDs 3a are covered with silicone resin comprising YAG phosphor, and a number of three blue LEDs 3a are covered with silicone encapsulant comprising a red light emitting nitride comprising phosphor. Additionally, the encapsulant may comprise light scattering particles. Hence, in this embodiment, no red LEDs are present.

[0070] However, the blue LEDs covered with nitride phosphor constitute red LED light sources.

[0071] As can be seen in figure 3, the light emitted by two different preferred LED devices of the lighting arrangement according to the present embodiment, "P12.9" and "P12.13", has been measured at a observation angle between -90° and + 90°.

[0072] Figure 3 relates to a graph 22, 22' showing the correlated colour temperature (CCT) of the light emitted by the lighting arrangement according to this embodiment of the invention. As can be derived from the graph, the CCT of the emitted light is between 4100 and 4210 Kelvin at an angle between -30° and +30°.

[0073] Figure 4 refers to a spectral power distribution of light emitted by a further preferred embodiment of the present invention, in which blue LEDs covered with a greenish light emitting phosphor and red LEDs are provided. In particular, in this exemplary embodiment, the lighting arrangement comprises a total number of 14 blue LEDs 3a that are covered by an encapsulant comprising a green light emitting phosphor, preferably a LuAG phosphor. The lighting arrangement further comprises a number of 4 red LEDs 3b.

[0074] It is however to be noted that the exact number of LED light sources provided at the supporting element of the lighting arrangement may vary in order to obtain a predefined spectral power distribution of the emitted light according to figure 4.

[0075] Thereby, in figure 4 two measured curves 10, 10' are shown which relate to intensities of two different exemplary devices of the lighting arrangement according to the present embodiment.

[0076] As can be derived from figure 4, the produced spectrum of the lighting arrangement has a first peak 11 within the wavelength region of between 440 to 460nm.

[0077] Within the wavelength region of 470 to 490nm, the intensity of the emitted light comprises a minimum 17. Thereby, the light intensity within this wavelength region is about 1.5 to 2 times smaller compared to the intensity in the wavelength range of 440 to 460nm of the emitted light spectrum. Accordingly, the pupil size of the human eye is prevented from negatively influencing the mesopic vision of the observer.

[0078] In the wavelength region of 490 to 510nm, the intensity of the emitted light comprises an intermediate peak 18 at about 510nm.

[0079] In the wavelength region between 520 and 600nm, the light intensity is about 50 to 80% of the light intensity of the wavelength region of 450 to 460nm.

[0080] A minimum light intensity 19 is provided at a wavelength region between 580 and 600nm. Thereby, the minimum 19 is about 20 to 40%, more preferably 25 to 35% of the intensity peak 12 provided in the wavelength range of 610 and 630nm.

[0081] The intensity peak 12 of the spectrum 10, 10' is about 120 to 160%, more preferably between 130 and 145% of the light intensity of the peak located between 440 to 460nm.

[0082] Spectral power distribution curves represented by figure 4 have the advantage that in the wavelength region of 500-550 and especially at shorter wavelengths around 505nm, where the rods under mesopic conditions are dominant, provides higher intensity values in comparison with the one shown by figure 2a.

Claims

1. A lighting arrangement comprising a supporting element (2) having at least one blue LED light source (3a) being at least partially covered with colour conversion layer (5a) and designed to emit a light of at least a first wavelength region, and at least one red LED based light source (3b) being designed to emit light of at least a second wavelength region, wherein the spectrum of the emitted light by the lighting arrangement is adapted to a predefined spectrum for mesopic vision, the spectrum having a first intensity peak (11) at a wavelength of 440 to 480nm and a second intensity peak (12) at a wavelength of 600 to 650nm.

2. A lighting arrangement according to Claim 1, wherein the adapted spectrum for mesopic vision comprises a minimum at a wavelength between 470 to 490nm which is about 1.5 to 6 times smaller than the intensity of the peak in the wavelength region of 440 to 480nm.

3. A lighting arrangement according to Claim 1 or 2, wherein the spectrum comprises an intensity peak of the emitted light in the wavelength range of 530 to 600nm which is about 40 to 95% of the light intensity of the intensity peak in the range of 440nm to 480nm.

4. A lighting arrangement according to any of the preceding claims, wherein the ratio of the light output of the blue and red LED light sources is between 3.5 to 1 and 5 to 1.

5. The lighting arrangement according to any of the preceding claims, wherein the blue LED light sources (3a) are blue LED dies that at least partially covered by a green light emitting phosphor selected from the group of yttrium, lutetium, gadolinium garnets or their mixtures.

6. The lighting arrangement according to any of Claims 1 to 5, wherein the blue LED light sources are at least partially covered by a YAG or a BOSE phosphor.

7. The lighting arrangement according to any of the preceding claims, wherein the red LED based light source is constituted by a red LED die (3b).

8. The lighting arrangement according to any of claims 1 to 7, wherein the red LED based light source is constituted by a blue LED die (3a) being covered by a colour conversion agent (5a), preferably a nitride

comprising phosphor.

9. The lighting arrangement according to any of the preceding claims, wherein the colour temperature of the lighting arrangement is between 4300 Kelvin and 4700 Kelvin.

10. The lighting arrangement according to any of the preceding claims, wherein the lighting arrangement shows a colour rendering index R_A greater than 70.

11. The lighting arrangement according to any of the preceding claims, wherein the emitted light is light with chromaticity x-coordinates between 0.3600 and 0.3850, and with chromaticity y-coordinates between 0.3760 and 0.4000.

12. The lighting arrangement according to any of the preceding claims, wherein the lighting arrangement has a minimum output (light flux) of 1884 lumen, preferably of 1890 lumen.

13. A lighting arrangement according to any of the preceding claims, wherein the spectral power distribution of the emitted light comprises an intensity peak in the wavelength range of 440 to 460nm.

14. A lighting arrangement according to any of the preceding claims, wherein the spectral power distribution of the emitted light comprises an intensity peak in the wavelength range of 600 to 630nm.

15. A lighting arrangement comprising a supporting element (2) having at least one blue LED light source (3a) being at least partially covered with colour conversion layer (5a) and designed to emit a light of at least a first wavelength region, and at least one red LED based light source (3b) being designed to emit light of at least a second wavelength region,
wherein said blue and red LED light sources (3a,3b) are adapted to mimic a predefined mesopic spectrum, the spectrum having a first intensity peak (11) at a wavelength of 440 to 480nm and a second intensity peak (12) at a wavelength of 600 to 650nm.

16. A lighting arrangement comprising a supporting element (2) having at least one blue LED light source (3a) designed to emit a light of at least a first wavelength region between 440 and 480nm and being at least partially covered with colour conversion layer (5a), and at least one red LED light source (3b) being designed to emit light of at least a second wavelength region between 600 and 635nm,
wherein the ratio of the number of the blue and the red LED light sources, respectively, is between 3.5 to 1 and 5 to 1.

17. A lighting arrangement comprising a supporting element (2) having at least one first blue LED light source (3a) designed to emit a light of at least a first wavelength region between 440 and 480nm and being at least partially covered with a first colour conversion layer (5a), preferably a YAG or a BOSE phosphor, to convert at least a portion of the emitted light of the least first wavelength region to a second wavelength between 550 and 590nm, and at least one second blue LED light source (3a) being covered with a second colour conversion layer, preferably a nitride comprising phosphor, to emit light of at least a third wavelength region between 610 and 700nm.

18. A method for adapting a predefined spectrum for mesopic vision by means of a lighting arrangement comprising at least a blue LED light source (3a) and a red LED based light source (3b), the method comprising the steps of:

- emitting light of a first wavelength region,
- converting said light at least partially from said first wavelength region to light of a higher wavelength,
- emitting light of a second wavelength region, the resulting spectral distribution of the emitted light having a first intensity peak (11) at a wavelength of 440 to 480nm and a second intensity peak (12) at a wavelength of 600 to 650nm.

Fig 1a)

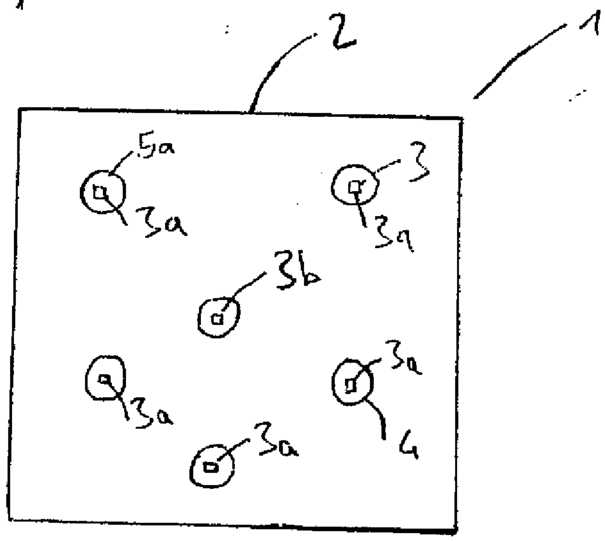


Fig 1b)

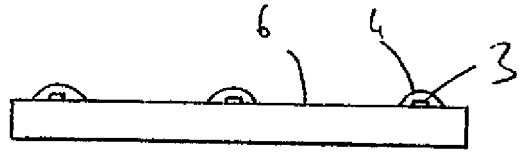
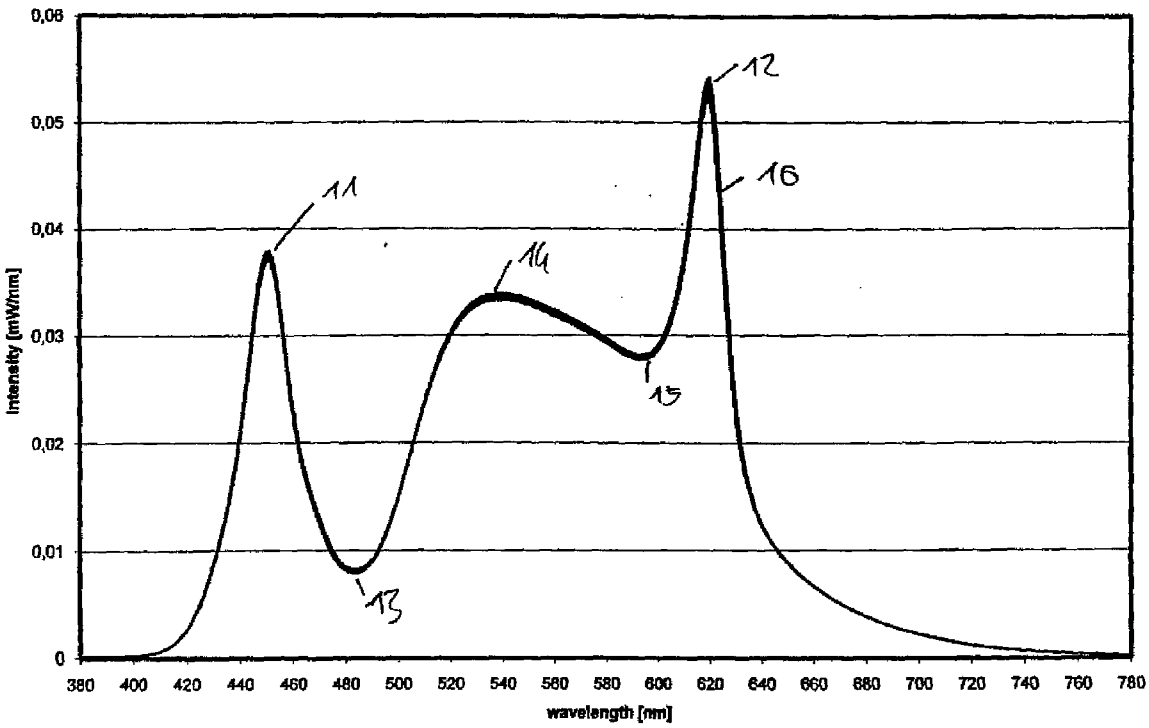


Fig 2a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0,02
0,01
0
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480
500
520
540
560
580
600
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680
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760
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wavelength [nm]
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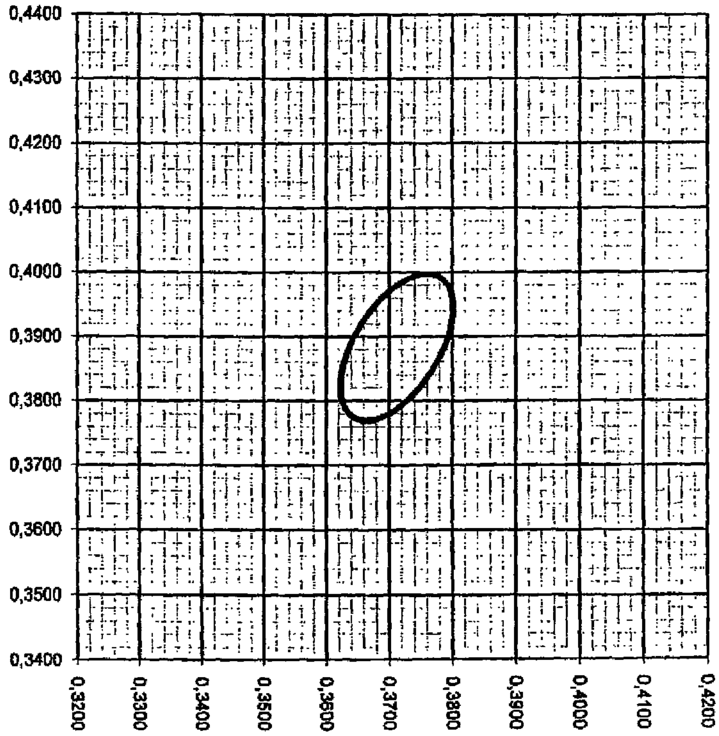
12
13
14
15
16

Fig 2b)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0,4200

Fig 3a)

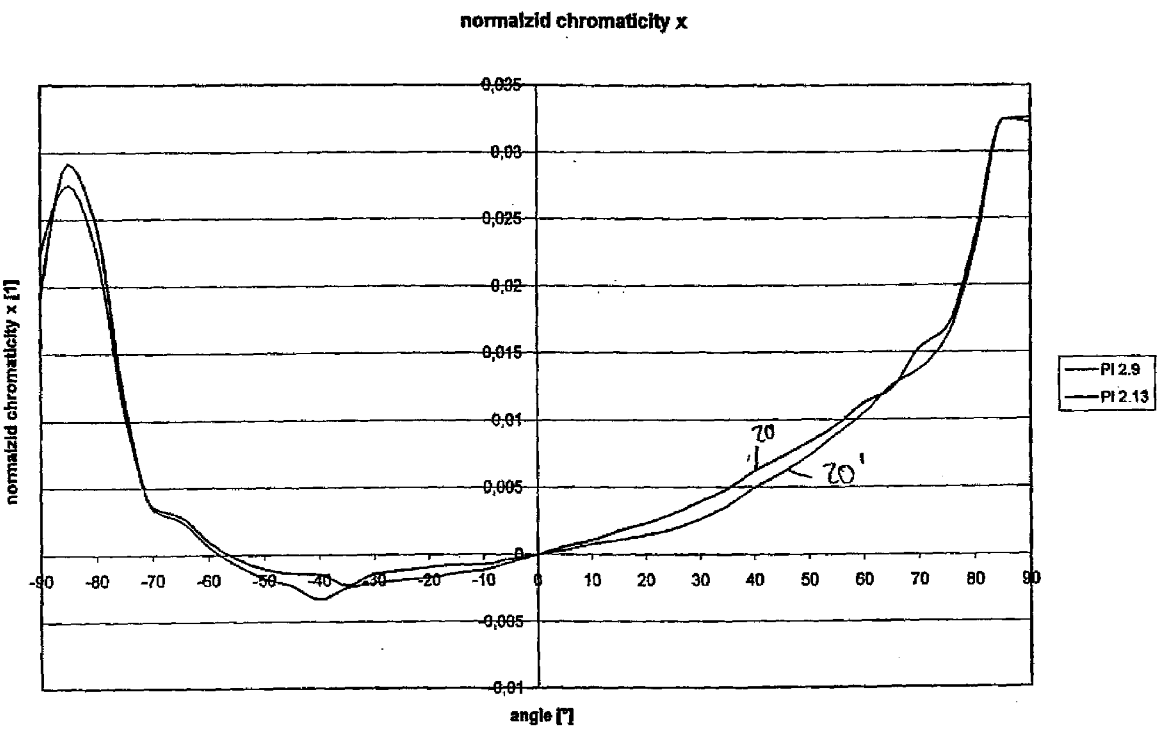

normalzid chromaticity x
normalzid chromaticity x [1]
0,035
0,03
0,025
0,02
0,015
0,01
0,005
0
-0,005
-0,01
-90
-80
-70
-60
-50
-40
-30
-20
-10
0
10
20
30
40
50
60
70
80
90
angle [°]
PI 2.9
PI 2.13
20
20'

Fig3b)

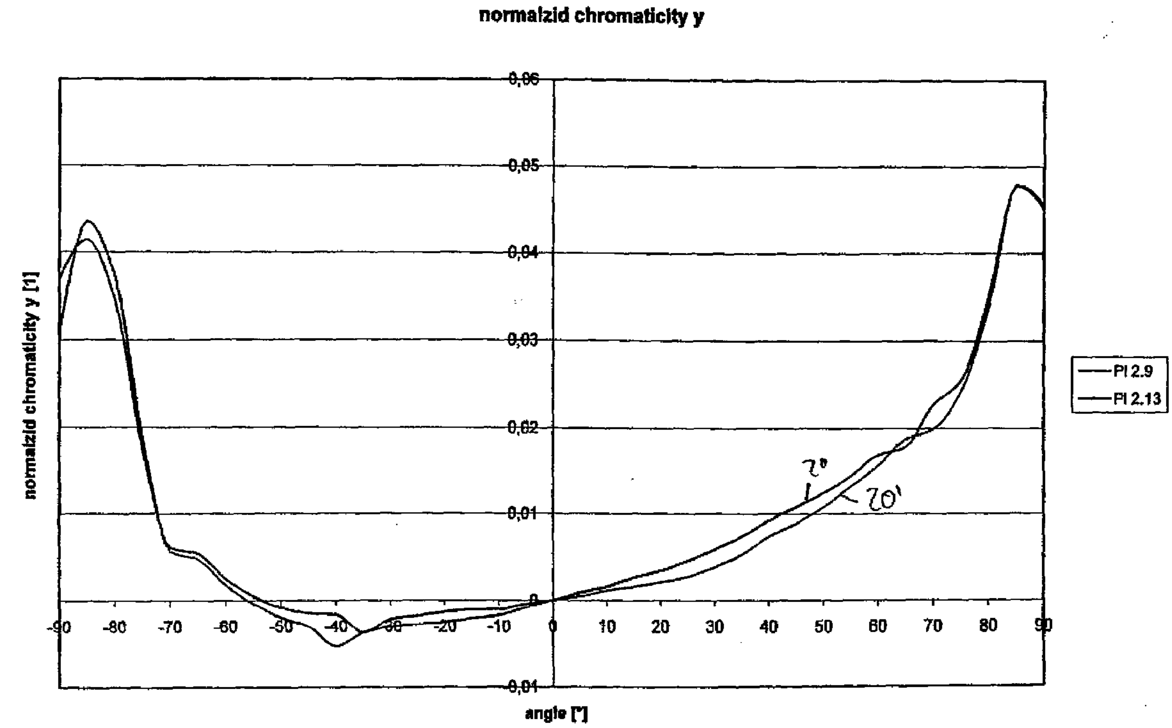

normalzid chromaticity y
0,06
0,05
0,04
0,03
0,02
0,01
0
-0,01
-90
-80
-70
-60
-50
-40
-30
-20
-10
0
10
20
30
40
50
60
70
80
90
normalzid chromaticity y [1]
angle [°]
PI 2.9
PI 2.13
20
20'

Fig3c)

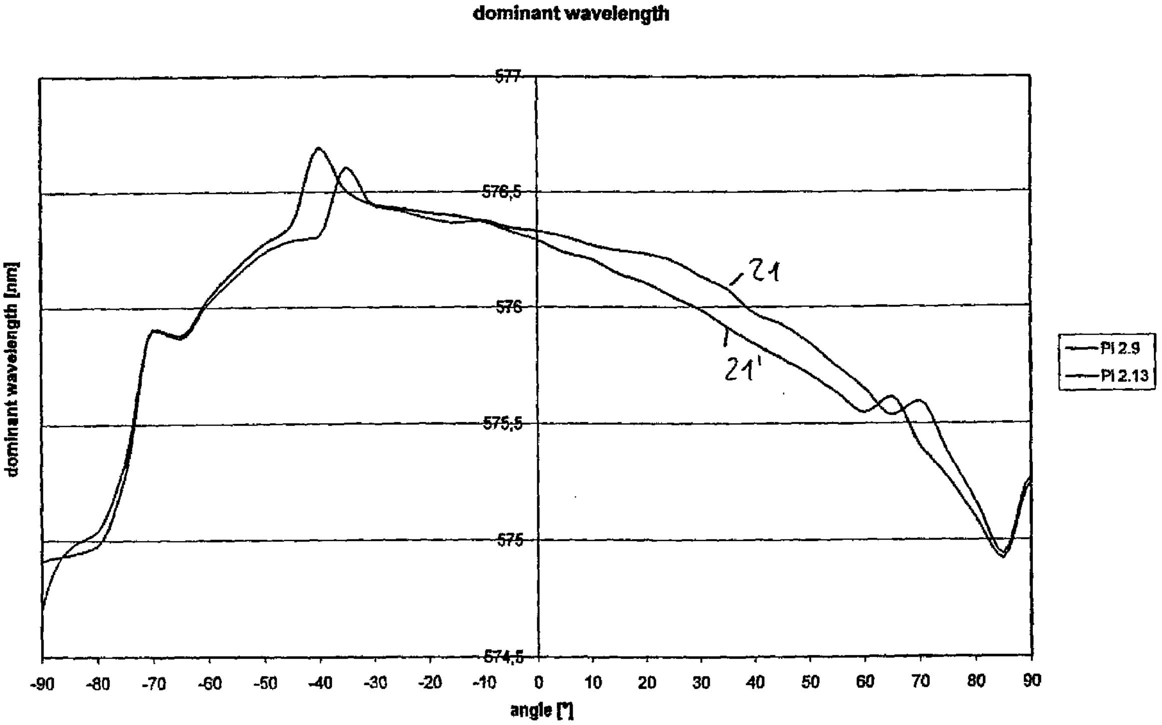

dominant wavelength
dominant wavelength [nm]
577
576,5
576
575,5
575
574,5
-90
-80
-70
-60
-50
-40
-30
-20
-10
0
10
20
30
40
50
60
70
80
90
angle [°]
21
21'
PI 2.9
PI 2.13

Fig 3d)

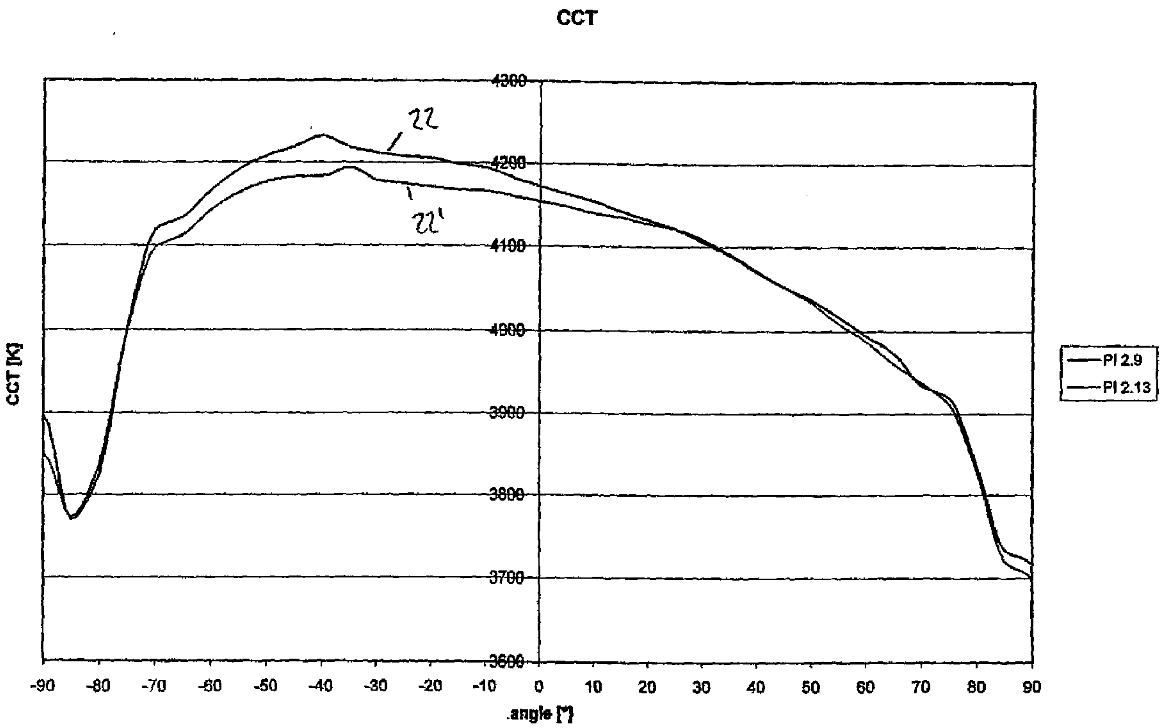
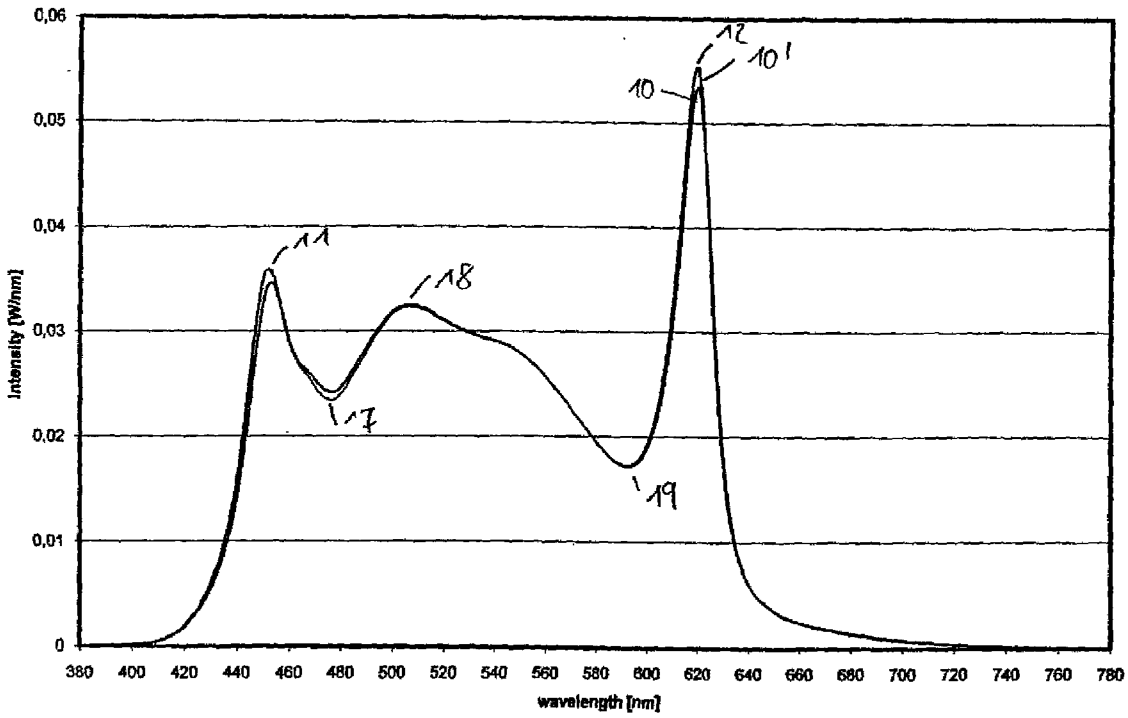

CCT
4300
4200
4100
4000
3900
3800
3700
3600
CCT [K]
-90
-80
-70
-60
-50
-40
-30
-20
-10
0
10
20
30
40
50
60
70
80
90
angle [°]
22
22'
PI 2.9
PI 2.13

Fig 4)


0,06
0,05
0,04
0,03
0,02
0,01
0
Intensity [W/nm]
380 400 420 440 460 480 500 520 540 560 580 600 620 640 660 680 700 720 740 760 780
wavelength [nm]
11
17
18
19
12
10
10'

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2006132533 A2 **[0008]**
- WO 2009013317 A1 **[0009]**