PHOTOBIOMODULATION (PBM) IN GENERAL LIGHTING

TECHNICAL FIELD

[0001] The invention relates generally to lighting, and more particularly to a lighting apparatus, a lighting system, and a method for providing a lighting apparatus that delivers radiation in a non-visible spectrum sufficient to induce photobiomodulation (PBM) response.

BACKGROUND ART

[0002] Photobiomodulation (PBM) involves irradiating a living organism at certain energy/power levels to induce biological or biochemical responses. The irradiation may be in the visible spectrum, such as red light, or in the non-visible spectrum, such as infrared (IR). There has been a significant amount of research about the medical benefits of employing PBM therapy to treat physical and psychological symptoms.

[0003] However, most of the equipment that administer PBM radiation are specialized devices that are only available at a very limited number of medical facilities. Moreover, these specialized devices are often so complicated that only a team of well-trained physicians, nurses and technicians can use them. These factors greatly limit the spread of the medical benefits of PBM within the general public.

[0004] Therefore, there is a need to overcome the abovementioned disadvantages of the currently available apparatuses and methods.

SUMMARY OF THE INVENTION

[0005] It would be desirable to provide an apparatus that is easy to use, energy efficient, cost effective and yet emits an amount of radiation sufficient to induce PBM response.

[0006] According to a first aspect of the present disclosure, a lighting arrangement for general lighting is provided. The lighting arrangement may comprise a light source, a radiation source and a driver circuit. The light source may be adapted to emit visible light suitable for general lighting. In an embodiment, the light source may be capable of or suitable for emitting visible light having a color point in a CIE XYZ color space, which color point has a distance less than 10 Standard

Deviation Color Matching (SDCM) to a black body line in said color space. The radiation source may be adapted to emit radiation in a predetermined spectrum. In an embodiment, the predetermined spectrum may be within the infrared band or in the range about 760-1400nm. The driver circuit may be adapted to provide a first driving current. The first driving current may be pulsed. The lighting arrangement may be adapted to provide the first driving current to the radiation source but not the light source. In use, the light source may be capable of emitting at least 250 lumens, preferably at least 1000 lumens, more preferably at least 2000 lumens

[0007] Traditional light sources already emit some radiation in the band that can induce PBM response in human. For example, the emission spectrum of common incandescent bulbs includes a small amount of red and near infrared light, two of the bands that have been associated with the ability to induce PBM response.

[0008] However, medical research indicates that the radiation needs to achieve a certain minimum amount of power density (measured in optical power per unit area) and dosage (measured in energy per unit area) within the PBM-inducing light spectrum before the radiation can induce a PBM response in the subject.

[0009] It is to be noted that the meaning of the word "light" alone in the present disclosure is not limited to visible light. The word "light" in the present disclosure may include electromagnetic radiation outside the visible light spectrum. By the same token, it is also to be noted that terms such as "optical power" are not limited to power of visible light.

[0010] The inventor noticed a surprising effect which was uncovered from analysis of research literature in the PBM field: photo-induced biological or biochemical responses may vary across power densities despite the same energy density or dosage (energy over unit area) being delivered. In other words, targeting the product of power and time (and power density and time) alone may be insufficient; appropriate combinations of power (density) and time matter. Sufficient power density, even if only for a short period, is needed to induce PBM response. Spreading the radiation over time to achieve the same amount of energy with a power density lower than a threshold may induce no or at most limited PBM response. That is, an insufficient power density is unlikely to be remedied by extending irradiation time.

[0011] The inventor recognized the problem that driving traditional light sources such as incandescent bulbs at a level that can provide sufficient power density at a certain

its potentially variable distances from the user via positioning systems or awareness sensors or the like. Such positioning systems or sensors may be part of the lighting arrangement, or exist in smart devices or other devices located at or nearby the user's body. The ability to keep a substantially constant amount of power density delivered to the user's body at variable distances between the lighting arrangement and the user may help maintain a stable delivery of effective amounts of power density to the user's body surface. The improved stability in the delivery of effective amounts of power density may help optimize the photobiological stimulation of specific biological effects.

[0053] According to another aspect of the present disclosure, a lighting method is provided. The light method may comprise: providing a light source that may be adapted to emit visible light suitable for general lighting; providing a radiation source that may be adapted to emit radiation in a predetermined spectrum; and supplying a first driving current that may be pulsed to the radiation source to generate the radiation in the predetermined spectrum. The light source may be capable of emitting visible light having a color point in a CIE XYZ color space, wherein the color point has a distance less than 10 Standard Deviation Color Matching (SDCM) to a black body line in said color space. The predetermined spectrum may be in the range about 760-1400nm. The first driving current may be not supplied to the light source. In use, the light source may be capable of emitting at least 250 lumens, preferably at least 1000 lumens, more preferably at least 2000 lumens.

[0053a] The duty cycle may be not greater than 20%. By sophisticated pulsing of the radiation source, an appropriate and beneficial amount of radiation in a predetermined spectrum may be provided at a reasonable amount of power consumption. Combining such radiation source into a general lighting apparatus may greatly expand it use and may turn it into a general lighting source with medical benefits that is easy to use. In addition, the method may have similar embodiments with similar effects and advantages as the embodiments of the above-discussed lighting arrangements.

[0054] According to another aspect of the present disclosure, a lamp for general lighting is provided. The lamp for general lighting may comprise one of the above-discussed lighting arrangements. In summary, such a lamp for general lighting may provide a dual-function visible light source.

[0055] According to another aspect of the present disclosure, a retrofit light bulb for general lighting is provided. The retrofit light bulb may comprise one of the above-discussed lighting arrangements. In summary, such a retrofit light bulb may provide