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(54) **YARN FOR ARTIFICIAL GRASS, ARTIFICIAL GRASS, ARTIFICIAL GRASS FIELD AND CORRESPONDING USE AND METHOD**

(57) The invention relates to a yarn for artificial grass, artificial grass, an artificial grass field and corresponding use and method. The yarn comprises a fluorescent substance and/or a photochromic substance such that the yarn has a first colour when illuminated with light having

a first irradiance spectrum typical for winter, and has a second colour differing visibly from the first colour when illuminated with light having a second irradiance spectrum typical for summer.

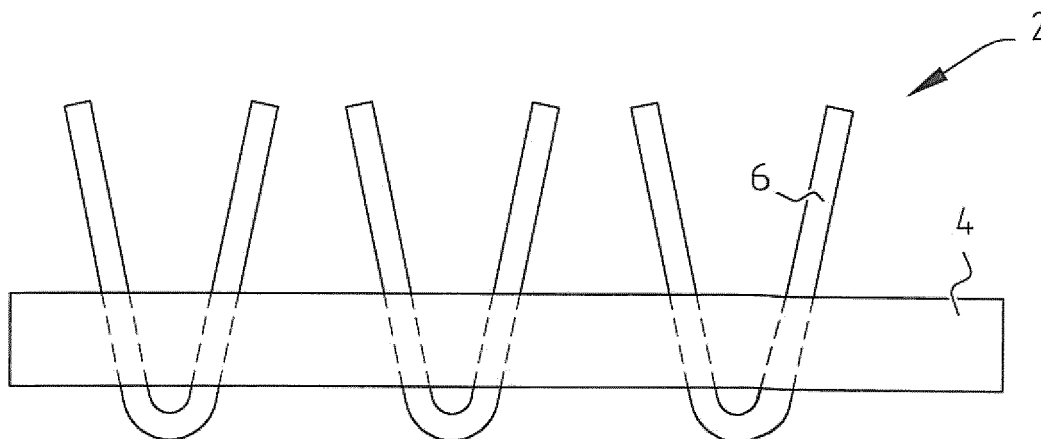


FIG. 1

Description

[0001] The invention relates to a yarn for artificial grass. Artificial grass is a synthetic grass manufactured from plastic. Artificial grass has the advantage relative to natural grass that it can withstand intensive use while being low-maintenance; mowing or watering are after all not necessary. Artificial grass is used for, among other purposes, sports fields, parks and in private gardens.

[0002] In the manufacture of artificial grass attempts are made to give the artificial grass the most natural possible appearance. The problem occurs however that the appearance of artificial grass does not change. Although conventional artificial grass appears natural in the spring and summer months, the appearance is unnatural in the autumn and winter months. Where natural grass has a paler colour in the autumn and winter months than in the spring and summer, artificial grass has the same colour throughout the year. Conventional artificial grass hereby appears unnatural for much of the year.

[0003] An object of the invention is to obviate or at least reduce the above stated problem by providing an artificial grass which has a different appearance in summer and spring than in autumn and winter.

[0004] This object is achieved with the yarn for artificial grass according to the invention, the yarn comprising a fluorescent substance and/or a photochromic substance such that the yarn has a first colour when illuminated with light having a first irradiance spectrum typical for winter, and has a second colour differing visibly from the first colour when illuminated with light having a second irradiance spectrum typical for summer.

[0005] The yarn preferably comprises a plastic.

[0006] The irradiance spectrum is a spectral irradiance characteristic of light incident on the yarn. Irradiance, also referred to as irradiation intensity, provides a measure for the amount of light incident on a surface and is usually expressed in W/m^2 . The irradiance spectrum defines the power per surface area for each wavelength of the light.

[0007] Due to the inclining position of the axis of rotation of the earth relative to its orbit around the sun the angle of incidence of sunlight varies over time, this resulting in the seasons. The amount of incident light, and also the irradiance spectrum, hereby depends on the season. In summer the overall energy incident per second is on average greater than in winter. Furthermore, the spectrum of the incident sunlight also changes. In summer the sunlight for instance comprises more blue and ultraviolet light than in winter.

[0008] The fluorescent substance and/or photochromic substance reacts to this difference between the winter irradiance spectrum and the summer irradiance spectrum, resulting in a difference clearly discernible to the human eye in the appearance of the yarn in winter as compared to summer. Artificial grass with yarn according to the invention is hereby more true to nature than conventional artificial grass.

[0009] A fluorescent substance absorbs light of a first

wavelength and shortly thereafter emits light at a different, usually longer wavelength.

[0010] A photochromic substance is a substance with a colour which changes when exposed to (sun)light. The photochromic substance absorbs light and undergoes a change from a first chemical form to a second chemical form, wherein the absorption spectra of the two chemical forms differ so that the perceived colour of the substance changes. In the context of the invention reference will be made only to the photochromic substances with change which is reversible, i.e. both from the first to the second form and vice versa.

[0011] The objectively measured colour of an object does of course always depend to greater or lesser extent on the illumination of the object. According to the invention however, a difference in irradiance spectrum as a result of the seasons provides for a colour change which goes beyond just the colour change resulting from the changing light conditions.

[0012] In the case of a fluorescent substance the emission spectrum of the yarn thus changes subject to the irradiance spectrum. In the case of the photochromic substance the absorption spectrum of the yarn changes subject to the irradiance spectrum.

[0013] It is noted that, owing to the colour constancy of human colour perception, the subjective colour perception does not depend on the light conditions, or at least does so to very limited extent. According to the invention the colour difference occurring as a result of the fluorescent/photochromic substance is discernible to the human eye. This means that the colour change can be perceived subjectively, despite the fact that the human brain corrects for changing light conditions.

[0014] The fluorescent substance and/or photochromic substance comprises for instance a fluorescent/photochromic colouring agent or fluorescent/photochromic pigment.

[0015] The first colour differs discernibly from the second colour. That is, the difference in colour of the yarn is discernible to the human eye.

[0016] According to the international standard of the Commission Internationale de l'Eclairage, the CIE, for colour measurements, a colour difference can be expressed in ΔE . This represents in this case the distance in the colour space between the first colour and the second colour. When the point of departure is the LAB colour space, according to the invention ΔE is preferably a minimum of 10, more preferably a minimum of 15, still more preferably a minimum of 20, still more preferably a minimum of 25 and most preferably a minimum of 30-50. Use is made here of a LAB scale wherein $0 \leq L \leq 100$, $-128 \leq a \leq 127$ and $-128 \leq b \leq 127$.

[0017] It is noted that a difference in lightness alone (L in the LAB colour space) is also a colour difference according to the invention.

[0018] In a preferred embodiment the fluorescent substance comprises a daylight fluorescent substance.

[0019] Daylight fluorescent substances are substanc-

es which fluoresce when exposed to daylight, i.e. sunlight. Daylight fluorescent substances usually absorb ultraviolet and/or blue light and subsequently emit light with a greater wavelength, for instance yellow or green. Since the irradiance spectrum comprises a greater overall power in summer than in winter (more energy per irradiated surface area), the fluorescence will occur mainly in summer.

[0020] The yarn preferably comprises a daylight fluorescent substance which fluoresces when irradiated with visible light, in particular blue light.

[0021] In a preferred embodiment the fluorescent substance, preferably the daylight fluorescent substance, emits light at least in the wavelength range of green and/or yellow.

[0022] Artificial grass incorporating the yarn according to the invention hereby appears particularly green in summer, while the green colour is less bright in winter so that the artificial grass - just as natural grass - is paler in winter.

[0023] It is noted that the yarn according to the invention can comprise additional colouring agents or pigments so as to also give the artificial grass some degree of colouring in winter and/or to determine the colour in the summer in combination with the fluorescent and/or photochromic substance.

[0024] In a preferred embodiment the yarn comprises a percentage by weight of fluorescent substance, preferably daylight fluorescent substance, of 0.5-2%, preferably 1-1.5%.

[0025] Experiments have shown that such a percentage by weight of fluorescent substance results in a colour change which greatly resembles that of natural grass. A percentage by weight of 2% is a clear upper limit here. At and above this limit the yarn has so much fluorescence that it creates an unnatural impression. Below 0.5% the visible colour difference is so small that the artificial grass appears to have substantially the same colour in summer and winter. At the moment a percentage by weight of about 1% is recommended.

[0026] In a preferred embodiment the fluorescent substance, preferably a daylight fluorescent substance, and/or the photochromic substance reacts to light in at least the wavelength range of blue light or UV light, preferably blue light.

[0027] In other words, the fluorescent/photochromic substance is sensitive to changes in the power of received blue light and/or UV light. The amount of blue and UV light in the sunlight is up to two times greater in summer than in winter. Because the substance will in any case react to a change in this wavelength range, the appearance of the yarn is effectively changed on the basis of the season.

[0028] The fluorescent/photochromic substance preferably reacts in any case to a change in irradiance of blue light. By adapting the fluorescent or photochromic substance to the difference in this specific frequency range the colour change of the yarn is particularly sensitive to the difference in sunlight in summer and winter.

[0029] In a preferred embodiment the fluorescent substance and/or the colour-changing substance reacts to light in at least the wavelength range of 10 nm - 495 nm, preferably 280 nm - 495 nm, more preferably 320 nm - 495 nm and most preferably 380 nm - 495 nm.

[0030] This wavelength corresponds to respectively UV to blue light, UV-B to blue light, UV-A to blue light and blue light.

[0031] In a preferred embodiment the yarn visibly changes colour at a difference in irradiance in the blue and/or UV range of a maximum of 20 W/m², preferably a maximum of 10 W/m², more preferably a maximum of 5 W/m², still more preferably a maximum of 1 W/m² and most preferably a maximum of 0.5 W/m².

[0032] In other words, a visible change of the fluorescent/photochromic substance already occurs when the difference in irradiance, i.e. overall irradiation intensity (W/m²), in the UV and blue part of the irradiance spectrum amounts to only 20 W/m², preferably only 10 W/m², more preferably only 5 W/m², still more preferably only 1 W/m² and most preferably only 0.5 W/m².

[0033] In a preferred embodiment the yarn comprises a UV stabilizer. The UV stabilizer prevents degradation of the yarn due to UV light from sunlight by absorbing UV light. Degradation of the fluorescent/photochromic substance as well as degradation of possibly present plastic are reduced by the UV stabilizer.

[0034] The UV stabilizer is particularly advantageous in combination with a fluorescent/photochromic substance which is sensitive to a change in the blue part of the spectrum. Although the sunlight also changes greatly in the UV part over the seasons, the UV stabilizer will absorb a large part of the UV light so that no, or hardly any, fluorescence or photochromic colour change can take place on the basis thereof. Combining the UV stabilizer with a fluorescent or photochromic substance sensitive to blue light results in a combination which is UV-resistant but still reacts to change in the sunlight as a result of the seasons. It is moreover the case that fluorescent substances in particular are subject to degradation due to UV light. The addition of a UV stabilizer is therefore particularly advantageous in embodiments in which the yarn comprises a fluorescent substance.

[0035] In a currently preferred embodiment of the invention the yarn comprises a RadGlo pigment from the company Radiant Color, particularly from the RadGlo EA-series, or a similar substance as daylight fluorescent substance. These fluorescent substances are sensitive to blue light, so that a seasonal colour difference can also be obtained in combination with a UV stabilizer. The daylight fluorescent pigment is preferably RadGlo EA-11 or a similar substance.

[0036] In a preferred embodiment the yarn comprises an additional colouring agent. The yarn comprises for instance a percentage by weight of additional colouring agent of 0.5-5%, preferably 1-3% and most preferably about 2%.

[0037] The additional colouring agent provides a base

colour, also when the light-sensitive substance, i.e. the fluorescent and/or photochromic substance, is not activated, or only activated to limited extent. In other words, the additional colouring agent also determines the colour of the yarn in winter.

[0038] The invention also relates to artificial grass, in particular an artificial grass turf, comprising yarn as described above, and an artificial grass field comprising such artificial grass. The yarn is preferably distributed substantially uniformly over the artificial grass. A substantially uniform colour change is in this way realized over the surface of the artificial grass.

[0039] It is possible to combine the yarn according to the invention with other yarns in artificial grass. The yarn according to the invention is for instance used with yarns which do not change colour. The yarn according to the invention is in that case however preferably also distributed substantially uniformly over the surface of the artificial grass, so that substantially the same colour change occurs over the whole surface of the artificial grass.

[0040] The invention also relates to the use of yarn comprising a fluorescent substance and/or a photochromic substance in an artificial grass which displays colour change depending on the season.

[0041] The invention relates particularly to the use of a yarn as described above in artificial grass.

[0042] Finally, the invention relates to a method for manufacturing artificial grass, comprising of incorporating into the artificial grass a yarn comprising a fluorescent substance and/or a photochromic substance such that the artificial grass has a first colour when illuminated with light having a first irradiance spectrum typical for winter, and has a second colour differing visibly from the first colour when illuminated with light having a second irradiance spectrum typical for summer.

[0043] The same advantages and effects as described above in respect of the yarn according to the invention apply for the artificial grass, the artificial grass field, the use and the method according to the invention. The features of these five aspects of the subject-matter can in particular be combined as desired according to the invention.

[0044] The method for instance comprises of forming a mixture with a continuous phase comprising a plastic and a dispersed phase comprising the fluorescent substance and/or photochromic substance.

[0045] The invention will be described hereinbelow on the basis of exemplary embodiments thereof, wherein reference is made to the accompanying figures.

Figure 1 shows a first embodiment of artificial grass according to the invention;

Figure 2 shows schematically an absorption spectrum of the fluorescent substance applied in the yarn according to the first embodiment;

Figure 3 shows schematically an emission spectrum of the fluorescent substance applied in the yarn according to the first embodiment;

Figure 4a shows schematically a first absorption spectrum of a photochromic substance applied in a second embodiment;

Figure 4b shows schematically a second absorption spectrum of a photochromic substance applied in a second embodiment.

[0046] Artificial grass 2 (figure 1) comprises underlayer 4 into which synthetic fibres 6 are tufted. Fibres 6 are tufted for this purpose into a tuft substrate, after which the tuft substrate is provided on the underside with a rubber or latex layer so as to thus form underlayer 4. Fibres 6 are manufactured from yarns according to an embodiment of the invention. Additional yarns are optionally provided, for instance yarns which do not change colour. Fibres 6 are in any case preferably distributed substantially homogeneously over underlayer 4 so that the seasonal colour change occurs in substantially the same way over substantially the whole surface.

[0047] In a first embodiment the fibres comprise 96% plastic, 1% fluorescent pigment and 3% additional colouring agent (expressed in percentages by weight). The fluorescent substance is for instance RADO HTR-series Green, RADO HTR series Lemon Yellow, Radiant Color EA-11 Green or Radiant Color RPC-10 Chartreuse. The plastic is for instance polyethylene (also referred to as polyethene). The additional colouring agent is for instance ColorService UN67058, corresponding to RAL6025. The plastic can moreover comprise a UV stabilizer. The plastic for instance comprises 1-10% UV stabilizer, for instance 2-8% UV stabilizer, for instance about 5% UV stabilizer. The UV stabilizer serves to stabilize both the plastic and the fluorescent substance.

[0048] Figure 2 shows a schematic view of an absorption spectrum of the fluorescent substance. The y-axis represents the absorption, expressed as the logarithmic ratio of I_{door} , transmitted light, and I_{in} , incident light. The x-axis represents λ , the wavelength. The fluorescent substance absorbs light with a wavelength of up to about 500 nm, i.e. UV light (10 nm - 380 nm) and blue light (380-495 nm). Greater wavelengths are not shown, although the fluorescent substance can for instance hardly absorb other wavelengths. The fluorescent substance hereby has a white or blue-white colour when it does not fluoresce.

[0049] When the fluorescent substance is not exposed to UV and blue light, the substance will not emit any light. When exposed to UV and blue light, the light energy is absorbed by the substance. Because of the process of fluorescence the substance will then begin emitting light. The emission spectrum is shown schematically in figure 3. The y-axis represents the spectral radiance in $\text{Wm}^{-2}\text{nm}^{-1}$. The x-axis represents the wavelength λ . The light emitted by the fluorescent substance has a longer wavelength than the UV light and blue light absorbed by the substance. The emission is in the green and yellow part of the spectrum. Fibres 6 will hereby appear greener when illuminated by sunlight with more blue light and UV

light, such as in summer.

[0050] Figure 4a shows schematically a first absorption spectrum of a photochromic substance. The photochromic substance displays a substantially uniform absorption of wavelengths in the UV and visible part of the light spectrum so that the photochromic substance is dark-coloured in a first state. Through the absorption of light however, the substance transposes into a second state, in which the substance has the absorption spectrum as according to figure 4b. In this second state a part of the wavelengths in the green and yellow range of the spectrum is no longer absorbed but reflected by the substance, so that the substance displays a green colour.

[0051] It is emphasized that the above examples serve only to illustrate the operation of the fluorescent and photochromic substances. Fluorescent and photochromic substances can in practice have other spectra.

[0052] A method for manufacturing artificial grass according to the invention will now be described. A mixture of 96% plastic, 1% daylight fluorescent pigment and 3% green pigment is prepared. This mixture is extruded to form monofilament yarn 6. Yarn 6 is then tufted into a tuft substrate, after which the tuft substrate is provided on the underside with a rubber or latex layer, so forming underlayer 4.

[0053] The invention is by no means limited to the above described preferred embodiments thereof. The rights sought are defined by the following claims, within the scope of which many modifications can be envisaged.

Claims

1. Yarn for artificial grass, comprising a fluorescent substance and/or a photochromic substance such that the yarn has a first colour when illuminated with light having a first irradiance spectrum typical for winter, and has a second colour differing visibly from the first colour when illuminated with light having a second irradiance spectrum typical for summer.
2. Yarn as claimed in claim 1, wherein the fluorescent substance is a daylight fluorescent substance.
3. Yarn as claimed in claim 1 or 2, wherein the fluorescent substance emits light at least in the wavelength range of green and/or yellow.
4. Yarn as claimed in claim 1, 2 or 3, wherein the yarn comprises a percentage by weight of fluorescent substance of 0.5-2%, preferably 1-1.5%.
5. Yarn as claimed in any of the foregoing claims, wherein the fluorescent substance and/or the photochromic substance reacts to light in at least the wavelength range of blue light or UV light, preferably blue light.
6. Yarn as claimed in claim 5, wherein the fluorescent substance and/or the photochromic substance reacts to light in at least the wavelength range of 10 nm - 495 nm, preferably 280 nm - 495 nm, more preferably 320 nm - 495 nm and most preferably 380 nm - 495 nm.
7. Yarn as claimed in claim 5 or 6, wherein the yarn visibly changes colour at a difference in irradiance in the blue and/or UV range of a maximum of 20 W/m², preferably a maximum of 10 W/m², more preferably a maximum of 5 W/m², still more preferably a maximum of 1 W/m² and most preferably a maximum of 0.5 W/m².
8. Yarn as claimed in any of the foregoing claims, wherein the yarn further comprises a UV stabilizer.
9. Yarn as claimed in any of the foregoing claims, comprising an additional colouring agent.
10. Yarn as claimed in any of the foregoing claims, wherein the second colour is optically lighter than the first colour.
11. Artificial grass comprising a yarn as claimed in any of the foregoing claims.
12. Artificial grass as claimed in claim 11, wherein the yarn is distributed substantially uniformly over the artificial grass.
13. Artificial grass field comprising artificial grass as claimed in claim 11 or 12.
14. Use of a yarn comprising a fluorescent substance and/or a photochromic substance in an artificial grass which displays colour change depending on the season.
15. Method for manufacturing artificial grass, comprising of incorporating into the artificial grass a yarn comprising a fluorescent substance and/or a photochromic substance such that the artificial grass has a first colour when illuminated with light having a first irradiance spectrum typical for winter, and has a second colour differing visibly from the first colour when illuminated with light having a second irradiance spectrum typical for summer.

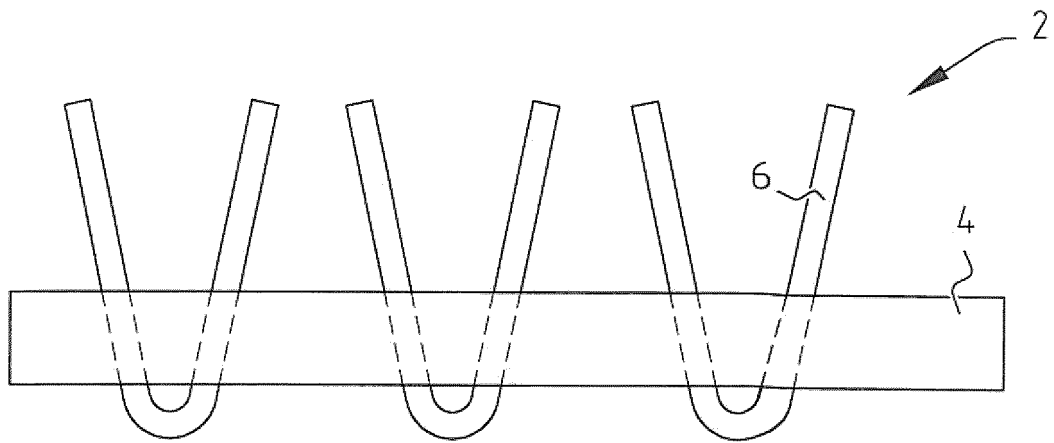


FIG. 1

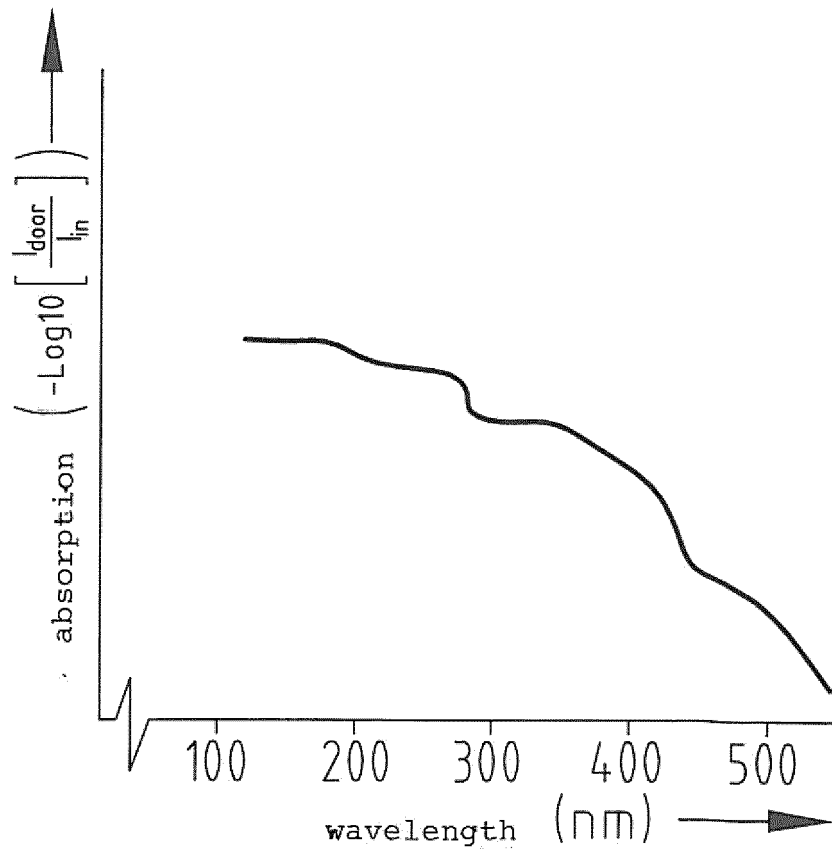


FIG. 2

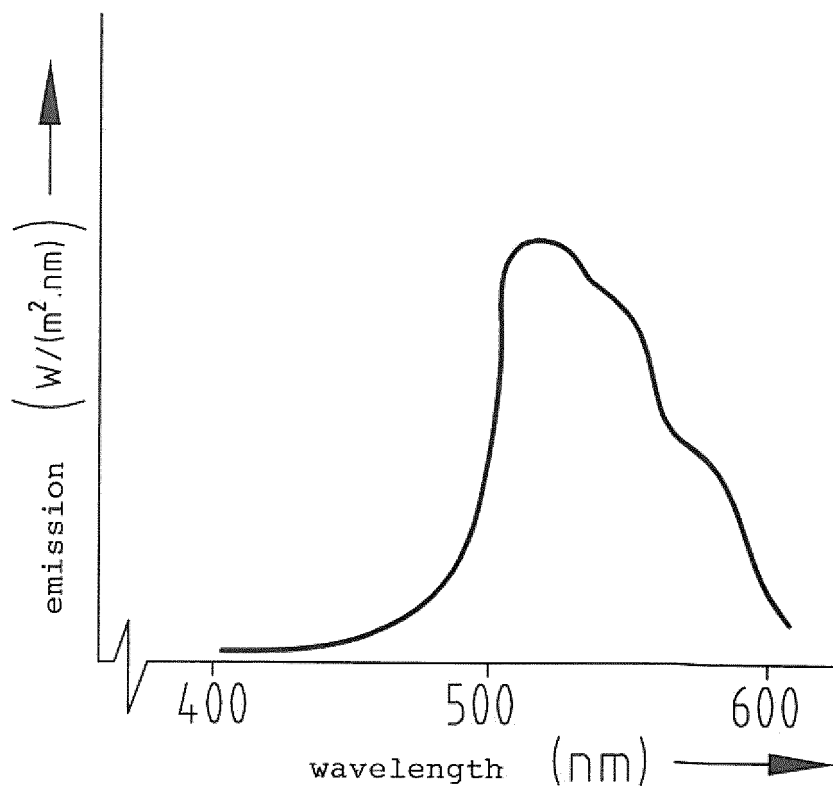


FIG. 3

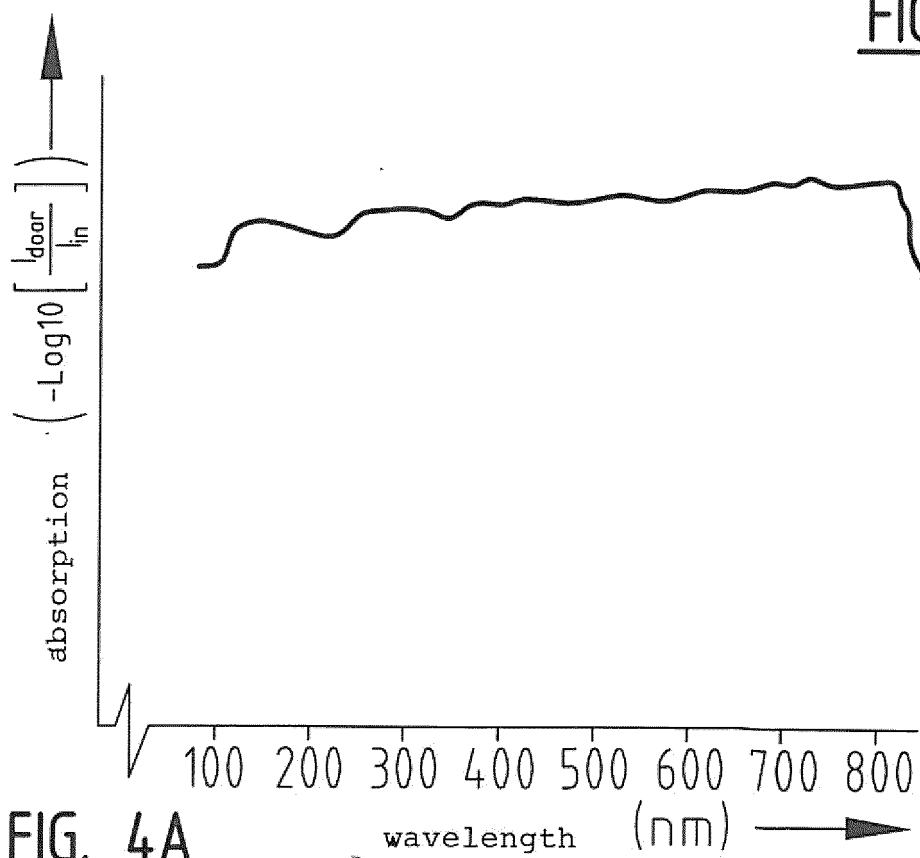


FIG. 4A

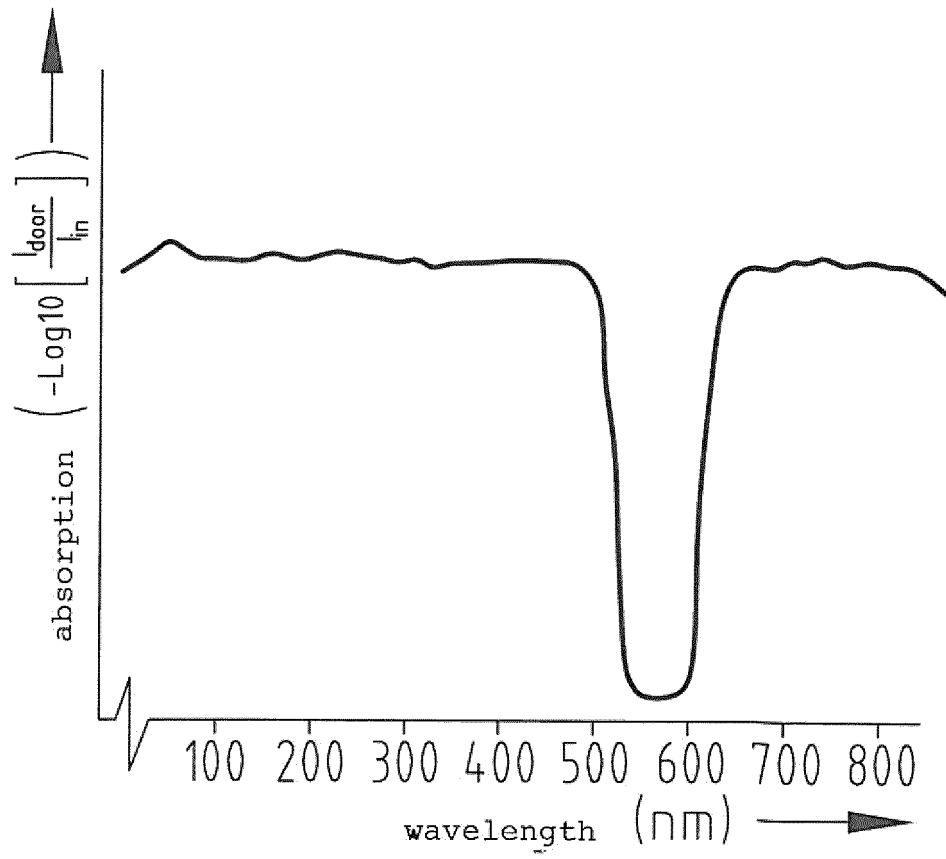


FIG. 4B



EUROPEAN SEARCH REPORT

Application Number
EP 15 17 2398

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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 11 January 2016	Examiner Pollet, Didier
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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