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(71) Applicant: **BIC Violex Single Member S.A.**
14569 Anoixi (GR)

(72) Inventor: **Chrysanthakopoulos, Nikolaos**
145 69 Anoixi (GR)

(74) Representative: **Peterreins Schley**
Patent- und Rechtsanwälte PartG mbB
Hermann-Sack-Straße 3
80331 München (DE)

(54) **WRITING SYSTEM WITH HUMIDITY CONTROLLED COLOR**

(57) In a first aspect, the present disclosure relates to a writing system comprising a writing instrument. The writing instrument comprises a liquid reservoir comprising a hygroscopic liquid and/or water and a writing surface comprising a writing surface film. The writing surface film comprises a plurality of layers. Further, the writing surface film is configured to display different colors depending on a water content in the writing surface film.

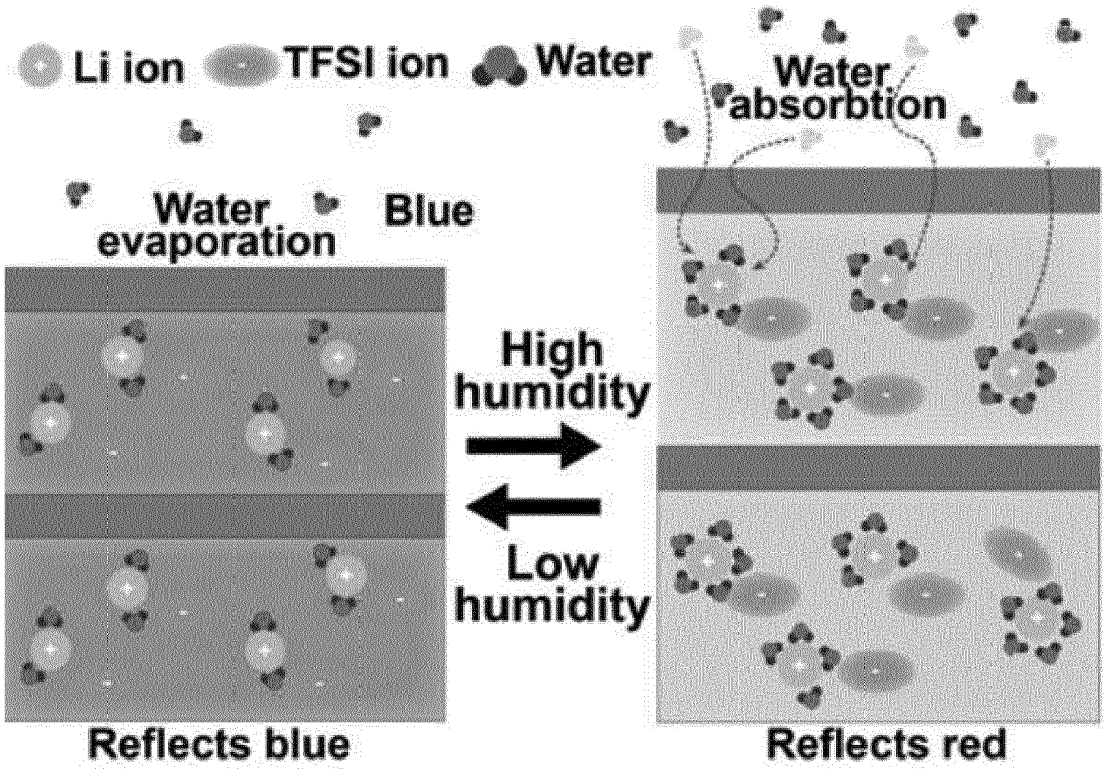

Figure 1

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Description

Technical Field

[0001] The present invention relates to the field of writing systems. More specifically, the present invention relates to writing systems comprising writing surfaces color-adjustable by humidity.

Background

[0002] Typical writing instruments comprise pigments or dyes as colorants. By switching between writing instruments comprising different colorants, a user can produce drawings with varying colors. Switching between writing instruments can be a nuisance to a user. Further, once a typical writing substrate, such as paper, is colored with a pigment or dye, the pigment or dye can hardly or not at all be removed. The paper is therefore a disposable product.

[0003] In nature structural coloration is observed. For example, the feather of peacocks or the fur of golden moles exhibit structural coloration. Structural coloration occurs when microscopically structured surfaces interfere with visible light. Surfaces may appear in different colors depending on the spatial configuration of the surface without the need for pigments and/or dyes. In the case of peacock feathers the feathers further show iridescence due to the structural coloration. Iridescence is a visual effect wherein certain surfaces appear to gradually change color with changing angle of view or illumination. Iridescence is rarely observed in images created by typical writing instrument comprising pigments or dyes.

[0004] The present disclosure aims to provide a novel writing system allowing the provision of different colors with a single writing instrument.

Summary

[0005] In a first aspect, the present disclosure relates to a writing system comprising a writing instrument. The writing instrument comprises a liquid reservoir comprising a hygroscopic liquid and/or water and a writing surface comprising a writing surface film. The writing surface film comprises a plurality of layers. Further, the writing surface film is configured to display different colors depending on a water content in the writing surface film.

[0006] In some embodiments the plurality of layers may comprise at least a first type of layer and a second type of layer.

[0007] In some embodiments the first type of layer may exhibit a thickness between about 15 nm to about 75 nm, more specifically between about 25 nm to about 65 nm and in particular between about 35 nm to about 55 nm.

[0008] In some embodiments the second type of layer may exhibit a thickness between about 50 nm to about 300 nm, more specifically between about 80 nm to about 250 nm and in particular between about 100 nm to about 165 nm.

[0009] In some embodiments the first type of layer and second type of layer may be arranged in an alternating order.

[0010] In some embodiments the plurality of layers may comprise at least 4 layers, more specifically at least 6 layers and in particular at least 8 layers.

[0011] In some embodiments the writing surface may have a local resolution between about 15 μm and about 200 μm, more specifically between about 30 μm and about 100 μm and in particular between about 50 μm and about 70 μm.

[0012] In some embodiments the thickness of the second type of layer may be configured to be adjustable.

[0013] In some embodiments the second type of layer may be configured to absorb water, wherein the absorption of water leads to an increase in thickness.

[0014] In some embodiments the writing surface may be configured to display different colors depending upon the water content of the second type of layer.

[0015] In some embodiments the distance between consecutive layers of first type of layers may depend on the water content in the writing surface film.

[0016] In some embodiments the distance between consecutive layers of first type of layers may depend on the water content in the second type of layer.

[0017] In some embodiments the first type of layer and second type of layer may form one or more photonic crystals.

[0018] In some embodiments the plurality of layers may comprise a block copolymer.

[0019] In some embodiments the block copolymer may comprise a first type block moiety and a second type block moiety.

[0020] In some embodiments the first type block moiety and the second type block moiety may form separate phases.

[0021] In some embodiments the first type of layer may comprise at least 90 %, more specifically, at least 95 % and in particular at least 98 % of the first type block moiety.

[0022] In some embodiments the second type of layer may comprise at least 90 %, more specifically, at least 95 % and in particular at least 98 % of the second type block moiety.

[0023] In some embodiments the plurality of layers may comprise a dopant, more specifically a metal salt and in particular copper chloride.

[0024] In some embodiments the second type of layer may comprise the dopant.

[0025] In some embodiments the first type block moiety may be hydrophobic and the second type block moiety is hydrophilic.

[0026] In some embodiments the block copolymer may comprise a 1D block copolymer, more specifically a self-assembled 1D block copolymer and in particular polystyrene-b-poly(2-vinylpyridine) or poly(2-vinylpyridine)-b-

polystyrene-b-poly(2-vinylpyridine).

[0027] In some embodiments the block copolymer may comprise a bottlebrush block copolymer, in particular polystyrene/hexanoate brush-coil copolymers, polylactide/polystyrene brush copolymers and/or polylactide/poly(n-butylacrylate) bottlebrush-copolymers.

[0028] In some embodiments the block copolymer may comprise an AB block copolymer, in particular poly(methyl methacrylate)-block-polystyrene.

[0029] In some embodiments the writing surface film may comprise a hydrogel, more specifically a cross-linked hydrogel, in particular a cross-linked interpenetrated hydrogel network.

[0030] In some embodiments the second type of layer may comprise the hydrogel.

[0031] In some embodiments the hydrogel may comprise a protein based, a synthetic and/or a polysaccharide based hydrogel.

[0032] In some embodiments the polysaccharide based hydrogel may comprise chitosan, alginate and/or starch.

[0033] In some embodiments the hydrogel may comprise poly(ethylene glycol) diacrylate.

[0034] In some embodiments the block copolymer and the hydrogel may form a cross-linked interpenetrating hydrogel network.

[0035] In some embodiments the second type block moieties and the hydrogel may form a cross-linked interpenetrating hydrogel network.

[0036] In some embodiments the writing surface film may have a thickness between about 200 nm to about 1200 nm, more specifically between about 250 nm to about 1100 nm and in particular between about 300 nm to about 1000 nm.

[0037] In some embodiments the second layer may comprise the hygroscopic liquid.

[0038] In some embodiments the hygroscopic liquid may comprise an ionic liquid.

[0039] In some embodiments the ionic liquid may comprise a salt derived from 1-methylimidazole, more specifically a salt of an 1-alkyl-3methylimidazolium and in particular a salt of 1-ethyl-3-methyl-imidazolium, 1-butyl-3-methylimidazolium, 1-methyl-3-octyl-imidazolium, 1-decyl-3-methylimidazolium, 1-dodecyl-3-methyl-dodecylimidazolium.

[0040] In some embodiments the ionic liquid may comprise a bis(trifluoromethylsulfonyl)amine lithium salt.

[0041] In some embodiments, the ionic liquid may comprise an imidazolium cation, N-heterocyclic cations derived from pyridine, quarternary ammonium cations, phosphonium cations, tetrafluoroborate, hexaflurophosphate, bis-trifluromethanesulfonimide, trifluoromethanesulfonate, dicyanamide, a protic ionic liquid and/or poly(ionic liquid)s.

[0042] In some embodiments the writing system may comprise a water reservoir.

[0043] In some embodiments the writing system may comprise the water reservoir within a water dispensing unit.

[0044] In some embodiments the writing instrument may comprise the water dispensing unit.

[0045] In some embodiments the writing instrument may comprise a control element configured to control a rate of water dispersion.

[0046] In some embodiments the rate of water dispersion may be adjusted between about 0.01 L/h to 0.5 L/h.

[0047] In some embodiments the control element may comprise a selection ring, a slider button and/or a touch sensor strip.

[0048] In some embodiments the control element may comprise a color identification, in particular a gradually colored strip.

[0049] In some embodiments the water dispersion unit may comprise a water atomizer, wherein the water atomizer may comprise a piezoelectric element, a mesh disc connected to the piezoelectric element, and a water outlet.

[0050] In some embodiments the piezoelectric element may be configured to oscillate when supplied with an electric frequency.

[0051] In some embodiments the piezoelectric element may be configured to oscillate with a frequency between about 1 kHz to about 20 MHz, more specifically between about 5 kHz to about 10 MHz and in particular between about 20 kHz to about 5 MHz.

[0052] In some embodiments the control element may be configured to control the electric frequency.

[0053] In some embodiments the mesh disc may comprise a mesh with an average mesh diameter between about 3 μm to about 30 μm.

[0054] In some embodiments the writing instrument may comprise a mixing chamber, wherein the mixing chamber may be configured to receive hygroscopic liquid and water.

[0055] In some embodiments writing system may comprise a curing agent dispenser.

[0056] In some embodiments the curing agent dispenser may comprise a curing agent.

[0057] In some embodiments the curing agent dispenser may be configured to dispense the curing agent on the writing surface.

[0058] In some embodiments the curing agent dispenser may be configured to dispense the curing agent into the mixing chamber.

[0059] In some embodiments the curing agent may be a varnish, in particular violin, an alkyd resin, spar varnish, a drying oil, polyurethane, lacquer, an acrylic resin, an epoxy resin, a two part epoxy resin.

[0060] In some embodiments the curing agent may comprise a solvent.

[0061] In some embodiments the curing agent may comprise tannic acid, alum, chrome alum, sodium chloride, aluminium salts, chromium, copper, iron, iodine, potassium, sodium, tungsten and/or tin.

[0062] In some embodiments the writing instrument may comprise a nib, a felt tip and/or a roller ball.

[0063] In some embodiments the writing instrument may comprise a writing orifice.

[0064] In some embodiments the writing instrument may comprise a hygroscopic liquid orifice, a water orifice and/or a curing agent orifice.

[0065] In a second aspect, the present disclosure relates to a writing instrument comprising a liquid reservoir comprising a hygroscopic liquid, a water reservoir comprising water, and a curing agent reservoir comprising a curing agent.

[0066] In a third aspect, the present disclosure relates to a writing surface comprising a writing surface film, wherein the writing surface film comprises a plurality of layers. Further, the writing surface film is configured to display different colors depending on a water content in the writing surface film.

[0067] In a fourth aspect, the present disclosure relates to a water dispersion unit comprising a water atomizer. The water atomizer comprises a piezoelectric element, a mesh disc connected to the piezoelectric element, and a water outlet.

Detailed Description

[0068] Hereinafter, a detailed description will be given of the present disclosure. The terms or words used in the description and the aspects of the present disclosure are not to be construed limitedly as only having common-language or dictionary meanings and should, unless specifically defined otherwise in the following description, be interpreted as having their ordinary technical meaning as established in the relevant technical field. The detailed description will refer to specific embodiments to better illustrate the present disclosure, however, it should be understood that the presented disclosure is not limited to these specific embodiments.

[0069] It has been surprisingly found that a writing surface film comprising a plurality of layers may display different colors depending on a water content in the writing surface film. This color-changing effect allows drawing and/or the writing on a writing surface film with water or a composition comprising water to create images and to adjust the color of these images by controlling the water content.

[0070] In principle, there are two not necessarily mutually exclusive ways of adjusting the color of the writing surface film:
The water content of the writing surface film may be adjusted by first writing with a writing instrument which dispenses a hygroscopic liquid to the writing surface. Then, water is added to the drawing or water is absorbed from surrounding air to adjust the color of the writing surface film.

[0071] In the second way of adjusting the color, the hygroscopic liquid may be infused into parts or all of the writing surface film prior to the drawing action. Subsequently, water or a composition comprising water may be dispensed from a writing instrument to create a colored writing or drawing on the writing surface.

[0072] Figure 1 shows a writing surface film comprising a hygroscopic liquid, more specifically the lithium salt of bis(trifluoromethylsulfonyl)amine. With increasing humidity, for example in the ambient air, the writing surface film absorbs more water, in particular in layers comprising the hygroscopic liquid. Due to the absorption of water, the width of the layers comprising the hygroscopic liquid increases. The width increase may, without wishing to be bound by theory, adjust the color of the writing surface film, more specifically adjust the color reflected by the writing surface film, for example from blue to red.

[0073] Accordingly, in a first aspect, the present disclosure relates to a writing system comprising a writing instrument. The writing instrument comprises a liquid reservoir comprising a hygroscopic liquid and/or water and a writing surface comprising a writing surface film. The writing surface film comprises a plurality of layers. Further, the writing surface film is configured to display different colors depending on a water content in the writing surface film.

[0074] Without wishing to be bound by theory, the color-changing effect may rely on structural coloration. In particular, the color-changing effect may rely on the writing surface film comprising the plurality of layers, which may form one or more one-dimensional photonic crystals. The term "one-dimensional photonic crystal" within this disclosure i.a. refers to its common meaning in the art. Additionally or alternatively the term "one-dimensional photonic crystal" may refer to a plurality of layers affecting the motion of light (photons), in particular a plurality of layers affecting the motion of light (photons) exhibiting a periodicity. Additionally or alternatively the term "one-dimensional photonic crystal" may refer to a plurality of layers having a photonic band-gap in at least one dimension. Additionally or alternatively the term "one-dimensional photonic crystal" may refer to a plurality of layers, wherein a first type of layer has a higher dielectric constant compared to a second type of layer, in particular wherein the first and second layer alternate. Again, without wishing to be bound by theory, one-dimensional photonic crystals may affect the motion of photons, in particular one-dimensional photonic crystals may affect the motion of photons by exhibiting a photonic band-gap. The photonic band-gap allows light with a wavelength outside the photonic band-gap range to propagate through the plurality of layers, while light with a wavelength in the range of the photonic band-gap range cannot propagate. For light to be diffracted, the periodicity of the plurality of layers must correspond approximately to half of the wavelength of the light. The photonic band-gap may therefore depend upon the periodicity of the layers. Again, without wishing to be bound by theory, when the writing surface film absorbs water, at least one of the layers of the plurality of layers may increase in thickness, thereby changing the periodicity of layers, which in turn changes the photonic band-gap, which finally changes the color the writing surface film displays.

[0075] The colors displayed by the writing surface film may furthermore be iridescent. Iridescent colors may be appealing to a user. Furthermore, the writing surface may be reusable, as water may evaporate from the writing surface film, returning it to a uniform color.

Writing Surface Film

[0076] In some embodiments the plurality of layers may comprise at least a first type of layer and a second type of layer. As mentioned above, the plurality of layers may comprise a first type and second type of layer having different dielectric constants, thereby forming one or more photonic crystal(s).

[0077] In some embodiments the first type of layer may exhibit a thickness between about 15 nm to about 75 nm, more specifically between about 25 nm to about 65 nm and in particular between about 35 nm to about 55 nm.

[0078] In some embodiments the second type of layer may exhibit a thickness between about 50 nm to about 300 nm, more specifically between about 80 nm to about 250 nm and in particular between about 100 nm to about 165 nm.

[0079] The thickness of the first type of layer and/or second type of layer may influence the periodicity of the plurality of layers, which in turn may influence the photonic band-gap.

[0080] In some embodiments the first type of layer and second type of layer may be arranged in an alternating order. A plurality of layers comprising a first type of layer and a second type of layer may exhibit a periodicity.

[0081] In some embodiments the plurality of layers may comprise at least 4 layers, more specifically at least 6 layers and in particular at least 8 layers. More layers may lead to a more intense coloration of the writing surface film.

[0082] In some embodiments the writing surface may have a local resolution between about 15 μm and about 200 μm, more specifically between about 30 μm and about 100 μm and in particular between about 50 μm and about 70 μm. A higher resolution may result in an image with sharper contours when drawing.

[0083] In some embodiments the thickness of the second type of layer may be configured to be adjustable.

[0084] In some embodiments the second type of layer may be configured to absorb water, wherein the absorption of water leads to an increase in thickness.

[0085] In some embodiments the writing surface may be configured to display different colors depending upon the water content of the second type of layer.

[0086] In some embodiments the distance between consecutive layers of first type of layers may depend on the water content in the writing surface film.

[0087] In some embodiments the distance between consecutive layers of first type of layers may depend on the water content in the second type of layer.

[0088] As previously described, again without wishing to be bound by theory, the periodicity of the plurality of layers may influence the color shown by the writing surface, in particular as the periodicity of the layers may influence the photonic band-gap in the material. The periodicity of the material may be altered by increasing the water content in at least one of the layers, e.g. the second type of layer, thereby leading to a change of color displayed by the writing surface. An increase of thickness the second type of layer may, e.g. when the first and second type of layer alternate, lead to an increase in the distance between two layers of the first type of layer.

[0089] In some embodiments the first type of layer and second type of layer may form one or more photonic crystals.

[0090] In some embodiments the plurality of layers may comprise a block copolymer.

[0091] In some embodiments the block copolymer may comprise a first type block moiety and a second type block moiety.

[0092] In some embodiments the first type block moiety and the second type block moiety may form separate phases. In some embodiments, some block copolymers may comprise a first type block moiety and second type block moiety exhibiting different properties. For example, the first type block moiety and the second type block moiety may exhibit different electrostatic properties. Without wishing to be bound by theory, the plurality of layers may form by e.g. self-assembly because the electrostatic properties may lead to an energy minimum when block moieties of the first type interact with other block moieties of the first type and block moieties of the second type interact with other block moieties of the second type. As a result, some block copolymers may spontaneously form separate phases, which in turn may form a plurality of phases. The plurality of phases may form a plurality of layers comprising a first type of layer and second type of layer.

[0093] In some embodiments the first type of layer may comprise at least 90 %, more specifically, at least 95 % and in particular at least 98 % of the first type block moiety.

[0094] In some embodiments the second type of layer may comprise at least 90 %, more specifically, at least 95 % and in particular at least 98 % of the second type block moiety.

[0095] In some embodiments the plurality of layers may comprise a dopant, more specifically a metal salt and in particular copper chloride. Dopants may improve the formation of separate phases by the block copolymer and hence the formation of a plurality of phases.

[0096] In some embodiments the second type of layer may comprise the dopant.

[0097] In some embodiments the first type block moiety may be hydrophobic and the second type block moiety is hydrophilic.

[0098] In some embodiments the block copolymer may comprise a 1D block copolymer, more specifically a self-assembled 1D block copolymer and in particular polystyrene-b-poly(2-vinylpyridine) or poly(2-vinylpyridine)-b-

polystyrene-b-poly(2-vinylpyridine).

[0099] In some embodiments the block copolymer may comprise a bottlebrush block copolymer, in particular polystyrene/hexanoate brush-coil copolymers, polylactide/polystyrene brush copolymers and/or polylactide/poly(n-butylacrylate) bottlebrush-copolymers.

[0100] In some embodiments the block copolymer may comprise an AB block copolymer, in particular poly(methyl methacrylate)-block-polystyrene.

[0101] In some embodiments the writing surface film may comprise a hydrogel, more specifically a cross-linked hydrogel, in particular a cross-linked interpenetrated hydrogel network.

[0102] In some embodiments the second type of layer may comprise the hydrogel.

[0103] The hydrogel may increase the water absorption rate and/or water absorption capacity of the plurality of layers, in particular the second type of layer. This may increase the speed at which the color may be changed and/or increase the achievable color range.

[0104] In some embodiments the hydrogel may comprise a protein based, a synthetic and/or a polysaccharide based hydrogel.

[0105] In some embodiments the polysaccharide based hydrogel may comprise chitosan, alginate and/or starch.

[0106] In some embodiments the hydrogel may comprise poly(ethylene glycol) diacrylate.

[0107] In some embodiments the block copolymer and the hydrogel may form a cross-linked interpenetrating hydrogel network.

[0108] In some embodiments the second type block moieties and the hydrogel may form a cross-linked interpenetrating hydrogel network. A cross-linked interpenetrating hydrogel network may provide an increased water absorption capacity. Further, the cross-linked interpenetrating hydrogel may increase the mechanical properties of layers formed by the second type block moieties and therefore the mechanical properties of the writing surface film.

[0109] In some embodiments the writing surface film may have a thickness between about 200 nm to about 1200 nm, more specifically between about 250 nm to about 1100 nm and in particular between about 300 nm to about 1000 nm.

Ionic Liquid

[0110] In some embodiments the second layer may comprise the hygroscopic liquid. As mentioned above, the hygroscopic liquid may be infused into the writing surface, instead of being added during the writing and/or drawing action.

[0111] In some embodiments the hygroscopic liquid may comprise an ionic liquid. Ionic liquids may be compatible with the second type of layer, in particular ionic liquids may be soluble in the second type of layer. Further, ionic liquids may be non-volatile and therefore remain in the second type of layer during for example storage. Furthermore, ionic liquids may exhibit strong hygroscopic properties increasing the rate and capacity of water absorption.

[0112] In some embodiments the ionic liquid may comprise a salt derived from 1-methylimidazole, more specifically a salt of an 1-alkyl-3methylimidazolium and in particular a salt of 1-ethyl-3-methyl-imidazolium, 1-butyl-3-methylimidazolium, 1-methyl-3-octyl-imidazolium, 1-decyl-3-methylimidazolium, 1-dodecyl-3-methyl-docecylimidazolium.

[0113] In some embodiments the ionic liquid may comprise a bis(trifluoromethylsulfonyl)amine lithium salt.

[0114] In some embodiments, the ionic liquid may comprise an imidazolium cation, N-heterocyclic cations derived from pyridine, quarternary ammonium cations, phosphonium cations, tetrafluoroborate, hexaflurophosphate, bis-trifluromethanesulfonimide, trifluoromethanesulfonate, dicyanamide, a protic ionic liquid and/or poly(ionic liquid)s.

Water Dispenser

[0115] In some embodiments the writing system may comprise a water reservoir.

[0116] In some embodiments the writing system may comprise the water reservoir within a water dispensing unit.

[0117] As mentioned above, the water may be applied as a liquid, e.g. by a pen comprising water. Alternatively or additionally, the humidity of the ambient air may be adjusted. Adjusting the humidity of the ambient air may be advantageous when the image was drawn using the hygroscopic liquid.

[0118] In some embodiments the writing instrument may comprise the water dispensing unit.

[0119] In some embodiments the writing instrument may comprise a control element configured to control a rate of water dispersion. Adjusting the rate of water dispersion may allow controlling the color the writing surface is set to.

[0120] In some embodiments the rate of water dispersion may be adjusted between about 0.01 L/h to 0.5 L/h.

[0121] In some embodiments the control element may comprise a selection ring, a slider button and/or a touch sensor strip.

[0122] In some embodiments the control element may comprise a color identification, in particular a gradually colored strip. The gradually colored strip may allow identifying which color is set by the control element, as the selected color on the strip may match the color produced during the writing action.

Atomiser

[0123] In some embodiments the water dispersion unit may comprise a water atomizer, wherein the water atomizer may comprise a piezoelectric element, a mesh

disc connected to the piezoelectric element, and a water outlet. The water atomizer may allow adjusting the air humidity of the surrounding air. For example, the water atomizer may be used to set the air humidity of air coming out of the water outlet to a certain level. The water atomizer may then be dragged over writing surface film to set the color of the writing and/or drawing which has been previously produced with the writing instrument using the ionic liquid. Alternatively or additionally, the water atomizer may be used to write and/or draw itself, in particular if the writing surface film already comprises the ionic liquid.

[0124] Alternatively or additionally, the water atomizer may be attached to a movable mount, wherein the movable mount is configured to move the atomizer across at least part of the writing surface film at a predefined speed. User's may hold the water atomizer over writing and/or drawing for a too long or too short period of time to achieve the desired color. By using a movable mount moving the water atomizer over the writing surface film at a predetermined speed, the desired color may be achieved more consistently.

[0125] In some embodiments the piezoelectric element may be configured to oscillate when supplied with an electric frequency. The oscillation of the piezoelectric element may in turn lead to oscillation of the attached mesh disc. Oscillation of the mesh disc may draw water from the water dispersion unit, e.g. the water reservoir, and disperse the water into fine droplets, depending on the average mesh diameter. The fine droplets may be absorbed by ambient air, which in turn adjusts the air humidity. Alternatively or additionally, the fine droplets may be observed by the writing surface film.

[0126] In some embodiments the piezoelectric element may be configured to oscillate with a frequency between about 1 kHz to about 20 MHz, more specifically between about 5 kHz to about 10 MHz and in particular between about 20 kHz to about 5 MHz.

[0127] In some embodiments the control element may be configured to control the electric frequency.

[0128] In some embodiments the mesh disc may comprise a mesh with an average mesh diameter between about 3 μm to about 30 μm.

Mixing Chamber

[0129] In some embodiments the writing instrument may comprise a mixing chamber, wherein the mixing chamber may be configured to receive hygroscopic liquid and water. A writing instrument comprising a mixing chamber may be preferable as it may allow setting the color before application of the water. As the dispersion of ink per area by for example ballpoint pens is relatively constant, the desired amount of absorbed water can be set by adjusting the proportion of water in the hygroscopic liquid and applying both at the same time.

Curing Dispenser

[0130] In some embodiments writing system may comprise a curing agent dispenser. The curing agent may be preferably applied after water has been added to the writing surface film to prohibit subsequent evaporation of the water out of the writing surface film, which in turn would change the color. Hence, the curing agent may be used to seal the writing surface film to preserve writing and/or drawings.

[0131] In some embodiments the curing agent dispenser may comprise a curing agent.

[0132] In some embodiments the curing agent dispenser may be configured to dispense the curing agent on the writing surface film.

[0133] In some embodiments the curing agent dispenser may be configured to dispense the curing agent into the mixing chamber. It may be preferable to dispense the curing agent together with the water or water and ionic liquid. When the curing agent or water and ionic liquid are dispensed simultaneously the water or water and ionic liquid may absorb into the writing surface film, while the curing agent cures to seal the writing surface film, which in turn may allow easier control of the set color and reduce the amounts of steps required to produce a drawing and/or writing on the writing surface film.

[0134] In some embodiments the curing agent may be a varnish, in particular violin, an alkyd resin, spar varnish, a drying oil, polyurethane, lacquer, an acrylic resin, an epoxy resin, a two part epoxy resin.

[0135] In some embodiments the curing agent may comprise a solvent. The solvent may prohibit preemptive curing and may evaporate when the curing is dispensed on the writing surface film.

[0136] In some embodiments, the curing agent may comprise a curing accelerator. In some embodiments the curing agent may comprise tannic acid, alum, chrome alum, sodium chloride, aluminium salts, chromium, copper, iron, iodine, potassium, sodium, tungsten and/or tin. The aforementioned substances may increase the rate of curing.

Pen

[0137] In some embodiments the writing instrument may comprise a nib, a felt tip and/or a roller ball.

[0138] In some embodiments the writing instrument may comprise a writing orifice.

[0139] In some embodiments the writing instrument may comprise a hygroscopic liquid orifice, a water orifice and/or a curing agent orifice.

Components

[0140] In a second aspect, the present disclosure relates to a writing instrument comprising a liquid reservoir comprising a hygroscopic liquid, a water reservoir comprising water, and a curing agent reservoir comprising a

curing agent.

[0141] In a third aspect, the present disclosure relates to a writing surface comprising a writing surface film, wherein the writing surface film comprises a plurality of layers. Further, the writing surface film is configured to display different colors depending on a water content in the writing surface film.

[0142] In a fourth aspect, the present disclosure relates to a water dispersion unit comprising a water atomizer. The water atomizer comprises a piezoelectric element, a mesh disc connected to the piezoelectric element, and a water outlet.

[0143] The present disclosure further relates to the following aspects.

Aspects

[0144]

1. A writing system comprising:
a writing instrument comprising:

a liquid reservoir comprising a hygroscopic liquid and/or water;
a writing surface comprising a writing surface film, wherein the writing surface film comprises:

a plurality of layers;
wherein the writing surface film is configured to display different colors depending on a water content in the writing surface film.

2. The writing system according to aspect 1, wherein the plurality of layers comprises at least a first type of layer and a second type of layer.

3. The writing system according to any preceding aspect, wherein the first type of layer exhibits a thickness between about 15 nm to about 75 nm, more specifically between about 25 nm to about 65 nm and in particular between about 35 nm to about 55 nm.

4. The writing system according to any preceding aspect, wherein the second type of layer exhibits a thickness between about 50 nm to about 300 nm, more specifically between about 80 nm to about 250 nm and in particular between about 100 nm to about 165 nm.

5. The writing system according to any preceding aspect, wherein the first type of layer and second type of layer are arranged in an alternating order.

6. The writing system according to any preceding aspect, wherein the plurality of layers comprises at least 4 layers, more specifically at least 6 layers and in particular at least 8 layers.

7. The writing system according to any preceding aspect, wherein the writing surface has a local resolution between about 15 μm and about 200 μm, more specifically between about 30 μm and about 100 μm and in particular between about 50 μm and about 70 μm.

8. The writing system according to any preceding aspect, wherein the thickness of the second type of layer is configured to be adjustable.

9. The writing system according to any preceding aspect, wherein the second type of layer is configured to absorb water, wherein the absorption of water leads to an increase in thickness.

10. The writing system according to any preceding aspect, wherein the writing surface is configured to display different colors depending upon the water content of the second type of layer.

11. The writing system according to any preceding aspect, wherein the distance between consecutive layers of first type of layers depends on the water content in the writing surface film.

12. The writing system according to any preceding aspect, wherein the distance between consecutive layers of first type of layers depends on the water content in the second type of layer.

13. The writing system according to any preceding aspect, wherein the first type of layer and second type of layer form one or more photonic crystals.

14. The writing system according to any preceding aspect, wherein the plurality of layers comprises a block copolymer.

15. The writing system according to any preceding aspect, wherein the block copolymer comprises a first type block moiety and a second type block moiety.

16. The writing system according to any preceding aspect, wherein the first type block moiety and the second type block moiety form separate phases.

17. The writing system according to any preceding aspect, wherein the first type of layer comprises at least 90 %, more specifically, at least 95 % and in particular at least 98 % of the first type block moiety.

18. The writing system according to any preceding aspect, wherein the second type of layer comprises at least 90 %, more specifically, at least 95 % and in particular at least 98 % of the second type block moiety.

19. The writing system according to any preceding aspect, wherein the plurality of layers comprises a dopant, more specifically a metal salt and in particular copper chloride.

20. The writing system according to any preceding aspect, wherein the second type of layer comprises the dopant.

21. The writing system according to any preceding aspect, wherein the first type block moiety is hydrophobic and the second type block moiety is hydrophilic.

22. The writing system according to any preceding aspect, wherein the block copolymer comprises a 1D block copolymer, more specifically a self-assembled 1D block copolymer and in particular polystyrene-b-poly(2-vinylpyridine) or poly(2-vinylpyridine)-b-polystyrene-b-poly(2-vinylpyridine).

23. The writing system according to any preceding aspect, wherein the block copolymer comprises a bottlebrush block copolymer, in particular polystyrene/hexanoate brush-coil copolymers, polylactide/polystyrene brush copolymers and/or polylactide/poly(n-butylacrylate) bottlebrush-copolymers.

24. The writing system according to any preceding aspect, wherein the block copolymer comprises an AB block copolymer, in particular poly(methyl methacrylate)-block-polystyrene.

25. The writing system according to any preceding aspect, wherein the writing surface film comprises a hydrogel, more specifically a cross-linked hydrogel, in particular a cross-linked interpenetrated hydrogel network.

26. The writing system according to any preceding aspect, wherein the second type of layer comprises the hydrogel.

27. The writing system according to any preceding aspect, wherein the hydrogel comprises a protein based, a synthetic and/or a polysaccharide based hydrogel.

28. The writing system according to any preceding aspect, wherein the polysaccharide based hydrogel comprises chitosan, alginate and/or starch.

29. The writing system according to any preceding aspect, wherein the hydrogel comprises poly(ethylene glycol) diacrylate.

30. The writing system according to any preceding aspect, wherein the block copolymer and the hydrogel form a cross-linked interpenetrating hydrogel network.

31. The writing system according to any preceding aspect, wherein the second type block moieties and the hydrogel form a cross-linked interpenetrating hydrogel network.

32. The writing system according to any preceding aspect, wherein the writing surface film has a thickness between about 200 nm to about 1200 nm, more specifically between about 250 nm to about 1100 nm and in particular between about 300 nm to about 1000 nm.

33. The writing system according to any preceding aspect, wherein the second layer comprises the hygroscopic liquid.

34. The writing system according to any preceding aspect, wherein the hygroscopic liquid comprises an ionic liquid.

35. The writing system according to any preceding aspect, wherein the ionic liquid comprises a salt derived from 1-methylimidazole, more specifically a salt of an 1-alkyl-3methylimidazolium and in particular a salt of 1-ethyl-3-methyl-imidazolium, 1-butyl-3-methylimidazolium, 1-methyl-3-octyl-imidazolium, 1-decyl-3-methylimidazolium, 1-dodecyl-3 -methyl-docecylimidazolium.

36. The writing system according to any preceding aspect, wherein the ionic liquid comprises a bis(trifluoromethylsulfonyl)amine lithium salt.

37. The writing system according to any preceding aspect, wherein the ionic liquid comprises an imidazolium cation, N-heterocyclic cations derived from pyridine, quarternary ammonium cations, phosphonium cations, tetrafluoroborate, hexaflurophosphate, bis-trifluromethanesulfonimide, trifluoromethanesulfonate, dicyanamide, a protic ionic liquid and/or poly(ionic liquid)s.

38. The writing system according to any preceding aspect, wherein the writing system comprises a water reservoir.

39. The writing system according to any preceding aspect, wherein the writing system comprises the water reservoir within a water dispensing unit.

40. The writing system according to any preceding aspect, wherein the writing instrument comprises the water dispensing unit.

41. The writing system according to any preceding

aspect, wherein the writing instrument comprises a control element configured to control a rate of water dispersion.

42. The writing system according to any preceding aspect, wherein the rate of water dispersion may be adjusted between about 0.01 L/h to 0.5 L/h.

43. The writing system according to any preceding aspect, wherein the control element comprises a selection ring, a slider button and/or a touch sensor strip.

44. The writing system according to any preceding aspect, wherein the control element comprises a color identification, in particular a gradually colored strip.

45. The writing system according to any preceding aspect, wherein the water dispersion unit comprises a water atomizer, wherein the water atomizer comprises:

a piezoelectric element,
a mesh disc connected to the piezoelectric element, and
a water outlet.

46. The writing system according to any preceding aspect, wherein the piezoelectric element is configured to oscillate when supplied with an electric frequency.

47. The writing system according to any preceding aspect, wherein the piezoelectric element is configured to oscillate with a frequency between about 1 kHz to about 20 MHz, more specifically between about 5 kHz to about 10 MHz and in particular between about 20 kHz to about 5 MHz.

48. The writing system according to any preceding aspect, wherein the control element is configured to control the electric frequency.

49. The writing system according to any preceding aspect, wherein the mesh disc comprises a mesh with an average mesh diameter between about 3 μm to about 30 μm.

50. The writing system according to any preceding aspect, wherein the writing instrument comprises a mixing chamber, wherein the mixing chamber is configured to receive hygroscopic liquid and water.

51. The writing system according to any preceding aspect, wherein writing system comprises a curing agent dispenser.

52. The writing system according to any preceding aspect, wherein the curing agent dispenser comprises a curing agent.

53. The writing system according to any preceding aspect, wherein the curing agent dispenser is configured to dispense the curing agent on the writing surface film.

54. The writing system according to any preceding aspect, wherein the curing agent dispenser is configured to dispense the curing agent into the mixing chamber.

55. The writing system according to any preceding aspect, wherein the curing agent is a varnish, in particular violin, an alkyd resin, spar varnish, a drying oil, polyurethane, lacquer, an acrylic resin, an epoxy resin, a two part epoxy resin.

56. The writing system according to any preceding aspect, wherein the curing agent comprises a solvent.

57. The writing system according to any preceding aspect, wherein the curing agent comprises tannic acid, alum, chrome alum, sodium chloride, aluminium salts, chromium, copper, iron, iodine, potassium, sodium, tungsten and/or tin.

58. The writing system according to any preceding aspect, wherein the writing instrument comprises a nib, a felt tip and/or a roller ball.

59. The writing system according to any preceding aspect, wherein the writing instrument comprises a writing orifice.

60. The writing system according to any preceding aspect, wherein the writing instrument comprises a hygroscopic liquid orifice, a water orifice and/or a curing agent orifice.

61. A writing instrument comprising:

a liquid reservoir comprising a hygroscopic liquid,
a water reservoir comprising water,
and a curing agent reservoir comprising a curing agent.

62. A writing surface comprising a writing surface film, wherein the writing surface film comprises:

a plurality of layers;
wherein the writing surface film is configured to display different colors depending on a water content in the writing surface film.

63. A water dispersion unit comprising a water atomizer, wherein the water atomizer comprises:

a piezoelectric element,
a mesh disc connected to the piezoelectric element, and
a water outlet.

Claims

1. A writing system comprising:
a writing instrument comprising:

a liquid reservoir comprising a hygroscopic liquid and/or water;
a writing surface comprising a writing surface film, wherein the writing surface film comprises:
a plurality of layers;
wherein the writing surface film is configured to display different colors depending on a water content in the writing surface film.

2. The writing system according to claim 1, wherein the plurality of layers comprises at least a first type of layer and a second type of layer.

3. The writing system according to any preceding claim, wherein the first type of layer exhibits a thickness between about 15 nm to about 75 nm, more specifically between about 25 nm to about 65 nm and in particular between about 35 nm to about 55 nm.

4. The writing system according to any preceding claim, wherein the second type of layer exhibits a thickness between about 50 nm to about 300 nm, more specifically between about 80 nm to about 250 nm and in particular between about 100 nm to about 165 nm.

5. The writing system according to any preceding claim, wherein the first type of layer and second type of layer are arranged in an alternating order.

6. The writing system according to any preceding claim, wherein the thickness of the second type of layer is configured to be adjustable.

7. The writing system according to any preceding claim, wherein the plurality of layers comprises a block copolymer.

8. The writing system according to any preceding claim, wherein the block copolymer comprises a first type block moiety and a second type block moiety.

9. The writing system according to any preceding claim, wherein the first type block moiety is hydrophobic and the second type block moiety is hydrophilic.

10. The writing system according to any preceding claim, wherein the block copolymer comprises a 1D block copolymer, more specifically a self-assembled 1D block copolymer and in particular polystyrene-b-poly(2-vinylpyridine) or poly(2-vinylpyridine)-b-polystyrene-b-poly(2-vinylpyridine).

11. The writing system according to any preceding claim, wherein the block copolymer comprises an AB block copolymer, in particular poly(methyl methacrylate)-block-polystyrene.

12. The writing system according to any preceding claim, wherein the writing surface film comprises a hydrogel, more specifically a cross-linked hydrogel, in particular a cross-linked interpenetrated hydrogel network; and/or wherein the second type of layer comprises the hydrogel.

13. A writing instrument comprising:

a liquid reservoir comprising a hygroscopic liquid,
a water reservoir comprising water,
and a curing agent reservoir comprising a curing agent.

14. A writing surface comprising a writing surface film, wherein the writing surface film comprises:

a plurality of layers;
wherein the writing surface film is configured to display different colors depending on a water content in the writing surface film.

15. A water dispersion unit comprising a water atomizer, wherein the water atomizer comprises:

a piezoelectric element,
a mesh disc connected to the piezoelectric element, and
a water outlet.

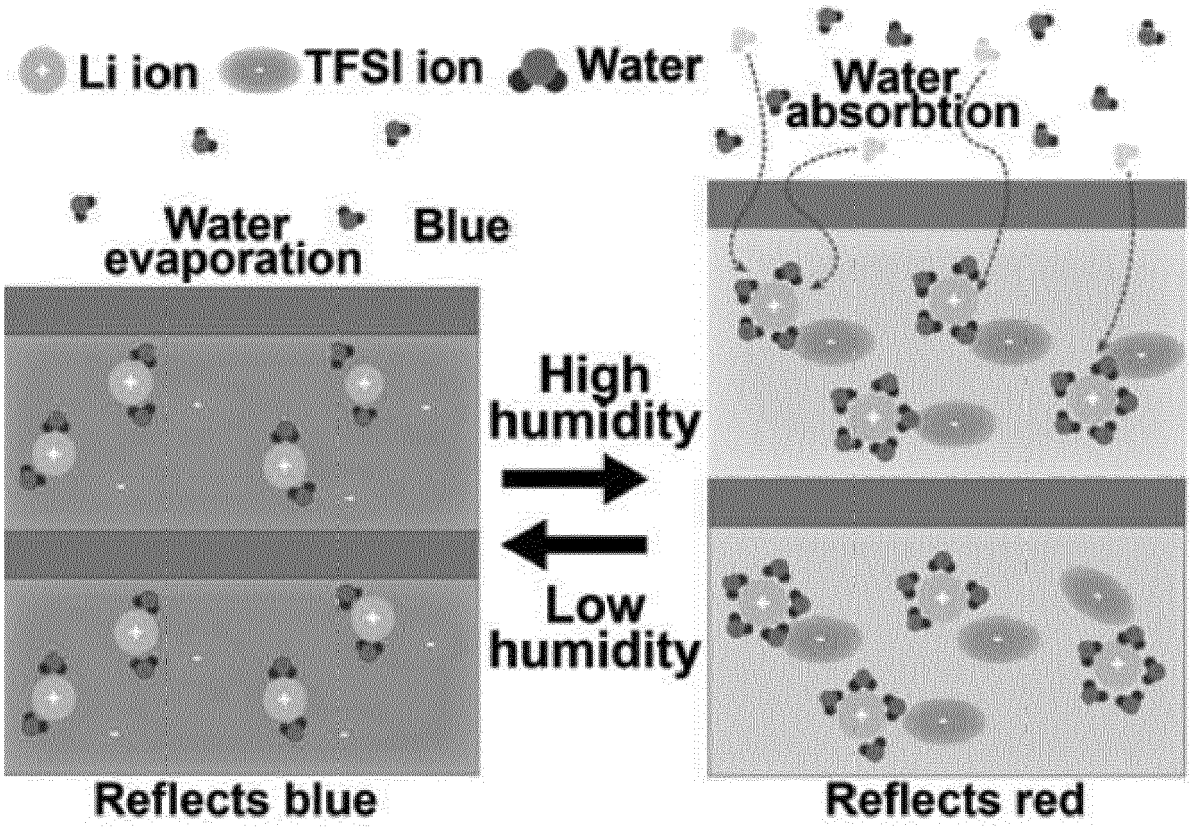
Li ion
TFSI ion
Water
Water absorbtion
Water evaporation
Blue
High humidity
Low humidity
Reflects blue
Reflects red

Figure 1

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EUROPEAN SEARCH REPORT

Application Number
EP 22 15 0335

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	KR 102 147 599 B1 (UNIV YONSEI IACF [KR]) 24 August 2020 (2020-08-24) * paragraph [0001] - paragraph [0105]; figures 1-11 *	1-12,14	INV. B43K5/00 B43K7/00 B43K8/00 B43L1/00
X	US 2005/226675 A1 (KWAN VINCENT W [US] ET AL) 13 October 2005 (2005-10-13) * paragraph [0002] - paragraph [0061]; figures 1-5 *	13	
A	KR 2009 0076065 A (NANOBRICK CO LTD [KR]) 13 July 2009 (2009-07-13) * the whole document *	1-14	

TECHNICAL FIELDS SEARCHED (IPC)

B43K
B43L

~~The present search report has been drawn up for all claims~~

Place of search	Date of completion of the search	Examiner
Munich	22 June 2022	Patosuo, Susanna

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

EPO FORM 1503 03.82 (P04C01)

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Application Number
EP 22 15 0335

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☒ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

1-14

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).

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LACK OF UNITY OF INVENTION
SHEET B

Application Number
EP 22 15 0335

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-14

Claim 1 relates to a writing system comprising:
a writing instrument comprising:
a liquid reservoir comprising a hygroscopic liquid and/or water;
a writing surface comprising a writing surface film, wherein the writing surface film comprises:
a plurality of layers;
wherein the writing surface film is configured to display different colors depending on a water content in the writing surface film.
Claim 13 relates to the writing instrument and claim 14 to the writing surface.

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2. claim: 15

Claim 15 relates to a water dispersion unit comprising a water atomizer, wherein the water atomizer comprises: a piezoelectric element, a mesh disc connected to the piezoelectric element, and a water outlet.

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 22 15 0335

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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22-06-2022

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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US 2005226675 A1	13-10-2005	TW 200533528 A	16-10-2005
		US 2005226675 A1	13-10-2005
		WO 2005102732 A1	03-11-2005
KR 20090076065 A	13-07-2009	NONE	

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82