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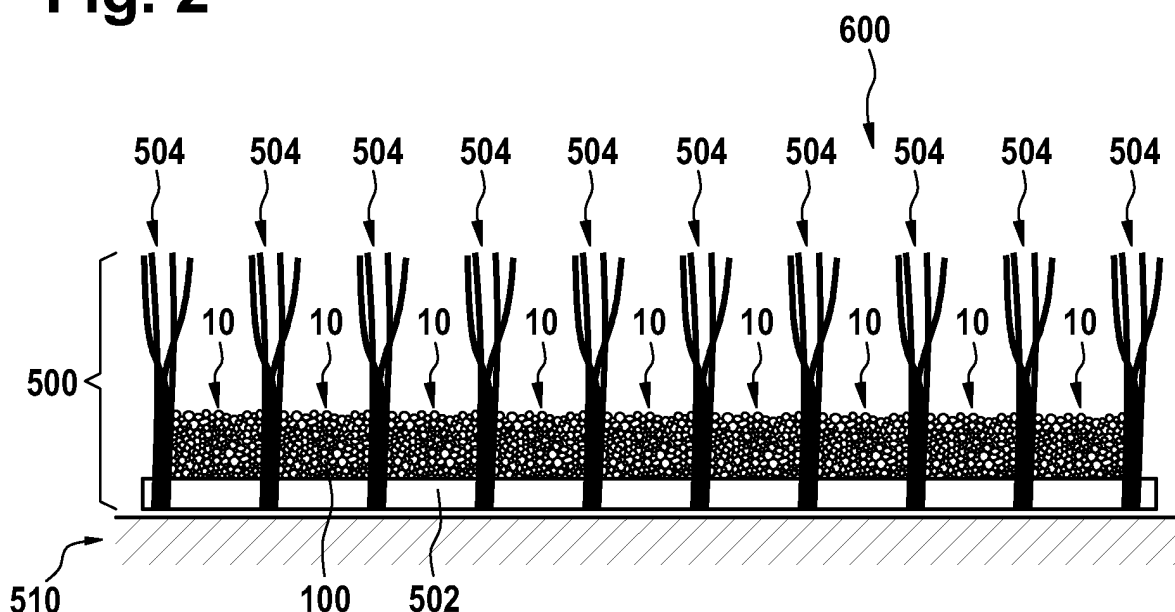
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(54) **ARTIFICIAL TURF AND ARTIFICIAL TURF INFILL**

(57) The present invention relates to an artificial turf (600), comprising an artificial turf carpet (500), wherein the artificial turf carpet comprises multiple artificial turf fiber tufts (504); and an artificial turf infill (10), which is scattered between the multiple artificial turf fiber tufts (504), wherein the artificial turf infill (10) comprises a plurality of microporous zeolite mineral particles (110), the particles (110) having pores (111) that form openings on the outer surface of the microporous zeolite mineral particles (110), wherein the outer surface of at least some

of the microporous zeolite mineral particles (110) is partly coated with a polyurethane coating (120), wherein the coating extends over some of the pores (111) forming respective covers (130) of the openings, wherein the polyurethane coating (120) coats a portion of the inner surface of the covered pores (111) in the region of the cover (130) and wherein the microporous zeolite mineral particles (110) have the same amount of their outer surface coated by the coating (120) relative to the total outer surface.

**Fig. 2**



## Description

[0001] The invention relates to artificial turf and a method for the manufacture of an artificial turf infill.

[0002] Artificial turf or artificial grass is a surface that is made up of fibers and is used to replace grass. The structure of the artificial turf is designed such that the artificial turf has an appearance that resembles grass. Artificial turf is typically used as a surface for sports such as soccer, American football, rugby, tennis and golf, or for playing fields or exercise fields. Furthermore, artificial turf is frequently used for landscaping applications.

[0003] Artificial turf may be manufactured using techniques for manufacturing carpets. For example, artificial turf fibers, which have the appearance of grass blades, may be tufted or attached to a backing. Oftentimes, artificial turf infill is placed between the artificial turf fibers.

[0004] Artificial turf infill is a granular material that covers the bottom portion of the artificial turf fibers. The use of artificial turf infill may have a number of advantages. For example, artificial turf infill may help the artificial turf fibers stand up straight. Artificial turf infill may also absorb impact from walking or running and provide an experience similar to being on real turf. The artificial turf infill may also help keep the artificial turf carpet flat and in place by weighing it down.

[0005] Even though the artificial turf known from the art is in constant development, artificial turf is often subjected to bad weather conditions, such as severe heat and temperature variations, which may lead to rapid degradation of the artificial turf, or even to problems in upkeep and maintaining the artificial turf in its optimal conditions for use.

[0006] Further, in the hot season, when the outside surfaces are subjected to severe heat, the use of artificial turf as a surface is extremely taxing for the person spending time on the turf, since the artificial turf with conventional artificial turf infill materials, as e.g. rubber, tend to heat up.

[0007] US 10,066,345 B2 discloses an artificial turf field system comprising a plurality of turf strands attached to a backing layer and an infill material positioned between the synthetic turf strands. The infill material includes a plurality of porous particles, wherein at least a portion of the porous particles have a partial polymer coating thereon and wherein the porous particles have varying amounts of their outer surface covered by the coating. Since the porous particles disclosed in US 10,066,345 show good water retention and the particles are partially covered, the porous particles are beneficial in inclement weather and the wear of the porous particles is reduced due to the partial cover. US 10,066,345 B2 further discloses that this polymer cover is applied to the porous particles by e.g. atomization of the polymer and spraying the polymer onto the particles as the particles are moving or falling. Hence, the particles are partially covered on one side with the polymer. The cover completely covers the pores of the porous particles in the area of the cover.

[0008] It is therefore the purpose of the invention to provide an alternative or improved artificial turf.

[0009] The invention provides for an improved artificial turf and artificial turf infill. The problem is solved by the features as specified in the independent claims. Embodiments of the invention are given in the dependent claims. The embodiments and examples described herein can freely be combined with each other unless they are mutually exclusive.

[0010] In one aspect, the invention relates to an artificial turf, comprising an artificial turf carpet, wherein the artificial turf carpet comprises multiple artificial turf fiber tufts and an artificial turf infill. The artificial turf may have a pile height between 2.5 cm and 7.5 cm. The pile height is the length of the artificial turf fibers above the backing or base of the artificial turf carpet. The artificial turf fiber tufts may be arranged in rows and may have a row spacing between 0.5 cm and 1.95 cm. The artificial turf further comprises granular artificial turf infill spread between the multiple artificial turf fiber tufts. The artificial turf infill material may provide support for the artificial turf grass fibers and may have a thickness of about 5-60 mm.

[0011] The artificial turf infill is scattered or brushed between the multiple artificial turf fiber tufts. It is within the scope of the invention that the artificial turf infill comprises a plurality of microporous zeolite mineral particles.

[0012] The term "zeolite mineral" as used herein refers to a group of more than 60 soft, white aluminosilicate minerals of tectosilicate type - a three-dimensional framework of interconnected tetrahedra, comprising to a large extent aluminum, silicon and oxygen atoms. Zeolite minerals have a crystalline structure built from  $[\text{AlO}_4]^{5-}$  and  $[\text{SiO}_4]^{4-}$  bonded together in such a way that all four oxygen atoms, located at the corners of each tetrahedron, are shared with adjacent tetrahedral crystals. The general formula of zeolites can be described as  $\text{Me}_{2/n}\text{O} \cdot \text{Al}_2\text{O}_3 \cdot x\text{SiO}_2 \cdot y\text{H}_2\text{O}$ , whereby Me is any alkaline or alkaline earth atom, n is the charge on that atom, x is the number of Si tetrahedrons (varying from 2 to 10), and y is the number of water molecules, typically between 2 and 7. Examples of natural zeolites include chabazite, erionite, mordenite, clinoptilolite, phillipsite and stilbite. Preferred zeolites according to the invention may include chabazite, erionite, mordenite, clinoptilolite, phillipsite and stilbite and may be obtained by mining due to their abundance in nature, resulting in lower production costs compared with the same amount of synthetic zeolites, such as faujasite, zeolite A, zeolite L, zeolite Y, zeolite X and ZSM-5. Synthetic zeolite minerals may also be used instead of or in addition to natural zeolites. The term "microporous zeolite mineral particle" as used in the invention refers to porous zeolite mineral particles such as those disclosed above, which are able to absorb and adsorb (also referred to as sorption) water, which can be reversibly released from the microporous zeolite mineral particles.

[0013] Since the microporous zeolite mineral particles are distributed between the artificial turf fiber tufts, water may be taken up by the microporous zeolite mineral particles and stored within the microporous zeolite mineral particles in

an enhanced matter, compared to known commonly used infill materials, such as rubber granules. In addition, seeping of water into the deeper layers of the sports flooring, from where it is not recoverable, may be reduced.

**[0014]** The microporous zeolite mineral particles have pores that form openings on the outer surface of the microporous zeolite mineral particles. Hence, the use of the microporous zeolite mineral as an infill material is advantageous, as the particles are able to regulate the presence of water and may thus provide for a cooling effect of the surface of the artificial turf. Hence, an increased playing comfort can be reached when the outside temperatures are high.

**[0015]** It is hereby envisaged that the outer surface of at least some microporous zeolite mineral particles is partly covered with a polyurethane coating. It may be feasible that 75 % to 99 % of the outer surface of a microporous zeolite mineral particle is partly covered with a polyurethane coating.

**[0016]** It is provided that the partial covering is applied on each side of each microporous zeolite mineral particle, but that there are gaps (holes) in the covering enclosing the particles. The partial coating is advantageous, since water can be absorbed and/or released by the microporous zeolite mineral particles through the pores contained in its surface areas, which are not covered by the polyurethane coating. In addition, since the microporous zeolite mineral particles are partly coated with the polyurethane coating, natural occurrence of abrasion and wear of the microporous zeolite mineral during use may be reduced, since the polyurethane coating may provide for a harder and thus protective surface compared to uncoated microporous zeolite mineral particles. It may also be advantageous that the Mohs hardness of polyurethane coating can be chosen to be higher or much higher than the Mohs hardness of the microporous zeolite mineral particles. It may be thus beneficial that the Mohs hardness of the polyurethane coating is at least one Mohs unit higher than the Mohs hardness of the selected microporous zeolite mineral particles.

**[0017]** The gaps in the coating of the inventive infill material may result during the manufacture of the infill material, as during the mixing, e.g. in a flow reactor or a batch reactor or a tumbler, the microporous zeolite mineral particles and a liquid polyurethane reaction mixture are mixed and while they are being mixed a solidification reaction is initiated. During the mixing and while the solidification takes place, the microporous zeolite mineral particles physically touch and interact with each other, thereby causing collision defects (e.g. gaps) in the coating and partly leaving the surface of the microporous zeolite particles uncovered. Thus, water may still be absorbed and released by the microporous zeolite mineral particles in these areas in which the pores of the microporous zeolite minerals are not covered by the polyurethane coating.

**[0018]** It is further envisaged that the polyurethane coating extends over some of the pores forming respective covers of the pore openings, wherein the polyurethane coating coats a portion of the inner surface of the covered pores in the region of the cover. The coating may penetrate a slight distance, for example between 0.2  $\mu\text{m}$  and 500  $\mu\text{m}$ , preferably between 1 and 150  $\mu\text{m}$  and most preferred between 10  $\mu\text{m}$  and 100  $\mu\text{m}$  into the surface pores and thus may interfere with the pores in a form-locking manner. Thereby the hold of the coating on the microporous zeolite mineral particles may be increased and at the same time the overall stability and hardness of the microporous zeolite mineral particles may be increased.

**[0019]** Further, since the infill material is preferably produced by mixing the microporous zeolite mineral particles with a liquid polyurethane reaction mixture and initializing the solidification reaction during the mixing, the microporous zeolite mineral particles have the same amount of their outer surface covered by the coating relative to the total outer surface. Substantially the same amount means that the outer surface of each of the partly coated microporous zeolite mineral particle is coated between 20 % and 99 %, preferably between 50 % to 98 % or between 70 % to 99 %, with the polyurethane coating. Further, since the outer surface of each of the partly coated microporous zeolite mineral particle is - with the exception of the gaps - essentially fully coated, fine dusts may be bound.

**[0020]** The granular artificial turf infill may further be comprised of microporous zeolite mineral particles, the surfaces of which are partly coated with a polyurethane coating, which are mixed with other artificial turf infill granules, such as rubber granules and/or cork granules. Hereby, the rubber granules and/or cork granules may be coated with a polyurethane coating.

**[0021]** As described above, the artificial turf infill comprising microporous zeolite mineral particles, which may be in the form of a granule, may be advantageous for regulating the presence of water on an artificial turf. For example, before a football game that is scheduled to be held in the sun or in hot conditions, water may be sprayed onto the artificial turf, and the microporous zeolite mineral particles of the turf infill may absorb an amount of water. As the sun or hot air heats the artificial turf with the artificial turf infill during the game, the evaporation of water may cool the playing surface and make the use of the artificial turf more pleasant for the players.

**[0022]** The spraying of water may be performed manually with a water hose or automatically with a sprinkler system.

**[0023]** In one embodiment of the invention, the artificial turf comprises a sprinkler system.

**[0024]** The use of a sprinkler system may be beneficial because it may be used to automatically moisten the surface of the artificial turf. For example, this may be a convenient means of watering the artificial turf surface during a time period that is defined based on the minimum release rate of the water from the microporous zeolite mineral. For example, the selected microporous mineral may have a specific surface area that enables the water to steadily release over a time period of two to three hours. In this case, the sprinkler system may be configured to water the artificial turf at a

predefined time (or predefined time duration) before a match.

**[0025]** In one embodiment, the microporous zeolite mineral particle is selected from the group consisting of chabazite, erionite, mordenite, clinoptilolite, faujasite, phillipsite, zeolite A, zeolite L, zeolite Y, zeolite X and ZSM-5. The zeolite used within the scope of the invention may thus be a zeolite that can be natural or obtained by synthesis.

**[0026]** Since artificial turf infill may be used to modify an artificial turf carpet to have more earth-like properties, a microporous zeolite, with a Mohs hardness above 3 and/or a strong absorbent power and/or a color that approximately resembles one of the well-known surface colors (e.g., red, brown, green), may preferably be used. The most preferred microporous zeolite mineral may be of the chabazite and/or clinoptilolite and/or mordenite type.

**[0027]** Further, the specific surface area of the microporous zeolite mineral particle can be chosen to be smaller than a predetermined maximum specific surface area. The maximum specific surface area of the mineral may, for example, be determined as the surface specific area that enables the water in the mineral to release, under a certain ambient temperature, at a predefined minimum rate.

**[0028]** In one embodiment of the invention, the polyurethane coating of the artificial turf infill is based on a liquid polyurethane reaction mixture, which may be a dispersion or solution, comprising

- at least one isocyanic prepolymer with a totally blocked isocyanic functionality;
- a hydroxyl component, wherein the hydroxyl component is selected from the group of polyether polyol or polyester polyol; and
- at least one catalyst selected from the group consisting of linear or cyclic tertiary amines such as triethylenediamine, or e.g. 1,4-Diazabicyclo[2.2.2]octane, cyclic amines such as 1,8-Diazabicyclo(5.4.0)undec-7-ene (DBU) and inorganic compounds such as sodium hydroxide (NaOH), chromium(III) oxide and zinc oxide (ZnO).

**[0029]** The use of an above-described liquid polyurethane reaction mixture may be advantageous, because it is a reaction mixture that can be solidified or cured (e.g., by cross-linking) under heat and/or by adding water. Therefore, the zeolite mineral particles and the liquid polyurethane reaction mixture may be mixed and solidified simultaneously in a batch reactor, a continuous reactor or a tumbler, resulting in the partial polyurethane coating or the coating with gaps. Further, the resulting polyurethane coating may be a waterborne polyurethane coating.

**[0030]** In an alternative embodiment of the invention, the polyurethane coating of the artificial turf infill is based on a liquid polyurethane reaction mixture comprising:

- i. NCO terminal polymer, one or more component selected from a prepolymer, a polymeric isocyanate, an oligomeric isocyanate, a monomer, such as
  - a. aromatic diisocyanate of the group of toluene diisocyanate and/or methylene- 2,2 -diisocyanate or
  - b. aliphatic diisocyanate of the group hexamethylene diisocyanate, isophorone diisocyanate, and/or 1,4-cyclohexyldiisocyanate; and
- ii. Hydroxyl component, wherein the hydroxyl component is selected from the group of polyether polyol or polyester polyol.

**[0031]** The use of an above-described liquid polyurethane reaction mixture may be advantageous, because it is a reaction mixture that can be solidified or cured (e.g., by cross-linking) by adding a catalyst, e.g. a secondary amine catalyst, a tertiary amine catalyst, such as triethylenediamine or e.g. 1,4-Diazabicyclo[2.2.2]octane, cyclic amines such as 1,8-Diazabicyclo(5.4.0)undec-7-ene (DBU) or a metal organic catalyst, and water. Therefore, the zeolite mineral particles and the liquid polyurethane reaction mixture may be mixed and solidified simultaneously in a controlled manner in a batch or continuous reactor, resulting in the partial polyurethane coating or the coating with holes.

**[0032]** In one embodiment, the polyurethane coating of the artificial turf infill comprises at least one further component selected from the group consisting of sand, colored sand, chalk, lime, colored pigments, copper(II)sulfate particles, flame retardants, UV absorbers and fillers.

**[0033]** Adding one or more of these further components to the polyurethane coating of the artificial turf infill may be beneficial in several different situations.

**[0034]** The colored pigments may be infrared-reflective pigments, which are beneficial due to their ability to reflect infrared light. This may further reduce the heating of the artificial turf infill. Further, as the infrared-reflective colored pigments may be contained solely in the partially applied polyurethane coating, the costs for the comparably expensive and precious pigments, since they are merely on the partly covered surface of the zeolite minerals, is reduced compared to fully coated infill materials.

**[0035]** It is further feasible that the colored pigments may be copper(II) sulfate particles, chromium oxide particles or iron oxide particles.

**[0036]** Copper(II) sulfate particles and/or iron oxide particles and/or chromium oxide particles may be beneficial due to their color, relatively low manufacturing costs and/or antibacterial properties. Other antibacterial components that

may be used are silver and/or chitosan particles, which both have natural antibacterial properties.

**[0037]** Sand, colored sand, chalk or lime can be beneficial since they are relatively cheap starting materials and they are naturally earth-colored. In addition, sand, colored sand, chalk or lime can be beneficial due to their ability to increase the viscosity of the polyurethane coating during the coating process.

**[0038]** The coating, which is based on a liquid polyurethane reaction mixture, may thus solidify into the polyurethane coating while covering the microporous zeolite mineral particles. High viscosity of the polyurethane coating may largely prevent too deep of penetration of the polyurethane coating into the surface pores of the microporous minerals.

**[0039]** According to embodiments, the color of the artificial turf infill is identical or similar to the color of the fibers or tufts that are used to manufacture an artificial turf carpet. This may provide a more realistic-looking playing surface or field.

**[0040]** According to embodiments, the zeolite mineral particles, which are usually softer than conventionally used artificial turf infill materials, are strengthened by the polyurethane coating with added further components and may therefore have superior wear qualities or increased weight, or may be better protected from environmental influences such as rain, acid rain, wind or others.

**[0041]** Fillers can be beneficial as they are able to increase the weight of the coating and thus the overall weight of the artificial turf infill. The used fillers may be selected from the group consisting of barium sulphate (barite), calcium carbonate (chalk), china clay (kaolin) or cold fly ash.

**[0042]** It may be envisaged that the coating may comprise between 0.1 wt.% to 80 wt.% of fillers.

**[0043]** According to one embodiment of the invention it may be envisaged that the polyurethane coating of the artificial turf infill comprises fillers, in particular barium sulphate (barite) and/or calcium carbonate (chalk), to increase the total weight of the artificial turf infill.

**[0044]** Barium sulphate and calcium carbonate may be particularly advantageous, as they have a high density, e.g. calcium carbonate has a density of 2.7 g/cm<sup>3</sup> and barium sulphate has a density between 4.0 and 4.5 g/cm<sup>3</sup>, are relatively cheap materials and may be used to provide a dense coating.

**[0045]** For this embodiment it is thus envisaged that the coating may comprise between 0.1 wt.% to 80 wt.%, preferably between 20 wt.% to 50 wt.%, of barium sulfate as filler or between 0.1 wt.% to 65 wt.%, preferably between 20 wt.% to 40 wt.%, of calcium carbonate as filler.

**[0046]** The increase in total weight of the artificial turf infill may provide the advantage that the artificial turf infill can be better protected from being washed away by rain or wind.

**[0047]** In another embodiment, the polyurethane coating of the artificial turf infill comprises a rheology additive that is adapted to induce a thixotropic flow behavior in the liquid polyurethane reaction mixture.

**[0048]** Adding a rheology additive with thixotropic capabilities may be advantageous in order to achieve a controllable viscosity-increasing thixotropic flow behavior of the (e.g., liquid or fluid) polyurethane coating while applying it, e.g. by mixing the liquid polyurethane reaction mixture with the microporous zeolite mineral particles, to the surface of the microporous zeolite mineral particles in order to control or reduce the depth of penetration of the liquid polyurethane reaction mixture into the pores contained in the surfaces of the microporous zeolite mineral particles.

**[0049]** Suitable rheology additives may be e.g. fumed silica (e.g. synthetic, hydrophobic, amorphous silica), also known as pyrogenic silica, made from flame pyrolysis of silicon tetrachloride or from quartz sand vaporized in a 3000 °C electric arc, hydrophobic fumed silica, bentonite, acrylates or a combination of the aforementioned additives.

**[0050]** It can also be within the present invention that the grain size of the microporous zeolite minerals is between 0.03 mm and 8.0 mm.

**[0051]** It is further within the present invention that the layer thickness of the polyurethane coating is between 0.001 mm and 2.0 mm.

**[0052]** In one embodiment, the polyurethane coating contains the following components, stated by weight:

|                  |                                             |
|------------------|---------------------------------------------|
| 0.1 - 80 wt.%    | of the at least one isocyanic prepolymer,   |
| 0.001 - 0.5 wt.% | of 1,8-diazabicyclo(5.4.0)undec-7-ene (DBU) |

and at least one further component selected from the group consisting of

|       |             |                     |
|-------|-------------|---------------------|
| 0.001 | - 30.0 wt.% | colored pigments,   |
| 0.001 | - 3.0 wt.%  | copper(II) sulfate, |
| 0.05  | - 60.0 wt.% | flame retardants,   |
| 0.01  | - 1.0 wt.%  | U.V. absorbers,     |
| 0.01  | - 60 wt.%   | filler,             |
| 0.01  | - 1.0 wt.%  | rheology additive,  |
| 0.001 | - 20.0 wt.% | water,              |

wherein the amounts by weight add up to 100 wt.% and the amounts by weight are based on the total weight of the polyurethane coating.

**[0053]** The colored pigments in this embodiment may be copper(II)sulfate particles and/or iron oxide particles and/or chromium oxide particles. Which colored particles are used depends on the desired color. The filler in this embodiment may be calcium carbonate and/or china clay. The rheology additive in this embodiment may be fumed silica and/or bentonite.

**[0054]** The advantages of adding color pigments and copper(II) sulfate to the polyurethane coating are described above. As a U.V. absorber a hindered amine light stabilizer (HALS), which is able to protect the polyurethane coating against UV degradation, may be used.

**[0055]** In another embodiment, the at least one further component further comprises a thermo-stabilizing agent, protecting the polyurethane coating against thermal degradation.

**[0056]** For all of the above embodiments, it may be envisaged that the microporous zeolite mineral particles may be charged with salt ions, in order to allow for an increased water adsorption and/or water desorption effect.

**[0057]** This incorporation of salt into the microporous zeolite mineral particles allows a synergy to operate between the following properties: the adsorption, absorption and release of water of the microporous zeolite mineral particle, and the ability to lower the freezing temperature of the water. Actually, in the presence of humidity, the microporous mineral particle is in a position to adsorb and/or absorb this humidity in order to prevent, on the one hand, a surface formation of a layer of slippery frost, in the case of a negative temperature, and on the other hand, an agglomeration of the artificial turf infills.

**[0058]** In the context of using the microporous mineral particle as infill material on outside artificial turf surfaces that are subjected to severe heat, the microporous mineral particle, loaded with salt and water, further may allow a further increased release of the water and the maintenance of relative humidity at the surface of said turf. Thus, on a turf surface subjected to severe heat, when it is refreshed by watering, the microporous mineral particle loaded with salt adsorbs and/or absorbs the water and then continuously releases those water molecules by desorption. This continuous release of the water by the microporous mineral particles avoids rapid evaporation of the water after watering the surface and allows a lower temperature to be maintained at the level of the field surface compared to the ambient temperature. Said microporous mineral particles loaded with salt thus further allows the amount of watering usually necessary to refresh a turf surface to be further reduced.

**[0059]** In a further aspect, the invention relates to an artificial turf infill, wherein the artificial turf infill comprises a plurality of microporous zeolite mineral particles. The microporous zeolite mineral particles comprise pores that form openings on the outer surface of the microporous zeolite mineral particles. It is within the scope of the invention that the outer surface of at least some of the microporous zeolite mineral particles is partly coated with a polyurethane coating, wherein the coating extends over some of the pores forming respective covers of the openings and wherein the polyurethane coating coats a portion of the inner surface of the covered pores in the region of the cover. Further, it is provided that each of the partly coated microporous zeolite mineral particles have approximately the same amount of their outer surface coated by the coating relative to the total outer surface.

**[0060]** The artificial turf infill may be an artificial turf infill as described above.

**[0061]** The artificial turf infill may comprise the same features and advantages as herein described embodiments and examples of the artificial turf infill of the artificial turf.

**[0062]** In one embodiment the polyurethane coating comprises at least one further component selected from the group consisting of sand, colored sand, chalk, lime, colored pigments, copper(II) sulfate particles, chromium particles, flame retardants, U.V. absorbers and fillers.

**[0063]** In one embodiment the artificial turf infill further comprises at least one granular component selected from the group consisting of cork granules, coated cork granules, rubber granules and coated rubber granules.

**[0064]** In one embodiment at least some of the microporous zeolite mineral particles are charged with a salt solution.

**[0065]** In one embodiment, the microporous zeolite mineral particles are selected from the group consisting of chabazite, erionite, mordenite, clinoptilolite, faujasite, phillipsite, zeolite A, zeolite L, zeolite Y, zeolite X and ZSM-5.

**[0066]** In one embodiment the polyurethane coating of the microporous zeolite mineral particles comprises a rheology additive, in particular fumed silica, hydrophobic fumed silica, bentonite, acrylate or a combination thereof.

**[0067]** In one embodiment the polyurethane coating of the microporous zeolite mineral particles comprises fillers, in particular barium sulphate (barite) and/or calcium carbonate (chalk), to increase the total weight of the artificial turf infill.

**[0068]** In one embodiment the polyurethane coating of the microporous zeolite mineral particles is based on a liquid polyurethane reaction mixture comprising

- at least one isocyanic prepolymer with a totally blocked isocyanic functionality;
- a hydroxyl component, wherein the hydroxyl component is selected from the group of polyether polyol or polyester polyol; and
- at least one catalyst selected from the group consisting of linear or cyclic tertiary amines such as triethylenediamine,

or e.g. 1,4-Diazabicyclo[2.2.2]octane, cyclic amines such as 1,8-Diazabicyclo(5.4.0)undec-7-ene (DBU) and inorganic compounds such as sodium hydroxide (NaOH), chromium(III) oxide and zinc oxide (ZnO).

**[0069]** The use of an above-described liquid polyurethane reaction mixture may be advantageous, because it is a reaction mixture that can be solidified or cured (e.g., by cross-linking) under heat and/or by adding water. Therefore, the zeolite mineral particles and the liquid polyurethane reaction mixture may be mixed and solidified simultaneously in a batch reactor, a continuous reactor or a tumbler, resulting in the partial polyurethane coating or the coating with gaps. Further, the resulting polyurethane coating may be a waterborne polyurethane coating.

**[0070]** In an alternative embodiment the polyurethane coating of the microporous zeolite mineral particles is based on liquid polyurethane reaction mixture comprising:

i. NCO terminal polymer, one or more component selected from a prepolymer, a polymeric isocyanate, an oligomeric isocyanate, a monomer, such as

- a. aromatic diisocyanate of the group of toluene diisocyanate and/or methylene- 2,2-diisocyanate or
- b. aliphatic diisocyanate of the group hexamethylene diisocyanate, isophorone diisocyanate, and/or 1,4-cyclohexyldiisocyanate; and ii. Hydroxyl component, wherein the hydroxyl component is selected from the group of polyether polyol or polyester polyol.

**[0071]** The use of an above-described liquid polyurethane reaction mixture may be advantageous, because it is a reaction mixture that can be solidified or cured (e.g., by cross-linking) by adding a catalyst, e.g. a secondary amine catalyst, a tertiary amine catalyst, such as triethylenediamine or e.g. 1,4-Diazabicyclo[2.2.2]octane, cyclic amines such as 1,8-Diazabicyclo(5.4.0)undec-7-ene (DBU) or a metal organic catalyst, and water. Therefore, the zeolite mineral particles and the liquid polyurethane reaction mixture may be mixed and solidified simultaneously in a controlled manner in a batch or continuous reactor, resulting in the partial polyurethane coating or the coating with holes.

**[0072]** It is understood that one or more of the aforementioned embodiments of the invention may be combined as long as the combined embodiments are not mutually exclusive.

**[0073]** Below, the following embodiments of the invention are explained in greater detail, by way of example only, making reference to the drawings, in which:

- Fig. 1 illustrates an example of an artificial turf carpet;
- Fig. 2 illustrates an example of artificial turf;
- Fig. 3 illustrates a sectional view of a microporous zeolite mineral;
- Fig. 4 illustrates a section of the sectional view of Fig. 3;
- Fig. 5 illustrates a sectional view of a microporous zeolite mineral particle, which is partially coated with a polyurethane coating;
- Fig. 6 illustrates a section of the sectional view of Fig. 5, in which the polyurethane coating comprises a further component and a rheology additive;
- Fig. 7 illustrates a further section of the sectional view of Fig. 6; and
- Fig. 8 illustrates an artificial turf infill.

**[0074]** Like-numbered elements in these figures are either equivalent elements or perform the same function. Elements that have been discussed previously will not necessarily be discussed in later figures if the function is equivalent.

**[0075]** Figs. 1 and 2 illustrate the manufacture of an artificial turf 600 using an artificial turf carpet 500 and artificial turf infill 10.

**[0076]** In Fig. 1, an artificial turf carpet 500 is shown. The artificial turf carpet 500 contains a backing 502. The artificial turf carpet 500 shown in Fig. 1 is a tufted artificial turf carpet. The artificial turf carpet is formed by artificial turf fiber tufts 504 that are tufted into the backing 502. The artificial turf fiber tufts 504 are tufted in rows. There is row spacing 506 between adjacent rows of tufts. The artificial turf fiber tufts 504 also extend a distance above the backing 502. The distance that the fibers 504 extend above the backing 502 is the pile height 508. In Fig. 1, it can be further seen that the artificial turf carpet 500 has been installed by placing or attaching it to the ground 510 or a floor. To manufacture the artificial turf, the artificial turf infill is made with partially polyurethane-coated zeolite mineral particles such as those shown in Figs. 5 to 6 and is spread out on the surface and distributed between the artificial turf fiber tufts 504.

**[0077]** Fig. 2 shows the artificial turf carpet 500 after the artificial turf infill 10 has been spread out and distributed between the artificial turf fiber tufts 504. It can be seen that the artificial turf infill 10 is a granulate made up of individual grains 100 or granules, such as is depicted in Figs. 3 and 5.

**[0078]** Fig. 3 shows a schematic sectional view of a microporous zeolite mineral particle 110, whose surface contains pores (indicated by the dots). For example, the microporous zeolite mineral 110 could be of the chabazite, erionite, and

mordenite or clinoptilolite type. In Fig. 3 a dotted circle is indicated, the schematic content of which is enlarged in Fig. 4. As shown in the enlarged sectional view in Fig. 4, the surface of the microporous zeolite mineral particle 110 contains pores 111, through which water may be absorbed and adsorbed and through which water can be reversibly released.

[0079] Fig. 5 shows the same microporous zeolite mineral particle after it has been partially coated with a polyurethane coating 120 and may thus be used as an infill material 10. As can be seen, at least some parts of the surface of the coated microporous zeolite mineral particle 110 are not covered by the polyurethane coating. In Fig. 5 a dotted circle is also indicated, the schematic content of which is enlarged in Fig. 6.

[0080] As shown in the enlarged sectional view in Fig. 6 the microporous zeolite mineral particle 110, which contains pores 111, has been partially coated with a polyurethane coating 120. The polyurethane coating 120 was formed by providing microporous zeolite mineral particles 110 and a liquid polyurethane reaction mixture in a batch reactor, tumbler or continuous reactor. Simultaneous mixing and initialization of the solidification reaction lead to the desired partial coating of the polyurethane coating 120 on the surface of the microporous zeolite mineral particle 110. The partial coating results from microporous zeolite mineral particles 110 colliding while being mixed with the initialized liquid polyurethane reaction mixture. Since the initialization of the solidification reaction takes place simultaneously, uncovered spaces (gaps or holes), created by collisions, remain on the surface of the microporous zeolite mineral particles and thus the artificial turf infill 10. Further, as shown in Fig. 6 the polyurethane coating 120 coats a portion of the inner surface of the microporous zeolite mineral particle 110 in the region of the cover. The coating 120 may penetrate with a slight distance, for example between 0.2  $\mu\text{m}$  and 500  $\mu\text{m}$ , preferably between 1 and 150  $\mu\text{m}$  and most preferred between 10  $\mu\text{m}$  and 100  $\mu\text{m}$  into the surface pores 111 and thus may interfere with the pores 111 in a form-locking manner. Thereby the hold of the coating on the microporous zeolite mineral particle 110 may be increased and at the same time the overall stability and hardness of the microporous zeolite mineral particle 110 may be increased. Further, since the infill material 10 is preferably produced by mixing the microporous zeolite mineral particles with a liquid polyurethane reaction mixture and initializing the solidification reaction during the mixing, the microporous zeolite mineral particles have substantially the same amount of their outer surface covered by the coating relative to the total outer surface. Substantially the same amount means that the outer surface of each microporous zeolite mineral particle is covered between 20 % and 99 %, preferably between 50 % to 98 % or between 70 % to 99 %, with the polyurethane coating 120. Since the outer surface of each microporous zeolite mineral particle 110 is - with the exception of the gaps - essentially fully coated, fine dusts may be bound. As further shown in another embodiment, the polyurethane coating 120 of this artificial turf infill granule contains a further component 121. The further component 121 may be for example sand and/or colored sand and/or chalk and/or lime. With the addition of sand and/or colored sand and/or chalk and/or lime to the liquid polyurethane reaction mixture of the polyurethane coating 120, the viscosity of the liquid polyurethane reaction mixture can be increased. Thus during the mixing of the liquid polyurethane reaction mixture with the microporous zeolite mineral particle 110 while manufacturing the artificial turf infill, some portions of the surfaces of the microporous zeolite mineral particles remain open upon application of the polyurethane coating, since the penetration depth of the polyurethane coating is a function of the viscosity. As further shown, the polyurethane coating 120 of this artificial turf infill may comprise a rheology additive 122. The rheology additive may be added in order to achieve thixotropic flow behavior of the liquid polyurethane reaction mixture during mixing of the liquid polyurethane reaction mixture with the microporous zeolite mineral particle 110. The viscosity of the liquid polyurethane reaction mixture is controllable via the addition of the rheology additive and thus the depth of penetration of the liquid polyurethane reaction mixture into the pores 111 contained in the surfaces of the microporous zeolite mineral particles 110 can be controlled. As can be seen in Fig. 6, the polyurethane coating is mainly solidified or cured on the outer surface of the microporous zeolite mineral particles 110, however the polyurethane coating 120 also coats a portion of the inner surface of the pores 111 in the region of the cover. The coating 120 may penetrate a slight distance, for example between 1  $\mu\text{m}$  and 500  $\mu\text{m}$ , into the surface pores 111, thereby interfering with the pores 111 in a form-locking manner. Thus the hold of the coating on the microporous zeolite mineral particles 110 may be increased and at the same time the overall stability and hardness of the microporous zeolite mineral particles 110 may be increased.

[0081] As shown in Fig. 7, which is an enlarged sectional view of the enlarged sectional view indicated in Fig. 6 by the dotted square, the microporous zeolite mineral particle 110, which contains pores 111, has been partially coated with a polyurethane coating 120. The microporous zeolite mineral particles 110 contain pores 111 that have openings on the outer surface of the microporous zeolite mineral particles 110. As depicted, the outer surface of the microporous zeolite mineral particle 110 is partly coated with a polyurethane coating 120, wherein the coating extends over some of the pores 111 forming respective covers (equals the pore size at the outer surface; indicated by 130) of the openings. The cover 130 covers the pore 111 in the area of the pore opening. As shown in the Fig. 7 for the two covered pores (i.e., the two right pores), the polyurethane coating 120 coats a portion of the inner surface of the covered pores 111 in the region of the cover 130. Hereby, the polyurethane coating 120 of the inner surface may be in the form of a plug, as indicated in the left covered pore 111 or in the form of a film, as indicated in the right covered pore 111.

[0082] Fig. 8 depicts an inventive artificial turf infill granule 10 (i.e., partly coated microporous zeolite mineral particles 110). The microporous zeolite mineral particle 110 has pores 111 that form openings on the outer surface of the micro-

porous zeolite mineral particles 110. As shown, the outer surface of the microporous zeolite mineral particles 110 is partly coated with a polyurethane coating 120, wherein the coating extends over most of the pores 111, thereby forming respective covers of the openings. The polyurethane coating 120 was formed by providing a plurality of microporous zeolite minerals particles 110 and a liquid polyurethane reaction mixture in a batch reactor, tumbler or continuous reactor. Simultaneous mixing and initialization of the solidification reaction lead to the desired partial coating of the polyurethane coating 120 on the surface of the microporous zeolite mineral particle 110. The partial coating results from collisions of microporous zeolite mineral particles 110 while being mixed with the initialized liquid polyurethane reaction mixture. Since the initialization of the solidification reaction takes place simultaneously, uncovered spaces (e.g., gaps or holes), created by collisions, remain on the surface of the microporous zeolite mineral particles and thus the artificial turf infill 10 granule. As indicated in Fig. 8, it may be feasible that 75 % to 99 % of the outer surface of the microporous zeolite mineral particle is partly covered with a polyurethane coating 120.

#### List of Reference Numerals

#### [0083]

- 10 artificial turf infill
- 100 grains or granules
- 110 microporous zeolite mineral particle (grain or granule)
- 111 pores
- 120 polyurethane coating
- 121 further component of polyurethane coating
- 122 rheology additive
- 130 cover
- 500 artificial turf carpet
- 502 backing
- 504 artificial turf fiber tufts
- 506 row spacing between adjacent rows of tufts
- 508 pile height
- 510 ground or floor
- 600 artificial turf

#### Claims

##### 1. An artificial turf (600), comprising:

- an artificial turf carpet (500), wherein the artificial turf carpet comprises multiple artificial turf fiber tufts (504); and
- an artificial turf infill (10), which is scattered between the multiple artificial turf fiber tufts (504), wherein the artificial turf infill (10) comprises a plurality of microporous zeolite mineral particles (110), the microporous zeolite mineral particles (110) having pores (111) that form openings on the outer surface of the microporous zeolite mineral particles (110), wherein the outer surface of at least some of the microporous zeolite mineral particles (110) is partly coated with a polyurethane coating (120), wherein the coating extends over some of the pores (111) forming respective covers (130) of the openings, wherein the polyurethane coating (120) coats a portion of the inner surface of the covered pores (111) in the region of the cover (130) and wherein the microporous zeolite mineral particles (110) have the same amount of their outer surface coated by the coating (120) relative to the total outer surface.

##### 2. The artificial turf (600) of claim 1, wherein the microporous zeolite mineral particles (110) are selected from the group consisting of chabazite, erionite, mordenite, clinoptilolite, faujasite, phillipsite, zeolite A, zeolite L, zeolite Y, zeolite X and ZSM-5.

##### 3. The artificial turf (600) of any of the preceding claims, wherein the polyurethane coating (120) is based on a liquid polyurethane reaction mixture comprising

- at least one isocyanic prepolymer with blocked isocyanic functionality;
- a hydroxyl component, wherein the hydroxyl component is selected from the group of polyether polyol or polyester polyol; and

- at least one catalyst selected from the group consisting of linear or cyclic tertiary amines such as triethylene-diamine, 1,4-Diazabicyclo[2.2.2]octane, cyclic amines such as 1,8-Diazabicyclo(5.4.0)undec-7-ene (DBU) and inorganic compounds such as sodium hydroxide (NaOH), chromium(III) oxide and zinc oxide (ZnO).

- 5     **4.** The artificial turf (600) of any of the preceding claims, wherein the polyurethane coating (120) is based on liquid polyurethane reaction mixture comprising at least one of the following components:
  - i. NCO terminal polymer, one or more component selected from a prepolymer, a polymeric isocyanate, an oligomeric isocyanate, a monomer, such as
    - 10         a. aromatic diisocyanate of the group of toluene diisocyanate and/or methylene-2,2-diisocyanate or
    - b. aliphatic diisocyanate of the group hexamethylene diisocyanate, isophorone diisocyanate, and/or 1,4-cyclohexyldiisocyanate; and
  - 15         ii. Hydroxyl component, wherein the hydroxyl component is selected from the group of polyether polyol or polyester polyol.
- 20     **5.** The artificial turf (600) according to at least one of the preceding claims, wherein the polyurethane coating (120) comprises at least one further component (121) selected from the group consisting of sand, colored sand, chalk, lime, color pigments, copper(II) sulfate particles, flame retardants, U.V. absorbers and fillers.
- 25     **6.** The artificial turf (600) according to one of the claims 1 to 4 or 5, wherein the polyurethane coating (120) comprises fillers, in particular barium sulphate (barite) and/or calcium carbonate (chalk), to increase the total weight of the artificial turf infill (10).
- 30     **7.** The artificial turf (600) according to at least one of the preceding claims, wherein the polyurethane coating (120) comprises a rheology additive (122), in particular fumed silica, hydrophobic fumed silica, bentonite, acrylate or a combination thereof.
- 35     **8.** An artificial turf infill (10), wherein the artificial turf infill (10) comprises a plurality of microporous zeolite mineral particles (110), the microporous zeolite mineral particles (110) having pores (111) that form openings on the outer surface of the microporous zeolite mineral particles (110), wherein the outer surface of at least some of the microporous zeolite mineral particles (110) is partly coated with a polyurethane coating (120), wherein the coating extends over some of the pores (111) forming respective covers (130) of the openings, wherein the polyurethane coating (120) coats a portion of the inner surface of the covered pores in the region of the cover (130) and wherein the microporous zeolite mineral particles (110) have the same amount of their outer surface coated by the coating (120) relative to the total outer surface.
- 40     **9.** The artificial turf infill (10) according to claim 8, wherein the polyurethane coating (120) comprises a rheology additive (122), in particular fumed silica, hydrophobic fumed silica, bentonite, acrylate or a combination thereof.
- 45     **10.** The artificial turf infill (10) according to claim 8 or claim 9, wherein the polyurethane coating (120) comprises at least one further component (121) selected from the group consisting of sand, colored sand, chalk, lime, colored pigments, copper(II) sulfate particles, flame retardants, U.V. absorbers and fillers.
- 50     **11.** The artificial turf infill (10) according to one of the claims 8 to 10, wherein the polyurethane coating (120) comprises fillers, in particular barium sulphate (barite) and/or calcium carbonate (chalk), to increase the total weight of the artificial turf infill (10).
- 55     **12.** The artificial turf infill (10) according to one of claims 8 to 11, wherein the artificial turf infill (10) further comprises at least one granular component selected from the group consisting of cork granules, coated cork granules, rubber granules and coated rubber granules.
- 13.** The artificial turf infill (10) according to one of claims 8 to 12, wherein at least some of the microporous zeolite mineral particles (110) are charged with a salt solution.
- 14.** The artificial turf infill (10) according to one of claims 8 to 13, wherein the microporous zeolite mineral particles (110) are selected from the group consisting of chabazite, erionite, mordenite, clinoptilolite, faujasite, phillipsite, zeolite

A, zeolite L, zeolite Y, zeolite X and ZSM-5.

15. The artificial turf infill (10) according to one of claims 8 to 14, wherein the polyurethane coating (120) is based on a liquid polyurethane reaction mixture comprising

- at least one isocyanic prepolymer with a totally blocked isocyanic functionality;
- a hydroxyl component, wherein the hydroxyl component is selected from the group of polyether polyol or polyester polyol; and
- at least one catalyst selected from the group consisting of linear or cyclic tertiary amines such as triethylene-diamine, or e.g. 1,4-Diazabicyclo[2.2.2]octane, cyclic amines such as 1,8-Diazabicyclo(5.4.0)undec-7-ene (DBU) and inorganic compounds such as sodium hydroxide (NaOH), chromium(III) oxide and zinc oxide (ZnO).

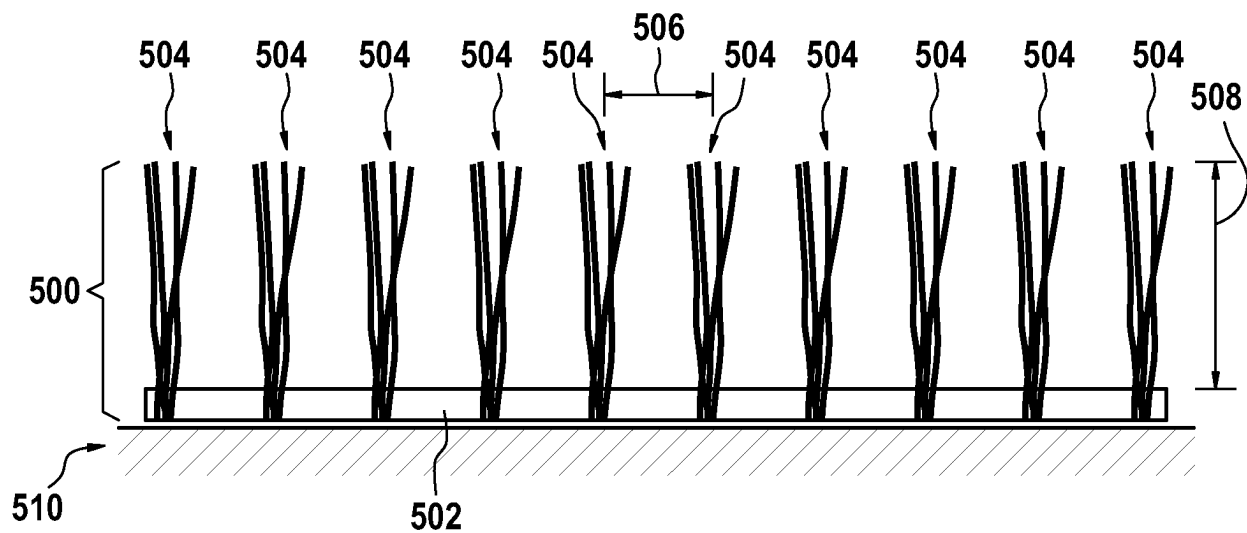
16. The artificial turf infill (10) according to one of claims 8 to 14, wherein the polyurethane coating (120) is based on liquid polyurethane reaction mixture comprising at least one of the following components:

- i. NCO terminal polymer, one or more component selected from a prepolymer, a polymeric isocyanate, an oligomeric isocyanate, a monomer, such as

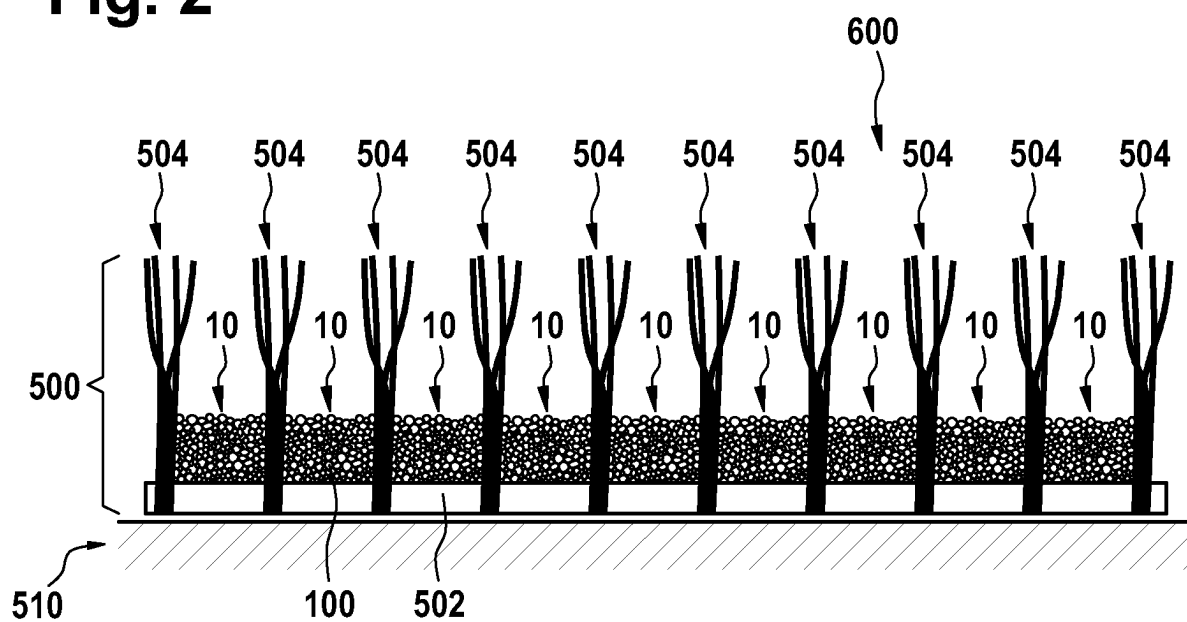
- a. aromatic diisocyanate of the group of toluene diisocyanate and/or methylene-2,2-diisocyanate or
- b. aliphatic diisocyanate of the group hexamethylene diisocyanate, isophorone diisocyanate, and/or 1,4-cyclohexyldiisocyanate; and

- ii. Hydroxyl component, wherein the hydroxyl component is selected from the group of polyether polyol or polyester polyol.

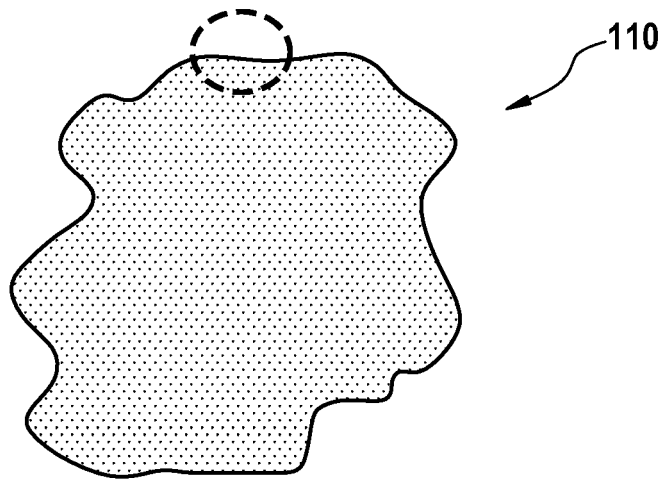
**Fig. 1**



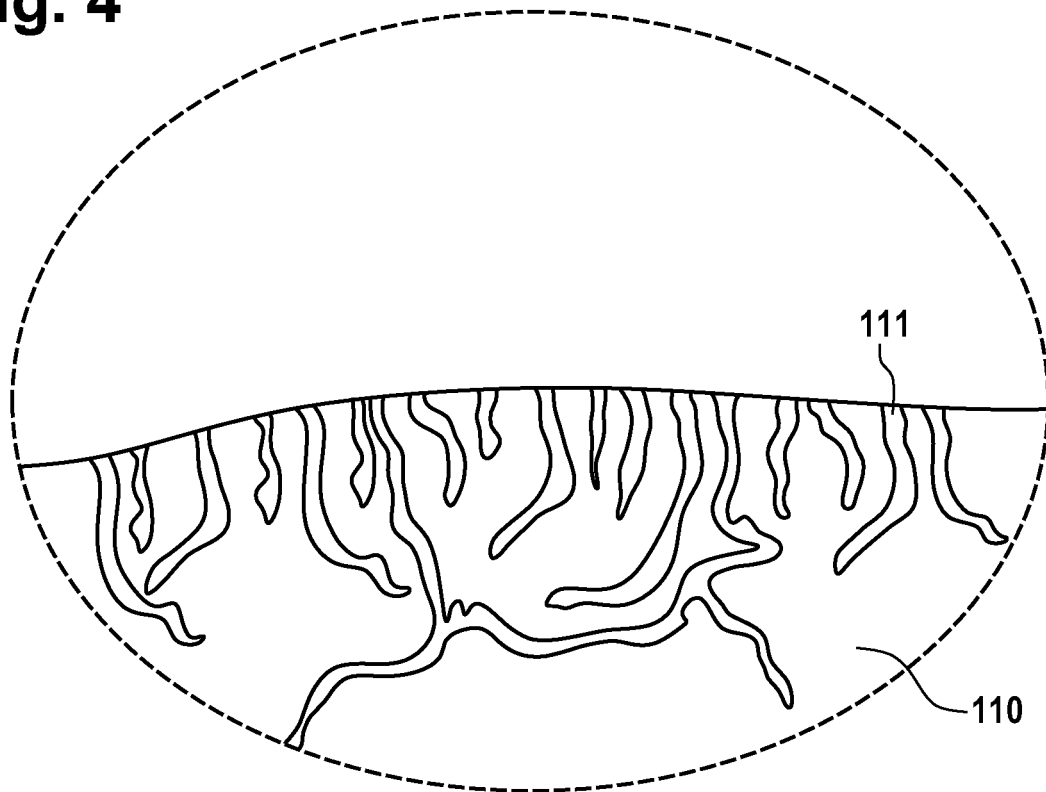
**Fig. 2**



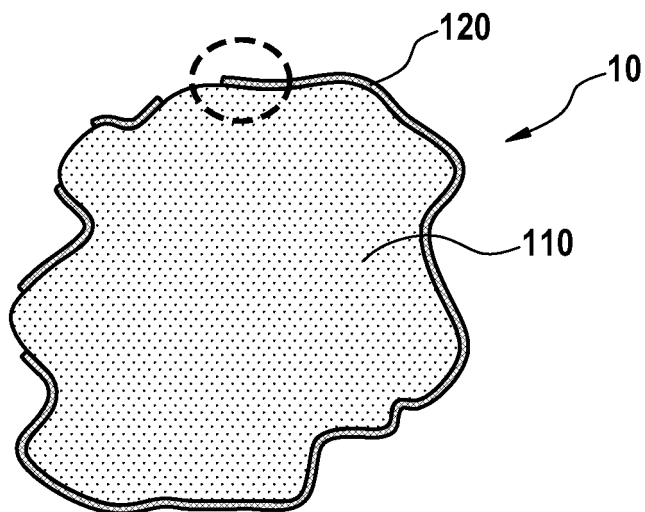
**Fig. 3**



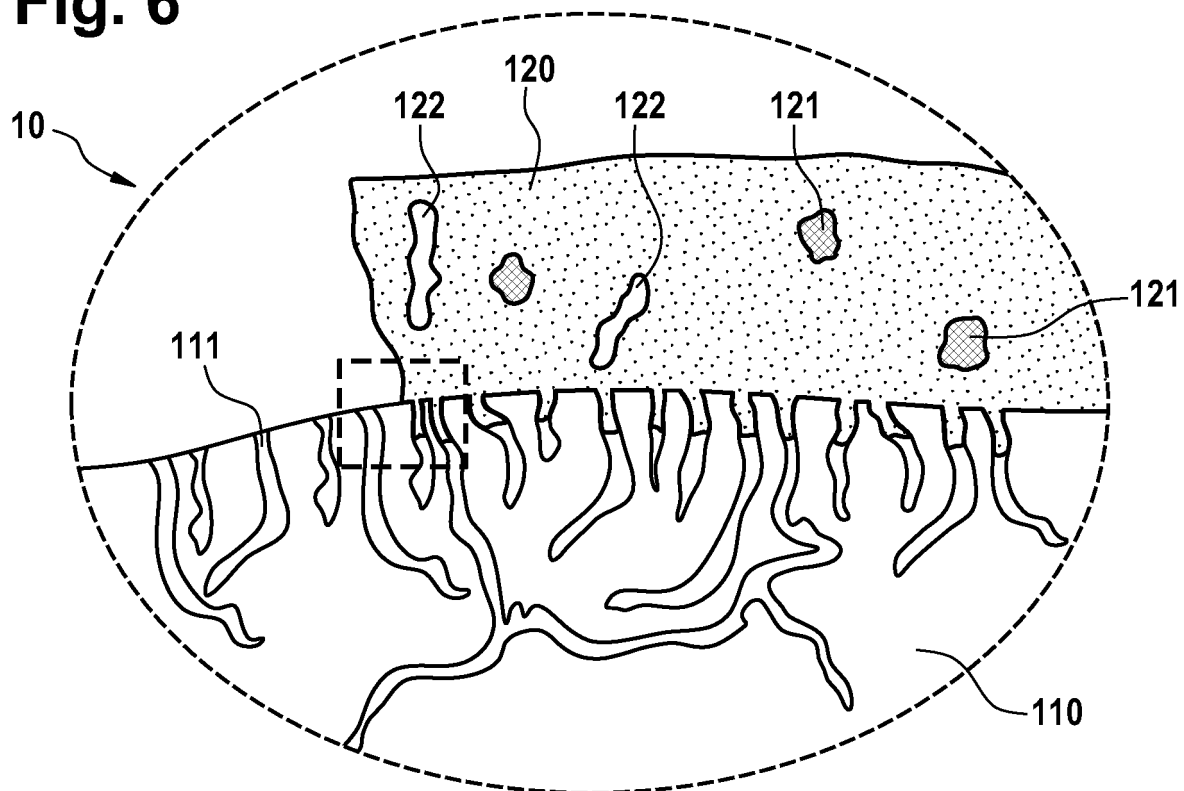
**Fig. 4**



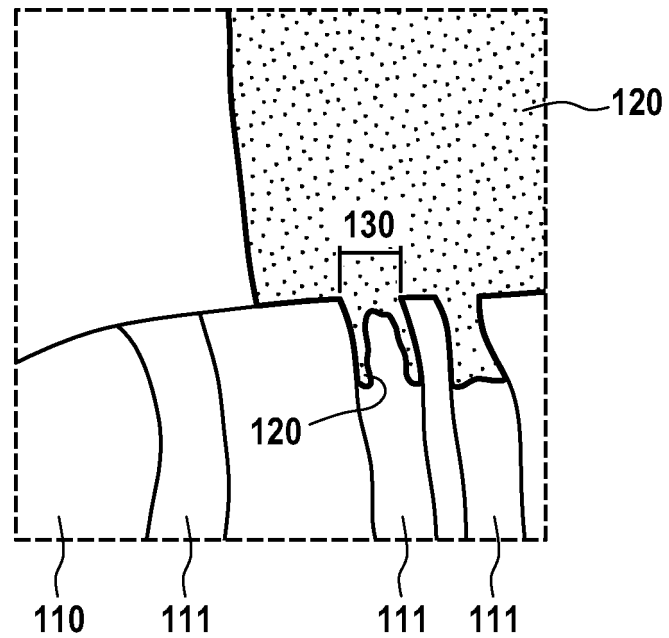
**Fig. 5**



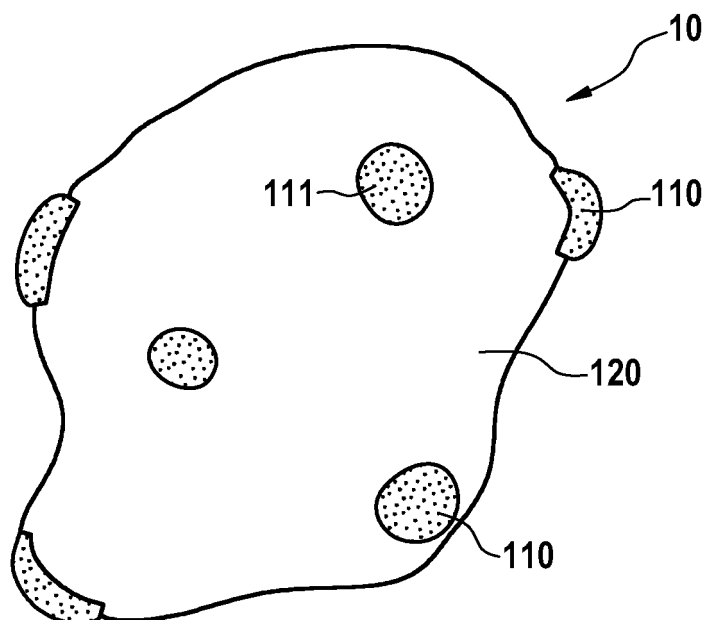
**Fig. 6**



**Fig. 7**



**Fig. 8**





## EUROPEAN SEARCH REPORT

 Application Number  
 EP 18 21 2778

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| 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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | WO 2012/058555 A2 (QUANTUM GROUP INC [US]; SAWAFTA REYAD I [US]; BRUNER JEFFREY W [US]) 3 May 2012 (2012-05-03)     | 1-3,8,12,14,15                                         | INV.<br>E01C13/08                               |
| Y                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | * the whole document *                                                                                              | 4,6,7,9,11,13,16                                       |                                                 |
| X,D                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | US 10 066 345 B2 (PROFILE PRODUCTS LLC [US]) 4 September 2018 (2018-09-04)                                          | 1,2,5,8,10,12,14                                       |                                                 |
| Y                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | * the whole document *                                                                                              | 3,4,6,7,9,11,13,15,16                                  |                                                 |
| Y                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | EP 3 216 821 A1 (POLYTEX SPORTBELÄGE PRODUKTIONS-GMBH [DE]; UNIRUBBER SP Z O O [PL]) 13 September 2017 (2017-09-13) | 3,4,15,16                                              |                                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | * paragraph [0024] - paragraph [0029] *                                                                             |                                                        |                                                 |
| Y                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | US 2016/333535 A1 (ROBINSON MICHAEL S [US] ET AL) 17 November 2016 (2016-11-17)                                     | 6,7,9,11                                               |                                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | * paragraph [0059] - paragraph [0062] *                                                                             |                                                        |                                                 |
| Y                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | EP 2 749 350 A2 (PINTAT BENOIT [FR]) 2 July 2014 (2014-07-02)                                                       | 13                                                     | TECHNICAL FIELDS SEARCHED (IPC)<br>E01C<br>C09D |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | * the whole document *                                                                                              |                                                        |                                                 |
| The present search report has been drawn up for all claims                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                     |                                                        |                                                 |
| Place of search<br><b>Munich</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                     | Date of completion of the search<br><b>20 May 2019</b> | Examiner<br><b>Kerouach, May</b>                |
| CATEGORY OF CITED DOCUMENTS<br>X : particularly relevant if taken alone<br>Y : particularly relevant if combined with another document of the same category<br>A : technological background<br>O : non-written disclosure<br>P : intermediate document<br>T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br>& : member of the same patent family, corresponding document |                                                                                                                     |                                                        |                                                 |

EPO FORM 1503 03.82 (P04C01)

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

EP 18 21 2778

5

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  
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

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| Patent document<br>cited in search report |    | Publication<br>date |    | Patent family<br>member(s) |  | Publication<br>date |
|-------------------------------------------|----|---------------------|----|----------------------------|--|---------------------|
| WO 2012058555                             | A2 | 03-05-2012          | EP | 2633123 A2                 |  | 04-09-2013          |
|                                           |    |                     | US | 2013199755 A1              |  | 08-08-2013          |
|                                           |    |                     | US | 2018142426 A1              |  | 24-05-2018          |
|                                           |    |                     | WO | 2012058555 A2              |  | 03-05-2012          |
| -----                                     |    |                     |    |                            |  |                     |
| US 10066345                               | B2 | 04-09-2018          | CA | 2889364 A1                 |  | 24-10-2015          |
|                                           |    |                     | US | 2015308056 A1              |  | 29-10-2015          |
|                                           |    |                     | US | 2018371708 A1              |  | 27-12-2018          |
| -----                                     |    |                     |    |                            |  |                     |
| EP 3216821                                | A1 | 13-09-2017          | AU | 2017229156 A1              |  | 26-07-2018          |
|                                           |    |                     | CA | 3010760 A1                 |  | 14-09-2017          |
|                                           |    |                     | CN | 108779259 A                |  | 09-11-2018          |
|                                           |    |                     | EP | 3216821 A1                 |  | 13-09-2017          |
|                                           |    |                     | EP | 3426720 A1                 |  | 16-01-2019          |
|                                           |    |                     | JP | 6505957 B1                 |  | 24-04-2019          |
|                                           |    |                     | KR | 20180124036 A              |  | 20-11-2018          |
|                                           |    |                     | US | 2019071546 A1              |  | 07-03-2019          |
|                                           |    |                     | WO | 2017153261 A1              |  | 14-09-2017          |
| -----                                     |    |                     |    |                            |  |                     |
| US 2016333535                             | A1 | 17-11-2016          | EP | 3294789 A1                 |  | 21-03-2018          |
|                                           |    |                     | US | 2016333535 A1              |  | 17-11-2016          |
|                                           |    |                     | WO | 2016187004 A1              |  | 24-11-2016          |
| -----                                     |    |                     |    |                            |  |                     |
| EP 2749350                                | A2 | 02-07-2014          | CA | 2838175 A1                 |  | 28-06-2014          |
|                                           |    |                     | EP | 2749350 A2                 |  | 02-07-2014          |
|                                           |    |                     | FR | 3000496 A1                 |  | 04-07-2014          |
|                                           |    |                     | US | 2014314499 A1              |  | 23-10-2014          |
| -----                                     |    |                     |    |                            |  |                     |

EPO FORM P0459

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

**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

- US 10066345 B2 [0007]
- US 10066345 B [0007]