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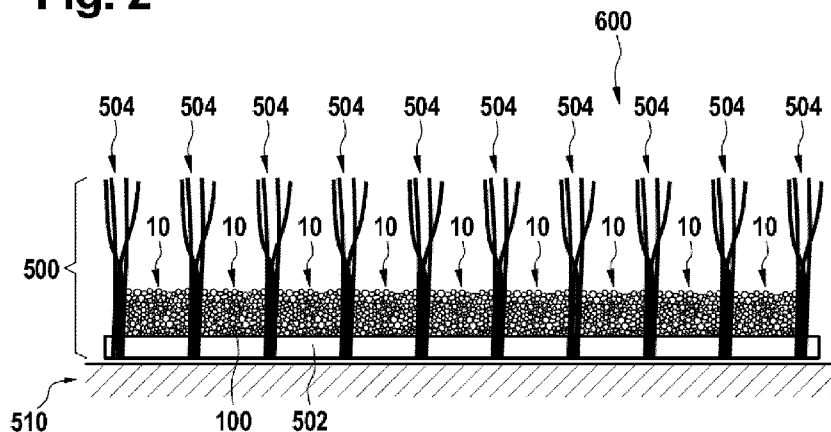
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(54) Title: ARTIFICIAL TURF INFILL AND ARTIFICIAL TURF

Fig. 2



(57) Abstract: The present invention relates to an artificial turf infill (10) and to an artificial turf (600) comprising the artificial turf infill (10). The artificial turf infill (10) comprises a plurality of microporous zeolite mineral particles, the particles having pores that form openings on the outer surface of the microporous zeolite mineral particles, wherein 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, wherein the polyurethane coating coats a portion of the inner surface of the covered pores in the region of the cover, and wherein the polyurethane coating extends over the entire surface of each partly coated microporous zeolite mineral particle with a uniform coverage ratio, the coverage ratio being between 20% and 99%.



Artificial turf infill and artificial turf

Description

The invention relates to artificial turf infill and an artificial turf.

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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.

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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.

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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 that of being on real turf. The artificial turf infill may also help keep the artificial turf carpet flat and in place by weighing it down.

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Even though artificial turf known from the art is constantly being improved, it is still often subjected to bad weather conditions, such as severe heat and temperature

variations, which may lead to rapid degradation, or even to problems in upkeep and maintenance of the artificial turf in its optimal conditions for use.

5 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 conventional artificial turf infill materials, such as rubber, tend to heat up.

10 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
15 10,066,345 B2 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, for example, atomization of the polymer and spraying of the polymer onto the particles as the particles are
20 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.

25 It is therefore the purpose of the invention to provide an alternative or improved artificial turf infill.

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
30 and examples described herein can freely be combined with each other unless they are mutually exclusive.

In one aspect, the problem is solved by providing a microporous zeolite mineral particle, the microporous zeolite mineral particle having pores that form openings on

the outer surface of the microporous zeolite mineral particle, wherein the outer surface of the microporous zeolite mineral particle is partly coated with a polyurethane coating, wherein the coating extends for a distance into some of the pores, forming reinforcements, the reinforcements forming openings that provide a passage for sorbing (absorbing and adsorbing) water into the pores and/or desorbing water from the pores.

Such microporous zeolite mineral particles can be used as artificial turf infill and may have advantageous effects. In particular, the mechanical resistance of the particles is increased by the coating while extending the cooling effect on the artificial turf due to the reduced water desorption rate from the particles. The slower desorption is due to the narrowing of some of the openings of the particles.

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 of 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 mm to 60 mm.

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, wherein the outer surface of at least some of the microporous zeolite mineral particles is partly coated with a polyurethane coating.

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 may be 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, or, in other words, that the polyurethane coating extends over the entire surface of each partly coated microporous zeolite mineral particle with a uniform coverage ratio, the coverage ratio being between 20% and 99%.

Alternatively, the microporous zeolite mineral particles may be partly coated with a polyurethane coating, wherein the coating extends for a distance into some of the pores forming reinforcements, the reinforcements forming openings that provide a passage for sorbing water into the pores or desorbing water from the pores. 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, or, in other words, that the polyurethane coating extends over the entire surface of each partly coated microporous zeolite mineral particle with a uniform coverage ratio, the coverage ratio being between 20% and 99%.

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.

- 5 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
10 is not recoverable, may be reduced.

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
15 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.

In a further aspect, the invention relates to an artificial turf infill, wherein the artificial
20 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
25 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 all 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, or, in other
30 words, that the polyurethane coating extends over the entire surface of each partly coated microporous zeolite mineral particle with a uniform coverage ratio, the coverage ratio being between 20% and 99%.

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 for a distance into some of the pores forming reinforcements, with the reinforcements forming openings that provide a passage for sorbing water into the pores or desorbing water from the pores. 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, or, in other words, that the polyurethane coating extends over the entire surface of each partly coated microporous zeolite mineral particle with a uniform coverage ratio, the coverage ratio being between 20% and 99%.

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For both artificial turf infills, 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.

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The polyurethane coating may be advantageous, as the polymerization reaction may be controlled given that the polyurethane educts are smaller than those of many fully polymerized polymers, such as polymers in a molten plastic mass. Thus, the surface and the micropores of the microporous zeolite mineral particles may be wetted with the educts (e.g., with a liquid polyurethane reaction mixture), and when the desired degree of wetting or the desired penetration depth into the surface pores is achieved, the polymerization can be initialized. Further, the reacted polyurethane polymer is chemically inert.

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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 the polyurethane coating may 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.

The gaps in the coating of the inventive infill material may result during the manufacture of the infill material, since 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 such as 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 those areas in which the pores of the microporous zeolite minerals are not covered by the polyurethane coating.

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.

For both artificial turf infills, it may be further envisaged that the coating may penetrate a slight distance, for example between 0.2 μm and 500 μm , preferably between 1 μm and 150 μm and preferably between 10 μm and 100 μm , into the surface pores, and thus may either interfere with the pores in a form-locking manner or form reinforcements in the pores, with the reinforcements forming openings that provide a passage for sorbing water into the pores or desorbing water from the pores. For both alternatives, 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.

Further, since the infill material of both alternatives 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 polyurethane coating extends over the entire surface of each partly coated microporous zeolite mineral
5 particle with a uniform coverage ratio. In other words, 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 of the partly coated microporous zeolite mineral particles is coated between 20% and 99% with the polyurethane coating.

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According to one embodiment, the coverage ratio of the polyurethane coating of each of the partly coated microporous zeolite mineral particles is between 50% and 98% or between 70% and 99%. With increased coverage ratio, the overall stability and hardness of the microporous zeolite mineral particles may be further increased.

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Further, since the outer surface of each of the partly coated microporous zeolite mineral particles may be – with the exception of the gaps or the openings in the reinforced pores – essentially fully coated, fine dusts may be bound.

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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.

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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 clinoptinolite
30 and/or mordenite type.

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.

- 5 The granular artificial turf infill of both alternative artificial turf infills may further comprise rubber granules and/or cork granules, which may be coated with a polyurethane coating.

10 For both alternative artificial turf infills, it may be further 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.

15 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
20 artificial turf infills.

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, may allow a further increased release of the
25 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 prevents rapid evaporation
30 of the water after the surface is watered, and allows a lower than ambient temperature to be maintained at the level of the field surface. Said microporous mineral particles loaded with salt thus further allow the amount of watering usually necessary to refresh a turf surface to be reduced.

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.

5 It is further within the present invention that the layer thickness of the polyurethane coating is between 0.001 mm and 2.0 mm.

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,
10 U.V. absorbers and fillers.

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

15 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 cost of the comparably expensive and precious pigments, since they are merely on the partly
20 covered surface of the zeolite minerals, is reduced from that of fully coated infill materials.

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

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Copper(II) sulfate particles and/or 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.

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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.

The coating, which may be 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-
5 deep of penetration of the polyurethane coating into the surface pores of the microporous minerals.

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.
10 This may provide a more realistic-looking playing surface or field.

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

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

It may be envisaged that the coating may comprise between 0.1 wt.% and 80 wt.% of fillers.
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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.
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Barium sulphate and calcium carbonate may be particularly advantageous, as they have a high density; calcium carbonate has a density of 2.7 g/cm³ and barium sulphate has a density of between 4.0 and 4.5 g/cm³. They are also relatively cheap materials and may be used to provide a dense coating.

For this embodiment it may thus be envisaged that the coating may comprise between 0.1 wt.% and 80 wt.%, preferably between 20 wt.% and 50 wt.%, of barium sulfate as filler, or between 0.1 wt.% and 65 wt.%, preferably between 20 wt.% and 40 wt.%, of calcium carbonate as filler.

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

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 a liquid polyurethane reaction mixture, which may be used as a basis of the coating.

Adding a rheology additive with thixotropic capabilities may be advantageous in order to achieve a controllable viscosity-increasing thixotropic flow behavior (i.e., liquid or fluid) of a 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.

Suitable rheology additives are 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.

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 (Cr₂O₃) and zinc oxide (ZnO).

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10 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 as described above for both alternatives or the coating with gaps. Further, the resulting polyurethane coating may be a waterborne polyurethane coating.

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

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- i. NCO-terminal polymer, one or more components selected from a prepolymer, a polymeric isocyanate, an oligomeric isocyanate or 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-cyclohexyl diisocyanate; and
- ii. Hydroxyl component, wherein the hydroxyl component is selected from the group of polyether polyol or polyester polyol.

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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, such as a secondary amine catalyst or 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 as described above for both alternatives or the coating with gaps.

In one embodiment of the invention, the polyurethane coating is a reaction product of a liquid polyurethane reaction mixture comprising

- 10 – 0.1 wt.% to 80 wt.% of an NCO-terminal prepolymer,
 - 0.001 wt.% to 0.5 wt.% of 1,8-diazabicyclo(5.4.0)undec-7-ene (DBU) and
 - 0.001 wt.% to 20.0 wt.% water,
- and optionally at least one further component selected from the group consisting of
- 15 • 0.001 wt.% to 30.0 wt.% colored pigments,
 - 0.001 wt.% to 3.0 wt.% copper(II) sulfate,
 - 0.05 wt.% to 60 wt.% flame retardants,
 - 0.01 wt.% to 1.0 wt.% U.V. absorbers,
 - 0.01 wt.% to 60 wt.% filler and
 - 20 • 0.01 wt.% to 1.0 wt.% rheology additive,

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.

The NCO-terminal prepolymer of this embodiment may be an NCO-terminal isocyanic prepolymer, which is a (oligomeric) urethane having at least one free isocyanate group, and which may be obtained by reacting polyisocyanates with polyols. The NCO-terminal prepolymer of this embodiment may have an NCO content of 5.5% to 11.5%, preferably an NCO content of 6.5% to 10.5% or, most preferred, an NCO content of 8.0% to 9.0%. Further, the NCO-terminal prepolymer of this embodiment may have a curing time in air of 35 hours to 45 hours. A suitable prepolymer is known under the trade name P2440 (Polytex Sportbeläge Produktions GmbH). The prepolymer may be mixed with the microporous zeolite particles in a batch or continuous reactor and the solidification reaction may be initialized (during

the mixing) by adding water and/or a catalyst. The prepolymer may be advantageously used for a moisture-curing 1 K system, in which the reaction (formation of urea groups) may be started with water and/or a catalyst, here 1,8-diazabicyclo(5.4.0)undec-7-ene (DBU). DBU may be in particular useful as a catalyst for a 1 K system, as it may be soluble in water. In addition, the curing rate of the polyurethane formation may be controlled by the addition of the DBU water mixture, time and temperature, so that, for example, the polyurethane coating may only penetrate the pores to a certain depth or the curing takes place very quickly. Correspondingly, curing may also be achieved such that the individual coated zeolite particles do not stick to each other.

The optional further component may provide further advantages.

The colored pigments 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. 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 U.V. degradation, may be used.

This embodiment may further comprise a thermo-stabilizing agent, protecting the polyurethane coating against thermal degradation.

It is understood that all of the aforementioned embodiments may be applied for both above described artificial turf infills. Further, 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.

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;
- 5 Fig. 5 illustrates a sectional view of a microporous zeolite mineral particle, which is partly 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;
- 10 Fig. 8 illustrates an artificial turf infill; and
- Fig. 9 illustrates a sectional view of a partly coated microporous zeolite mineral particle, the coating of which extends for a distance into a pore and forms a reinforcement.

15 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.

20 Figs. 1 and 2 illustrate the manufacture of an artificial turf 600 using an artificial turf carpet 500 and artificial turf infill 10.

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
25 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
30 ground 510 or to 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 and 6 and is spread out on the surface and distributed between the artificial turf fiber tufts 504.

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.

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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, 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.

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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.

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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.

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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. 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

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cover. The coating 120 may penetrate a slight distance, for example between 0.2 μm and 500 μm , preferably between 1 μm and 150 μm and most preferred between 10 μm and 100 μm , into the surface pores 111 and thus may interfere with the pores 111 in a form-locking manner; this will increase the hold of the coating on the

5 microporous zeolite mineral particle 110, 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 (here comprising 0.1 wt.% to 80 wt.% of an NCO-terminal prepolymer and optionally at least one

10 further component selected from the group consisting of 0.001 wt.% to 30.0 wt.% colored pigments, 0.001 wt.% to 3.0 wt.% copper(II) sulfate, 0.05 wt.% to 60 wt.% flame retardants, 0.01 wt.% to 1.0 wt.% U.V. absorbers, 0.01 wt.% to 60 wt.% filler and 0.01 wt.% to 1.0 wt.% rheology additive) and initializing the solidification reaction during the mixing by adding a catalyst and water (here comprising 0.001

15 wt.% to 0.5 wt.% of 1,8-diazabicyclo(5.4.0)undec-7-ene (DBU) and 0.001 wt.% to 20.0 wt.% water), 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

20 between 50% and 98% or between 70% and 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

25 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

30 110 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 purpose of the rheology

additive may be 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 seen in Fig. 6, the polyurethane coating is mainly solidified or cured on the outer surface of the microporous zeolite mineral particles 110, but 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 μm and 500 μm , 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.

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 covers (equal to 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 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.

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 microporous 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 covers over the openings. The polyurethane coating 120 was formed by providing a plurality of 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 particles 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 possible that 75% to 99% of the outer surface of the microporous zeolite mineral particle is partly covered with a polyurethane coating 120.

As shown in an enlarged sectional view in Fig. 9, 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 and from controlling the polymerization reaction. Since the initialization of the solidification reaction takes place simultaneously, uncovered spaces (e.g., gaps or holes; not shown) 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. 9, the polyurethane coating 120 extends for a distance into the pore 111, forming a reinforcement 140, with the reinforcement 140 forming an opening 150 that provides a passage for sorbing water into the pore 111 or desorbing water from the pore 111.

The coating 120 may penetrate with a slight distance, for example between 0.2 μm and 500 μm , preferably between 1 μm and 150 μm and most preferred between 10 μm and 100 μm , into the surface pores 111, and thus may interfere with the pores 111 in a form-locking manner. This may increase the hold of the coating on the microporous zeolite mineral particle 110, 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 (here, comprising 0.1 wt.% to 80 wt.% of an NCO-terminal prepolymer and optionally at least one further component selected from the group consisting of 0.001 wt.% to 30.0 wt.% colored pigments, 0.001 wt.% to 3.0 wt.% copper(II) sulfate, 0.05 wt.% to 60 wt.% flame retardants, 0.01 wt.% to 1.0 wt.% U.V. absorbers, 0.01 wt.% to 60 wt.% filler and 0.01 wt.% to 1.0 wt.% rheology additive) and initializing the solidification reaction during the mixing by adding a catalyst and water (here, comprising 0.001 wt.% to 0.5 wt.% of 1,8-diazabicyclo(5.4.0)undec-7-ene (DBU) and 0.001 wt.% to 20.0 wt.% water), 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% and 98% or between 70% and 99%, with the polyurethane coating 120. Since the outer surface of each microporous zeolite mineral particle 110 is, with the exception of the gaps and the reinforcements 140 with the openings 150, essentially fully coated, fine dusts may be bound. The viscosity of the liquid polyurethane reaction mixture may be controlled by an addition of a rheology additive. Therefore 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 may be controlled. As can be seen in Fig. 9, the polyurethane coating is mainly solidified or cured on the outer surface of the microporous zeolite mineral particles 110, but the polyurethane coating 120 also coats a circumferential portion of the inner surface of the pores 111. The coating 120 may penetrate a slight distance, for example between 1 μm and 500 μm , into the surface pores 111, thereby interfering with the pores 111 in a form-locking manner. This may increase the hold of the coating on the microporous zeolite

mineral particles 110, and at the same time the overall stability and hardness of the microporous zeolite mineral particles 110 may be increased.

List of Reference Numerals

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	10	artificial turf infill
	100	grains or granules
10	110	microporous zeolite mineral particle (grain or granule)
	111	pores
	120	polyurethane coating
	121	further component of polyurethane coating
	122	rheology additive
15	130	cover
	140	reinforcement
	150	opening
	500	artificial turf carpet
	502	backing
20	504	artificial turf fiber tufts
	506	row spacing between adjacent rows of tufts
	508	pile height
	510	ground or floor
25	600	artificial turf

CLAIMS

1. 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 polyurethane coating (120) extends over the entire surface of each partly coated microporous zeolite mineral particle (110) with a uniform coverage ratio, the coverage ratio being between 20% and 99%.
2. 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 for a distance into some of the pores (111), forming reinforcements (140), the reinforcements (140) forming openings (150) that provide a passage for sorbing water into the pores (111) and/or desorbing water from the pores (111), and wherein the polyurethane coating (120) extends over the entire surface of each partly coated microporous zeolite mineral particle (110) with a uniform coverage ratio, the coverage ratio being between 20% and 99%.
3. The artificial turf infill (10) according to claim 1 or claim 2, wherein the coverage ratio of the polyurethane coating (120) of each of the partly coated microporous zeolite mineral particles (110) is between 50% and 98% or between 70% and 99%.

4. The artificial turf infill (10) according to any one of claims 1 to 3, 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.
- 5
5. The artificial turf infill (10) according to any one of claims 1 to 4, wherein at least some of the microporous zeolite mineral particles (110) are charged with a salt solution.
- 10
6. The artificial turf infill (10) according to any one of claims 1 to 5, wherein the layer thickness of the polyurethane coating (120) is between 0.001 mm and 2.0 mm.
- 15
7. The artificial turf infill (10) according to any one of claims 1 to 6, 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.
- 20
8. The artificial turf infill (10) according to any one of claims 1 to 7, 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).
- 25
9. The artificial turf infill (10) according to any one of claims 1 to 8, wherein the polyurethane coating (120) comprises a rheology additive (122), in particular fumed silica, hydrophobic fumed silica, bentonite, acrylate or a combination thereof.
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10. The artificial turf infill (10) according to any one of claims 1 to 9, wherein the artificial turf infill (10) further comprises coated cork granules and coated rubber granules.

11. The artificial turf infill (10) according to any one of claims 1 to 10, wherein the polyurethane coating (120) is based on a liquid polyurethane reaction mixture comprising
- 5 – 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
- 10 cyclic tertiary amines such as triethylenediamine or 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 (Cr_2O_3) and zinc oxide (ZnO).
12. The artificial turf infill (10) according to any one of claims 1 to 10, wherein the polyurethane coating (120) is based on liquid polyurethane reaction mixture comprising at least one of the following components:
- 20 i. NCO-terminal polymer, one or more component selected from a prepolymer, a polymeric isocyanate, an oligomeric isocyanate and 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-cyclohexyl diisocyanate; and
 - 25 ii. Hydroxyl component, wherein the hydroxyl component is selected from the group of polyether polyol or polyester polyol.
13. The artificial turf infill (10) according to any one of claims 1 to 10, the polyurethane coating (120) being a reaction product of a liquid polyurethane reaction mixture comprising
- 30 – 0.1 wt.% to 80 wt.% NCO-terminal prepolymer,
 - 0.001 wt.% to 0.5 wt.% 1,8-diazabicyclo(5.4.0)undec-7-ene (DBU) and
 - 0.001 wt.% to 20.0 wt.% water,

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

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

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 (120).

14. A microporous zeolite mineral particle (110), the microporous zeolite mineral particle (110) having pores (111) that form openings on the outer surface of the microporous zeolite mineral particle (110), wherein the outer surface of the microporous zeolite mineral particle (110) is partly coated with a polyurethane coating (120), wherein the coating extends for a distance into some of the pores (111), forming reinforcements (140), the reinforcements (140) forming openings (150) that provide a passage for sorbing water into the pores (111) and/or desorbing water from the pores (111).

15. Use of the microporous zeolite mineral particle in accordance with claim 14 as artificial turf infill.

16. 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) according to one of the claims 1 to 13.

Fig. 1

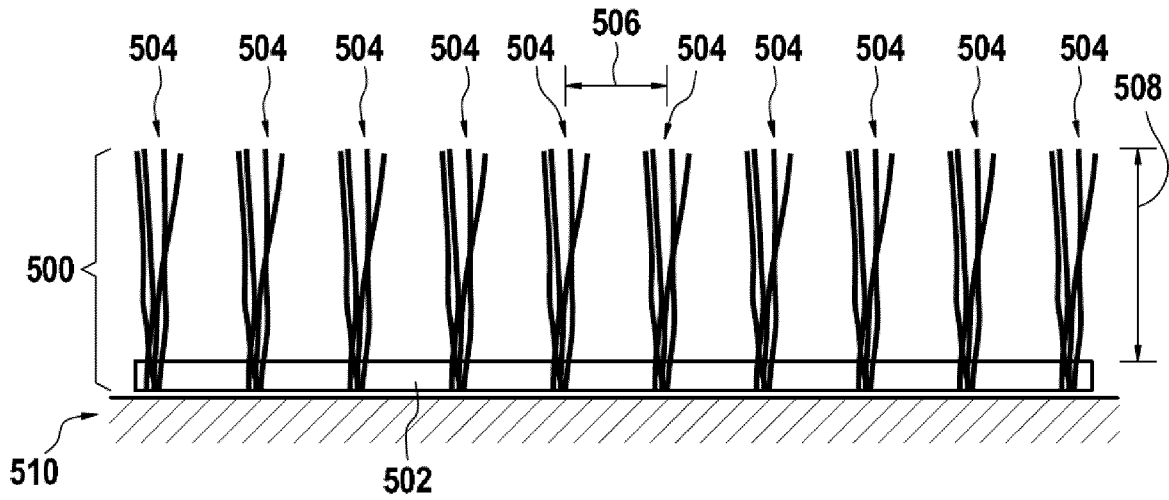


Fig. 2

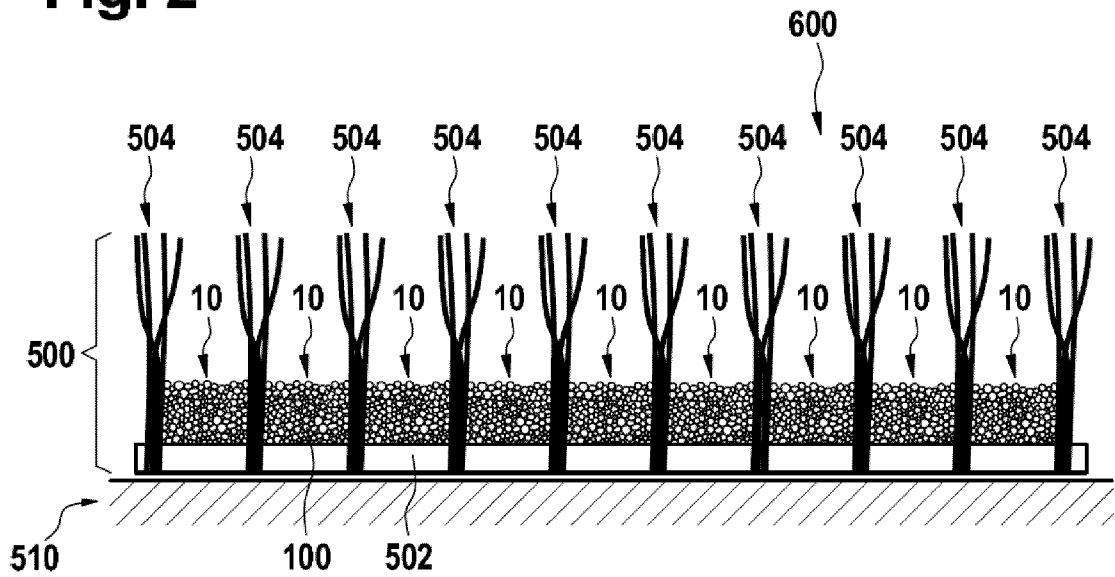


Fig. 3

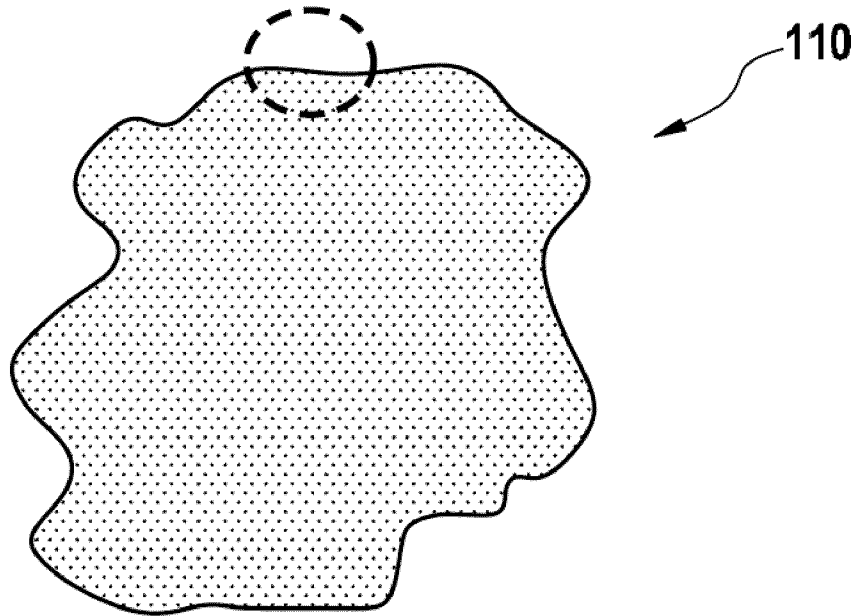


Fig. 4

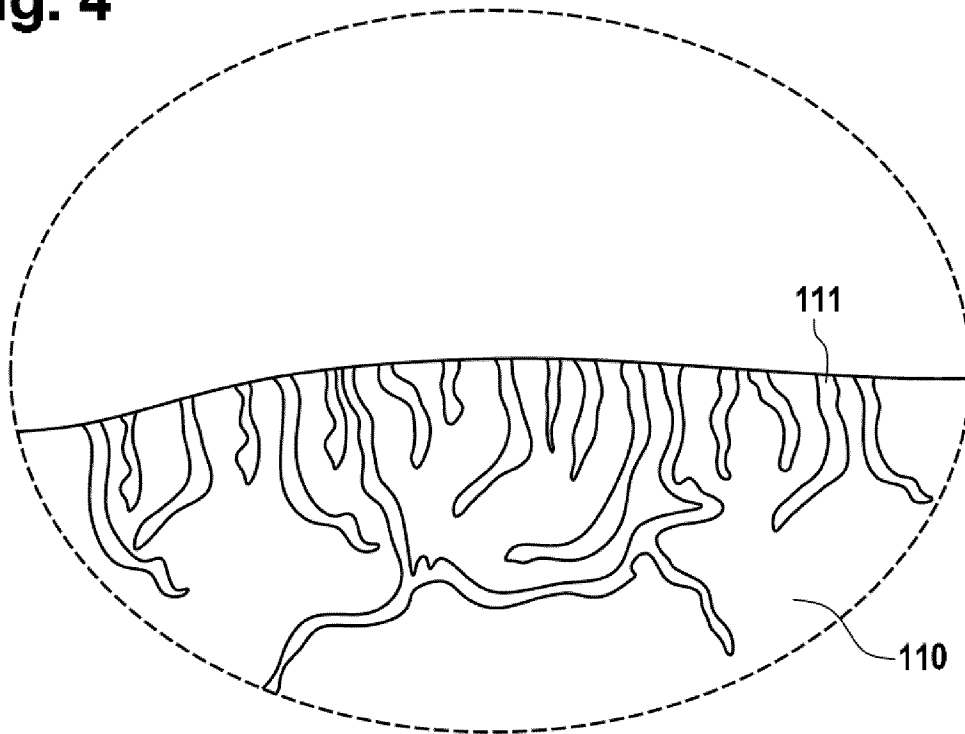


Fig. 5

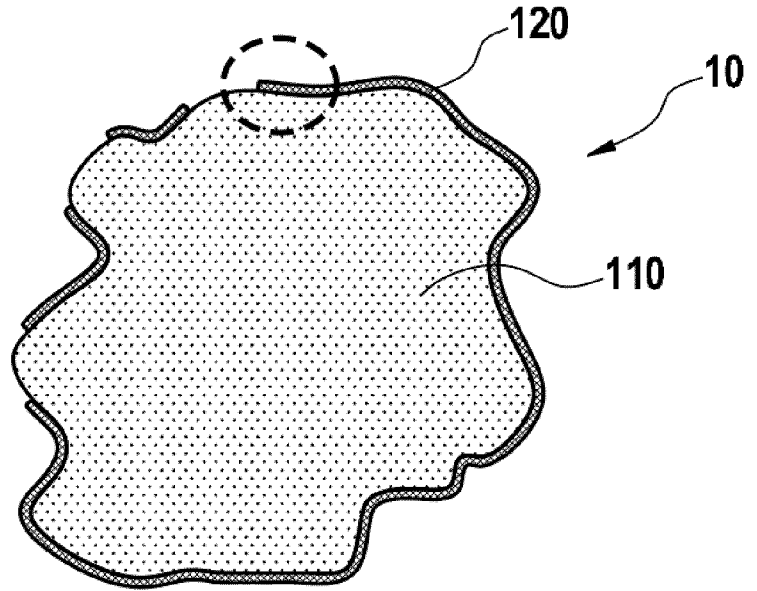


Fig. 6

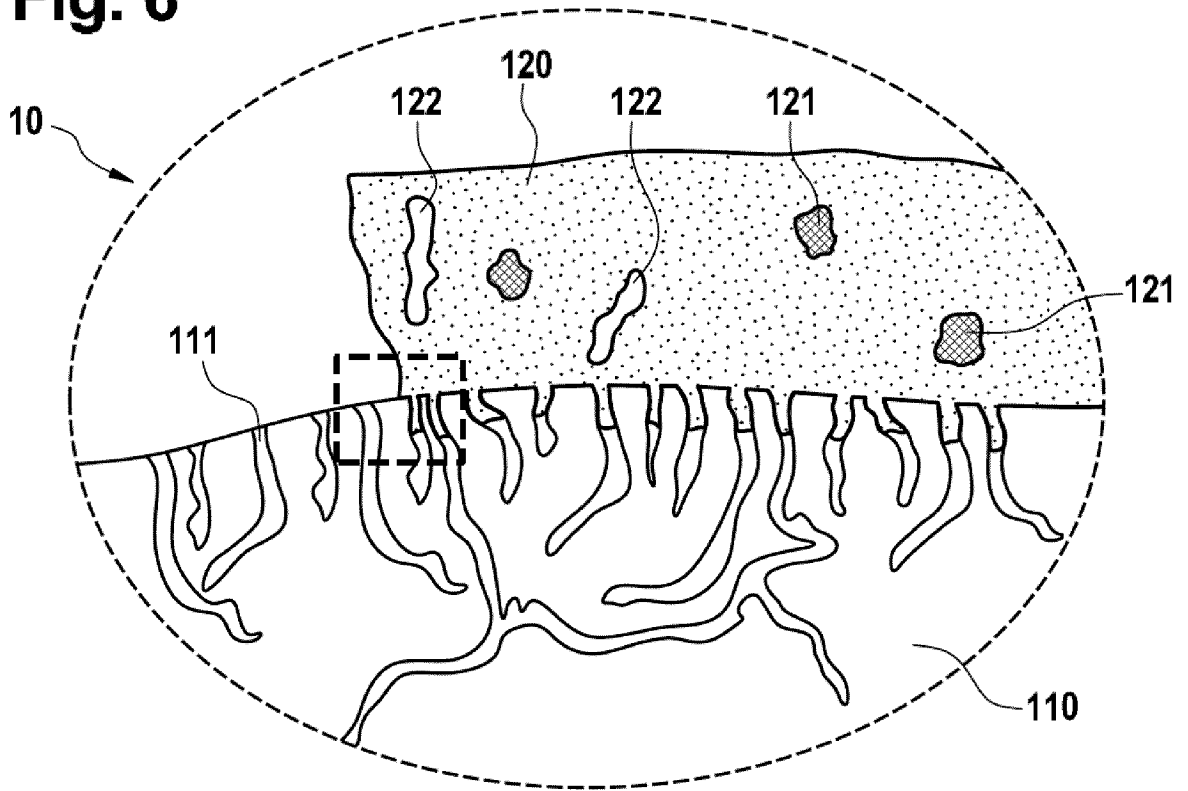


Fig. 7

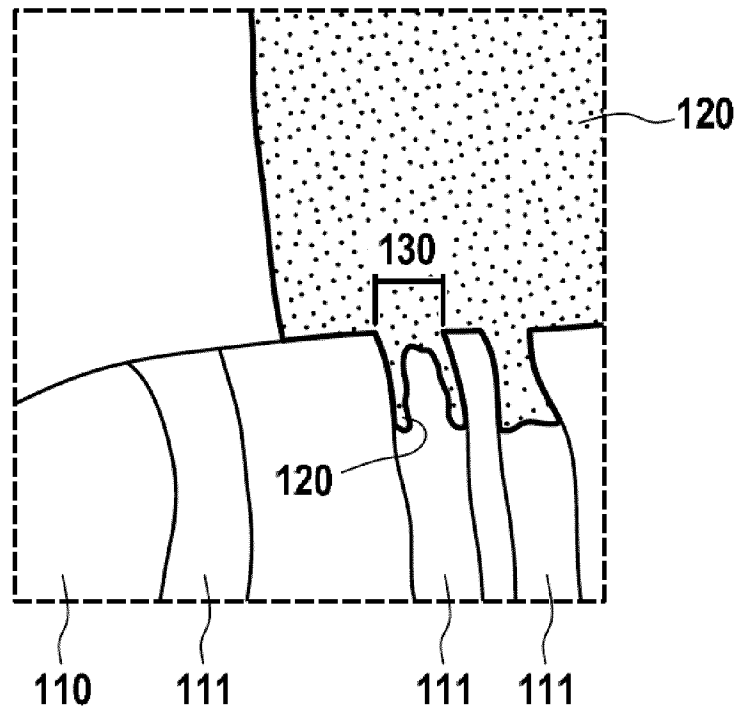


Fig. 8

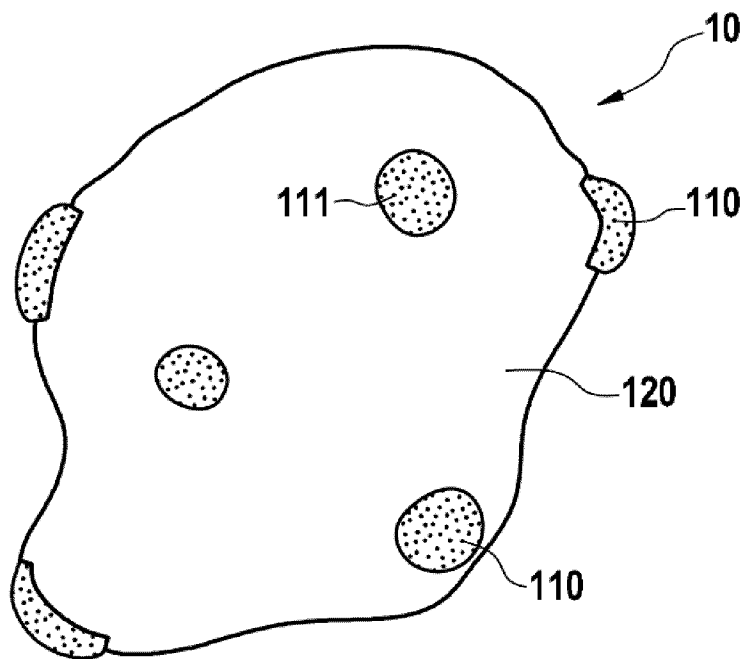
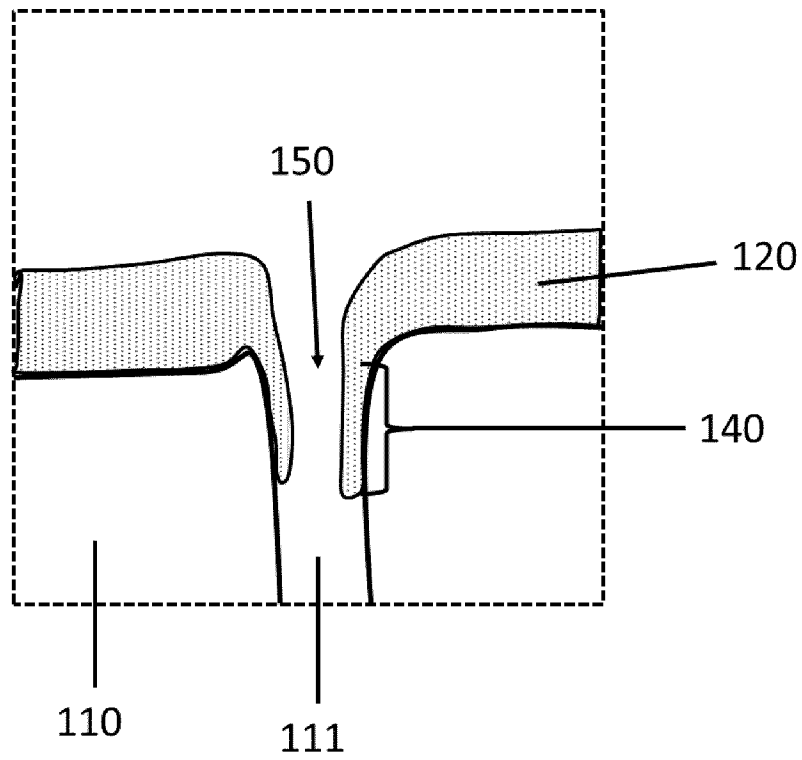


Fig. 9



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/085384

A. CLASSIFICATION OF SUBJECT MATTER
INV. E01C13/08
ADD.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
E01C C09D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

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Y	the whole document	5,8,9, 12,13
X	US 10 066 345 B2 (PROFILE PRODUCTS LLC [US]) 4 September 2018 (2018-09-04)	1-4,6,7, 10,14-16
Y	cited in the application the whole document	5,8,9, 11-13
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	paragraph [0024] - paragraph [0029]	
	-/--	

Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
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- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search 16 March 2020	Date of mailing of the international search report 23/03/2020
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Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Kerouach, May
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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/085384

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Information on patent family members

International application No

PCT/EP2019/085384

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