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(54) **Method for applying a layer of a particulate material to the surface of a substrate**

(57) The present invention relates to a method for providing at least part of a surface of a substrate with one or more functional properties, comprising the steps of applying to the said part of the surface a layer of an adhesive, subjecting the adhesive to an electric charge, de-

positing a layer of a particulate material on top of the adhesive using electrostatic deposition, wherein the layer thickness of the adhesive is smaller than the average particle diameter of the particles of the particulate material, and hardening or curing the adhesive.

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Description

[0001] The present invention relates to a method for providing at least part of a surface of a substrate with one or more functional properties. The present invention also relates to a substrate or a backing material, having a surface at least part of which has been functionalised.

[0002] Methods for applying a structural effect to the surface of a substrate are well known in the art. Particularly known is the technique for applying a textured, velvety appearance to a surface, by electrostatic application of short fibres, frequently referred to as "flocking". Flock design applications are found on many items for decorative purposes, such as decorative wall coverings, garments, greeting cards, trophies, promotional items, toys, book covers etc. The velvety texture of the flocked part is achieved by the positioning of a plurality of parallel extending fibres with an identical length, in a desired orientation with respect to the adhering surface. To orient the fibres in a plane substantially perpendicular to the adhering surface, the fibres are coated with a polarizing coating to provide each fibre with a negative and positive charged end. The technique of flocking can be applied to a wide variety of substrates such as glass, metal, plastic, paper, textiles, etc. Typical flocking materials include synthetic fibrous plastic materials, for example nylon, rayon or polyester, in particular their monofilament fibres with an average diameter of from 10 nm to 100 μm and a length of 0.25 mm to 5 mm. The use of particles with larger dimensions, in particular a larger diameter, has not been reported.

[0003] Fibre deposition is usually carried out using dedicated equipment which makes use of electrostatic fibre deposition. A substrate is coated with an adhesive, and either the substrate or the adhesive is connected to an electrode, and earthened. The fibres are propelled at high velocity to the adhesive coated substrate by means of an electrostatic field. In order to achieve that the fibres extend under a desired angle with respect to the surface of the substrate, the substrate is enveloped within an electrostatic field whose lines of force extend in the desired angle with respect to the substrate. As the fibres collide with the substrate, they will align themselves with the electrostatic field, impinge and penetrate the adhesive at the desired angle to the substrate and stick to the adhesive. After the adhesive has cured, the excess of unattached fibres may be removed.

[0004] A limiting step in the flocking process is the manufacture of suitable short fibres from long fibres. Because of numerous barriers, in particular particle, surface, technical, surface-particle, surface-particle-technical and economic barriers, the flocking technology currently exclusively uses as particles very small - typically petroleum based coloured - plastic fibres with an average diameter of from 10 nm to 100 μm and a length of 0.25 mm to 5 mm.

[0005] US4,899,411 discloses a process for applying a flocking fiber to a cloth surface of a shoe, wherein a clean dry cloth shoe is sprayed with an adhesive, which

adheres to the cloth substrate without excess penetration. The adhesive is selected such that it shows a short set time and is not water soluble when set. Flock fibers are carried into a charge in an electrostatic field, voltage is applied to the electric field, and the flock fibers are applied so that they adhere to the adhesive surface. After the shoe has been dried in a drying oven, it is ready for use.

[0006] JP03260179 discloses a method for producing a flexible, powder-attached sheet body with a peelable paper, wherein an adhesive is applied to the sheet body and a flock is deposited using electrostatic flocking. As the flock is prepared from an aqueous dispersion, the deposited flock will be rather thick and inhomogeneous.

[0007] US5,019,748 discloses an electroluminescent panel and a method for its manufacturing. According to that method, electroluminescent phosphor particles of a particle size varying from e.g. 5 to 38 micron are deposited electrostatically from a phosphor particle batch, onto a carrier strip coated with a cured first dielectric layer. The largest particles are disposed substantially side-by-side without stacking of large particles atop one another. The layer thickness does not exceed the largest size phosphor particulate in the batch. A substantially uniform distribution across the surface is said to be achieved. The carrier strip with the deposited phosphor particulate layer is then moved past a second adhesive depositing device to deposit a second transparent high dielectric constant radiation-curable adhesive on the phosphor particulate layer to fill interstitial voids between the phosphor particles and overcoat the particles on the side opposite from the first adhesive layer to a selected thin depth of overcoat. The second dielectric layer is directly cured. The first and second cured dielectric layers encapsulate the phosphor particles in a thin high dielectric constant matrix. The second dielectric layer is then coated with a thin metallic layer.

[0008] US4,319,942 discloses an adhesive composition useful for the production of composite structures or laminates consisting of a fiber flocked rubber sheet and a metal base, wherein the adhesive fulfils the functions of adhering the flocked fiber to the rubber sheet as well as adhering the rubber sheet to the metal base. The rubber sheet may be cured at the same time as the adhesive composition.

[0009] Currently there is an increased tendency to the use of natural materials, the appreciation of their properties is continuously growing. For example materials like cork, wood and natural stones such as marble or granite find widespread use in a wide variety of applications. However, the resources of these natural materials are limited. Artificial materials seeking to imitate these natural materials have been developed, which however do not always provide the properties appreciated in the original material.

[0010] The invention therefore seeks to provide a method for providing a surface of a substrate with functional properties, which would otherwise only be obtain-

able with a substrate that is entirely of a material showing those functional properties.

[0011] This is achieved according to the present invention with a method showing the technical features of the characterising portion of the first claim.

[0012] Thereto, the method according to the invention electrostatic spray deposition for providing at least part of a surface of a substrate with one or more functional properties, comprising the steps of applying to the said part of the surface a layer of an adhesive, subjecting the adhesive and/or the substrate to an electric charge, depositing a layer of a particulate material on top of the adhesive using electrostatic spray deposition, wherein the layer thickness of the adhesive is smaller than the average particle diameter of the particles of the particulate material, and hardening or curing the adhesive.

[0013] In electrostatic spray deposition, particles that may be electrostatically charged are subjected to an electrostatic field that propels the particles at high speed on to the adhesive coated substrate. Because of the high velocity that is imparted to the particles, the particles will penetrate the adhesive film to a maximum possible degree, thereby ensuring a strong adhesion to the substrate and a maximal stacking density of the particles. The electrostatic field is generated between the adhesive and/or the substrate and a particulate material deposition device. The adhesive may be subjected to an electric charge, or else an electric charge applied to the substrate will induce an electric charge at the adhesive applied on top of the substrate.

[0014] By selecting the thickness of the adhesive layer such that it is smaller than or equal to the average particle diameter of the particles of the particulate material, it may be ensured that the amount of particulate material applied to the substrate may be limited to a monolayer. Thereby, the maximum extent to which a particle may be embedded is a full embedding. Often particles will be embedded in the adhesive only partially, and part of the particle will extend from the adhesive and be exposed. An appropriate selection of the thickness of the adhesive layer thus permits to apply a particulate material to the surface of a substrate and thereby provide the substrate surface with the desired material properties and inherent functionality of the particulate material. This may be achieved by using a minimum amount of particulate material.

[0015] Any excess particulate material that does not adhere to the substrate surface, may be removed. Usually this will be the material that is applied in excess of a monolayer. To that end a suitable technique may be chosen which does not affect the layer of the particulate material that is adhering to the substrate surface, nor the properties of the particulate material. Suitable techniques include application of compressed air, brushing, but other techniques considered suitable by the skilled person may be used as well.

[0016] The method of the present invention shows the advantage that it is suitable for use with a wide variety

of particulate materials. In other words the skilled person has the possibility of choosing from a wide variety of functionalities he wants to apply to a substrate, at a minimum risk to affecting the intrinsic properties of the particulate material and/or the intrinsic properties of the substrate.

[0017] In the method of this invention the substrate may possibly be electrically charged, and subjected to some heating or IR or UV radiation or any other circumstances needed to achieve curing or hardening of the adhesive. Although hardening and/or curing may result in some heat effect, the temperature of the particles and the pressure to which they are subjected will usually not raise to such an extent that the nature and/or properties of the particles will be affected in an undesired manner. Mostly the temperature of the particulate material will remain virtually unaffected. Also, displacement of the particulate material in the electrostatic field during electrostatic deposition will usually not result in the particulate material to undergo any chemical reaction, although the occurrence of a chemical reaction may be sought on purpose by selecting an appropriate composition of the particulate material. Advantageously, there is a minimum risk that electrostatic spray deposition to apply the particulate material and hardening or curing of the adhesive, would affect the substrate or the substrate surface. Advantageously also, the present invention shows a minimum risk to affecting the nature and/or properties of the particulate material.

[0018] In electrostatic spray deposition, particles are directed towards the surface of a substrate under the influence of an electrostatic field. Without wanting to be bound to any theory, the inventors believe that the preservation of material properties and inherent functionality may be attributed to the fact that the particles of the particulate material are embedded in the adhesive to a limited extent only, the remaining part of the particles extending with respect to the adhesive and being exposed to the environment. The exposed part therewith presents the particle material properties and functionality to the environment. The present invention thus permits to transfer the properties of a particulate material to the surface of a substrate, and thereby minimise the amount of particulate material consumed needed to achieve this. The particles that have been applied to and adhere to the substrate surface have been found to perform their function much more effectively in comparison to free particles. The process of this invention permits to minimise waste since the non-adhering particles may be re-used. Moreover, by an appropriate choice of the adhesive and the particles adhering thereto, the particles may be removed from the substrate surface after they have performed their function.

[0019] Typical examples of properties or functionality that may be imparted by a particulate material to the surface of the substrate include colour, density, absorption properties for example heat - sound - vapour - smell, resilience, fire resistance properties, hydrophobic or hydrophilic properties, anti-microbial properties, anti-corro-

sion properties, structural effects, conductivity, taste, smell, haptic, look, to name but a few, or a combination of two or more of the afore-mentioned properties.

[0020] In a typical example according to this invention, the surface of a wall or a floor is coated with a monolayer of cork particles, to provide the wall with the typical properties of cork, such as heat and sound insulating properties, shock reduction and absorption properties, at minimum material consumption. Moreover, if the functionality of the substrate is to be changed in a later stage, a further material can be applied on top of the particulate monolayer. The present invention thus shows the additional advantage of permitting to apply the properties and functionality of a material to the surface of a substrate, whereby only a minimum amount of material is needed.

[0021] Although today plenty of techniques exist with which a material can be applied to the surface of a substrate, currently no technique exists with which one single technique permits to apply particles of one or more materials of widely varying origin, nature, size, shape and functionality to the surface of a substrate, the nature, shape and composition of which may vary as well, as is done by the present invention. Thereby the particulate material may be applied, in a way which preserves the properties that are inherent to these particles and the material of which they are made. The present invention therewith addresses actual sustainability criteria, which seek to minimise material and energy use per unit of surface area and per unit of function.

[0022] A vast number of particulate materials is capable of being electrostatically charged, and is thereby suitable for use in electrostatic spray deposition. To improve the property of the particulate material of being capable to be electrostatically charged, or to render particulate materials which as such may not be electrostatically charged capable of being electrostatically charged, the particulate material used in the invention may be subjected to a pre-treatment. A suitable pre-treatment comprises subjecting the particulate material in advance of its deposition on the adhesive, to an ionising pre-treatment, in particular a chemical ionising pre-treatment. An ionising pre-treatment may comprise contacting the particulate material with a salt solution or a dispersion of an ionic salt, which is left to dry on the particles, so that the ions adhere to the particles and a charge is introduced to the particle surface. An example of a chemical ionising pre-treatment suitable for use with this invention includes contacting the particulate material with an aqueous solution of an organic or inorganic salt or a mixture of two or more salts which may be organic and/or inorganic, or subjecting the particulate material to an ionising plasma treatment. For maximum expression of the particle function, the ionising salt may be removed from the particle surface, for example by washing or dissolution or any other technique considered suitable by the skilled person, taking into account the nature of the particulate material and the nature and envisaged use of the substrate. However, the skilled person may use other techniques

to ionise the particulate material.

[0023] The present invention is suitable for use with a wide variety of particulate materials, in particular materials of natural origin, more particularly natural materials which themselves take the form of a particle in nature, for example seeds, grains, flowers, etc. Other suitable natural materials are those which may be converted into particles by any suitable treatment, for example milling, sawing, grinding etc. Examples of such materials include cork, bark, wood, cereals, seeds, for example flower seeds or cereal seeds, press cakes from juice or oil extractions, lignocellulosic side streams from cereal processing, other lignocellulosic materials, grind coffee, short natural fibres, fish scales, shells, whole algae cells, particles of edible materials such as starch and flour, synthetic and mineral particles etc.. Within the scope of this invention, the substrate surface may also be provided with a mixture of two or more of the afore mentioned materials as the particulate material. According to another embodiment, a first part of the substrate surface may be coated with a first particulate material, a second part of the surface may be coated with a second particulate material different from the first. Within the scope of the present invention, synthetic materials may be used as well as a source for the particulate material, for example particulate materials of petrochemical origin, for example plastic materials.

[0024] The average particle size of the particulate material used with the present invention may vary within wide ranges. In a preferred embodiment the particles of the particulate material have an average particle size between 1.0 nm and 2.5 cm, preferably between 100 nm and 2.5 cm, more preferably between 1 micrometer, and 2 cm, most preferably between 5 micrometer and 1.5 cm, most preferably between 10 micrometer and 1.5 cm. Particles having an average particle size of at least 1 micrometer, more preferably at least 5 micrometer, most preferably at least 10 micrometer, may be preferred. The use of larger particles with an average particle size of at least 10 micrometer may be associated with a desirable visual effect. The particulate material may be mono disperse or poly disperse with regard to the average particle size. The particle size distribution curve, showing the number of particles as a function of their size, may be wide or narrow.

[0025] The shape of the particles of the particulate material used in the present invention may vary widely and may be chosen by the skilled person taking into account the nature of the intended use of the substrate. Particles may for example have a non-symmetrical shape or a more symmetrical shape, particles may for example be substantially ball shaped, fibrous, cylindrical, cubic, they may have the form of seeds etc., or a mixture of two or more different shapes. The particles may have a shape which is also selected from the group of rounded, oblong, edged, grain like, or a mixture of two or more hereof. The particles may be massive or hollow, they may have a high or small porosity. The particulate material of the

present invention may consist of a material with one single shape or a mixture of various shapes.

[0026] Where appropriate, before being applied to the substrate surface, the particulate material may be pre-treated to give it an envisaged functionality. This way, the particulate material may be impregnated for example with a perfume or a chemical, for example an herbicide, insecticide or fungicide, which is released from the material in a delayed release.

[0027] According to the invention the particles are preferably applied to the surface of the substrate in a random orientation, and extend randomly in all directions. A random orientation may be easily achieved with particles having a symmetric shape, in particular with particles the dimensions of which in x, y and z direction are virtually the same or differ within limited ranges only. For example, preferred particles to be applied in random orientation have a length/width or a height/width ratio of smaller than 3. If the application so requires, the particles may be oriented as well, and all extend in a same direction. For example, where use is made of seeds as the particulate material to coat a bottle, the seeds may all extend with their length axis extending parallel to the bottle axis. According to another embodiment, the particles on a first part of the substrate surface take a first orientation, and the particles on a second part of the substrate surface take a second orientation which may be the same as or different from the first orientation. The orientation of the particles with respect to the surface may be adapted by amending the orientation of the surface with respect to the electrostatic spray deposition device.

[0028] The inventors have observed that when use is made of particles with an average particle size of at least 1 micrometer, more preferably at least 5 micrometer, most preferably at least 10 micrometer, and a length/width or a height width ration that is higher than 1, for example 1.5 or 2.0 or more, particles will usually not orient themselves perpendicular to the substrate surface, but will rather take a position where their longitudinal axis extends under an angle of less than 90°, for example less than 60° or less than 30° with respect to the substrate surface. Often such particles will orient themselves substantially parallel to the substrate surface.

[0029] Within the scope of this invention, the wording "adhesive" refers to any material or formulation of adhesive-components that can be used as a binder for binding the particulate material to the surface of the substrate or backing material to be coated. Usually the adhesive will be selected in such a way that it is suitable for use in the appropriate climate and technology conditions. Within the scope of this invention, a wide variety of adhesive materials may be used, i.e. synthetic as well as natural adhesives may be used, the adhesive may for example be bio-based or food grade. The skilled person will be capable of selecting the appropriate adhesive taking into account the nature of the substrate, the nature of the particulate material and the envisaged application. Examples of suitable bio-based adhesives include carbo-

hydrates, proteins, oils, modified oils, natural latex, natural resins etc. Other examples of suitable adhesives suitable for use with this invention include acrylic based adhesives, epoxy adhesives, adhesives made from polymers of synthetic latex, polychloroprene, acrylonitrile, styrene-butadiene, urethanes or any combinations thereof, combinations with acrylics and melamine or other cross-linking resins and systems, or any combinations thereof.

[0030] The thickness of the layer of the adhesive material used in the method of this invention may vary within wide ranges. The skilled person will be capable of selecting the appropriate thickness taking into account the particle size distribution of the particulate material, and the layer thickness of particulate material to be applied. Preferably the thickness of the layer of the adhesive material is selected so as to permit adhesion of a monolayer of the particulate material only, in particular the layer thickness of the adhesive will usually be smaller than or equal to the average particle diameter of the particles of the particulate material. The thickness of the layer of the adhesive material is also determined by the surface roughness of the substrate surface and the porosity of the substrate.

[0031] After the particulate material has been applied to the substrate surface the adhesive needs to be hardened or cured. The way in which hardening or curing of the adhesive is achieved may vary depending on the nature of the adhesive. Hardening or curing may for example be achieved by curing of the adhesive at low temperature, by exposing the adhesive to UV-light or subjecting the adhesive to electron beam curing or by any other suitable technique known to the skilled person. If so desired, a combination of two or more of the aforementioned techniques may be used as well.

[0032] The adhesive may be applied to the entire surface of the substrate or to certain parts of the substrate surface only. The adhesive may be applied randomly or according to a certain geometric pattern, depending on the pattern in which the particulate material is to be applied. Throughout the surface the same adhesive may be used, or the nature of the adhesive may be varied over the surface. Since the particles only adhere to the part of the surface area to which the adhesive has been applied, it is therefor also possible to cover only a limited surface area, or a plurality of discrete surface areas with the particulate material.

[0033] The person skilled in the art will be capable of identifying for a certain particulate material, the optimal adhesive and the optimal thickness of the adhesive layer in particular when it is envisaged to realise a specific function for a specific surface-particulate material combination. The skilled person may thereto make use of experimental design techniques which involve statistical parameter optimisation techniques, for example Plackett-Burman experimental design, performed by high-throughput test technology.

[0034] The method of the present invention is suitable

for use with a wide variety of materials, in particular a wide variety of substrates, adhesives and particulate materials. The method of the present invention is suitable for use with two-dimensional surfaces as well as surfaces which extend in three dimensions. By varying the nature of the particulate material, the average particle size of the particulate material and the particle size distribution of the particulate material, the appearance and functionality of a substrate surface may be varied. This way for example the appearance of the coated surface may vary from a coating in which the particles are oriented in a single direction, to a surface covered with particles extending in all directions.

[0035] Within the scope of this invention, "Electrostatic spray deposition" refers to the technique of electrostatic spray deposition of particles which is well known to the skilled person and which is for example used in the technique of flocking. Within the scope of this invention, electrostatic spraying deposition may be carried out using a heated particulate material and/or a heated substrate surface. It may however be preferred to carry out the electrostatic spray deposition under ambient conditions of temperature and pressure.

[0036] The conditions in which electrostatic deposition of the particle material is carried out are preferably selected such that the particulate material may penetrate the adhesive to a sufficient extent. Optimum coating in combination with a desired adhesive strength of the particles to the surface may thereby be achieved. Thus a surface layer may be produced with a good wear resistance, with irreversibly and strongly adhered particles.

[0037] The inventors believe that electrostatic spray deposition contributes to the preservation of the material properties and inherent functionality of the particulate material, since application or coating of the particulate material to the adhesive may be carried out at any desired temperature or pressure, and will be chosen by the skilled person taking into account the nature of the adhesive and the nature of the particulate material.

[0038] Any particulate material present on the substrate surface, in excess of a monolayer may be removed before taking the substrate coated with the particulate material into use. This material can be re-collected and may be re-used. Thus, the amount of waste may be reduced to a minimum. Removal of excess particulate material may be carried out using any technique considered suitable by the skilled person. Preferably however a removal technique is selected from the group of contacting the substrate surface with compressed air, brushing or other similar techniques.

[0039] After the particulate material has been applied to the substrate surface, the substrate is in principle suitable for its intended use. For some applications it may however be desirable to coat the particulate material with a coating, for example a protective coating, for example a coating to shield the particulate material from moisture, from the ambient environment, to impart an additional colour or additional physical or chemical properties to the

particulate material.

[0040] Within the scope of this invention, with "substrate surface" is meant, the surface of any product, made of any suitable material. The substrate may be two-dimensional, for example a sheet, a thin plate, a thin laminate, a wall, a ceiling, a floor or any other two dimensional object. The substrate may be chosen from a wide variety of materials, it may for example be made of a natural or a biological material, it may be mineral-based or petroleum-based, a dead material or a living material. Examples of two dimensional surfaces suitable for use with this invention include stone or plaster wall surfaces, wood, cork, metal, glass, ceramic, fibre-reinforced composites panels, sheets of a thermoset resin, sheets of a thermoplastic resin, textile, food products such as biscuits, chocolate bars, bread, meat, ... The surface may also be the surface of a three dimensional object, for example a bottle, a cube or any other object or combination of objects. Examples of three dimensional objects suitable for use with this invention include boat surface, car parts, drinking cups, design objects, fruit, meat, skin, nails, ... Still other applications include design panels for interior, luxury packaging, furniture, design products, food products, industrial catalysts, water and gas purification panels. A special application is the use of this technique to apply cork particles on boat hulls in order to reduce drag and fouling.

[0041] The present invention also relates to a substrate having a surface, at least one part of which is functionalised, wherein the functionalised part is covered with a layer of at least one adhesive, a face of the adhesive opposite the face contacting the substrate surface being covered with a monolayer of at least one particulate material, wherein the adhesive has a layer thickness which is smaller than or equal to the average particle diameter of the particles of the particulate material, wherein the particulate material is capable of being electrostatically charged and wherein the particles are at most partly embedded in the adhesive..

[0042] The nature of the particulate material, substrate surface and adhesive are as described above. Also the positioning of the particulate material is as described above.

[0043] In a particular embodiment, the substrate takes the form of a sheet, and one surface of the sheet is coated with a particulate material. The thus coated substrate is suitable for being applied to the surface of a further substrate, wherein the surface coated with the particulate material is further coated with a layer of an adhesive. The adhesive then assures adhesion of the particulate coated substrate to the further substrate. This way a layer imparting desired properties, for example sound or heat insulating properties, may be installed between two adjacent substrate surfaces.

[0044] Several particle deposition techniques exist for the treatment of a surface. However, none of the existing techniques appears capable of applying a structural effect to the surface of a substrate.

[0045] In powder coating, a melting powder is applied to a conductive substrate by electrostatic means, and the powder is molten at a temperature above 150°C. Although the technique is suitable for coating two and three dimensional surfaces, the finishing effect is 'paint-like', the functionality of the powder is not maintained, and almost no structure can be applied while the energy consumption to achieve the curing temperature is high. Powder coating is suited for use with conductive substrates only and is not suitable for use with non-melting powders. Extensive cleaning using chemicals is needed to remove any trace of dirt or grease. Nonconductive substrates such as wood panels need to be pre-treated to render them conductive, before the powder coating is applied. Powder coating is not suited for substrates with melting temperature or glass transition temperature below the curing temperature of the powder. This excludes most thermoplastic substrates.

[0046] Sandpaper is produced by electrostatic attraction of mineral powder on a flexible substrate that has been coated with an adhesive, curing the adhesive at elevated temperature, applying a second layer of adhesive, followed by a second cure at elevated temperature. Application of the second adhesive layer impacts the particle properties such as colour, gloss, anti-microbial and absorption properties of the surface. This technique is not suitable for use with three dimensional objects.

[0047] Another existing technology involves compounding of a powder of a natural or bio-based material in a thermoplastic resin. Due to the high compounding temperatures, often above 130°C, the natural or bio-based material is discoloured and turns brown, thus implying an unwanted colour to the resin in which it is incorporated. When use is made of particles of a low density compressible material such as for example cork, the high pressure prevailing in the compounding process causes the particles to be compressed, as a result of which they lose their density-reduction properties. A similar effect is produced when incorporating plastic foam particles in a thermoplastic resin. Other properties that may be adversely affected by the compounding process of thermoplastic compounds are the structure effects induced by the particulate material, which may turn out differently than expected and the absorption and antimicrobial properties of the compounded thermoplastic material. In order to achieve a sufficient decorative or structural effect, which is observable at the surface of the substrate, high concentrations of natural material need to be incorporated in the thermoplastic resin, as the natural material will be distributed over the mass of the thermoplastic resin. As the natural material is incorporated in the thermoplastic resin, it cannot provide a structural effect to the substrate surface. Compounding of a natural particulate material in a thermosetting resin permits to minimise discoloration when blending it into the thermosetting resin, since this can be done at low temperature and pressure. However, the resulting coverage of the surface of a substrate by the particulate material obtained

by moulding of the thermosetting resin is limited, giving a rather glossy surface. Furthermore, as a result of moulding of the thermosetting resin, several functional properties inherent to the nature of the particulate material deteriorate, such as absorption properties, anti-microbial properties, structure effects.

[0048] Application of a suspension of particulate material in a binder using for example blade coating or air-knife coating, is another well known technique used to apply a layer of a mineral material of virtually constant thickness to for example a paper surface or a surface of a different material. However, an even distribution of the suspension on a three dimensional object is difficult to achieve. Adhesion strength may vary with the nature of the substrate material (metal, plastics, smaller or larger porosity...) and application of larger particles with an average particle size above 100 µm proved to be difficult. Dusting of a particulate material on a surface covered with a layer of an adhesive material, often gives an uneven particle distribution over the surface, varying degree of coverage, and is difficult to carry out on three dimensional objects.

[0049] The present invention is further elucidated in the figures and figure description below.

Figure 1 shows a cylinder, having a first and second part of its surface coated with respectively a first and second particulate material.

Figure 2 shows a surface of a substrate coated with particles of a varying particle size, wherein the particles extend in a wide variety of directions.

[0050] Figure 1 shows a cylinder 1, having a first part 2 of its surface covered with a first adhesive on top of which a first particulate material has been applied. The particulate material consists of mainly cubic particles which extend in random direction, the particles have a uniform size. A second part 3 of the surface of the cylinder is coated with a second adhesive which may be the same as the first adhesive or different therefrom. On top of the second adhesive a second particulate material has been applied, which is substantially beam shaped, and the beams extend parallel to each other. The beam shaped particles have a uniform particle size.

[0051] The present invention is further elucidated in the examples below.

Examples.

Example 1. A design object.

[0052] A glass bottle, with the exception of the neck of the bottle, was covered with an acrylic based adhesive. The adhesive was earthed. The bottle was subjected to an electric field. Cork particles having an average particle size of between 0.5 and 1.0 mm were sprayed to the surface of the bottle, by electrostatic spray deposition.

[0053] This way, the cork bottle could be covered with

a monolayer of cork particles.

Example 2. A slow release surface.

[0054] A HDF plate was covered with a bio-based urethane adhesive with a spray gun. The adhesive was set to dry at an ambient temperature for 5' in order to saturate the absorbing substrate. A second coat of adhesive (<100 µm thick) was sprayed followed by the electrostatic application of a layer of 50-250 µm corncob particles treated to improve their conductivity until an even coverage was obtained. Excess particles were removed by the electrostatic tool. The coated plate was dried for 20' at 80°C and further brushed to remove non-adhered particles. The resulting plate shows a smooth wear-resistant layer of corncob particles evenly distributed on the surface. The surface retains the absorbing properties of corncob particles so then various liquids can now be sprayed absorbed and slowly released by the material.

Example 3. Coating of a flexible substrate.

[0055] A sheet of a cured thermosetting resin was produced. One surface of the sheet was covered with an adhesive with a spray gun. The adhesive was set to dry at an ambient temperature for 5 minutes. The adhesive was earthed. The substrate was subjected to an electric field. Cork particles having an average particle size of between 0.5 and 1.0 mm were sprayed to the surface of the substrate by electrostatic spray deposition to cover the substrate with a monolayer of cork particles. Any excess particles were removed using brushing. The resulting coated sheet shows an improved shock absorbing property obtained by the inherent resilience of the cork granules.

Claims

1. A method for providing at least part of a surface of a substrate with one or more functional properties, comprising the steps of applying to the said part of the surface a layer of an adhesive, subjecting the adhesive to an electric charge, depositing a layer of a particulate material on top of the adhesive using electrostatic deposition, wherein the layer thickness of the adhesive is smaller than the average particle diameter of the particles of the particulate material, and hardening or curing the adhesive.
2. A method as claimed in claim 1, wherein in advance of depositing the particulate material onto the substrate, the particulate material is subjected to an ionising pre-treatment.
3. A method as claimed in claim 2, wherein the ionising treatment of the particulate material involves applying a coating to the particles of the particulate mate-

rial, in particular contacting the particulate material with a solution of an organic or inorganic salt, or subjecting the particulate material to a plasma treatment, or a combination of these techniques.

4. A method as claimed in any of the previous claims, wherein the particulate material is a mixture of particles having a symmetrical shape or an asymmetrical shape.
5. A method as claimed in claim 4, wherein the particles have a shape which is selected from the group of rounded, oblong, edged, grain like, or a mixture of two or more hereof.
6. A method as claimed in any of the previous claims, wherein the particles of the particulate material have an average particle size between 1.0 nm and 2.5 cm, preferably between 100 nm and 2.5 cm, more preferably between 1 micrometer, and 2 cm, most preferably between 5 micrometer and 1.5 cm, most preferably between 10 micrometer and 1.5 cm.
7. A method as claimed in any of the previous claims, wherein the particles are deposited on the substrate surface in a random orientation.
8. The method of any of the previous claims, wherein an excess of particulate material that has not adhered to the adhesive, is removed from the substrate surface.
9. The method the previous claim, wherein removal of excess particulate material is carried out using a technique selected from contacting the functionalised surface with compressed air, by brushing the functionalised surface or a combination hereof.
10. The method of any of the previous claims, wherein hardening or curing of the adhesive is achieved by heating the adhesive to an appropriate temperature, by UV curing, electron-curing or a combination of two or more of these techniques.
11. A method according to any one of the previous claims, wherein the at least one particulate material is applied to one or more discrete areas of the substrate surface.
12. A substrate having a surface, at least one part of which is functionalised, wherein the functionalised part is covered with a layer of at least one adhesive, a face of the adhesive opposite the face contacting the substrate surface being covered with a monolayer of at least one particulate material, wherein the adhesive has a layer thickness which is smaller than or equal to the average particle diameter of the particles of the particulate material, wherein the partic-

ulate material is capable of being electrostatically charged and wherein the particles are at most partly embedded in the adhesive..

13. A substrate according to claim 12, wherein the particulate material takes a random orientation. 5

14. A substrate as claimed in claim 12 or 13, wherein the particles of the particulate material have an average particle size between 1.0 nm and 2.5 cm, preferably between 100 nm and 2.5 cm, more preferably between 1 micrometer, and 2 cm, most preferably between 5 micrometer and 1.5 cm, most preferably between 10 micrometer and 1.5 cm. 10

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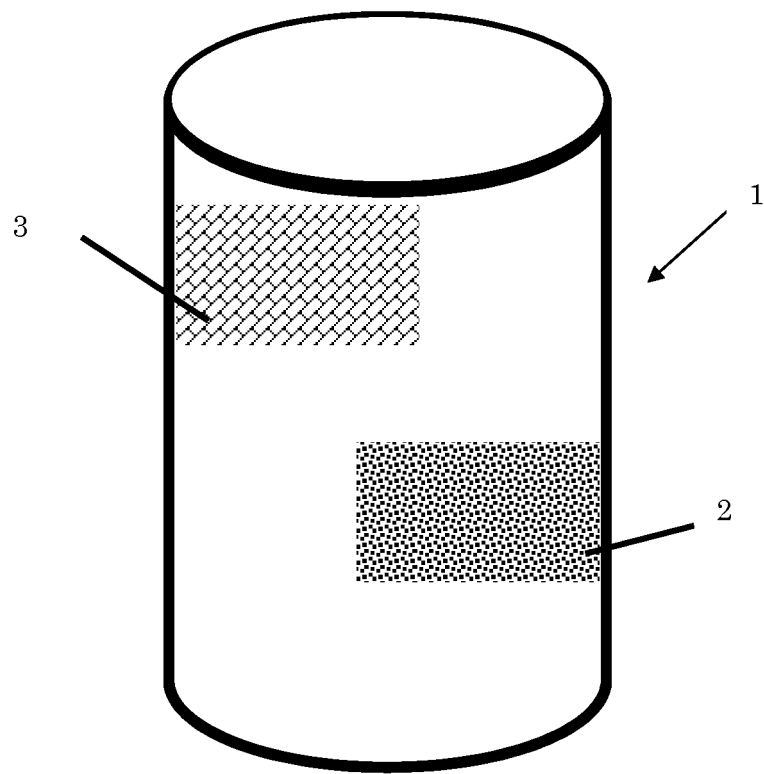


Fig. 1

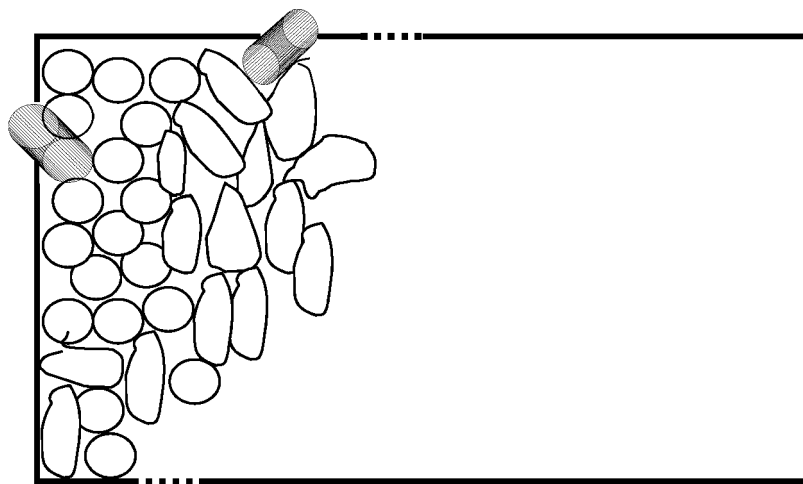


Fig. 2



EUROPEAN SEARCH REPORT

 Application Number
 EP 15 15 3799

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