



(51) International Patent Classification:

D06C 29/00 (2006.01) *B24D 11/00* (2006.01)
A47L 13/16 (2006.01) *C11D 17/04* (2006.01)
A47L 13/17 (2006.01)

(21) International Application Number:

PCT/US2016/059657

(22) International Filing Date:

31 October 2016 (31.10.2016)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

14/934,529 6 November 2015 (06.11.2015) US

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(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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(54) Title: METHODS FOR FABRICATING FIBROUS STRUCTURES CONTAINING SHAPED PARTICLES

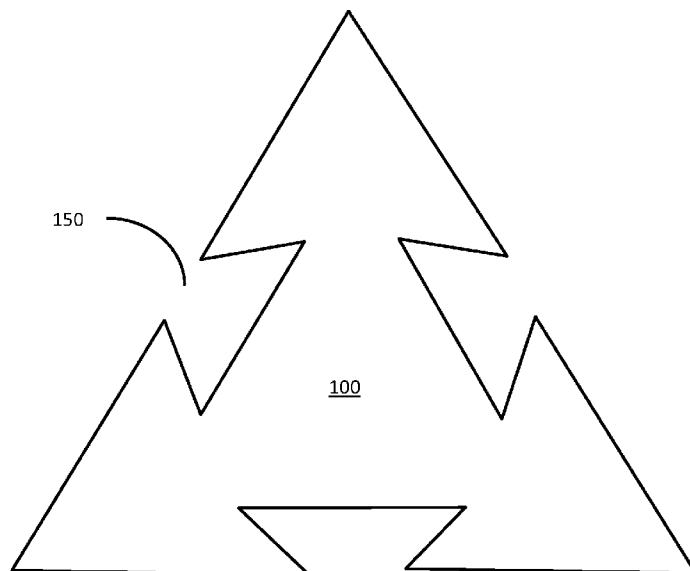


Fig. 1

(57) Abstract: A process for mechanically anchoring a shaped particle on a fibrous substrate, the process comprising steps of: providing a fibrous substrate comprising at least one fibrous layer; depositing the particle onto the surface of at least 1 fibrous layer of the substrate; and vibrating the substrate.



(84) **Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE,

SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

METHODS FOR FABRICATING FIBROUS STRUCTURES CONTAINING SHAPED PARTICLES

FIELD OF THE INVENTION

5 The invention relates to processes for manufacturing fibrous structures containing shaped particles. The invention relates particularly to processes for manufacturing fibrous structures containing shaped particles adapted as cleaning elements.

BACKGROUND OF THE INVENTION

10 Articles containing abrasive components such as particles are known in the art. Such articles may be used for cleaning a variety of surfaces; especially those surfaces that tend to become soiled with difficulty to remove stains and soils.

Such articles may comprise a substrate and a plurality of abrasive particles where the abrasive particles are disposed either on the surface of the substrate or within the substrate such that the
15 abrasive particles at least partially protrude from at least one surface and the substrate during use. Examples of substrates that might include such abrasive particles include nonwoven articles including disposable wipes, paper towel, floor wipes, home care napkins, beauty care napkins, and baby wipes. Examples of abrasive particles include inorganic particles such as carbonate salt, clay, silica, silicate, shale ash, perlite and/or organic particles such as polymeric beads
20 comprised of polypropylene, PVC, melamine, urea, polyacrylate and derivatives.

When used as a component of a nonwoven article, many commonly known abrasive particles may not be fully satisfactory. The abrasive particles may separate from the rest of the article, in particular while scouring is exercised with the article. This may lead to inefficient cleaning and to unacceptable deposition of particles on the surface to be cleaned. Separately, the abrasive
25 particles may move or “roll” while scouring, relative to the substrate, again leading to a loss of their abrasive cleaning efficiency.

The inventors have discovered that this could be alleviated by the use of particles having specific shape. This shape may be expressed as the “Solidity” of the particles.. Selecting particles of the specified solidity may lead to both improvements in extent to which the particles are retained by
30 the substrate, and improvements in cleaning by preventing “rolling” of the particles and

maintaining the orientation of the particles, relative to the substrate and therefore relative to the surface being cleaned, during scouring.

Also, maintaining the orientation of the particles relative to the substrate may generate less damage to the surface to be cleaned.

5 The performance of the abrasive particles improves when the particles are bound to the substrate. When the particles are not physically immobilized on or in the substrate, the performance may decrease and the abrasive particles may fall off the sheet before or during use, creating an undesirable residue on the target surface and the hands of the user. When glues are used to bind the particles, the glue often covers a significant fraction of the particles, hindering its effectiveness and scrubbing performance. When the amount of glue is minimized, the adhesion of particles on the substrate may be ineffective, especially upon usage. Therefore it is highly desirable to provide a particle with a shape engineered to deliver both good scrubbing and self adhesion on the substrate, via mechanical anchoring.

15 SUMMARY OF THE INVENTION

In one aspect, a process for mechanically anchoring a shaped particle on a fibrous substrate, the process comprising steps of: providing a fibrous substrate comprising at least one fibrous layer; depositing the particle onto the surface of at least 1 fibrous layer of the substrate; and vibrating the substrate.

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BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 provides a schematic cross-sectional view of a particle according to one embodiment of the invention.

Fig. 2 provides a schematic perspective view of a portion of an article according to one embodiment of the invention.

25

DETAILED DESCRIPTION OF THE INVENTION

All percentages, ratios and proportions used herein are by weight percent unless otherwise specified.

30 As used herein, the mean Equivalent Circle Diameter (ECD) is measured according to ASTM F1877-05 Section 11.3.2 or similar to the area-equivalent diameter (ISO 9276-6:2008(E) section 7). The mean ECD of particle population is calculated as the volume-weighted average of

respective ECD of a particle population of at least 1000 particles, or at least 10,000 particles, or above 50,000 particles, or above 100,000 particles after excluding from the measurement and calculation the data of particles having area-equivalent diameter (ECD) of below 10 micrometers.

- 5 As used herein, the term Feret Diameter is defined as the distance between two parallel tangents of the projection of the particle at an arbitrary angle.

As used herein, Form factor is a mesoshape descriptor and is a quantitative, 2-dimension image analysis shape description and is being measured according to ISO 9276-6:2008(E) section 8.2. Form factor is sometimes described in literature as being the difference between a particle's
10 shape and a perfect sphere. Form factor values range from 0 to 1, where a form factor of 1 describes a perfectly spherical particle or disc-shaped particle as measured in a two dimensional projected image.

$$\text{Form Factor} = \frac{4\pi A}{P^2}$$

where A is projection area, which is 2D descriptor and P is the length of the perimeter of the particle. The applicants refer herein to Form factor as being volume-weighted mean Form Factor
15 extracted from a distribution of particle measurements. As used herein, the MOHS hardness scale refers to an internationally recognized scale for measuring the hardness of a compound versus a compound of known hardness, see Encyclopedia of Chemical Technology, Kirk-Othmer, 4th Edition Vol 1, page 18 or Lide, D.R (ed) CRC Handbook of Chemistry and Physics, 73rd edition, Boca Raton, Fla.: The Rubber Company, 1992-1993. Many MOHS Test kits are
20 commercially available containing material with known MOHS hardness. For measurement and selection of abrasive material with selected MOHS hardness, it is recommended to execute the MOHS hardness measurement with un- shaped particles e.g.: with spherical or granular forms of the abrasive material since MOHS measurement of shaped particles will provide erroneous results.

- 25 As used herein, the Shore® D hardness of the materials may be determined according to ASTM D2240-05 (2010). Shore® D hardness measurement may be carried out by using an ASTM durometer, such as the Type D Style Durometer available from Pacific Transducer Corp. of Los Angeles, California, or from ELECTROMATIC Equipment Co., Inc. 600 Oakland Ave Cedarhurst, NY 11516.

As used herein, Solidity is a quantitative, 2-dimensional image analysis shape description, and is being measured according to ISO 9276-6:2008(E) section 8.2 as implemented via the Occhio Nano 500 Particle Characterisation Instrument with its accompanying software Callistro version 25 (Occhio s.a. Liege, Belgium). While particle shape can be defined in 3-dimension with dedicated analytical technique, the applicant has found, that the characterization of the particles shape in 2-dimension is most relevant and correlates with the abrasive performance of the cleaning particles. During the particle shape analysis protocol, the particles are orientated toward the surface – via gravity deposition - similarly to the expected particle orientation during the cleaning process. Hence, the object of the present invention regards the characterization of 2-D shape of a particle/particle population as defined by the projection of its shape on the surface on which the particle/particle population is deposited.

The non-spherical particle herein has at least one edge or surface having a concave curvature. Solidity is a mesoshape parameter, which describes the overall concavity of a particle or particle population. Solidity values range from 0 to 1, where a solidity number of 1 describes a non-concave particle, as measured in literature as being:

$$\text{Solidity} = A/A_c$$

Where A is the projected area of the particle and A_c is the area of the convex hull (envelope) bounding the projection of the particle. The applicants refer herein to solidity as being volume-weighted mean solidity extracted from a distribution of particle measurements.

As used herein, the terms “mean solidity”, or “mean Form factor”, mean the volume-weighted average of the solidity, or Form Factor values from a population of at least 1000 particles, or at least 10,000 particles, or above 50,000 particles, or above 100,000 particles, after excluding from the measurement and calculation, the solidity or form factor data of particles having area-equivalent diameter (ECD) of below 10 micrometers.

As used herein, the Vickers hardness HV is measured at 23 °C according to standard methods ISO 14577-1, ISO 14577-2, ISO 14577-3. The Vickers hardness is measured from a solid block of the raw material at least 2 mm in thickness. The Vickers hardness micro indentation measurement is carried out by using the Micro-Hardness Tester (MHT), manufactured by CSM Instruments SA, Peseux, Switzerland. As per the ISO 14577 instructions, the test surface should be flat and smooth, having a roughness (Ra) value less than 5% of the maximum indenter

penetration depth. For a 200 micrometer maximum depth this equates to a Ra value less than 10 micrometer. As per ISO 14577, such a surface may be prepared by any suitable means, which may include cutting the block of test material with a new sharp microtome or scalpel blade, grinding, polishing or by casting melted material onto a flat, smooth casting form and allowing it to thoroughly solidify prior testing.

Suitable general settings for the Micro-Hardness Tester (MHT) are as follows:

Control mode: Displacement, Continuous

Maximum displacement: 200 μm Approach speed: 20 nm/s

Zero point determination: at contact

10 Hold period to measure thermal drift at contact: 60s

Force application time: 30s

Frequency of data logging: at least every second

Hold time at maximum force: 30s

Force removal time: 30s

15 Shape / Material of indenter tip: Vickers Pyramid Shape / Diamond Tip

As used herein, the term nonwoven means: a manufactured sheet, web or batt of directionally or randomly orientated fibers, bonded by friction, and/or cohesion and/or adhesion, excluding paper and products which are woven, knitted, tufted, stitch-bonded incorporating binding yarns or filaments, or felted by wet-milling, whether or not additionally needled. The fibers may be of natural or man-made origin and may be staple or continuous filaments or be formed in situ. Commercially available fibers have diameters ranging from less than 0.001 mm to more than 0.2 mm and they come in several different forms: short fibers (known as staple, or chopped), continuous single fibers (filaments or monofilaments), untwisted bundles of continuous filaments (tow), and twisted bundles of continuous filaments (yarn). Nonwoven fabrics can be formed by many processes such as meltblowing, spunbonding, solvent spinning, electrospinning, and carding. The basis weight of nonwoven fabrics is usually expressed in grams per square meter (gsm).

In one embodiment, a disposable dry fibrous substrate comprises non-spherical, abrasive, cleaning particles mechanically anchored to the fibers of the substrate.

The fibrous substrate

The fibrous substrate, or web, may comprise synthetic fibers and/or natural fibers. The fibers
5 may be water insoluble. The fibrous substrate may have a basis weight of between 10 and 100 grams per square meter.

Synthetic fibers suitable for use in the substrate of the disclosed wipe may include, but are not limited to, nylons, polyesters, acrylics, olefin fibers such as polyethylene and polypropylene, carbon fibers, glass fibers, metal fibers.

10 The natural fibers may be cellulose-containing fibers including, but not limited to, cotton fiber, flax fiber, hemp fiber, sisal fiber, jute fiber, kenaf fiber, bamboo fiber, coconut fiber, and wood pulp. Naturally derived fiber suitable for use in this disclosure may include, but are not limited to, rayon, lyocell, and viscose or other materials derived from natural fibers. For example, lyocell may be derived from wood pulp, viscose may be derived from wood or cotton fibers, and rayon
15 may be derived from a wide variety of cellulose-containing natural fibers. The web of fibers may comprise at least 80% of cellulosic fibers. The web of fibers may be a paper substrate.

The web of fibers may be formed by water or air or mechanical entanglement, meltblown, spunbond, thermally or chemically bond. The fibers may comprise carded, staple, wet laid, air
20 laid and/or spunbond fibers. The web of fibers may be made according to a hydro-entangling process.

Processes to prepare the web of fibers comprising paper include wet-laid papermaking processes and air-laid papermaking processes, and embossing and printing processes. Such processes typically comprise the steps of preparing a fiber composition in the form of a suspension in a
25 medium, either wet, more specifically aqueous medium, or dry, more specifically gaseous (i.e., with air as medium). The aqueous medium used for wet-laid processes is oftentimes referred to as a fiber slurry. The fibrous suspension is then used to deposit a plurality of fibers onto a forming wire or papermaking belt such that an embryonic fibrous structure can be formed, after which drying and/or bonding the fibers together results in a fibrous structure. Further processing
30 the fibrous structure can be carried out such that a finished fibrous structure can be formed. For

example, in typical papermaking processes, the finished fibrous structure is the fibrous structure that is wound on the reel at the end of papermaking, and can subsequently be converted into a finished product (e.g., a sanitary tissue product). Fibrous structures can be made by methods known in the art, including by the method and apparatus described in U.S. Patent No. 4,637,859,
5 issued Jan. 20, 1987, to Trokhan.

The article may comprise one or more webs of fibers disposed in face-to-face relationships with each other. The respective webs may be adhesively, thermally or mechanically bonded to each other. The abrasive particle elements may be disposed upon the surfaces of the layers or webs of the article. The particles may be disposed upon the layers in a pattern. The pattern may cover less
10 than 30% of the surface area of the substrate. The pattern may be disposed upon an external surface of a multi-layer substrate, or upon an internal surface of the overall substrate between respective layers of the overall structure.

The abrasive particles:

In one embodiment, the shaped particles have a longitudinal length (L) and a predetermined
15 complex cross-sectional shape extending on a plane perpendicular to said longitudinal length (L). The cross-sectional shape has at least one vertex. An edge extends along the length L from the vertex. The particles further comprise an anchoring element disposed away from the edge. The ratio of said length (L) to a perimeter-equivalent diameter of said predetermined cross-sectional shape “ECD P_{Hull} ” is between about 0.5 and about 5.

20 The anchoring element comprises the development of a portion of the cross-sectional shape along the length L. The anchoring element may comprise a simple curved hook shape extended along L, or the anchor element may comprise a more complex polygonal, curved, or hybrid, curved and polygonal cross-sectional portion extended along L. Exemplary anchor element cross-sectional shapes include: barbs, catches, hasps, crooks, claws and modifications of letters and numbers
25 including M, S, C, W, 3, and 6. In one embodiment, the anchoring element may be considered to have at least one concavity as described below. The relative dimensions of the particle, the anchoring element, and the fibers of a substrate enable the anchoring elements to capture the substrate fibers and to entangle the particle among the fibers attaching the particles to the substrate.

30 In one embodiment, the predetermined cross-sectional shape comprises a plurality of vertices wherein edges extend along L from each of the vertices. The shape further comprises a plurality of anchoring elements, each anchoring element disposed away from at least one edge.

In one embodiment, the abrasive cleaning particles comprise extruded, and/or three-dimensional printed, elements having a longitudinal length (L) extending parallel to a z-axis and a complex cross-sectional shape extending on a plane perpendicular to said longitudinal length (L) and parallel to an x-y plane of the fiber. The complex cross-sectional shape has at least one concave, or hollowed inward, area. The elements have at least one elongate protrusion projecting in a direction parallel to the longitudinal length (L), each protrusion having at least one edge. The complex cross-sectional shape is a predetermined cross-sectional shape. In one embodiment, the abrasive particles may have an appearance which contrasts with that of the substrate. In this embodiment, the user of the article may easily discern the presence of the particles as part of the article.

In one embodiment, the diameter of the largest inscribed disk $D_{\text{max-in-disk}}$ disposed in the x-y plane into one concavity of the element is at least equal or above the minimum Feret diameter F_{min} of the smallest fiber of the dry substrate.

The $D_{\text{max-in-disk}}$ and minimum Feret diameter may each be measured using microscopy to obtain images of the fibers and particles together with appropriate measurement tools as are known in the art.

In one embodiment, $D_{\text{max-in-disk}}$ is between 1.5 to 20 times the minimum Feret diameter F_{min} of the smallest fiber of the dry substrate. In one embodiment, $D_{\text{max-in-disk}}$ is between 2 to 10 times the minimum Feret diameter F_{min} of the smallest fiber of the dry substrate. In one embodiment, $D_{\text{max-in-disk}}$ is between 4 to 8 times the minimum Feret diameter F_{min} of the smallest fiber of the dry substrate.

In one embodiment, the minimum Feret diameter F_{min} of the smallest fiber of the disposable dry substrate is between 8 to 100 microns. In one embodiment, the minimum Feret diameter F_{min} of the smallest fiber of the disposable dry substrate is between 10 to 50 microns. In one embodiment, the minimum Feret diameter F_{min} of the smallest fiber of the disposable dry substrate is between 10 to 25 microns.

In one embodiment, $D_{\text{max-in-disk}}$ is between 10 and 400 microns. In one embodiment, $D_{\text{max-in-disk}}$ is between 20 and 200 microns. In one embodiment, $D_{\text{max-in-disk}}$ is between 40 and 160 microns. In one embodiment, $D_{\text{max-in-disk}}$ is between 60 and 120 microns. In one embodiment, from 20 to 200 microns. In one embodiment, from 40 to 160 microns. In one embodiment, from 60-120 microns.

In one embodiment, the cross-sectional shape of the elements has a form factor of from 0.05 to 0.5 as measured according to ISO 9276-6. In one embodiment, the cross-sectional shape of said

elements has a form factor of from 0.1 to 0.4. In one embodiment, the cross-sectional shape of said elements has a form factor of from 0.1 to 0.3. In one embodiment, the cross-sectional shape of said elements has a form factor of from 0.1 to 0.2.

In one embodiment, the cross-sectional shape of the elements has a solidity of from 0.1 to 0.7.

5 In one embodiment, the cross-sectional shape of the elements has a solidity of from 0.2 to 0.6.

In one embodiment, the cross-sectional shape of the elements has a solidity of from 0.2 to 0.55.

In one embodiment, the cross-sectional shape of the elements has a solidity of from 0.2 to 0.45.

In one embodiment, the ratio of the length (L) to equivalent circle diameter of said predetermined cross-sectional shape "ECD P_{Hull} " is from 0.5 to 5. In one embodiment, the ratio of the length (L) to equivalent circle diameter of said predetermined cross-sectional shape "ECD P_{Hull} " is from 0.8 to 4. In one embodiment, the ratio of the length (L) to equivalent circle diameter of said predetermined cross-sectional shape "ECD P_{Hull} " is from 1 to 3. In one embodiment, the ratio of the length (L) to equivalent circle diameter of said predetermined cross-sectional shape "ECD P_{Hull} " is from 1.5 to 2.5. In one embodiment, the length of the elements (L) is between 50 and 1000 microns. In one embodiment, the length of the elements (L) is between 100 and 500 microns. In one embodiment, the length of the elements (L) is between 200 and 400 microns. In one embodiment, the ECD P_{Hull} is from 40 μm to 800 μm . In one embodiment, the ECD P_{Hull} is from 100 μm to 600 μm . In one embodiment, the ECD P_{Hull} is from 200 μm to 400 μm . In one embodiment, the abrasive particles may have an ECD of between 5% and 100% of the thickness of the fibrous substrate.

In one embodiment, the cross-sectional shape has a maximum Feret diameter F_{max} of between 100 μm and 800 μm . In one embodiment, the cross-sectional shape has a maximum Feret diameter F_{max} of between 200 μm and 500 μm . In one embodiment, the cross-sectional shape has a maximum Feret diameter F_{max} of between 250 μm and 400 μm . In one embodiment, the cross-sectional shape has a maximum Feret diameter F_{max} of between 50 μm and 350 μm .

In one embodiment, the elements may comprise portions of an extruded fiber which has been segmented. The material of the fiber may be organic or inorganic. In one embodiment, the material may comprise a thermoplastic resin.

In one embodiment, the elements comprises from 3 to 30 protrusions. In one embodiment, the elements comprises from 3 to 24 protrusions. In one embodiment, the elements comprises from 3 to 20 protrusions. In one embodiment, the elements comprises from 3 to 15 protrusions. In one embodiment, the elements comprises from 3 to 6 protrusions. The protrusions may be in the form of abrasive wings. The protrusions may comprise at least one edge having an angle defined

between the surfaces defining the tip of the edge. In one embodiment, the angle may be between 10 and 90 degrees. In one embodiment, the angle may be between 20 and 80 degrees. In one embodiment, the angle may be between 30 and 60 degrees. In one embodiment, the protrusion may comprise an edge having a tip diameter of between 1 μm and 50 μm . In one embodiment, the protrusion may comprise an edge having a tip diameter of between 2 μm and 25 μm . In one embodiment, the protrusion may comprise an edge having a tip diameter of between 2 μm and 15 μm .

In one embodiment, the abrasive particle elements may be comprised of a material selected from the group consisting of polyethylene, polypropylene, polyvinyl chloride, polycarbonate, melamine, urea, polyurethane, polyacrylate, polystyrene, phenolic polyesters, polyamide, minerals and mixtures thereof. In one embodiment, the abrasive particles comprise a biodegradable material having a biodegradability rate of greater than 50% according to ASTM6400 test method, and selected from the group consisting of polyhydroxy-alkanoates, polyhydroxyButyrate, polyhydroxyButyrate-co-valerate, polyhydroxyButyrate-co-hexanoate and mixtures thereof, poly(lactic acid), polycaprolactone, polyesteramide, aliphatic and/or, aromatic copolyesters containing a mix of succinic, adipic, terephthalic diacids, propanediol, butanediol, pentanediol monomer and mixtures thereof; thermoplastic starch; and mixtures thereof.

In one embodiment, the abrasive particles comprise from 5 to 70%, by weight of particle, of reinforcing filler particles selected from the group consisting of organic materials, inorganic materials and mixtures thereof, wherein the organic material is selected from the group consisting of: nut shell, wood, cotton, flax or bamboo fibers, corn cob, rice hull, sugars, carbohydrates, starch from corn, maize, potato, or urea; other plant parts selected from the group consisting of stems, roots, leaves, seeds; polyesters; biodegradable polyesters selected from the group consisting of polyhydroxy-alkanoates, poly(lactic acid), polycaprolactone, polyesteramide, aliphatic and/or copolyesters, and mixtures thereof; and mixtures thereof; the inorganic material being selected from the group consisting of carbonate or sulfate salt, phyllosilicate material and mixtures thereof, talc, kaolinite, vermiculite, mica, muscovite, pyrophyllite, bentonite, montmorillonite, feldspar, and mixtures thereof.

Abrasive particles comprised of relatively hard materials may function better in the article. In one embodiment, the underlying material of the abrasive particles has a Mohs hardness of between 1 and 5. In one embodiment, the underlying material of the abrasive particles has a Mohs hardness of between 2 and 4. In one embodiment, the underlying material of the abrasive particles has a

Mohs hardness of between 2.5 and 3. In one embodiment, the underlying material of the abrasive particles has a Shore D® hardness between 40 and 90.

The abrasive particle elements of the invention may be produced by extruding a material, through an extruder nozzle orifice along an extruding axis, and slicing the extruded thermoplastic material into elements having a predetermined length (L). In one embodiment, the extruder nozzle orifice has a predetermined cross-sectional shape on a plane perpendicular to the extruding axis. The predetermined cross-sectional shape may be the inverse image of the predetermined cross-sectional shape of the extruded elements. In one embodiment, the material comprises a thermoplastic material or curable mineral comprising slurry.

In one embodiment, the temperature at the nozzle is kept at a temperature T_n , wherein $T_n = T_m - T$, and T is greater than 20°C, T_m being the melting temperature of said thermoplastic material.

In one embodiment, T is between 30 and 180 C. In one embodiment, T is between 80 and 150C.,

In one embodiment, the articles of the invention may be fabricated by air spraying the particles onto the surface of at least 1 fibrous layer of the substrate and vibrating the substrate. In one

embodiment, the articles of the invention may be fabricated by pre-mixing the fibers and the abrasive particulates and optionally vibrating the mixture during the formation of the fibrous layer. In one embodiment, the vibration may occur at a vibration frequency ranging between 20 and 20000 Hz.

Figure 1 provides a cross-sectional illustration of a particle 100 having concave portions 150, according to one embodiment of the invention. Figure 2 provides a perspective schematic illustration of a combination of a particle 100 and article fibers 200 according to one embodiment of the invention.

The dimensions and values disclosed herein are not to be understood as being strictly limited to the exact numerical values recited. Instead, unless otherwise specified, each such dimension is intended to mean both the recited value and a functionally equivalent range surrounding that value. For example, a dimension disclosed as “40 mm” is intended to mean “about 40 mm.”

Every document cited herein, including any cross referenced or related patent or application and any patent application or patent to which this application claims priority or benefit thereof, is hereby incorporated herein by reference in its entirety unless expressly excluded or otherwise limited. The citation of any document is not an admission that it is prior art with respect to any invention disclosed or claimed herein or that it alone, or in any combination with any other reference or references, teaches, suggests or discloses any such invention. Further, to the extent that any meaning or definition of a term in this document conflicts with any meaning or

definition of the same term in a document incorporated by reference, the meaning or definition assigned to that term in this document shall govern.

While particular embodiments of the present invention have been illustrated and described, it would be obvious to those skilled in the art that various other changes and modifications can be made without departing from the spirit and scope of the invention. It is therefore intended to cover in the appended claims all such changes and modifications that are within the scope of this invention.

CLAIMS

What is claimed is:

1. A process for mechanically anchoring a shaped particle on a fibrous substrate, the process characterized by comprising steps of:
 - i. providing a fibrous substrate comprising at least one fibrous layer;
 - ii. depositing the particle onto the surface of at least 1 fibrous layer of the substrate ;
and
 - iii. vibrating the substrate.
2. The process according to claim 1 wherein the step of vibrating the substrate comprises vibrating the substrate at a frequency between 20 and 20,000 hz.
3. A process for mechanically anchoring a shaped particle on a fibrous substrate directly during the formation of the fibrous substrate, the process comprising steps of:
 - i. mixing fibers and the shaped particles; and
 - ii. vibrating the substrate during the formation of the fibrous substrate.
4. The process according to claim 2 wherein the step of vibrating the substrate comprises vibrating the substrate at a frequency between 20 and 20,000 hz.
5. The process according to Claim 1, wherein said abrasive particles comprise elements having a longitudinal length (L) and a predetermined complex cross-sectional shape extending on a plane perpendicular to said longitudinal length (L), wherein the cross-sectional shape has at least one vertex, wherein an edge extends along the length L from the vertex, wherein the particles further comprise an anchoring element disposed away from the edge, and the ratio of said length (L) to a perimeter-equivalent diameter of said predetermined cross-sectional shape: "ECD P_{Hull} " is between 0.5 and 5.

1/2

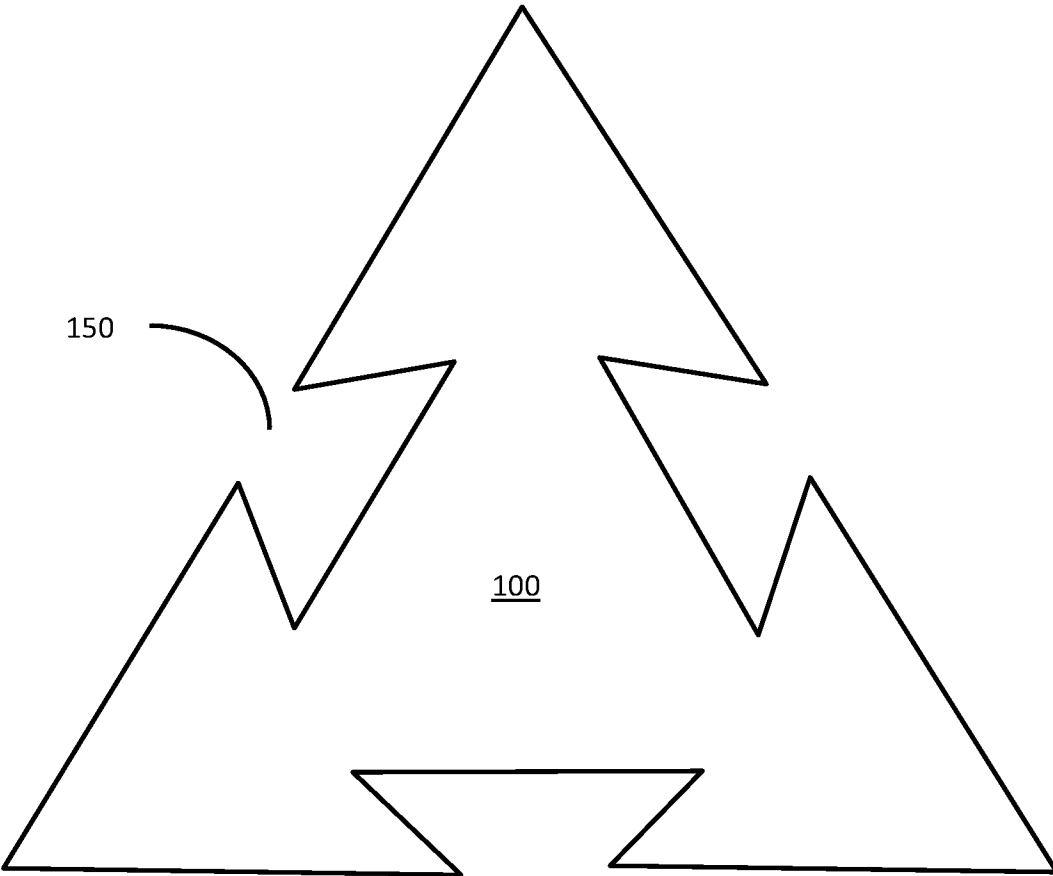
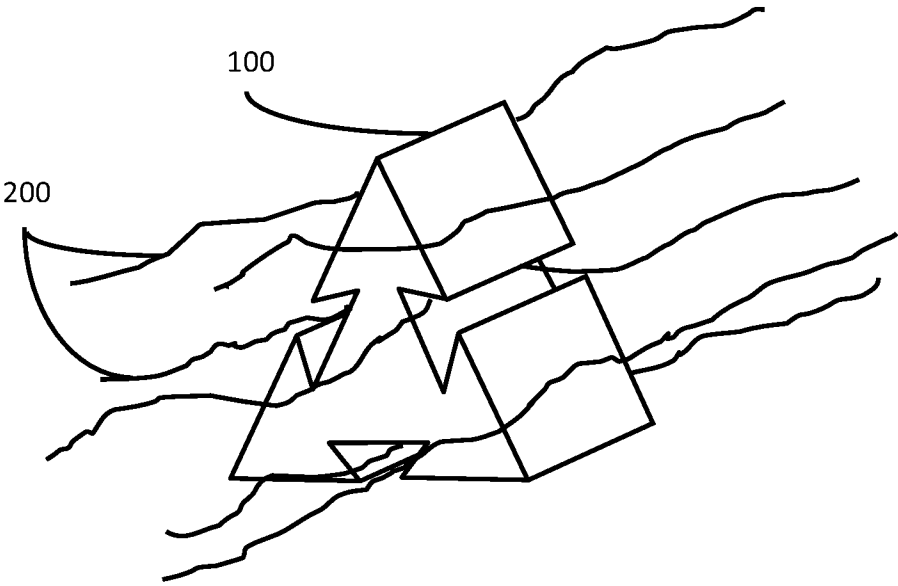


Fig. 1

2/2



1000

Fig. 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/059657

A. CLASSIFICATION OF SUBJECT MATTER
INV. D06C29/00 A47L13/16 A47L13/17 B24D11/00 C11D17/04
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)
D06C A47L B24D C11D

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2003/009949 A1 (PRICHARD PAUL D [US] ET AL) 16 January 2003 (2003-01-16) claims 1,6 -----	1-5
A	US 6 328 773 B1 (BEARDSLEY KRIS A [US] ET AL) 11 December 2001 (2001-12-11) abstract -----	1-5
A	US 2003/143911 A1 (BOISSEAU VINCENT [FR] ET AL) 31 July 2003 (2003-07-31) abstract -----	1-5



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

9 January 2017

Date of mailing of the international search report

16/01/2017

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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