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(54) Title: FLUSHABLE FIBROUS STRUCTURES

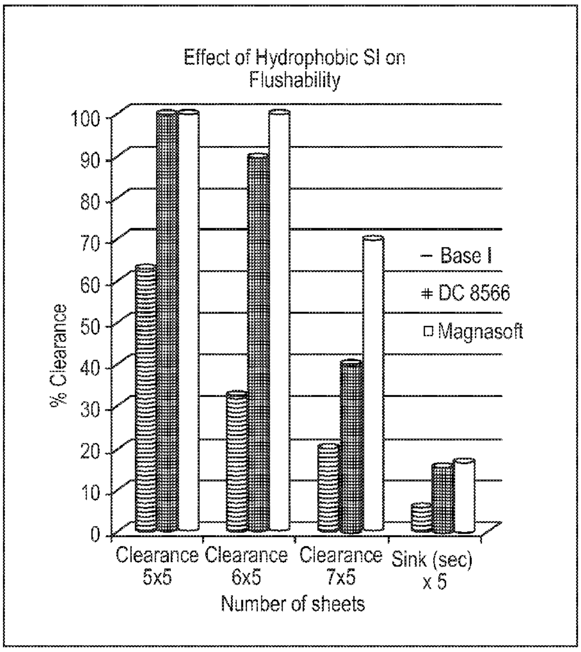

Fig. 3

(57) Abstract: Flushable fibrous structure products, including sanitary tissue products, are described. As discussed in the background section, there is a relatively narrow desirable range of floatation/sink time that can be predicative of flushability success. Fibrous structures that float can have difficulty exiting a toilet bowl. And fibrous structures that sink too fast can cause a plug at the exit point of a toilet bowl. Thus, fibrous structures and sanitary tissue products comprising the same that do not float but sink sufficiently slow when placed into a toilet so as not to cause a plug are provided.

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FLUSHABLE FIBROUS STRUCTURES

FIELD OF THE INVENTION

The present invention relates to flushable fibrous structure products.

BACKGROUND OF THE INVENTION

Flushable fibrous structures, such as toilet tissue and flushable wet wipes, are well known. There are numerous characteristics that affect how well the products exit a toilet bowl. On one hand, fibrous structures that sink too quickly can form a temporary plug at the exit of the toilet bowl, which can in turn affect the ultimate flushability of the structures. On the other hand, fibrous structures that float or take a significant amount of time to sink may not experience a sufficient level of forces during a flush to draw the fibrous structure toward and through the exit of the toilet bowl. The present invention illustrates fibrous structures that strike an appropriate balance in view of this dichotomy.

BRIEF DESCRIPTION OF THE DRAWINGS

The following detailed description of specific aspects of the present invention can be best understood when read in conjunction with the drawings enclosed herewith.

Fig. 1 is a schematic of an exemplary prior art milling process useful for separating attached trichome fibers from a host plant.

Fig. 2 is a schematic of illustrative process steps according to the present invention useful for liberating separated trichome fibers from a feedstock comprising leaves, stems, and trichome fibers.

Fig. 3 is a first bar chart that includes flushability results of sanitary tissue products with and without a silicone additive.

Fig. 4 is a second bar chart that includes flushability results of sanitary tissue products with and without a silicone additive.

Fig. 5 is another bar chart that includes flushability results of sanitary tissue products with and without trichome fibers.

DETAILED DESCRIPTION OF THE INVENTION

The following text sets forth a broad description of numerous different embodiments of the present invention. The description is to be construed as exemplary only and does not describe every possible embodiment since describing every possible embodiment would be impractical, if not impossible. And it will be understood that any feature, characteristic, component, composition, ingredient, product, step or methodology described herein can be deleted, combined with or substituted for, in whole or part, any other feature, characteristic, component, composition, ingredient, product, step or methodology described herein. Numerous alternative embodiments could be implemented, using either current technology or technology developed after the filing date of this patent, which would still fall within the scope of the claims. All publications and patents cited herein are incorporated herein by reference.

It should also be understood that, unless a term is expressly defined in this specification using the sentence "As used herein, the term `______` is hereby defined to mean..." or a similar sentence, there is no intent to limit the meaning of that term, either expressly or by implication, beyond its plain or ordinary meaning, and such term should not be interpreted to be limited in scope based on any statement made in any section of this patent (other than the language of the claims). No term is intended to be essential to the present invention unless so stated. To the extent that any term recited in the claims at the end of this patent is referred to in this patent in a manner consistent with a single meaning, that is done for sake of clarity only so as to not confuse the reader, and it is not intended that such a claim term be limited, by implication or otherwise, to that single meaning. Finally, unless a claim element is defined by reciting the word "means" and a function without the recital of any structure, it is not intended that the scope of any claim element be interpreted based on the application of 35 U.S.C. § 112, sixth paragraph.

“Fiber” as used herein means an elongate physical structure having an apparent length greatly exceeding its apparent diameter, i.e. a length to diameter ratio of at least about 10. Fibers having a non-circular cross-section and/or tubular shape are common; the “diameter” in this case may be considered to be the diameter of a circle having cross-sectional area equal to the cross-sectional area of the fiber. More specifically, as used herein, “fiber” refers to fibrous structure-making fibers. The present invention contemplates the use of a variety of fibrous structure-making fibers, such as, for example, natural fibers, such as trichome fibers and/or wood pulp fibers, or synthetic fibers, or any other suitable fibers, and any combination thereof.

“Fibrous structure” as used herein means a structure that comprises one or more fibers. Non-limiting examples of processes for making fibrous structures include known wet-laid papermaking processes and air-laid papermaking processes. Such processes typically include steps of preparing a fiber composition in the form of a suspension in a 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 belt such that an embryonic fibrous structure is formed, after which drying and/or bonding the fibers together results in a fibrous structure. Further processing the fibrous structure may be carried out such that a finished fibrous structure is 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 may subsequently be converted into a finished product, e.g. a sanitary tissue product.

Non-limiting types of fibrous structures according to the present invention include conventionally felt-pressed fibrous structures; pattern densified fibrous structures; and high-bulk, uncompacted fibrous structures. The fibrous structures may be of a homogenous or multilayered (two or three or more layers) construction; and the sanitary tissue products made therefrom may be of a single-ply or multi-ply construction.

In one example, the fibrous structure of the present invention is a pattern densified fibrous structure characterized by having a relatively high-bulk region of relatively low fiber density and an array of densified regions of relatively high fiber density. The high-bulk field is characterized as a field of pillow regions. The densified zones are referred to as knuckle regions. The knuckle regions exhibit greater density than the pillow regions. The densified zones may be discretely spaced within the high-bulk field or may be interconnected, either fully or partially, within the high-bulk field. Typically, from about 8% to about 65% of the fibrous structure surface comprises densified knuckles. The knuckles may exhibit a relative density of at least 125% of the density of the high-bulk field. Processes for making pattern densified fibrous structures are well known in the art as exemplified in U.S. Patent Nos. 3,301,746; 3,974,025; 4,191,609; and 4,637,859.

The present invention is directed to flushable fibrous structure products, including sanitary tissue products. As discussed in the background section above, there is a relatively narrow desirable range of floatation/sink time. Fibrous structures that float can have difficulty exiting a toilet bowl. And fibrous structures that sink too fast can cause a plug at the exit point of a toilet bowl. Thus, the present invention is directed to fibrous structures and sanitary tissue products comprising the same that do not float but sink sufficiently slow when placed into a toilet so as not to cause a plug.

Flushability evaluations can be made according to the Flushability Test methods described below. These methods can assess toilet bowl clearances during a flushing event, and can also assess the float and sink characteristics of a sanitary tissue product. Independent of the flushability assessments, the inventors have discovered that contact angle of a fibrous structure is one indicator of how well it will flush according to the present invention. Some fibrous structures and sanitary tissue embodiments of the present invention have a contact angle of greater than or equal to 75 degrees, 80 degrees, 90 degrees, and 100 degrees. While relatively high contact angles can be desirable, fibrous structures of the present invention should not float indefinitely when placed into a toilet bowl, as it can negatively impact ultimate flushability of the structure.

Fibrous structures of the present preferably comprise a fiber blend. The fibers blends typically include wood fibers, which can often be referred to as wood pulps include chemical pulps, such as kraft (sulfate) and sulfite pulps, as well as mechanical and semi-chemical pulps including, for example, groundwood, thermomechanical pulp, chemi-mechanical pulp (CMP), chemi-thermomechanical pulp (CTMP), neutral semi-chemical sulfite pulp (NSCS). Chemical pulps, however, may be preferred since they impart a superior tactile sense of softness to tissue sheets made therefrom. Pulps derived from both deciduous trees (hereinafter, also referred to as "hardwood") and coniferous trees (hereinafter, also referred to as "softwood") may be utilized. The hardwood and softwood fibers can be blended, or alternatively, can be deposited in layers to provide a stratified and/or layered web. U.S. Patent Nos. 4,300,981 and 3,994,771 are incorporated herein by reference for the purpose of disclosing layering of hardwood and softwood fibers. Also applicable to the present invention are fibers derived from recycled paper, which may contain any or all of the above categories as well as other non-fibrous materials such as fillers and adhesives used to facilitate the original papermaking. The wood pulp fibers may be short (typical of hardwood fibers) or long (typical of softwood fibers). Non-limiting examples of short fibers include fibers derived from a fiber source selected from the group consisting of Acacia, Eucalyptus, Maple, Oak, Aspen, Birch, Cottonwood, Alder, Ash, Cherry, Elm, Hickory, Poplar, Gum, Walnut, Locust, Sycamore, Beech, Catalpa, Sassafras, Gmelina, Albizia, Anthocephalus, and Magnolia. Non-limiting examples of long fibers include fibers derived from Pine, Spruce, Fir, Tamarack, Hemlock, Cypress, and Cedar. Softwood fibers derived from the kraft process and originating from more-northern climates may be preferred. These are often referred to as northern softwood kraft (NSK) pulps.

Hydrophobic Fibers

The inventors have discovered that the addition of a percentage of relatively hydrophobic fibers to the fiber blend can improve flushability. "Relatively hydrophobic" as that term is used herein includes fibers that are generally considered hydrophobic, fibers that are less hydrophilic than hardwood and softwood fibers, and naturally hydrophilic fibers that have been treated to be less hydrophilic. In one aspect of the present invention, trichome fibers (discussed in greater detail below) can be included into the fiber blend as a relatively hydrophobic fiber that can improve flushability of the fibrous structure. In one example, the hydrophobic fibers comprise fibers harvested from a plant. Other relatively hydrophobic fibers include synthetic fibers, such as, for example, wet spun fibers, dry spun fibers, melt spun (including melt blown) fibers, synthetic pulp fibers and mixtures thereof. Synthetic fibers may, for example, be comprised of cellulose (often referred to as "rayon"); cellulose derivatives such as esters, ether, or nitrous derivatives; polyolefins (including polyethylene and polypropylene); polyesters (including polyethylene terephthalate); polyamides (often referred to as "nylon"); acrylics; non-cellulosic polymeric carbohydrates (such as starch, chitin and chitin derivatives such as chitosan); polylactic acids, polyhydroxyalkanoates, polycaprolactones, and mixtures thereof.

Trichome fibers are one exemplary relatively hydrophobic fiber type that can be utilized to improve flushability of a fibrous structure. Fibrous structures according to this invention may contain from about 0.1% to about 100% and/or from about 0.5% to about 90% and/or from about 0.5% to about 80% and/or from about 0.5% to about 50% and/or from about 1% to about 40% and/or from about 2% to about 30% and/or from about 5% to about 25% by weight on a dry fiber basis of trichome fibers.

"Trichome" as used herein means an epidermal attachment of a varying shape, structure and/or function of a non-seed portion of a plant. In one example, a trichome is an outgrowth of the epidermis of a non-seed portion of a plant. The outgrowth may extend from an epidermal cell. In one embodiment, the outgrowth is a trichome fiber. The outgrowth may be a hairlike or bristlelike outgrowth from the epidermis of a plant. The term "individualized trichome fibers" as used herein means trichome fibers which have been artificially separated by a suitable method for individualizing trichome fibers from their host plant. In other words, individualized trichome fibers, as used herein, means that the trichome fibers become separated from a non-seed portion of a host plant by some non-naturally occurring action. In one example, individualized trichome fibers are artificially separated in a location that is sheltered from nature. Primarily, individualized trichome fibers will be fragments or entire trichome fibers with essentially no remnant of the host plant attached. However, individualized trichome fibers can also comprise a minor fraction of trichome fibers retaining a portion of the host plant still attached, as well as a minor fraction of trichome fibers in the form of a plurality of trichome fibers bound by their individual attachment to a common remnant of the host plant. Individualized trichome fibers may comprise a portion of a pulp or mass further comprising other materials, including non-trichome-bearing fragments of the host plant. "Trichome fibers", as that term is used herein is interchangeable with the term "individualized trichome fibers" as defined above.

Individualized trichomes may be converted into chemical derivatives including but not limited to cellulose derivatives, for example, regenerated cellulose such as rayon; cellulose ethers such as methyl cellulose, carboxymethyl cellulose, and hydroxyethyl cellulose; cellulose esters such as cellulose acetate and cellulose butyrate; and nitrocellulose. Individualized trichomes may also be used in their physical form, usually fibrous, and herein referred to "trichome fibers", as a component of fibrous structures.

Trichome fibers are different from seed hair fibers in that they are not attached to seed portions of a plant. For example, trichome fibers, unlike seed hair fibers, are not attached to a seed or a seed pod epidermis. Cotton, kapok, milkweed, and coconut coir are non-limiting examples of seed hair fibers. Further, trichome fibers are different from nonwood bast and/or core fibers in that they are not attached to the bast, also known as phloem, or the core, also known as xylem portions of a nonwood dicotyledonous plant stem. Non-limiting examples of plants which have been used to yield nonwood bast fibers and/or nonwood core fibers include kenaf, jute, flax, ramie and hemp. Further trichome fibers are different from monocotyledonous plant derived fibers such as those derived from cereal straws (wheat, rye, barley, oat, etc), stalks (corn, cotton, sorghum, *Hesperaloe funifera*, etc.), canes (bamboo, bagasse, etc.), grasses (esparto, lemon, sabai, switchgrass, etc), since such monocotyledonous plant derived fibers are not attached to an epidermis of a plant. Further, trichome fibers are different from leaf fibers in that they do not originate from within the leaf structure. Sisal and abaca are sometimes liberated as leaf fibers. Finally, trichome fibers are different from wood pulp fibers since wood pulp fibers are not outgrowths from the epidermis of a plant; namely, a tree. Wood pulp fibers rather originate from the secondary xylem portion of the tree stem.

Essentially all plants have trichomes. Those skilled in the art will recognize that some plants will have trichomes of sufficient mass fraction and/or the overall growth rate and/or robustness of the plant so that they may offer attractive agricultural economy to make them more suitable for a large commercial process, such as using them as a source of chemicals, e.g. cellulose, or assembling them into fibrous structures, such as disposable fibrous structures. Trichomes may have a wide range of morphology and chemical properties. For example, the trichomes may be in the form of fibers; namely, trichome fibers. Such trichome fibers may have a high length to diameter ratio.

The following sources are offered as non-limiting examples of trichome-bearing plants (suitable sources) for obtaining trichomes, especially trichome fibers.

Non-limiting examples of suitable sources for obtaining trichomes, especially trichome fibers, are plants in the *Labiatae (Lamiaceae)* family commonly referred to as the mint family.

Examples of suitable species in the *Labiatae* family include *Stachys byzantina*, also known as *Stachys lanata* commonly referred to as lamb's ear, woolly betony, or woundwort. The term *Stachys byzantina* as used herein also includes cultivars *Stachys byzantina* 'Primrose Heron', *Stachys byzantina* 'Helene von Stein' (sometimes referred to as *Stachys byzantina* 'Big Ears'), *Stachys byzantina* 'Cotton Boll', *Stachys byzantina* 'Variegated' (sometimes referred to as *Stachys byzantina* 'Striped Phantom'), and *Stachys byzantina* 'Silver Carpet'.

Additional examples of suitable species in the *Labiatae* family include the *arcticus* subspecies of *Thymus praecox*, commonly referred to as creeping thyme and the *pseudolanuginosus* subspecies of *Thymus praecox,* commonly referred to as wooly thyme.

Further examples of suitable species in the *Labiatae* family include several species in the genus *Salvia* (sage), including *Salvia leucantha*, commonly referred to as the Mexican bush sage; *Salvia tarahumara*, commonly referred to as the grape scented Indian sage; *Salvia apiana*, commonly referred to as white sage; *Salvia funereal*, commonly referred to as Death Valley sage; *Salvia sagittata*, commonly referred to as balsamic sage; and *Salvia argentiae*, commonly referred to as silver sage.

Even further examples of suitable species in the *Labiatae* family include *Lavandula lanata,* commonly referred to as wooly lavender; *Marrubium vulgare,* commonly referred to as horehound; *Plectranthus argentatus,* commonly referred to as silver shield; and *Plectranthus tomentosa.*

Non-limiting examples of other suitable sources for obtaining trichomes, especially trichome fibers are plants in the *Asteraceae* family commonly referred to as the sunflower family.

Examples of suitable species in the *Asteraceae* family include *Artemisia stelleriana*, also known as silver brocade; *Haplopappus macronema*, also known as the whitestem goldenbush; *Helichrysum petiolare; Centaurea maritime,* also known as *Centaurea gymnocarpa* or dusty miller*; Achillea tomentosum,* also known as wooly yarrow; *Anaphalis margaritacea,* also known as pearly everlasting; and *Encelia farinose,* also known as brittle bush.

Additional examples of suitable species in the *Asteraceae* family include *Senecio brachyglottis* and *Senecio haworthii*, the latter also known as *Kleinia haworthii.*

Non-limiting examples of other suitable sources for obtaining trichomes, especially trichome fibers, are plants in the *Scrophulariaceae* family commonly referred to as the figwort or snapdragon family.

An example of a suitable species in the *Scrophulariaceae* family includes *Pedicularis kanei,* also known as the wooly lousewort.

Additional examples of suitable species in the *Scrophulariaceae* family include the mullein species *(Verbascum)* such as *Verbascum hybridium,* also known as snow maiden*; Verbascum thapsus*, also known as common mullein; *Verbascum baldaccii*; *Verbascum bombyciferum*; *Verbascum broussa; Verbascum chaixii; Verbascum dumulsum; Verbascum laciniatum; Verbascum lanatum; Verbascum longifolium; Verbascum lychnitis; Verbascum olympicum; Verbascum paniculatum; Verbascum phlomoides; Verbascum phoeniceum; Verbascum speciosum; Verbascum thapsiforme; Verbascum virgatum; Verbascum wiedemannianum*; and various mullein hybrids including *Verbascum* 'Helen Johnson' and *Verbascum* 'Jackie'.

Further examples of suitable species in the *Scrophulariaceae* family include *Stemodia tomentosa* and *Stemodia durantifolia.*

Non-limiting examples of other suitable sources for obtaining trichomes, especially trichome fibers include *Greyia radlkoferi* and *Greyia flanmaganii* plants in the *Greyiaceae* family commonly referred to as the wild bottlebrush family.

Non-limiting examples of other suitable sources for obtaining trichomes, especially trichome fibers include members of the *Fabaceae* (legume) family. These include the *Glycine max,* commonly referred to as the soybean, and *Trifolium pratense L,* commonly referred to as medium and/or mammoth red clover.

Non-limiting examples of other suitable sources for obtaining trichomes, especially trichome fibers include members of the *Solanaceae* family including varieties of *Lycopersicum esculentum*, otherwise known as the common tomato.

Non-limiting examples of other suitable sources for obtaining trichomes, especially trichome fibers include members of the *Convolvulaceae* (morning glory) family, including *Argyreia nervosa,* commonly referred to as the wooly morning glory and *Convolvulus cneorum,* commonly referred to as the bush morning glory.

Non-limiting examples of other suitable sources for obtaining trichomes, especially trichome fibers include members of the *Malvaceae* (mallow) family, including *Anoda cristata*, commonly referred to as spurred anoda and *Abutilon theophrasti*, commonly referred to as velvetleaf.

Non-limiting examples of other suitable sources for obtaining trichomes, especially trichome fibers include *Buddleia marrubiifolia,* commonly referred to as the wooly butterfly bush of the *Loganiaceae* family; the *Casimiroa tetrameria,* commonly referred to as the wooly leafed sapote of the *Rutaceae* family; the *Ceanothus tomentosus,* commonly referred to as the wooly leafed mountain liliac of the *Rhamnaceae* family; the 'Philippe Vapelle' cultivar of *renardii* in the *Geraniaceae* (geranium) family; the *Tibouchina urvilleana,* commonly referred to as the Brazilian spider flower of the *Melastomataceae* family; the *Tillandsia recurvata,* commonly referred to as ballmoss of the *Bromeliaceae* (pineapple) family; the *Hypericum tomentosum,* commonly referred to as the wooly St. John's wort of the *Hypericaceae* family; the *Chorizanthe orcuttiana,* commonly referred to as the San Diego spineflower of the *Polygonaceae* family; *Eremocarpus setigerus*, commonly referred to as the doveweed of the *Euphorbiaceae* or spurge family; *Kalanchoe tomentosa,* commonly referred to as the panda plant of the *Crassulaceae* family; and *Cynodon dactylon*, commonly referred to as Bermuda grass, of the *Poaceae* family; and *Congea tomentosa*, commonly referred to as the shower orchid, of the *Verbenaceae* family.

Suitable trichome-bearing plants are commercially available from nurseries and other plant-selling commercial venues. For example, *Stachys byzantina* may be purchased and/or viewed at Blanchette Gardens, Carlisle, MA.

In one example, a trichome fiber suitable for use in the fibrous structures of the present invention comprises cellulose. In yet another example, a trichome fiber suitable for use in the fibrous structures of the present invention comprises a fatty acid. In still another example, a trichome fiber suitable for use in the fibrous structures of the present invention is hydrophobic.

In yet another example, a trichome fiber suitable for use in the fibrous structures of the present invention is less hydrophilic that softwood fibers.

Trichome fibers can be liberated from a non-seed portion of a host plant through various processes. An exemplary prior art process is shown in Fig. 1, wherein the process steps in Fig. 1 focus on milling a trichome-containing feedstock of material, and wherein the process steps in Fig. 2 focus on disassociating separated trichome fibers from non-desirable material, classifying, and collecting trichome fibers useful for making fibrous structures. Referring to Fig. 1, a feedstock that includes leaves, stems, and attached trichome fibers is fed into a vacuum system 10 that has two outlets, an upper outlet 12 to collect dust, and a lower outlet 14 to collect further processable material 16. The main purpose of vacuum system 10 is to transport the feedstock and to begin cleaning the feedstock of dirt, dust, and other waste material. Material 16 continues on to a cyclone 18 that also contains a upper outlet 20 for collecting dust, and a lower outlet 22 that feeds a hammermill 24. Magnets 26 and 28 are included to remove any metal that has been introduced into the feedstock via harvesting, transportation, or handling equipment. Hammermill 24 breaks the leaves and stems up into smaller pieces and separates at least some of the trichome fibers from leaves and stems. Referring to Fig. 2, material 30 coming out of hammermill 24 is then directly or indirectly routed to a screw conveyor 101 to feed a venturi mechanism 102. A blower 104 communicates pressurized fluid 105 to venturi mechanism 102. Pressurized fluid 105 becomes entrained with the milled feedstock 100 and is directed to a fluid flow resistor in the form of a breaker plate 106. Forces encountered because of the venturi mechanism 102 and impacting the breaker plate 106 disassociate at least some of the separated trichome fibers from the leaf and stem pieces to create a refined feedstock 110.

Trichome fibers can be sorted and collected through various techniques of processing refined feedstock 110. As exemplified in Fig. 2, refined feedstock 110 is communicated to a first air classifier 112. Screening equipment and air classifying equipment are well known in the art. A suitable air classifier is the Hosokawa Alpine 50ATP, sold by Hosokawa Micron Powder Systems of Summit, NJ. Other suitable classifiers are available from the Minox Siebtechnik.

A portion of refined feedstock 110 exits air classifier 112 as a waste stream 114. While a target of waste stream 114 are the milled stems, milled leaves, and dirt, inevitably some of the separated trichome fibers and still attached trichome fibers will be lost through the waste stream 114. The remaining portion of refined feedstock 110 is routed to a second air classifier 120 wherein outlet 122 primarily communicates trichome fiber fines to a first collection device and outlet 124 primarily communicates trichome fibers that are larger than the fines to a second collection device.

As noted above, outlet 122 of air classifier 120 allows for the collection of trichome fiber fines, which include fibers having a length of less than 100 microns. Employment of at least some trichome fibers having a length of less than 100 microns into a fibrous structure is believed to impart an increased flushability benefit to a fibrous structure compared to employment of only trichome fibers having a length of 100 microns or more. This is because the shorter fibers have a larger surface area per weight and therefore play a bigger role in driving hydrophobicity of the structure in which they are incorporated. Fibers having a length of less than 100 microns were essentially making their way into a waste stream in prior art liberating processes, and thus, were not collected for incorporation into fibrous structures.

Fiber blends may comprise other fibers, including animal fibers, mineral fibers, other plant fibers (in addition to the trichomes of the present invention) and mixtures thereof. Animal fibers may, for example, be selected from the group consisting of: wool, silk and mixtures thereof. The other plant fibers may, for example, be derived from a plant selected from the group consisting of: wood, cotton, cotton linters, flax, sisal, abaca, hemp, hesperaloe, jute, bamboo, bagasse, kudzu, corn, sorghum, gourd, agave, loofah and mixtures thereof. In one example, the fiber blend comprises softwood fibers, hardwood fibers, and hydrophobic fibers, such as trichome fibers.

The fibrous structure may comprise fibers, films and/or foams that comprise a hydroxyl polymer and optionally a crosslinking system. Non-limiting examples of suitable hydroxyl polymers include polyols, such as polyvinyl alcohol, polyvinyl alcohol derivatives, polyvinyl alcohol copolymers, starch, starch derivatives, chitosan, chitosan derivatives, cellulose derivatives such as cellulose ether and ester derivatives, gums, arabinans, galactans, proteins and various other polysaccharides and mixtures thereof. For example, a web of the fibrous structure may comprise a continuous or substantially continuous fiber comprising a starch hydroxyl polymer and a polyvinyl alcohol hydroxyl polymer produced by dry spinning and/or solvent spinning (both unlike wet spinning into a coagulating bath) a composition comprising the starch hydroxyl polymer and the polyvinyl alcohol hydroxyl polymer.

The fibrous structure may comprise other additives, such as wet strength additives, softening additives, solid additives (such as starch, clays), dry strength resins, wetting agents, lint resisting and/or reducing agents, absorbency-enhancing agents, immobilizing agents, especially in combination with emollient lotion compositions, antiviral agents including organic acids, antibacterial agents, polyol polyesters, antimigration agents, polyhydroxy plasticizers and mixtures thereof. Such other additives may be added to the fiber furnish, the embryonic fibrous web and/or the fibrous structure. Such other additives may be present in the fibrous structure at any level based on the dry weight of the fibrous structure. The other additives may be present in the fibrous structure at a level of from about 0.001 to about 50% and/or from about 0.001 to about 20% and/or from about 0.01 to about 5% and/or from about 0.03 to about 3% and/or from about 0.1 to about 1.0% by weight, on a dry fibrous structure basis.

Non-limiting types of fibrous structures include conventionally felt-pressed fibrous structures; pattern densified fibrous structures; and high-bulk, uncompacted fibrous structures. The fibrous structures may be of a homogenous or multilayered (two or three or more layers) construction; and the sanitary tissue products made therefrom may be of a single-ply or multi-ply construction.

In one example, the fibrous structure is a pattern densified fibrous structure characterized by having a relatively high-bulk region of relatively low fiber density and an array of densified regions of relatively high fiber density. The high-bulk field is characterized as a field of pillow regions. The densified zones are referred to as knuckle regions. The knuckle regions exhibit greater density than the pillow regions. The densified zones may be discretely spaced within the high-bulk field or may be interconnected, either fully or partially, within the high-bulk field. Typically, from about 8% to about 65% of the fibrous structure surface comprises densified knuckles, the knuckles may exhibit a relative density of at least 125% of the density of the high-bulk field. Processes for making pattern densified fibrous structures are well known in the art as exemplified in U.S. Patent Nos. 3,301,746; 3,974,025; 4,191,609 and 4,637,859.

The fibrous structures of the present invention may be in the form of through-air-dried fibrous structures, differential density fibrous structures, differential basis weight fibrous structures, wet laid fibrous structures, air laid fibrous structures (examples of which are described in U.S. Patent Nos. 3,949,035 and 3,825,381), conventional dried fibrous structures, creped or uncreped fibrous structures, patterned-densified or non-patterned-densified fibrous structures, compacted or uncompacted fibrous structures, nonwoven fibrous structures comprising synthetic or multicomponent fibers, homogeneous or multilayered fibrous structures, double re-creped fibrous structures, foreshortened fibrous structures, co-form fibrous structures (examples of which are described in U.S. Patent No. 4,100,324) and mixtures thereof.

The fibrous structures may exhibit a substantially uniform density or may exhibit differential density regions, in other words regions of high density compared to other regions within the patterned fibrous structure. Typically, when a fibrous structure is not pressed against a cylindrical dryer, such as a Yankee dryer, while the fibrous structure is still wet and supported by a through-air-drying fabric or by another fabric or when an air laid fibrous structure is not spot bonded, the fibrous structure typically exhibits a substantially uniform density.

The fibrous structures of the present invention may be subjected to any suitable post processing including, but not limited to, printing, embossing, calendaring, slitting, folding, combining with other fibrous structures, and the like.

Hydrophobic Additive

Alternative to or in addition to including a percentage of relatively hydrophobic fibers, a hydrophobic additive can be added to the fibrous structure during the dry end of the making/converting of the fibrous structure. Numerous techniques can be employed to deposit the additive onto one or more surfaces of the fibrous structure, including, but not limited to, slot coating and spraying. Hydrophobic additives can also be included during the wet end of making the fibrous structure, such as, for example, including a hydrophobic additive in a fiber slurry.

In some embodiments, the hydrophobic additive has an HLB value from about 5 to about 13, or about 7 to about 13. It is believed that additives in this HLB value can control the sinking time of fibrous structures in a toilet bowl. If the additive has an HLB value that is outside of this range, then the fibrous structure may float or may not significantly affect the sink time of the fibrous structure to alter its flushability profile.

A representative, non-limiting list of suitable hydrophobic additives include OMNIBULK from Kemira Chemicals and various silicones, including AP6087 (amino silicone) from Dow Corning, DC-8566 (amino silicone) from Dow Corning, DC-8800 (polyether silicone) from Dow Corning, DC-8166 (amino silicone) from Dow Corning, and MAGNASOFT Fluid (Diamino silicone) from Momentive Performance Materials.

"Sanitary tissue product" as used herein means a soft, low density (i.e. < about 0.15 g/cm^3) web useful as a wiping implement for post-urinary and post-bowel movement cleaning (toilet tissue and wet wipe). The sanitary tissue product may be convolutedly wound upon itself about a core or without a core to form a sanitary tissue product roll. The sanitary tissue products may exhibit a basis weight between about 10 g/m^2 to about 120 g/m^2 and/or from about 15 g/m^2 to about 110 g/m^2 and/or from about 20 g/m^2 to about 100 g/m^2 and/or from about 30 to 90 g/m^2. In addition, the sanitary tissue product may exhibit a basis weight between about 40 g/m^2 to about 120 g/m^2 and/or from about 50 g/m^2 to about 110 g/m^2 and/or from about 55 g/m^2 to about

105 g/m^2 and/or from about 60 to 100 g/m^2 as measured according to the Basis Weight Test Method described herein.

The sanitary tissue products may exhibit a total dry tensile of at least 150 g/in and/or from about 200 g/in to about 1500 g/in and/or from about 250 g/in to about 850 g/in as measured according to the Total Dry Tensile Test Method described herein.

In another example, the sanitary tissue product may exhibit a total dry tensile of at least 300 g/in and/or at least 350 g/in and/or at least 400 g/in and/or at least 450 g/in and/or at least 500 g/in and/or from about 500 g/in to about 1500 g/in and/or from about 550 g/in to about 850 g/in and/or from about 600 g/in to about 800 g/in as measured according to the Total Dry Tensile Test Method described herein. In one example, the sanitary tissue product exhibits a total dry tensile strength of less than 1000 g/in and/or less than 850 g/in as measured according to the Total Dry Tensile Test Method described herein.

"Basis Weight" as used herein is the weight per unit area of a sample reported in lbs/3000 ft^2 or g/m^2. Basis weight is measured by preparing one or more samples of a certain area (m^2) and weighing the sample(s) of a fibrous structure according to the present invention and/or a sanitary tissue product comprising such fibrous structure on a top loading balance with a minimum resolution of 0.01 g. The balance is protected from air drafts and other disturbances using a draft shield. Weights are recorded when the readings on the balance become constant. The average weight (g) is calculated and the average area of the samples (m^2) is measured. The basis weight (g/m^2) is calculated by dividing the average weight (g) by the average area of the samples (m^2).

The following description illustrates a non-limiting approach for the preparation of a sanitary tissue product comprising a fibrous structure according to the present invention on a pilot-scale Fourdrinier fibrous structure making machine. Individualized trichomes can be first prepared from *Stachys byzantina* bloom stalks consisting of the dried stems, leaves, and pre-flowering buds, by processing dried *Stachys byzantina* plant matter through steps as shown in Figs. 1 and 2 above.

Special care must be taken while processing the trichomes. Sixty pounds of trichome fiber is pulped in a 50 gallon pulper by adding water in half amount required to make a 1% trichome fiber slurry. This is done to prevent trichome fibers over flowing and floating on surface of the water due to lower density and hydrophobic nature of the trichome fiber. After mixing and stirring a few minutes, the pulper is stopped and the remaining trichome fibers are pushed in while water is added. After pH adjustment, it is pulped for 30 minutes, then dumped in a separate chest for delivery onto the machine headbox. This allows one to place trichome fibers in one or more layers, alone or mixed with other fibers, such as hardwood fibers and/or softwood fibers. During this particular run, the trichome fibers are added exclusively on the wire outer layer as the product is converted wire side up; therefore it is desirable to add the trichome fibers to the wire side (the side where the tactile feel senses paper the most).

The aqueous slurry of eucalyptus fibers is prepared at about 3% by weight using a conventional repulper. This slurry is also passed through a stock pipe toward the stock pipe containing the trichome fiber slurry.

The 1% trichome fiber slurry is combined with the 3% eucalyptus fiber slurry in a proportion which yields about 13.3% trichome fibers and 86.7% eucalyptus fibers. The stockpipe containing the combined trichome and eucalyptus fiber slurries is directed toward the wire layer of headbox of a Fourdrinier machine.

In order to impart temporary wet strength to the finished fibrous structure, a 1% dispersion of temporary wet strengthening additive (e.g., Fennorez 91® commercially available from Kemira) is prepared and is added to the NSK fiber stock pipe at a rate sufficient to deliver 0.3% temporary wet strengthening additive based on the dry weight of the NSK fibers. The absorption of the temporary wet strengthening additive is enhanced by passing the treated slurry through an in-line mixer.

The trichome fiber and eucalyptus fiber slurry is diluted with white water at the inlet of a fan pump to a consistency of about 0.15% based on the total weight of the eucalyptus and trichome fiber slurry. The NSK fibers, likewise, are diluted with white water at the inlet of a fan pump to a consistency of about 0.15% based on the total weight of the NSK fiber slurry. The eucalyptus/trichome fiber slurry and the NSK fiber slurry are both directed to a layered headbox capable of maintaining the slurries as separate streams until they are deposited onto a forming fabric on the Fourdrinier.

The fibrous structure making machine has a layered headbox having a top chamber, a center chamber, and a bottom chamber. The eucalyptus/trichome combined fiber slurry is pumped through the top headbox chamber, eucalyptus fiber slurry is pumped through the bottom headbox chamber, and, simultaneously, the NSK fiber slurry is pumped through the center headbox chamber and delivered in superposed relation onto the Fourdrinier wire to form thereon a three-layer embryonic web, of which about 83% is made up of the eucalyptus/trichome fibers and 17% is made up of the NSK fibers. Dewatering occurs through the Fourdrinier wire and is assisted by a deflector and vacuum boxes. The Fourdrinier wire is of a 5-shed, satin weave configuration having 87 machine-direction and 76 cross-machine-direction monofilaments per inch, respectively. The speed of the Fourdrinier wire is about 750 fpm (feet per minute).

The embryonic wet web is transferred from the Fourdrinier wire, at a fiber consistency of about 15% at the point of transfer, to a patterned drying fabric. The speed of the patterned drying fabric is the same as the speed of the Fourdrinier wire. The drying fabric is designed to yield a pattern densified tissue with discontinuous low-density deflected areas arranged within a continuous network of high density (knuckle) areas. This drying fabric is formed by casting an impervious resin surface onto a fiber mesh supporting fabric. The supporting fabric is a 45 x 52 filament, dual layer mesh. The thickness of the resin cast is about 12 mils above the supporting fabric. A suitable process for making the patterned drying fabric is described in published application US 2004/0084167 A1.

Further de-watering is accomplished by vacuum assisted drainage until the web has a fiber consistency of about 30%.

While remaining in contact with the patterned drying fabric, the web is pre-dried by air blow-through pre-dryers to a fiber consistency of about 65% by weight.

After the pre-dryers, the semi-dry web is transferred to the Yankee dryer and adhered to the surface of the Yankee dryer with a sprayed creping adhesive. The creping adhesive is an aqueous dispersion with the actives consisting of about 22% polyvinyl alcohol, about 11% CREPETROL A3025, and about 67% CREPETROL R6390. CREPETROL A3025 and CREPETROL R6390 are commercially available from Hercules Incorporated of Wilmington, Del. The creping adhesive is delivered to the Yankee surface at a rate of about 0.15% adhesive solids based on the dry weight of the web. The fiber consistency is increased to about 97% before the web is dry creped from the Yankee with a doctor blade.

The doctor blade has a bevel angle of about 25 degrees and is positioned with respect to the Yankee dryer to provide an impact angle of about 81 degrees. The Yankee dryer is operated at a temperature of about 350°F (177°C) and a speed of about 800 fpm. The fibrous structure is wound in a roll using a surface driven reel drum having a surface speed of about 656 feet per minute. The fibrous structure may be subsequently converted into a sanitary tissue product having a basis weight of from about 10 pounds/3000 square feet about 70 pounds/3000 square feet.

Toilet Tissue Examples

Sanitary tissue products in the form of toilet tissue were prepared for contact angle measurements and flushability assessment. Table 1 below includes a control toilet tissue comprising a blend of NSK fibers, eucalyptus fibers, and a softener additive (“K” designation). The remaining toilet tissue examples also comprise a fiber blend of NSK fibers and eucalyptus fibers along with at least one of trichome fibers, a silicone dry end additive, and the softener additive. One can see that the addition of a hydrophobic fiber (trichome) drives up the contact angle. One can also see that the addition of silicone also drives up the contact angle. The softener additive has an opposite effect on contact angle.

Table 1: Contact Angle

Sample	Contact Angle, degrees (avg of 5 measurements)
Control + softener additive	68.6
3% trichome fibers	90.3
3% trichome fibers + softener additive	84.0
5% trichome fibers + 10# of silicone additive	118.0
5% trichome fibers + 10# of silicone additive + softener additive	102.5
7.5% trichome fibers + 7.5# of silicone additive	112.7
7.5% trichome fibers + softener additive	96.9
10% trichome fibers	99.9

Additional toilet tissue samples were prepared for flushability testing. The samples include a control (“base”) that does not contain a silicone additive, and several other product samples that contain varying silicone additives. Figs. 3 and 4 show bowl clearances (multiple sheets) and sink times (single sheet) of the samples. A few different flush scenarios were tested, including 25-sheet loading, 30-sheet loading, and 35-sheet loading. The y-axis is the percentage of bowl clearance according to the Flushability Test described below. Note that the sink times reported in Figs. 3 and 4 are in seconds and have been multiplied by 5 to better fit the scale of the chart. Fig. 5 shows bowl clearances for sanitary tissue products with and without the inclusion of trichome fibers.

Table 2, below, shows the effect of including hydrophobic fibers and a silicone additive in a fibrous structure and sanitary tissue product comprising the same. It is desirable to design a fibrous structure that does not float and that sinks slower than the control sample; thus, no faster than 2.5 seconds and/or slower than 2.5 seconds and/or slower than 3.0 seconds and/or slower than 3.5 seconds.

Table 2: Sink Time

Sample	Sink Time, seconds
Control (including 7.5# softener additive)	2.4
5% trichome fibers + 7.5# softener additive	2.6
5% trichome fibers	3.1
5% trichome fibers + 7.5# of silicone additive	4.0
7.5% trichome fibers + 7.5# softener additive	3.7
7.5% trichome fibers	4.5
7.5% trichome fibers + 7.5# silicone additive	4.4

Test Methods

Unless otherwise specified, all tests described herein including those described under the Definitions section and the following test methods are conducted on samples that have been conditioned in a conditioned room at a temperature of 73°F ± 4°F (about 23°C ± 2.2°C) and a relative humidity of 50% ± 10% for 2 hours prior to the test. All tests are conducted in such conditioned room. Do not test samples that have defects such as wrinkles, tears, holes, and like.

Contact Angle Method

A Fibro DAT 1100 contact angle measurement system was used to measure dynamic contact angle of the samples. A 4 microliter drop of deionized water is dispensed onto the sample by the instrument and contact angle is recorded for a period of 2 minutes. The average contact angle values reported in Table 1 represent an average of 5 replicate measurements, each of which being taken at a 0.1 second reading time.

Flushability Test Method

While numerous different toilet brands and designs can be used for flushability assessments, a KOHLER PORTRAIT Lite 6 liter toilet was used for evaluating the samples herein. The water supply to the toilet was targeted at 20°C (+/- 1°C). The toilet water volume was also verified by the following check procedure:

1. Tare a 2 ½ gallon or a 5 gallon bucket on the Toledo Scale located in the Flush Lab. Check to make sure that you are zeroing at the Kg function.
2. Flush toilet to be tested to set the water level in the bowl. Wait for the toilet to completely refill before continuing. When the water has stopped flowing out of the drainline, place the bucket at the end of the drainline.
3. Flush toilet and catch the water at the end of the drain line. Allow the water to drain for 2 minutes then remove the bucket from the end of the drainline and take to the floor scale.
4. Weigh the bucket and record volume on data sheet. Repeat until you have 5 recorded flushes with an average final flush volume. The flush volume must be within 0.2kg of the volume the toilet is supposed to flush.

Ten sequential flushes (all at the same sheet count loading) are performed for each product sample. The loadings usually begin with a sheet count that is expected to clear the toilet successfully in all 10 flushes. The loadings are increased incrementally for each trial. The samples are prepared by tearing tissue samples off a roll in strips of 5 sheets each. Each strip is folded to the size of one sheet, with the ends of the strips folded to the inside. Each stack is weighed and the mass recorded before dosing to the toilet.

General flushing instructions:

1. Turn on the water tempering system and make sure that it is set to the correct temperature.
2. Once the water in the system is at temperature, flush the specified toilet to be used in the testing until the water temperature in the tank is at the specified temperature ± 1.0°C. These extra flushes can be used to verify the volume of the toilet.
3. Once the toilet has refilled completely, place each strip of tissue in the center of the water spot of the bowl at 10 second intervals. It is important to drop the tissue flat down into the water. The tissue should be placed so that the fold is facing the right side of the toilet. The next strip should be placed directly on top of and aligned with the previous piece even if the previous strip has rotated a bit. It is important to drop the sample from just above the piece already in the toilet so that hits squarely, not letting one side touch the strip in the toilet ahead of the other side. Following these loading instructions reduces the variability of the results.
4. Wait 10 seconds after dosing the final strip before flushing the toilet.
5. Observe the evacuation of the toilet bowl and record the data.

6. Wait until the toilet tank is completely refilled and there is no more water running into the tank before starting to dose the next loading.
7. Repeat the loading, flushing and data recording for each loading until the 10 flush trial is complete.
8. Continue on with the next replicate of that loading or the next loading.

Figs. 3, 4, and 5 show the results with the percentage of the 10 flushing events clearing the bowl for each sample.

Total Dry Tensile Strength Test Method

Cut at least eight 1 inch wide strips of the fibrous structure and/or sanitary tissue product to be tested in the machine direction. Cut at least eight 1 inch wide strips in the cross direction. If the machine direction and cross direction are not readily ascertainable, then the cross direction will be the strips that result in the lower peak load tensile. For the wet measurements, each sample is wetted by submerging the sample in a distilled water bath for 30 seconds. The wet property of the wet sample is measured within 30 seconds of removing the sample from the bath.

For the actual measurements of the properties, use a Thwing-Albert Intelect II Standard Tensile Tester (Thwing-Albert Instrument Co. of Philadelphia, Pa.). Insert the flat face clamps into the unit and calibrate the tester according to the instructions given in the operation manual of the Thwing-Albert Intelect II. Set the instrument crosshead speed to 4.00 in/min and the 1st and 2nd gauge lengths to 4.00 inches. The break sensitivity is set to 20.0 grams and the sample width is set to 1.00 inch. The energy units are set to TEA and the tangent modulus (Modulus) trap setting is set to 38.1 g.

After inserting the fibrous structure sample strip into the two clamps, the instrument tension can be monitored. If it shows a value of 5 grams or more, the fibrous structure sample strip is too taut. Conversely, if a period of 2-3 seconds passes after starting the test before any value is recorded, the fibrous structure sample strip is too slack.

Start the tensile tester as described in the tensile tester instrument manual. When the test is complete, read and record the following with units of measure:

Peak Load Tensile (Tensile Strength) (g/in)

Peak Elongation (Elongation) (%)

Peak CD TEA (Wet CD TEA) (in-g/in^2)

Tangent Modulus (Dry MD Modulus and Dry CD Modulus) (at 15g/cm)

Test each of the samples in the same manner, recording the above measured values from each test. Average the values for each property obtained from the samples tested to obtain the reported value for that property.

Total Dry Tensile (TDT) = Peak Load MD Tensile (g/in) + Peak Load CD Tensile (g/in)

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 single or multi ply sanitary tissue for disposal in a toilet, the sanitary tissue comprising a fibrous structure comprising a contact angle value of greater than or equal to 75 degrees.

2. The sanitary tissue of Claim 1, wherein the fibrous structure comprises hydrophobic fibers.

3. The sanitary tissue of Claim 1 or 2, wherein the hydrophobic fibers comprise fibers harvested from a plant, preferably wherein the plant is in the *Stachys* genus.

4. The sanitary tissue of any of the preceding claims, wherein the fibrous structure comprises trichome fibers.

5. The sanitary tissue of any of the preceding claims, wherein the fibrous structure comprises a fiber blend that comprises softwood fibers, hardwood fibers, and hydrophobic fibers, preferably wherein the hydrophobic fibers comprise trichome fibers.

6. The sanitary tissue of any of the preceding claims, wherein a sheet of the sanitary tissue sinks in a time no faster than 2.5 seconds.

7. The sanitary tissue of any of the preceding claims, wherein the fibrous structure comprises both hydrophobic fibers and a hydrophobic additive, preferably wherein the hydrophobic fibers comprises trichome fibers and the hydrophobic additive comprises a silicone.

8. The sanitary tissue of any of the preceding claims, wherein the fibrous structure further comprises an additive selected from the group consisting of: softener additives, temporary wet strength additives and mixtures thereof.

9. The sanitary tissue of any of the preceding claims wherein the fibrous structure comprises a fiber blend of wood fibers and hydrophobic fibers, and a contact angle value of greater than or equal to about 85, wherein at least some of the hydrophobic fibers have a length of less than 100 microns.

10. The sanitary tissue of any of the preceding claims wherein the fibrous structure comprises a fiber blend, the fiber blend comprises softwood fibers and hardwood fibers,
wherein at least one of the following is included: i) hydrophobic fibers in the fibrous structure and ii) hydrophobic additive disposed on an outer surface of the fibrous structure,
wherein 30 sheets of the sanitary tissue product does not float when placed into a toilet bowl, and
wherein the 30 sheets of the sanitary tissue product clears a toilet bowl at a level of greater than 30% of the time according to the Flushability Test.

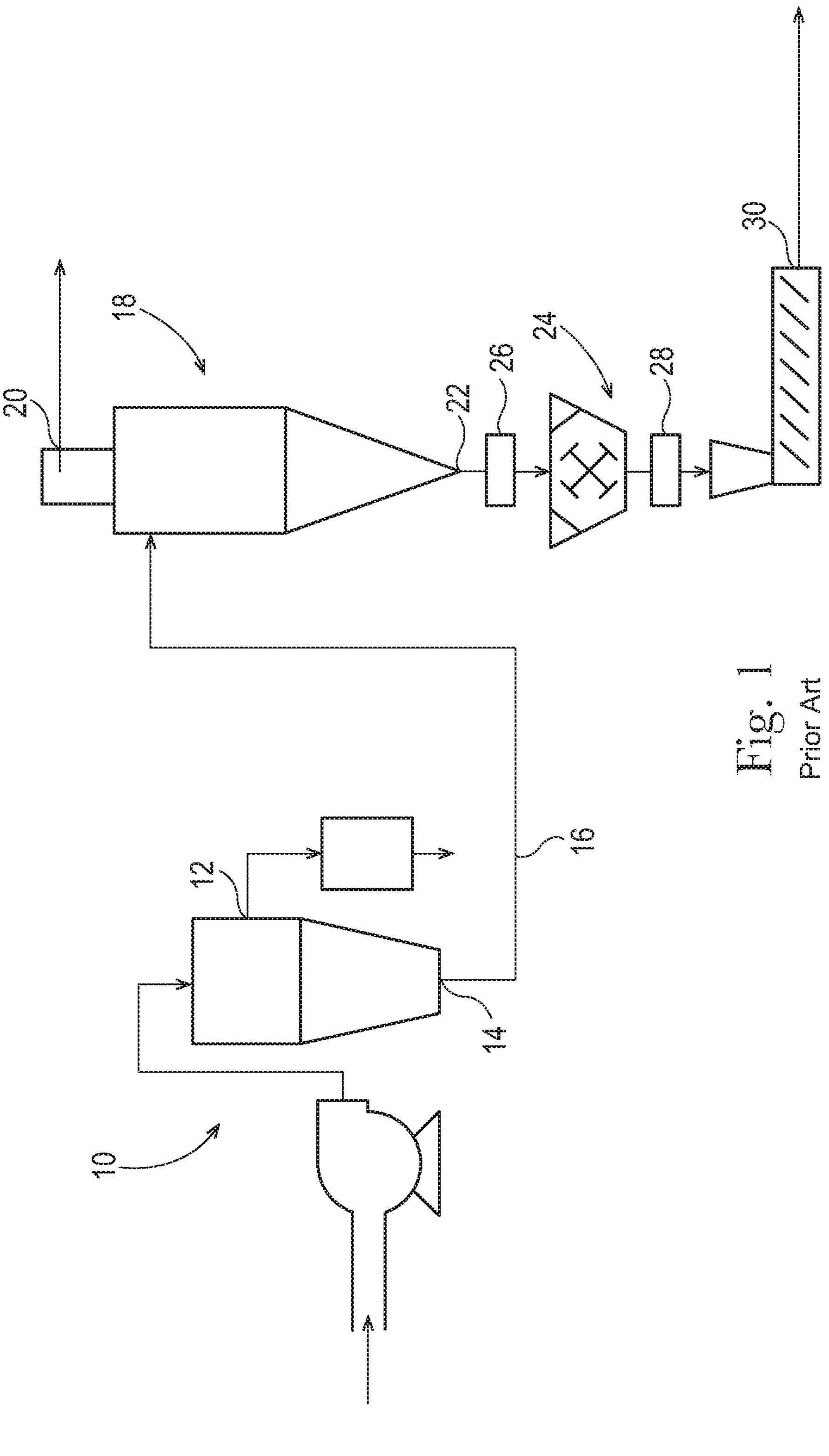


Fig. 1
Prior Art

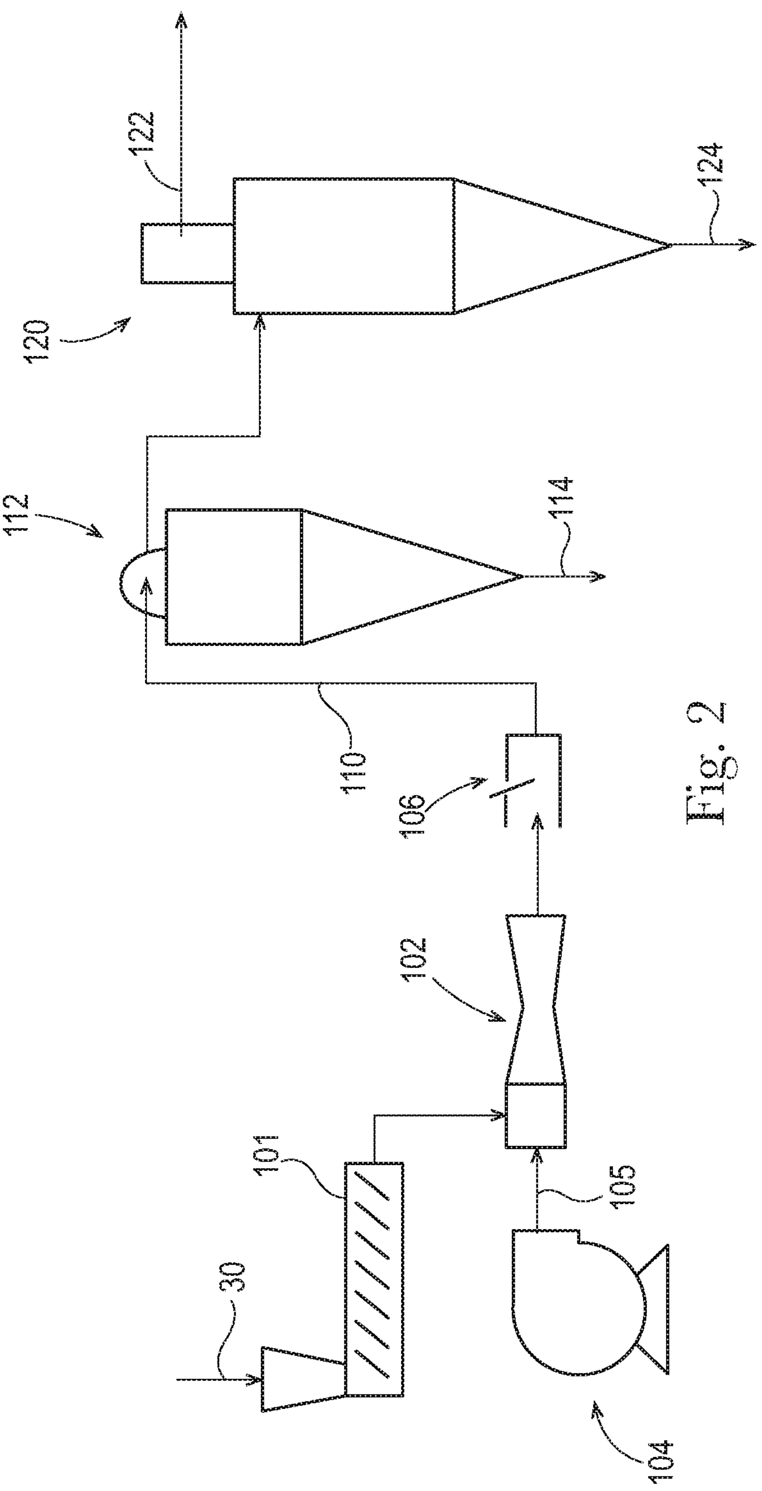


Fig. 2

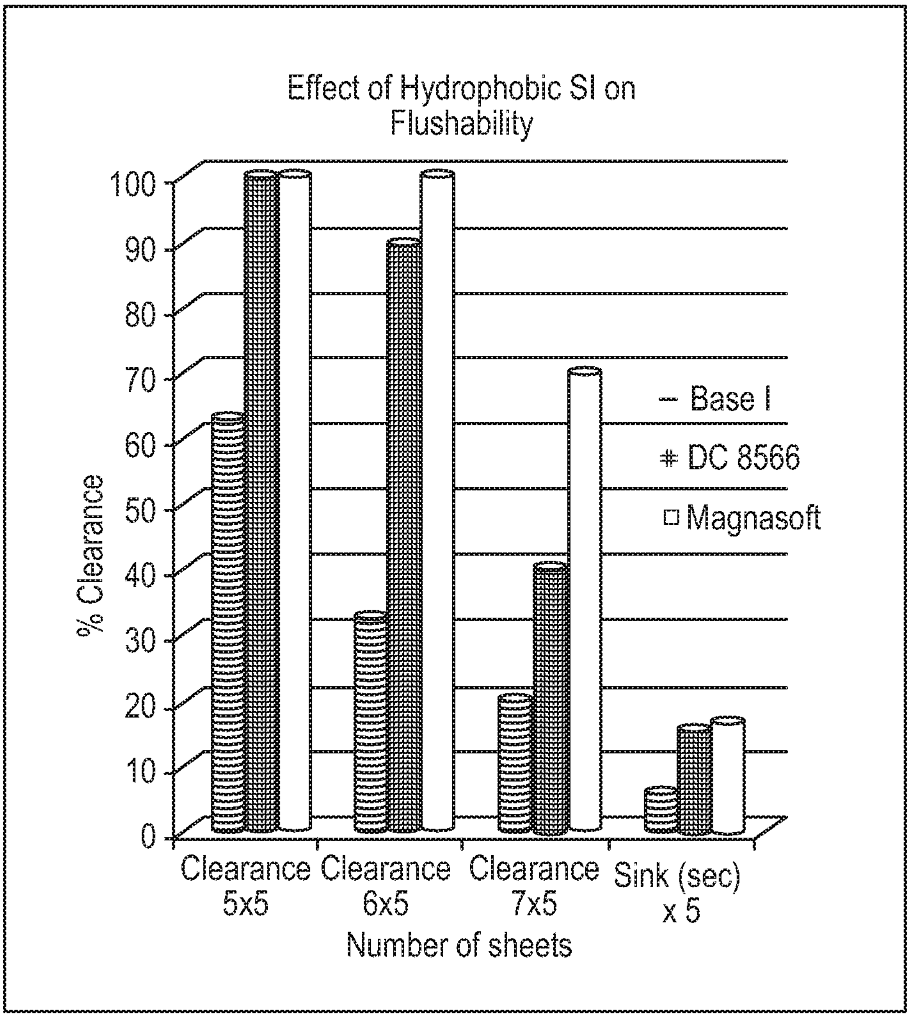

Effect of Hydrophobic SI on Flushability
100
90
80
70
60
50
40
30
20
10
0
% Clearance
Base I
DC 8566
Magnasoft
Clearance 5x5
Clearance 6x5
Clearance 7x5
Sink (sec) x 5
Number of sheets

Fig. 3

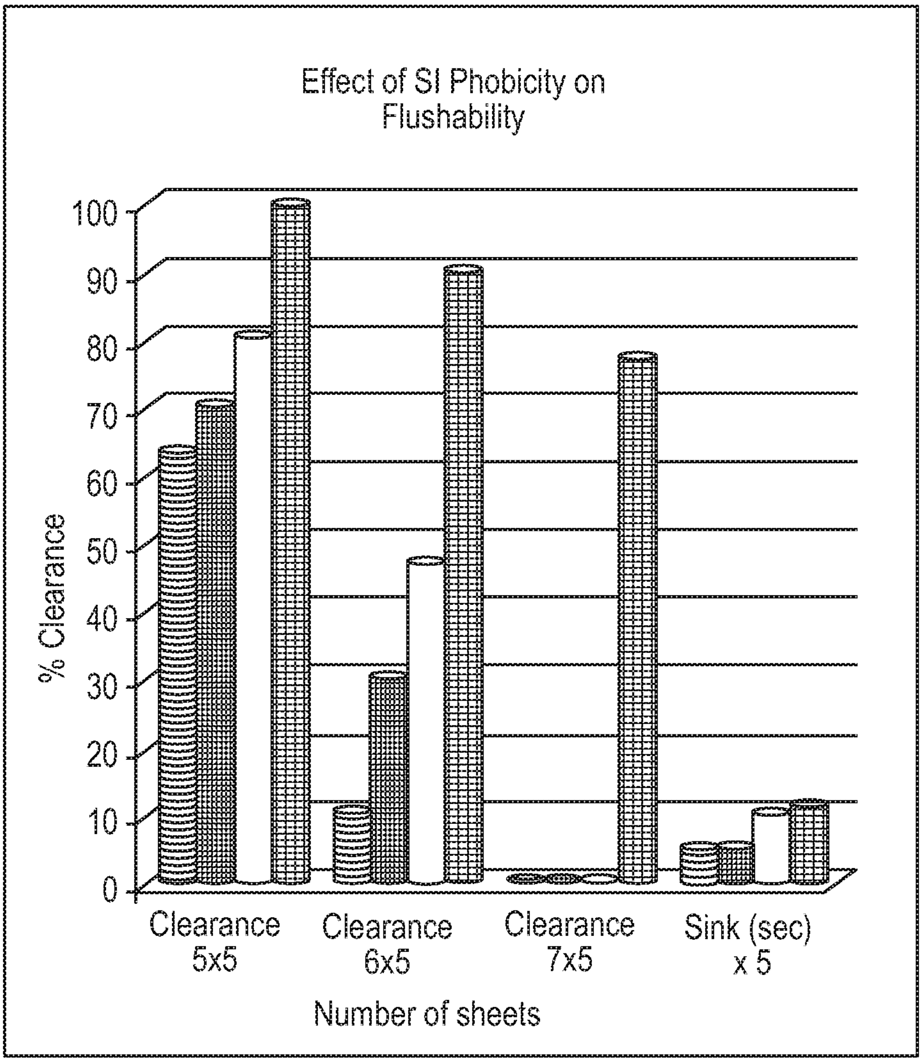
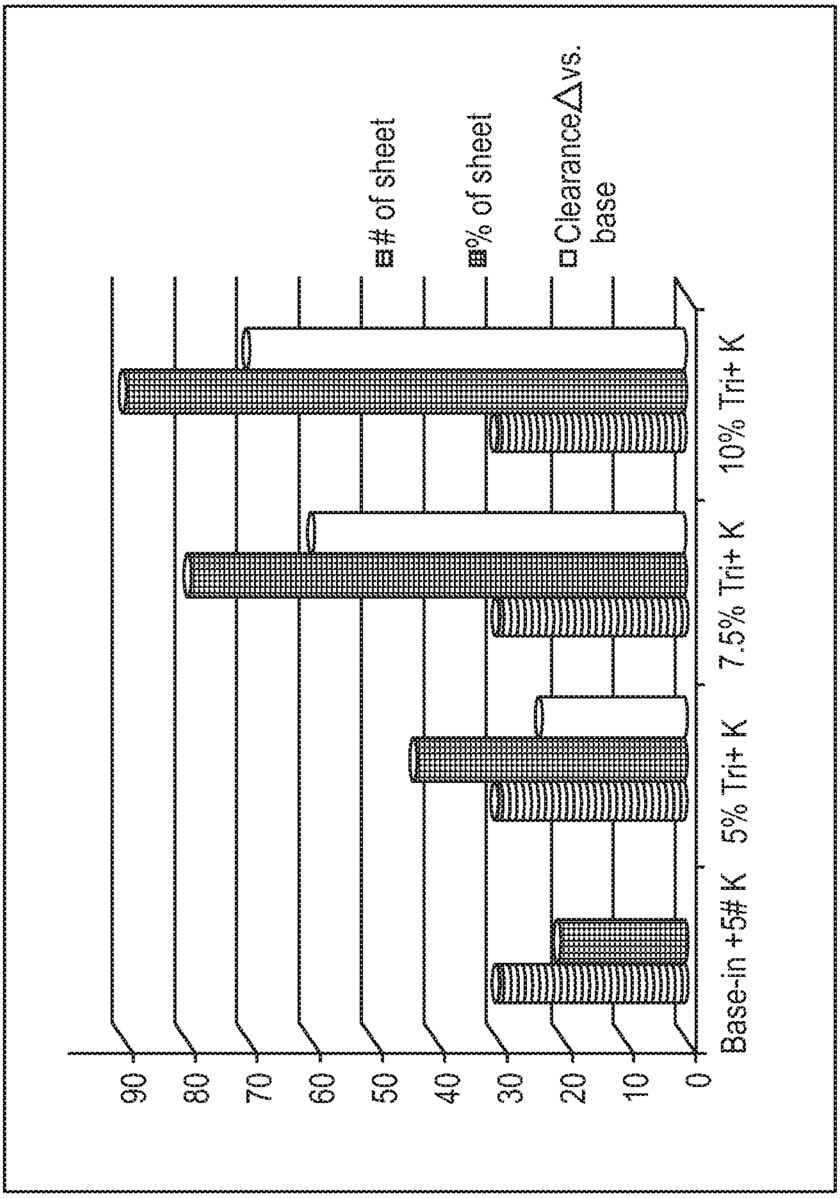

Effect of SI Phobicity on Flushability
100
90
80
70
60
50
40
30
20
10
0
% Clearance
Clearance 5x5
Clearance 6x5
Clearance 7x5
Sink (sec) x 5
Number of sheets

Fig. 4



# of sheet
% of sheet
Clearance∆vs. base
90
80
70
60
50
40
30
20
10
0
Base-in +5# K
5% Tri+ K
7.5% Tri+ K
10% Tri+ K

Fig. 5