Claims

1. An impregnated natural fiber comprising:

a cuticle and an interior lumen, the cuticle circumscribing the interior lumen; and

water insoluble particulates possessing a preselected property embedded in the fiber, wherein the particulates are selected from the group consisting of: huntite, magnesium hydroxide, alumina trihydrate, silver oxide, copper oxide, magnesium oxide, zinc oxide, a ceramic compound, diatomaceous earth, ground silica, nano-silica, polysiloxane, acrylic compound, titanium dioxide, a encapsulated nanosphere containing various pharmaceuticals, benzoyl peroxide, powdered graphite, graphene powder, and single walled nano-carbon tubes,

wherein said particulates comprise ~~from 0.1%~~ greater than 5200 mg/kg to 30% w/w of the impregnated natural fiber and said embedded particulates impart their preselected property to the fiber when embedded therein, and where the particulates are embedded on both the cuticle and within the lumen of the fiber~~, wherein the impregnated fiber exhibits a tensile strength in excess of 36 g/tex~~.

~~2. The impregnated fiber of claim 1, wherein the impregnated fiber, after bleaching and optical whitening, comprises greater than 5200 mg/kg of said particulates relative to the impregnated fiber.~~

~~3~~2. The impregnated natural fiber of claim 1~~ or 2~~, wherein the impregnated natural fiber exhibits an increase in tensile strength after impregnation that is at least 15% greater than the average tensile strength of untreated fibers drawn from the same fiber source as the fiber of the impregnated natural fiber.

~~4~~3. The impregnated natural fiber ~~as in any one~~ of claims ~~1-3~~ or 2, wherein the impregnated natural fiber exhibits a micronaire value in excess of 4.85.

~~5~~4. The impregnated natural fiber ~~as in any one of~~ claim~~s~~ 1~~-3~~ or 2, wherein the impregnated natural fiber exhibits a micronaire value after impregnation at least 20% greater than the average micronaire value of untreated fibers drawn from the same fiber source as the fiber of the impregnated natural fiber.

~~6~~5. The impregnated natural fiber as in any one of claims 1-~~5~~4, wherein ~~the~~ a yarn formed from the impregnated natural fiber still exhibits the preselected property after 100 home washings or 50 industrial washings.

~~7~~6. The impregnated natural fiber as in any one of claims 1-~~6~~5, wherein the impregnated natural fiber and yarn made therefrom still exhibit the preselected property after the fiber has been bleached and optically whitened.

~~8~~7. The impregnated natural fiber as in any one of claims 1-~~7~~6, wherein the fibers and yarn made therefrom still retain particulate material in their lumens after bleaching and optical whitening while the number of particulates from an exterior face of the cuticle of the fiber have been reduced by at least 95%.

~~9~~8. The impregnated natural fiber as in any one of claims 1-~~8~~7, wherein the impregnated particulates comprise at least 0.5-20 wt.% of the impregnated natural fiber.

~~10~~9. The impregnated natural fiber as in any one of claims 1-~~9~~8, wherein the insoluble particulates are nano-sized particulates between 0.1 and 0.5 microns.

~~11~~10. The impregnated natural fiber as in any one of claims 1-~~10~~9, wherein the fiber is a cellulose fiber.

~~12~~11. The impregnated natural fiber as in any one of claims 1-~~11~~ 10 wherein the insoluble particulates are preselected to impart antimicrobial properties, including antibacterial and/or antifungal, and/or antiviral properties,

to the fiber ~~and are chosen from the group consisting of silver oxides, copper oxides, magnesium oxide, zinc oxide, zeolites, ceramic compounds and combinations thereof~~.

~~13~~12. Yarn spun from a plurality of impregnated natural fibers, said impregnated natural fibers comprised as in any one of claims 1-~~12~~11.

~~14~~13. An article comprising the impregnated natural fibers as in any one of claims 1-~~12~~11, the article selected from a group consisting of the following classes of articles: wearing apparel; medical and hospital supplies, uniforms, curtains, scrubs, sheets, pillowcases, blankets, slippers, patient gowns, towels and any textile or product made from a textile used in a healthcare environment, an elderly care facility, a public or private institution, or as a domestic product used in the home.

~~15~~14. An article comprising yarn spun from the impregnated natural fibers as in claim ~~13~~12, said article selected from a group consisting of the following classes of articles: wearing apparel; medical and hospital supplies, uniforms, curtains, scrubs, sheets, pillowcases, blankets, slippers, patient gowns, towels and any textile or product made from a textile used in a healthcare environment, an elderly care facility, a public or private institution, or as a domestic product used in the home.

~~16~~15. A system for producing sliver fibers impregnated with insoluble particulates, said system comprising:

a conveyor for conveying at least one sliver fiber ribbon;

a dispenser for containing a paste which comprises: i) at least one insoluble particulate material possessing at least one preselected property, ii) a thickening agent and iii) water, the paste from the dispenser dispensed on the at least one sliver fiber ribbon; and

a bore sonotrode in ultrasonic communication with a transducer for generating ultrasonic waves which are transmitted through said dispensed paste to the at least one sliver fiber ribbon, the ultrasonic waves embedding, the at least one insoluble particulate material in the at least one sliver fiber.

~~17~~16. A method for impregnating sliver fibers with insoluble particulates, comprising the steps of:

a. obtaining a paste comprising:

i. at least one insoluble particulate material having a preselected desired property;

ii. water; and,

iii a thickening agent;

b. providing at least one ribbon of sliver fibers;

c. dispensing the paste on the at least one sliver fiber ribbon; and

d. conveying the paste-coated at least one sliver fiber ribbon through a bore of a bore sonotrode and so that ultrasonic waves are transmitted through the at least one sliver fiber ribbon so that the at least one insoluble particulate material in the paste on the at least one sliver fiber ribbon is embedded in the ribbon, thereby imparting the desired property of the at least one particulate material to the sliver fibers.

~~18. The method of claim 17, wherein the sonotrode is a bore sonotrode having a plurality of bores.~~

~~19~~17. The method ~~as in any one~~ of claim~~s~~ ~~17~~16~~-18~~, further comprising a step of bleaching and/or optically whitening the at least one impregnated sliver fiber ribbon.

~~20~~18. The method ~~as in any one~~ of claim~~s~~ ~~17~~16 or ~~-19~~17, wherein the at least one insoluble particulate material is selected from an element, a compound, a composition and any combination of the above.