Claims

1. A process of making a textile material antimicrobial, the process comprising the steps of:
   - treating the textile material using an exhaust process, wherein
     two or more antimicrobial agents selected from the group consisting of a quaternary ammonium organosilane compound, silver cations, propiconazole, and polyhexamethylene biguanide, or
     two or more antimicrobial agents selected from the group consisting of polyglucosamine, silver cations, propiconazole, and polyhexamethylene biguanide, or
     three or more antimicrobial agents selected from the group consisting of a quaternary ammonium organosilane compound, polyglucosamine, silver cations, propiconazole, and polyhexamethylene biguanide
     are applied to the textile material;
   - drying and curing the textile material, wherein curing is conducted at a curing temperature of at least 150 °C, preferably 160 °C, more preferably at least 170 °C, even more preferably at least 175 °C, and most preferably at least about 180 °C, and of at most 205 °C, preferably at most 195 °C, further preferably at most 190 °C, more preferably at most 185 °C;
   - preferably washing the cured textile material; and
   - preferably drying the washed textile material.

2. A process of making a textile material antimicrobial, comprising a first process cycle comprising the steps of:
   - treating the textile material using a liquor application process, preferably an exhaust process, wherein the liquor comprises one or more antimicrobial agents;
   - preferably subjecting the treated textile material to a heat treatment;
   - preferably washing the textile material; and

- preferably drying the washed textile material;

and comprising a second process cycle being performed after the first process cycle and comprising the steps of:

- treating the textile material using a liquor application process, such as an exhaust or preferably a padding process, wherein the liquor comprises one or more antimicrobial agents;
- drying and curing the treated textile material, wherein curing is conducted at least partially at a curing temperature of at least 150 °C, preferably 160 °C, more preferably at least 170 °C, even more preferably at least 175 °C, and most preferably at least about 180 °C;
- preferably washing the cured textile material; and
- preferably drying the washed textile material.

3. The process of claim 2, wherein the heat treatment comprises drying of the textile material.

4. The process of claims 2 or 3, wherein the process is a process according to claim 1.

5. A process of making a textile material antimicrobial, the process comprising the steps of:

- treating the textile material using an exhaust process, wherein the liquor comprises one or more antimicrobial agents and wherein during the exhaust process, the liquor has a temperature of at least 45 °C;
- drying and curing the textile material, wherein curing is conducted at a curing temperature of at least 170 °C, more preferably at least 175 °C, and most preferably at least about 180 °C;
- preferably washing the cured textile material; and
- preferably drying the washed textile material.

6. The process of any one of claims 2 to 5, wherein the one or more antimicrobial agents in the liquor are selected from the group consisting of a quaternary ammonium organosilane compound, silver cations, polyglucosamine, propiconazole, and polyhexamethylene biguanide, preferably wherein the liquor of the exhaust, first and/or second process cycle or the liquors of the exhaust, first and second process cycle together comprise at least two, preferably at least three, more preferably at least four, most preferably all five antimicrobial agents selected from the group consisting of a quaternary ammonium organosilane compound, silver cations, polyglucosamine, propiconazole, and polyhexamethylene biguanide.

7. A process of making a textile material antimicrobial, the process comprising the steps of:
   - treating the textile material using an exhaust process, wherein the liquor comprises one or more antimicrobial agents selected from the group consisting of silver cations trapped in an aluminosilicate or a polymeric matrix, a quaternary ammonium organosilane compound, polyglucosamine, propiconazole, and polyhexamethylene biguanide, and wherein during the exhaust process, the liquor has a temperature of at least 45 °C;
   - drying and curing the textile material, wherein curing is conducted at a curing temperature of at least 150 °C, preferably at least 160 °C, more preferably at least 170 °C, even more preferably at least 175 °C, and most preferably at least about 180 °C;
   - preferably washing the cured textile material; and
   - preferably drying the washed textile material.

8. The process of any one of claims 1 to 7, wherein the liquor comprises a solvent and the antimicrobial agents form a homogeneous mixture with the solvent.

9. The process of any one of claims 5 to 8, wherein the process is a process according to any one of claim 1 to 4.

10. The process of any one of the preceding claims, wherein during the exhaust process, the liquor has a temperature of at least 45 °C, in particular at least 50 °C, preferably at least 60 °C, more preferably at least 70 °C, more preferably at least 75 °C, most preferably at least about 80 °C, and/or a temperature below boiling temperature, preferably at most 95 °C, more preferably at most 90 °C, particularly at most 85 °C, and most preferably at most about 80 °C.

11. The process of any one of claims 1 to 10, wherein curing is conducted at an ambient temperature of at most 205 °C, preferably at most 195 °C, more preferably at most 190 °C, particularly at most 185 °C, and most preferably at most about 180 °C.

12. The process of any one of claims 1 to 11, wherein the starting textile material is a cellulosic textile material, a preferably non-inert synthetic textile material, or a blend comprising preferably at least 25% of a cellulosic and/or a preferably non-inert synthetic textile material, preferably wherein the starting textile material is a multifilament yarn or preferably a multifilament fabric.

13. A textile material obtainable by a process according to any one of claims 1 to 12, preferably wherein the antimicrobial agents are adhered or bound or covalently bound to the textile material in a non-leaching manner.

14. A substrate, comprising
    - propiconazole and at least one of the antimicrobial agents selected from the group consisting of quaternary ammonium organosilane compound, polyglucosamine, polyhexamethylene biguanide, silver cations; or

- at least three, preferably all four of the antimicrobial agents selected from the group consisting of silver cations, polyhexamethylene biguanide, propiconazole, chitosan; or
- at least a quaternary ammonium organosilane compound, silver cations, and chitosan

in a non-leaching manner.

15. The substrate of claim 14, wherein the substrate is a textile material to which the antimicrobial agents are adhered or bound or covalently bound, and/or wherein the substrate is a textile material according to claim 13.

16. The textile material of claims 13 or 15, wherein non-leaching means that for any amount of 0.1% by weight of an antimicrobial agent adhered or bound or covalently bonded to the textile material, based on the weight of the textile material, leaching of one, any, or all of the one or more antimicrobial agents in exposure to water within a test period of 24 hours, preferably within a test period of 48 hours, more preferably within a test period of 72 hours, and most preferably within a test period of 7 days, is at most 5.0 ppm, preferably at most 2.0 ppm, more preferably at most 1.0 ppm, more preferably at most 0.5 ppm, most preferably at most 0.1 ppm, preferably when tested according to the following method:
    - soaking the textile material in preferably distilled exposure water in a ratio of 1000 ml water per 10 grams of textile material,
    - keeping the textile material entirely soaked in the exposure water during the test period, preferably at a temperature between 21 °C and 25 °C; and

    after the test period, extracting exposure water and testing it for the presence of each of the antimicrobial agents, preferably using a GC-MS method.

17. The textile material of any one of claims 13 or 15 or 16, exhibiting a reduction value of Escherichia coli ATCC 25922 and/or Staphylococcus aureus ATCC 6538 and/or ATCC 43300 and/or Klebsiella pneumonia ATCC 4352 and/or ATCC 13883 and/or Vibrio cholera ATCC 14035 and/or Clostridium difficile ATCC 43598 spores, measured in accordance with ASTM standard E 2149-10 and/or AATCC test method 100-1999 and/or AATCC test method 100-2012, of at least at least 99.9%, preferably at least 99.99%, more preferably at least 99.999%, most preferably at least 99.9999%, within 24 hours of contact time, preferably within 6 hours of contact time, more preferably within 1 hour of contact time, even more preferably within 15 minutes of contact time, particularly within 15 minutes of contact time, most preferably within 5 minutes of contact time, preferably wherein the reduction value is achieved even after at least 25 laundry washes in a laundry washing machine at 85±15 °C for 40-50 minutes, preferably using brand name non-antimicrobial, non-ionic and non-chlorine containing laundry detergent, preferably followed by a standard rinse cycle and preferably dried at 62-96 °C for 20-30 minutes.

18. The textile material of any one of claims 13 or 15 or 16 to 17, exhibiting after 25 laundry washes a reduction value of Staphylococcus aureus ATCC 6538 and/or ATCC 43300 and/or Escherichia coli ATCC 11229 and/or Pseudomonas aeruginosa ATCC 15442 and/or Salmonella enterica ATCC 10708 and/or Staphylococcus aureus (MRSA) ATCC 33592 and/or ATCC 43300 and/or Klebsiella pneumonia ATCC 13883 and/or Vibrio cholera ATCC 14035 and/or Clostridium difficile ATCC 43598 spores of at least 99%, preferably at least 99.9%, more preferably at least 99.99%, even more preferably at least 99.999%, most preferably at least 99.9999%, within 10 minutes on continuous reinoculations followed by dry and wet alternate abrasion cycles when tested in accordance with EPA protocol 90072PA4.

19. An air filter or a water filter comprising a textile material as a filter medium, the textile material comprising

- at least one, preferably at least two, more preferably at least three antimicrobial agents selected from the group consisting of a quaternary ammonium organosilane compound, polyglucosamine, propiconazole, and polyhexamethylene biguanide; or
- at least two, preferably at least three, more preferably at least four antimicrobial agents selected from the group consisting of a quaternary ammonium organosilane compound, polyglucosamine, propiconazole, polyhexamethylene biguanide and silver salt,

wherein the antimicrobial agents are preferably adhered or bound or covalently bound to the textile material in a non-leaching manner.

20. A water filter comprising a textile material as a filter medium, the textile material being obtainable by a process comprising the steps of:
- treating the textile material using a liquor application process, such as an exhaust process, wherein the liquor comprises a solvent and one or more antimicrobial agents,
- drying and curing the textile material, wherein curing is conducted at a curing temperature of at least 150 °C, preferably at least 160 °C, more preferably at least 170 °C, even more preferably at least 175 °C, and most preferably at least about 180 °C;
- preferably washing the cured textile material; and
- preferably drying the washed textile material;

wherein the process is preferably a process according to any one of claims 1 to 12.

21. The water filter of claim 19 or 20, wherein the textile material is a textile material according to any one of claims 13 or 15 to 18.