Claims

1. Composite body having, on a porous substrate and in the interstices of the substrate that includes fibres, preferably of an electrically nonconductive material, a porous layer (1) composed of oxide particles bonded to one another and partly to the substrate that include at least one oxide selected from oxides of the elements Al, Zr, Ti and Si, preferably selected from Al_2O_3, ZrO_2, TiO_2 and SiO_2, and having, at least on one side, a further porous layer (2) including oxide particles bonded to one another and partly to layer (1) that include at least one oxide selected from oxides of the elements Al, Zr, Ti and Si, preferably selected from Al_2O_3, ZrO_2, TiO_2 and SiO_2,
where the oxide particles present in layer (1) have a greater median particle size than the oxide particles present in layer (2), and where the median particle size (d50) of the oxide particles in layer (1), determined as specified in the description, is from 0.5 to 4 µm and the median particle size (d50) of the oxide particles in layer (2), determined as specified in the description, is from 0.015 to 0.15 µm, preferably 0.04 to 0.06 µm,
characterized in that a polymer coating (PB) containing one or more polysiloxanes is present atop or above layer (2).

2. Composite body according to Claim 1,
characterized in that
the composite body has a toluene flow rate at 130°C and transmembrane pressure 30 bar (30 *10^5 Pa), determined as specified in the description, of greater than 130 L/m²h, preferably greater than 250 L/m²h, more preferably greater than 300 L/m²h and most preferably greater than 400 L/m²h.

3. Composite body according to Claim 1 or 2,
characterized in that
the composite body has a thickness of 100 to 400 µm, preferably 125 to 200 µm and more preferably of 130 to 170 µm.

4. Composite body according to at least one of Claims 1 to 3,
characterized in that
the substrate is a nonwoven fabric, knit or laid scrim, preferably a nonwoven fabric or laid scrim, more preferably a nonwoven fabric.

5. Composite body according to at least one of Claims 1 to 4,
characterized in that
the fibres have a dimension of 1 to 200 g/km of fibre and are preferably composed of polyacrylonitrile, polyamide, polyester and/or polyolefin.

6. Composite body according to at least one of Claims 1 to 5, characterized in that the substrate has a thickness of 50 to 150 µm, preferably 100 to 130 µm, and a basis weight of 40 to 150 g/m², preferably 50 to 120 g/m², preferably 50 to 100 g/m² and most preferably 60 g/m².

7. Composite body according to at least one of Claims 1 to 6, characterized in that the composite body has an average pore size of 60 to 140, preferably 75 to 130 nm.

8. Composite body according to at least one of Claims 1 to 7, characterized in that the composite body, on the surface of the layer (2), has a surface roughness Sdq, determined as specified in the description, of less than 10 µm, more preferably of less than 8 µm.

9. Process for producing a composite body, preferably according to at least one of Claims 1 to 18, characterized in that it has the following steps:

(a) applying a coating composition (BM1) to and into a substrate having fibres and interstices between the fibres, where the coating composition is produced by combining

(a1) a dispersion (D1) of oxide particles produced by mixing oxide particles selected from the oxides of the elements Ti, Al, Zr and/or Si and having a median particle diameter (d50) of 0.5 to 4 µm with water, an inorganic acid, preferably nitric acid, and a dispersing aid,

(a2) a dispersion (D2) of oxide particles produced by mixing oxide particles selected from the oxides of the elements Ti, Al, Zr and/or Si and having a median particle diameter (d50) of 15 to 150 nm, preferably 40 to 60 nm, with water,

(a3) a binder formulation (BF1), produced by mixing at least two organofunctional silanes with an alkanol, preferably ethanol, an inorganic acid, preferably boric acid, and water,

(b) consolidating the coating composition (BM1) at a temperature of 100°C to 275°C, preferably 120 to 240°C, in order to create a first layer (S1‘),

(c) optionally applying a coating composition (BM2) to at least layer (S1‘), where the coating composition (BM2) is produced by combining

(c1) a dispersion (D3) of oxide particles produced by mixing oxide particles selected from the oxides of the elements Ti, Al, Zr and/or Si and having a median particle diameter (d50) of 0.5 to 4 µm with water, an inorganic acid, preferably nitric acid, and a dispersing aid,

(c2) a dispersion (D4) of oxide particles produced by mixing oxide particles selected from the oxides of the elements Ti, Al, Zr and/or Si and having a median particle diameter (d50) of 15 to 150 nm, preferably 40 to 60 nm, with water,

(c3) a binder formulation (BF2), produced by mixing at least two organofunctional silanes with an alkanol, preferably ethanol, an inorganic acid, preferably boric acid, and water,

(d) optionally consolidating the coating composition (BM2) at a temperature of 100°C to 275°C, preferably 120 to 240°C, in order to create a second layer (S2‘),

(e) applying a coating composition (BM3) to layer (S1‘) or, if present, layer (S2‘), where the coating composition (BM3) has been produced by combining water and an inorganic acid with an

(e1) aqueous dispersion (D5) including oxide particles selected from the oxides of the elements Ti, Al, Zr and/or Si and having a median particle diameter (d50) of 15 to 150 nm, preferably 40 to 60 nm, and with ethanol and with a

(e2) binder formulation (BF3) comprising at least two organofunctional silanes,

(f) consolidating the coating composition at a temperature of 100°C to 275°C, preferably 120 to 240°C, in order to create a layer (S3‘),

(g) optionally applying a coating composition (BM4) to layer (S3‘), where the coating composition (BM4) has been produced by combining water and an inorganic acid with an

(g1) aqueous dispersion (D6) including oxide particles selected from the oxides of the elements Ti, Al, Zr and/or Si and having a median particle diameter of 15 to 150 nm, preferably 40 to 60 nm, and with ethanol and with a

(g2) binder formulation (BF4) comprising at least two organofunctional silanes,

(h) optionally consolidating the coating composition at a temperature of 100°C to 275°C, preferably 120 to 240°C, in order to create a layer (S4‘), and

(i) applying a polymer coating containing polysiloxanes to layer (S3’) or, if present, to layer (S4’).

10. Process according to Claim 9,
characterized in that
the organofunctional silanes used are 3-glycidyloxytriethoxysilane, methyltriethoxysilane and tetraethoxysilane.

11. Process according to Claim 9 or 10,
characterized in that
3-glycidyloxytriethoxysilane, methyltriethoxysilane and tetraethoxysilane are used in binder formulation (BF1) and (BF2) in a mass ratio of 2 to 4:0.5 to 1.5:1, more preferably of 2.5 to 3.5:0.75 to 1.25:1, most preferably 3:1:1.

12. Process according to at least one of Claims 9 to 11,
characterized in that
3-glycidyloxytriethoxysilane, methyltriethoxysilane and tetraethoxysilane are used in binder formulation (BF3) and (BF4) in a mass ratio of 0.5 to 1.5:1.5 to 2.5:1, more preferably of 0.75 to 1.25:1.75 to 2.25:1, most preferably 1:2:1.

13. Process according to at least one of Claims 9 to 12,

characterized in that
the coating compositions (BM3) and (BM4) are of identical composition.

14. Process according to at least one of Claims 9 to 13,
characterized in that
the coating compositions (BM1) and (BM2) are of identical composition.

15. Process according to at least one of Claims 9 to 14,
characterized in that
the substrate used is a polymer nonwoven including fibres selected from polyacrylonitrile, polyester, polyamide and/or polyolefin.

16. Process according to at least one of Claims 9 to 15,
characterized in that
the consolidating is effected by passage through a hot air oven, an IR oven or another oven.

17. Use of a composite material according to at least one of Claims 1 to 8 or produced according to any of Claims 9 to 16 in organophilic nanofiltration, preferably as organophilic nanofiltration membrane, more preferably for separation of organic compounds from organic solvent-containing streams of matter.

18. Use according to Claim 17, characterized in that the separation is performed at temperatures of greater than 100°C, preferably greater than 120°C and more preferably greater than 150°C.

19. Separation apparatus comprising a composite material according to at least one of Claims 1 to 8 or produced according to any of Claims 9 to 16.

Amended Claims

1. Flexible composite body having, on a porous substrate and in the interstices of the substrate that includes fibres of an electrically nonconductive material, a porous layer (1) composed of oxide particles bonded to one another and partly to the substrate that include at least one oxide selected from oxides of the elements Al, Zr and Si, preferably selected from Al_2O_3, ZrO_2 and SiO_2, and having, at least on one side, a further porous layer (2) including oxide particles bonded to one another and partly to layer (1) that include at least one oxide selected from oxides of the elements Al, Zr and Si, preferably selected from Al_2O_3, ZrO_2 and SiO_2,
where the oxide particles present in layer (1) have a greater median particle size than the oxide particles present in layer (2), and where the median particle size (d50) of the oxide particles in layer (1), determined as specified in the description, is from 0.5 to 4 µm and the median particle size (d50) of the oxide particles in layer (2), determined as specified in the description, is from 0.015 to 0.15 µm, preferably 0.04 to 0.06 µm,
characterized in that a polymer coating (PB) containing one or more polysiloxanes is present atop or above layer (2) and in that the substrate is a nonwoven fabric, knit or laid scrim, preferably a nonwoven fabric or laid scrim, more preferably a nonwoven fabric, wherein "flexible" means that the composite body can be wound without damage around a bar or around a tube having a diameter of down to 15 mm.

2. Composite body according to Claim 1,
characterized in that
the composite body has a toluene flow rate at 130°C and transmembrane pressure 30 bar (30 *10^5 Pa), determined as specified in the description, of greater than 130 L/m²h, preferably greater than 250 L/m²h, more preferably greater than 300 L/m²h and most preferably greater than 400 L/m²h.

3. Composite body according to Claim 1 or 2,
characterized in that
the composite body has a thickness of 100 to 400 µm, preferably 125 to 200 µm and more preferably of 130 to 170 µm.

4. Composite body according to at least one of Claims 1 to 3,
characterized in that
the fibres have a dimension of 1 to 200 g/km of fibre and are preferably composed of polyacrylonitrile, polyamide, polyester and/or polyolefin.

5. Composite body according to at least one of Claims 1 to 4,
characterized in that

the substrate has a thickness of 50 to 150 µm, preferably 100 to 130 µm, and a basis weight of 40 to 150 g/m^2, preferably 50 to 120 g/m^2, preferably 50 to 100 g/m^2 and most preferably 60 g/m^2.

6. Composite body according to at least one of Claims 1 to 5,
characterized in that
the composite body has an average pore size of 60 to 140, preferably 75 to 130 nm, wherein the average pore size is determined by means of gas flow porometry as described in the description.

7. Composite body according to at least one of Claims 1 to 6,
characterized in that
the composite body, on the surface of the layer (2), has a surface roughness Sdq, determined as specified in the description, of less than 10 µm, more preferably of less than 8 µm.

8. Process for producing a flexible composite body, preferably according to at least one of Claims 1 to 7,
characterized in that it has the following steps:
(a) applying a coating composition (BM1) to and into a substrate having fibres and interstices between the fibres, where the coating composition is produced by combining
(a1) a dispersion (D1) of oxide particles produced by mixing oxide particles selected from the oxides of the elements Al, Zr and/or Si and having a median particle diameter (d50) of 0.5 to 4 µm with water, an inorganic acid, preferably nitric acid, and a dispersing aid,
(a2) a dispersion (D2) of oxide particles produced by mixing oxide particles selected from the oxides of the elements Al, Zr and/or Si and having a median particle diameter (d50) of 15 to 150 nm, preferably 40 to 60 nm, with water,
(a3) a binder formulation (BF1), produced by mixing at least two organofunctional silanes with an alkanol, preferably ethanol, an inorganic acid, preferably boric acid, and water,
(b) consolidating the coating composition (BM1) at a temperature of 100°C to 275°C, preferably 120 to 240°C, in order to create a first layer (S1‘),
(c) optionally applying a coating composition (BM2) to at least layer (S1‘), where the coating composition (BM2) is produced by combining
(c1) a dispersion (D3) of oxide particles produced by mixing oxide particles selected from the oxides of the elements Al, Zr and/or Si and having a median particle diameter (d50) of 0.5 to 4 µm with water, an inorganic acid, preferably nitric acid, and a dispersing aid,
(c2) a dispersion (D4) of oxide particles produced by mixing oxide particles selected from the oxides of the elements Al, Zr and/or Si and having a median particle diameter (d50) of 15 to 150 nm, preferably 40 to 60 nm, with water,
(c3) a binder formulation (BF2), produced by mixing at least two organofunctional silanes with an alkanol, preferably ethanol, an inorganic acid, preferably boric acid, and water,

(d) optionally consolidating the coating composition (BM2) at a temperature of 100°C to 275°C, preferably 120 to 240°C, in order to create a second layer (S2‘),

(e) applying a coating composition (BM3) to layer (S1‘) or, if present, layer (S2‘), where the coating composition (BM3) has been produced by combining water and an inorganic acid with an

(e1) aqueous dispersion (D5) including oxide particles selected from the oxides of the elements Al, Zr and/or Si and having a median particle diameter (d50) of 15 to 150 nm, preferably 40 to 60 nm, and with ethanol and with a

(e2) binder formulation (BF3) comprising at least two organofunctional silanes,

(f) consolidating the coating composition at a temperature of 100°C to 275°C, preferably 120 to 240°C, in order to create a layer (S3‘),

(g) optionally applying a coating composition (BM4) to layer (S3‘), where the coating composition (BM4) has been produced by combining water and an inorganic acid with an

(g1) aqueous dispersion (D6) including oxide particles selected from the oxides of the elements Al, Zr and/or Si and having a median particle diameter of 15 to 150 nm, preferably 40 to 60 nm, and with ethanol and with a

(g2) binder formulation (BF4) comprising at least two organofunctional silanes,

(h) optionally consolidating the coating composition at a temperature of 100°C to 275°C, preferably 120 to 240°C, in order to create a layer (S4‘), and

(i) applying a polymer coating containing polysiloxanes to layer (S3’) or, if present, to layer (S4’),

characterized in that

the organofunctional silanes used are 3-glycidyloxytriethoxysilane, methyltriethoxysilane and tetraethoxysilane, and

in that the substrate used is a polymer nonwoven including fibres selected from polyacrylonitrile, polyester, polyamide and/or polyolefin, wherein “flexible” means that the composite body can be wound without damage around a bar or around a tube having a diameter of down to 15 mm.

9. Process according to Claim 8,

characterized in that

3-glycidyloxytriethoxysilane, methyltriethoxysilane and tetraethoxysilane are used in binder formulation (BF1) and (BF2) in a mass ratio of 2 to 4:0.5 to 1.5:1, more preferably of 2.5 to 3.5:0.75 to 1.25:1, most preferably 3:1:1.

10. Process according to at least one of Claims 8 or 9,

characterized in that

3-glycidyloxytriethoxysilane, methyltriethoxysilane and tetraethoxysilane are used in binder formulation (BF3) and (BF4) in a mass ratio of 0.5 to 1.5:1.5 to 2.5:1, more preferably of 0.75 to 1.25:1.75 to 2.25:1, most preferably 1:2:1.

11. Process according to at least one of Claims 8 to 10,
characterized in that
the coating compositions (BM3) and (BM4) are of identical composition.

12. Process according to at least one of Claims 8 to 11,
characterized in that
the coating compositions (BM1) and (BM2) are of identical composition.

13. Process according to at least one of Claims 8 to 12,
characterized in that
the consolidating is effected by passage through a hot air oven, an IR oven or another oven.

14. Use of a composite material according to at least one of Claims 1 to 7 or produced according to any of Claims 8 to 13 in organophilic nanofiltration, preferably as organophilic nanofiltration membrane, more preferably for separation of organic compounds from organic solvent-containing streams of matter.

15. Use according to Claim 14, characterized in that the separation is performed at temperatures of greater than 100°C, preferably greater than 120°C and more preferably greater than 150°C.

16. Separation apparatus comprising a composite material according to at least one of Claims 1 to 7 or produced according to any of Claims 8 to 13.

Claims

1. Flexible composite body having, on a porous substrate and in the interstices of the substrate that includes fibres of an electrically nonconductive material, a porous layer (1) composed of oxide particles bonded to one another and partly to the substrate that include at least one oxide selected from oxides of the elements Al, Zr and Si, preferably selected from Al_2O_3, ZrO_2 and SiO_2, and having, at least on one side, a further porous layer (2) including oxide particles bonded to one another and partly to layer (1) that include at least one oxide selected from oxides of the elements Al, Zr and Si, preferably selected from Al_2O_3, ZrO_2 and SiO_2,
where the oxide particles present in layer (1) have a greater median particle size than the oxide particles present in layer (2), and where the median particle size (d50) of the oxide particles in layer (1), determined as specified in the description, is from 0.5 to 4 µm and the median particle size (d50) of the oxide particles in layer (2), determined as specified in the description, is from 0.015 to 0.15 µm, preferably 0.04 to 0.06 µm,
characterized in that a polymer coating (PB) containing one or more polysiloxanes is present atop or above layer (2) and in that the substrate is a nonwoven fabric, wherein “flexible” means that the composite body can be wound without damage around a bar or around a tube having a diameter of down to 15 mm and wherein
the composite body, on the surface of the layer (2), has a surface roughness Sdq, determined as specified in the description, of less than 10 µm, more preferably of less than 8 µm.

2. Composite body according to Claim 1,
characterized in that
the composite body has a toluene flow rate at 130°C and transmembrane pressure 30 bar (30 $*10^5$ Pa), determined as specified in the description, of greater than 130 L/m²h, preferably greater than 250 L/m²h, more preferably greater than 300 L/m²h and most preferably greater than 400 L/m²h.

3. Composite body according to Claim 1 or 2,
characterized in that
the composite body has a thickness of 100 to 400 µm, preferably 125 to 200 µm and more preferably of 130 to 170 µm.

4. Composite body according to at least one of Claims 1 to 3,
characterized in that
the fibres have a dimension of 1 to 200 g/km of fibre and are preferably composed of polyacrylonitrile, polyamide, polyester and/or polyolefin.

5. Composite body according to at least one of Claims 1 to 4,

characterized in that

the substrate has a thickness of 50 to 150 µm, preferably 100 to 130 µm, and a basis weight of 40 to 150 g/m^2, preferably 50 to 120 g/m^2, preferably 50 to 100 g/m^2 and most preferably 60 g/m^2.

6. Composite body according to at least one of Claims 1 to 5,

characterized in that

the composite body has an average pore size of 60 to 140, preferably 75 to 130 nm, wherein the average pore size is determined by means of gas flow porometry as described in the description.

7. Process for producing a flexible composite body, preferably according to at least one of Claims 1 to 6,

characterized in that it has the following steps:

(a) applying a coating composition (BM1) to and into a substrate having fibres and interstices between the fibres, where the coating composition is produced by combining

(a1) a dispersion (D1) of oxide particles produced by mixing oxide particles selected from the oxides of the elements Al, Zr and/or Si and having a median particle diameter (d50) of 0.5 to 4 µm with water, an inorganic acid, preferably nitric acid, and a dispersing aid,

(a2) a dispersion (D2) of oxide particles produced by mixing oxide particles selected from the oxides of the elements Al, Zr and/or Si and having a median particle diameter (d50) of 15 to 150 nm, preferably 40 to 60 nm, with water,

(a3) a binder formulation (BF1), produced by mixing at least two organofunctional silanes with an alkanol, preferably ethanol, an inorganic acid, preferably boric acid, and water,

(b) consolidating the coating composition (BM1) at a temperature of 100°C to 275°C, preferably 120 to 240°C, in order to create a first layer (S1‘),

(c) optionally applying a coating composition (BM2) to at least layer (S1‘), where the coating composition (BM2) is produced by combining

(c1) a dispersion (D3) of oxide particles produced by mixing oxide particles selected from the oxides of the elements Al, Zr and/or Si and having a median particle diameter (d50) of 0.5 to 4 µm with water, an inorganic acid, preferably nitric acid, and a dispersing aid,

(c2) a dispersion (D4) of oxide particles produced by mixing oxide particles selected from the oxides of the elements Al, Zr and/or Si and having a median particle diameter (d50) of 15 to 150 nm, preferably 40 to 60 nm, with water,

(c3) a binder formulation (BF2), produced by mixing at least two organofunctional silanes with an alkanol, preferably ethanol, an inorganic acid, preferably boric acid, and water,

(d) optionally consolidating the coating composition (BM2) at a temperature of 100°C to 275°C, preferably 120 to 240°C, in order to create a second layer (S2‘),

(e) applying a coating composition (BM3) to layer (S1‘) or, if present, layer (S2‘), where the coating composition (BM3) has been produced by combining water and an inorganic acid with an

(e1) aqueous dispersion (D5) including oxide particles selected from the oxides of the elements Al, Zr and/or Si and having a median particle diameter (d50) of 15 to 150 nm, preferably 40 to 60 nm, and with ethanol and with a

(e2) binder formulation (BF3) comprising at least two organofunctional silanes,

(f) consolidating the coating composition at a temperature of 100°C to 275°C, preferably 120 to 240°C, in order to create a layer (S3‘),

(g) optionally applying a coating composition (BM4) to layer (S3‘), where the coating composition (BM4) has been produced by combining water and an inorganic acid with an

(g1) aqueous dispersion (D6) including oxide particles selected from the oxides of the elements Al, Zr and/or Si and having a median particle diameter of 15 to 150 nm, preferably 40 to 60 nm, and with ethanol and with a

(g2) binder formulation (BF4) comprising at least two organofunctional silanes,

(h) optionally consolidating the coating composition at a temperature of 100°C to 275°C, preferably 120 to 240°C, in order to create a layer (S4‘), and

(i) applying a polymer coating containing polysiloxanes to layer (S3’) or, if present, to layer (S4’),

characterized in that

the organofunctional silanes used are 3-glycidyloxytriethoxysilane, methyltriethoxysilane and tetraethoxysilane, and

in that the substrate used is a polymer nonwoven including fibres selected from polyacrylonitrile, polyester, polyamide and/or polyolefin, wherein “flexible” means that the composite body can be wound without damage around a bar or around a tube having a diameter of down to 15 mm.

8. Process according to Claim 7,
characterized in that
3-glycidyloxytriethoxysilane, methyltriethoxysilane and tetraethoxysilane are used in binder formulation (BF1) and (BF2) in a mass ratio of 2 to 4:0.5 to 1.5:1, more preferably of 2.5 to 3.5:0.75 to 1.25:1, most preferably 3:1:1.

9. Process according to at least one of Claims 7 or 8,
characterized in that
3-glycidyloxytriethoxysilane, methyltriethoxysilane and tetraethoxysilane are used in binder formulation (BF3) and (BF4) in a mass ratio of 0.5 to 1.5:1.5 to 2.5:1, more preferably of 0.75 to 1.25:1.75 to 2.25:1, most preferably 1:2:1.

10. Process according to at least one of Claims 7 to 9,
characterized in that

the coating compositions (BM3) and (BM4) are of identical composition.

11. Process according to at least one of Claims 7 to 10,
characterized in that
the coating compositions (BM1) and (BM2) are of identical composition.

12. Process according to at least one of Claims 7 to 11,
characterized in that
the consolidating is effected by passage through a hot air oven, an IR oven or another oven.

13. Use of a composite material according to at least one of Claims 1 to 6 or produced according to any of Claims 7 to 12 in organophilic nanofiltration, preferably as organophilic nanofiltration membrane, more preferably for separation of organic compounds from organic solvent-containing streams of matter.

14. Use according to Claim 13, characterized in that the separation is performed at temperatures of greater than 100°C, preferably greater than 120°C and more preferably greater than 150°C.

15. Separation apparatus comprising a composite material according to at least one of Claims 1 to 6 or produced according to any of Claims 7 to 12.