In an advantageous alternative according to the invention, said first alcohol solvent comprises an additive, preferably selected from the group of ethylene glycol, polyethylene glycol 200, polyethylene glycol 400, polyethylene glycol 1500, polyethylene glycol 10000 and polyethylene glycol 15,00000, ethoxylated natural fatty acids, preferably based on stearyl alcohol, more particularly Brij® S10, Pluronic ~~F120~~F127®, sodium dodecylbenzene sulfonate and 4-hydroxybenzoic acid as well as mixtures thereof.

According to a preferential embodiment, said functionalization solvent is selected from the group consisting of ethylene glycol, polyethylene glycol 200, polyethylene glycol 400, polyethylene glycol 1500, polyethylene glycol 10000 and polyethylene glycol 15,00000, ethoxylated natural fatty acids, preferably based on stearyl alcohol, more particularly Brij® S10, Pluronic ~~F120~~F127®, and sodium dodecylbenzene sulfonate, para-hydroxybenzoic acid, as well as mixtures thereof.

Preferentially, said agent bearing a carboxyl or carboxylate function is a carboxylic acid or the associated carboxylate selected from the group of monofunctional or polyfunctional carboxylic acids, optionally having alcohol chains and/or optionally benzene rings and/or having saturated or unsaturated carbon chains, preferably, said agent bearing a carboxyl or carboxylate function is 4-hydroxybenzoic acid.

Advantageously, said agent bearing a carboxyl or carboxylate function is a carboxylic amino acid, in particular tyrosine.

Other embodiments of the method according to the invention are indicated in the appended claims.

The object of the invention is also a composite material, for example obtained with the method according to the present invention.

In particular, the present invention relates to a material comprising a substrate and at least one coating based on powder characterized in that said coating consists of said powder and has an adhesion to said substrate of more than 17 N/mm^2 according to the ASTM4541 standard.

Advantageously, the material includes according to the present invention, an nth coating ($n \geq 2$) based on an nth powder, in which said nth coating consists of said nth powder.

In the material according to the invention, preferably, said powder is a powder comprising an alkaline metal oxide, an earth-alkaline metal oxide, a transition metal oxide, a low metal oxide, a metalloid oxide, a lanthanide oxide, an actinide oxide, preferably, a metal

CLAIMS

1. A method for manufacturing a composite material comprising a substrate and a coating based on powder, comprising

a) functionalization of the substrate comprising a treatment of a surface of said substrate with a first solution containing at least one first ~~alcohol~~ solvent selected from the group consisting of water and of organic alcohols, either saturated or unsaturated with a linear chain, comprising at least one alcohol function, and preferably selected from the group of methoxyethanol, ethanol, ethylene glycol, 1-propanol, methanol, n-butanol, 2-phenylethanol and 2-propanol and mixtures thereof,

b) formation of a first stable colloidal sol,

c) at least one application of at least one layer of said first colloidal sol on the functionalized substrate,

d) drying of said at least one layer of said first colloidal sol and

e) formation of a first coating layer formed with said first colloidal sol, adhering to said substrate, by heating to a temperature above 50°C and below 500°C, characterized in that the method further comprises:

~~f)~~ before the formation of said first stable colloidal sol, functionalization of a first powder by an agent bearing a carboxyl or carboxylate function and in that said first stable colloidal sol is based on said first powder, functionalized by an agent bearing a carboxyl or carboxylate function in a second solvent, said coating being formed with said first uniformly distributed powder.

2. The method according to claim 1, wherein said steps c) and d) are repeated alternately a predetermined number of times corresponding to the number of layers of said first powder in order to form said first coating.

3. The method according to claim 1 or claim 2, further comprising the steps:

a) functionalization of an nth powder ($n \geq 2$) and formation of an nth ($n \geq 2$) colloidal sol containing said nth ($n \geq 2$) powder, functionalized in a Zth ($Z \geq n+1$) solvent,

b) application of at least one layer of said nth colloidal sol of said nth powder on the substrate coated with said (n -1)th coating,

c) drying of said at least one layer of said nth colloidal sol and,

d) optionally formation of a coating layer formed with said nth colloidal sol of said nth powder, adhering to said (n-1)th coating, by heating to a temperature above 50°C and below 500°C.

4. The method according to claim 3, wherein said steps b) and c) are alternately repeated a predetermined number of times corresponding to the number of layers of said nth powder in order to form said nth coating.

5. The method according to any of claims 1 to 4, wherein said first and/or said nth colloidal sol contains water.

6. The method according to any of claims 1 to 5, wherein said powder is a powder comprising an alkaline oxide, an earth-alkaline oxide, a transition metal oxide, a low metal oxide, a metalloid oxide, a lanthanide oxide, an actinide oxide, preferably a metal oxide and/or a silicon oxide, more preferentially comprising one or several oxides selected from the group of lithium, sodium, cerium, titanium, vanadium, chromium, molybdenum, manganese, iron, cobalt, palladium, copper, zinc, cadmium, aluminum, silicon, tin and lead oxides and combinations thereof, such as mixed oxides of cobalt and lithium, of iron and manganese, of lithium and titanium, and the like.

7. The method according to any of the preceding claims, wherein said substrate is selected from the group consisting of metal, glass or quartz, a ceramic support, or any other material coated with titanium dioxide and silicon oxides.

8. The method according to claim 7, wherein said metal is selected from the group consisting of steel, in particular low, medium or high carbon steel, either rolled or not, coated or not, shaped or not, flat or shaped stainless steel, platinum, optionally deposited on another support, aluminum, rolled or not, optionally shaped, more particularly, said metal is selected from the group of sheet-coated steel, pre-painted steel, sheet aluminum or steel coated with a titanium dioxide layer.

9. The method according to claim 7, wherein said glass or quartz is selected from the group consisting of either alkaline or not glass, flat or shaped glass such as

in the form of a tube, threads or fibers, quartz in the form of a sheet, of a tube, of threads or further of fibers and the like.

10. The method according to any of claims 1 to 9, wherein said first and/or said nth colloidal sol is formed in the presence of an agent bearing a carboxyl or carboxylate function.

11. The method according to claim 10, wherein said step for functionalization of said first powder with formation of said first colloidal sol containing said first functionalized powder comprises the steps:

a) preparing a first solution S1 of said agent bearing a carboxyl or carboxylate function in said second solvent (SO1), which is selected from organic alcohols either saturated or unsaturated with a linear chain, comprising at least one alcohol function,

b) preparing a suspension Sp1 by dispersing said first powder into said first solution S1,

c) adding water to said first solution S1 in order to form a dilute solution S1d,

d) mixing said dilute solution S1d and said suspension Sp1 at a temperature comprised between 10°C and the reflux temperature of said second solvent, and

e) homogenizing said mixture until said first colloidal sol containing said first functionalized powder is obtained.

12. The method according to claim 10 or claim 11 wherein said method depends on claim 3 to 9 and not 1 to 2, wherein said step for functionalization of said nth (n ≥ 2) powder with formation of an nth (n ≥ 2) colloidal sol containing said nth functionalized powder (n ≥ 2) comprise the following steps:

a) preparing an nth (n ≥ 2) solution Sn of said agent bearing a carboxyl or carboxylate function in said Zth (Z ≥ n+1) solvent (SOz_2),

b) preparing a suspension Spn by dispersing said nth powder (n ≥ 2) into said nth (n ≥ 2) solution Sn,

c) adding water to said nth (n ≥ 2) solution Sn in order to form an nth dilute solution (n ≥ 2), Snd,

d) mixing said nth (n ≥ 2) dilute solution Snd and said suspension Spn at a temperature comprised between 10°C and the reflux temperature of said

Zth (Z ≥ n+1) ~~alcohol~~ solvent selected from the group consisting of water and of organic alcohols, either saturated or unsaturated with a linear chain, comprising at least one alcohol function, and preferably selected from the group of methoxyethanol, ethanol, ethylene glycol, 1-propanol, methanol, n-butanol, 2-phenylethanol and 2-propanol and mixtures thereof and

e) homogenizing said mixture until said nth (n ≥ 2) colloidal sol is obtained containing said nth functionalized powder (n ≥ 2).

13. The method according to any of claims 1 to 9, wherein said first powder is functionalized in a functionalization solvent Sf, optionally in the presence of water and wherein said first colloidal sol is formed by the steps:

a) preparing a suspension Sp1 by dispersing said first functionalized powder into said second solvent SO_1.

b) adding water to said second solvent SO_1 in order to form a dilute solution S_1d,

c) mixing said dilute solution S1d and said suspension Sp1 at a temperature comprised between 10°C and the reflux temperature of said second solvent SO1,

d) homogenizing said mixture until an intermediate colloidal sol containing said first functionalized powder is obtained and,

e) adding to said intermediate colloidal sol a solution containing an agent bearing a carboxyl or carboxylate function in a third solvent, preferably an alcoholic solvent in order to form said first colloidal sol SOL1.

14. The method according to claim 13, ~~when it~~wherein said method depends on claim 3 to 9 and not 1 to 2, wherein said nth powder (n ≥ 2) is functionalized in a functionalization solvent Sf, optionally in the presence of water and wherein said ~~first~~ nth colloidal sol is formed by the steps:

a) preparing a suspension Spn by dispersing said nth powder (n ≥ 2) in said Zth (Z ≥ n+1) solvent (SOZ),

b) adding water to said Zth solvent (Z ≥ n+1) in order to form a dilute solution Snd,

c) mixing said dilute solution Snd and said suspension Spn at a temperature comprised between 10°C and the reflux temperature of said Zth solvent (Z ≥ n+1),

d) homogenizing said mixture until an intermediate colloidal sol of a solution containing said nth functionalized powder is obtained,

e) adding to said intermediate colloidal sol a solution containing an agent bearing a carboxyl or carboxylate function in a third solvent, preferably an alcohol solvent in order to form said nth colloidal sol SOLn.

15. The method according to any of claims 1 to 14, wherein ~~said first alcohol solvent~~, said second solvent, ~~said third solvent and said Zth (Z ≥ n+1) solvent are~~is selected independently of each other from the group consisting of water and of organic alcohols, either saturated or unsaturated with a linear chain, comprising at least one alcohol function, and preferably selected from the group of methoxyethanol, ethanol, ethylene glycol, 1-propanol, methanol, n-butanol, 2-phenylethanol and 2-propanol and mixtures thereof and may be either identical or different.

16. The method according to any of claims 3 to 14, wherein said third solvent is selected independently of each other from the group consisting of water and of organic alcohols, either saturated or unsaturated with a linear chain, comprising at least one alcohol function, and preferably selected from the group of methoxyethanol, ethanol, ethylene glycol, 1-propanol, methanol, n-butanol, 2-phenylethanol and 2-propanol and mixtures thereof and may be either identical or different.

17. The method according to any of claims 13 or 14, wherein said Zth (Z ≥ n+1) solvent is selected independently of each other from the group consisting of water and of organic alcohols, either saturated or unsaturated with a linear chain, comprising at least one alcohol function, and preferably selected from the group of methoxyethanol, ethanol, ethylene glycol, 1-propanol, methanol, n-butanol, 2-phenylethanol and 2-propanol and mixtures thereof and may be either identical or different.

18~~6~~. The method according to any of claims 1 to 15, wherein said first alcohol solvent comprises an additive, preferably selected from the group of ethylene glycol, polyethylene glycol 200, polyethylene glycol 400, polyethylene glycol 1500,

polyethylene glycol 10,000 and polyethylene glycol 1,500,000, ethoxylated natural fatty alcohols, preferably based on stearyl alcohol, more particularly Brij® S10, Pluronic F127~~0~~®, sodium dodecylbenzene sulfonate and 4-hydroxybenzoic acid as well as mixtures thereof.

19~~7~~. The method according to any of claims 13 to 18~~6~~, wherein said functionalization solvent is selected from the group consisting of ethylene glycol, polyethylene glycol 200, polyethylene glycol 400, polyethylene glycol 1500, polyethylene glycol 10,000 and polyethylene glycol 1,500,000, ethoxylated natural fatty alcohols, preferably based on stearyl alcohol, more particularly Brij® S10, Pluronic F127~~0~~®, and sodium dodecylbenzene sulfonate, para-hydroxybenzoic acid, as well as mixtures thereof.

20~~18~~. The method according to any of claims 1 to 19~~7~~, wherein said agent bearing a carboxyl or carboxylate function is selected from the group of monofunctional or polyfunctional carboxylic acids, optionally having alcohol chains and/or optionally benzene rings and/or having saturated or unsaturated carbon chains, preferably, said agent bearing a carboxyl or carboxylate function is 4-hydroxybenzoic acid.

21~~19~~. A material comprising a substrate and at least one coating based on powder characterising that said coating consists of said powder and exhibits adherence to said substrate greater than 17 N/mm^2 according to the ASTM4541 standard.

22~~0~~. The material according to claim 21~~19~~, further comprising an nth coating ($n \geq 2$) based on an nth powder, wherein said nth coating consists of said nth powder.

23~~1~~. The material according to claim 21~~19~~ or 22~~0~~, wherein said powder is a powder comprising an alkaline metal oxide, an earth-alkaline metal oxide, a transition metal oxide, a low metal oxide, a metalloid oxide, a lanthanide oxide, an actinide oxide, preferably a metal oxide and/or a silicon oxide, more preferentially comprising one or more oxides selected from the group of lithium, sodium, cerium, titanium, vanadium, chromium, molybdenum, manganese, iron, cobalt, palladium, copper, zinc, cadmium, aluminum, silicon, tin and lead oxides and combinations thereof, such

as mixed oxides of cobalt and lithium, of iron and manganese, of lithium and of titanium, and the like.

242. The material according to any of claims 2119 to 231, wherein said substrate is selected from the group consisting of a metal, of glass or quartz, of a ceramic support, or of any other material coated with titanium dioxide and silicon oxides.

253. The material according to claim 242, wherein said metal is selected from the group consisting of steel, in particular low, medium or high carbon steel, either rolled or not, coated or not, shaped or not, flat or shaped stainless steel, platinum, optionally deposited on another support, aluminum, either rolled or not, optionally shaped, more particularly, said metal is selected from the group of sheet-coated steel, pre-painted steel, sheet aluminum or steel coated with a titanium dioxide layer.

264. The material according to claim 242, wherein said glass or quartz is selected from the group consisting of an alkaline glass or not, either flat or shaped such as in the form of a tube, threads or fibers, quartz in the form of a sheet, a tube, threads or further fibers and the like.

In an advantageous alternative according to the invention, said first alcohol solvent comprises an additive, preferably selected from the group of ethylene glycol, polyethylene glycol 200, polyethylene glycol 400, polyethylene glycol 1500, polyethylene glycol 10000 and polyethylene glycol 15,00000, ethoxylated natural fatty acids, preferably based on stearyl alcohol, more particularly Brij® S10, Pluronic F120®, sodium dodecylbenzene sulfonate and 4-hydroxybenzoic acid as well as mixtures thereof.

According to a preferential embodiment, said functionalization solvent is selected from the group consisting of ethylene glycol, polyethylene glycol 200, polyethylene glycol 400, polyethylene glycol 1500, polyethylene glycol 10000 and polyethylene glycol 15,00000, ethoxylated natural fatty acids, preferably based on stearyl alcohol, more particularly Brij® S10, Pluronic F120®, and sodium dodecylbenzene sulfonate, para-hydroxybenzoic acid, as well as mixtures thereof.

Preferentially, said agent bearing a carboxyl or carboxylate function is a carboxylic acid or the associated carboxylate selected from the group of monofunctional or polyfunctional carboxylic acids, optionally having alcohol chains and/or optionally benzene rings and/or having saturated or unsaturated carbon chains, preferably, said agent bearing a carboxyl or carboxylate function is 4-hydroxybenzoic acid.

Advantageously, said agent bearing a carboxyl or carboxylate function is a carboxylic amino acid, in particular tyrosine.

Other embodiments of the method according to the invention are indicated in the appended claims.

The object of the invention is also a composite material, for example obtained with the method according to the present invention.

In particular, the present invention relates to a material comprising a substrate and at least one coating based on powder characterized in that said coating consists of said powder and has an adhesion to said substrate of more than 17 N/mm^2 according to the ASTM4541 standard.

Advantageously, the material includes according to the present invention, an nth coating ($n \geq 2$) based on an nth powder, in which said nth coating consists of said nth powder.

In the material according to the invention, preferably, said powder is a powder comprising an alkaline metal oxide, an earth-alkaline metal oxide, a transition metal oxide, a low metal oxide, a metalloid oxide, a lanthanide oxide, an actinide oxide, preferably, a metal

CLAIMS

1. A method for manufacturing a composite material comprising a substrate and a coating based on powder, comprising

f) functionalization of the substrate comprising a treatment of a surface of said substrate with a first solution containing at least one first alcohol solvent,

g) formation of a first stable colloidal sol,

h) at least one application of at least one layer of said first colloidal sol on the functionalized substrate,

i) drying of said at least one layer of said first colloidal sol and

j) formation of a first coating layer formed with said first colloidal sol, adhering to said substrate, by heating to a temperature above 50°C and below 500°C, characterized in that the method further comprises:

k) before the formation of said first stable colloidal sol, functionalization of a first powder and in that said first stable colloidal sol is based on said first powder, functionalized in a second solvent, said coating being formed with said first uniformly distributed powder.

2. The method according to claim 1, wherein said steps c) and d) are repeated alternately a predetermined number of times corresponding to the number of layers of said first powder in order to form said first coating.

3. The method according to claim 1 or claim 2, further comprising the steps:

a) functionalization of an nth powder ($n \geq 2$) and formation of an nth ($n \geq 2$) colloidal sol containing said nth ($n \geq 2$) powder, functionalized in a Zth ($Z \geq n+1$) solvent,

b) application of at least one layer of said nth colloidal sol of said nth powder on the substrate coated with said (n -1)th coating,

c) drying of said at least one layer of said nth colloidal sol and,

d) optionally formation of a coating layer formed with said nth colloidal sol of said nth powder, adhering to said (n-1)th coating, by heating to a temperature above 50°C and below 500°C.

4. The method according to claim 3, wherein said steps b) and c) are alternately repeated a predetermined number of times corresponding to the number of layers of said nth powder in order to form said nth coating.

5. The method according to any of claims 1 to 4, wherein said first and/or said nth colloidal sol contains water.

6. The method according to any of claims 1 to 5, wherein said powder is a powder comprising an alkaline oxide, an earth-alkaline oxide, a transition metal oxide, a low metal oxide, a metalloid oxide, a lanthanide oxide, an actinide oxide, preferably a metal oxide and/or a silicon oxide, more preferentially comprising one or several oxides selected from the group of lithium, sodium, cerium, titanium, vanadium, chromium, molybdenum, manganese, iron, cobalt, palladium, copper, zinc, cadmium, aluminum, silicon, tin and lead oxides and combinations thereof, such as mixed oxides of cobalt and lithium, of iron and manganese, of lithium and titanium, and the like.

7. The method according to any of the preceding claims, wherein said substrate is selected from the group consisting of metal, glass or quartz, a ceramic support, or any other material coated with titanium dioxide and silicon oxides.

8. The method according to claim 7, wherein said metal is selected from the group consisting of steel, in particular low, medium or high carbon steel, either rolled or not, coated or not, shaped or not, flat or shaped stainless steel, platinum, optionally deposited on another support, aluminum, rolled or not, optionally shaped, more particularly, said metal is selected from the group of sheet-coated steel, pre-painted steel, sheet aluminum or steel coated with a titanium dioxide layer.

9. The method according to claim 7, wherein said glass or quartz is selected from the group consisting of either alkaline or not glass, flat or shaped glass such as in the form of a tube, threads or fibers, quartz in the form of a sheet, of a tube, of threads or further of fibers and the like.

10. The method according to any of claims 1 to 9, wherein said first and/or said nth colloidal sol is formed in the presence of an agent bearing a carboxyl or carboxylate function.

11. The method according to claim 10, wherein said step for functionalization of said first powder with formation of said first colloidal sol containing said first functionalized powder comprises the steps:

a) preparing a first solution S1 of said agent bearing a carboxyl or carboxylate function in said second solvent (SO1), which is selected from organic alcohols either saturated or unsaturated with a linear chain, comprising at least one alcohol function,

b) preparing a suspension Sp1 by dispersing said first powder into said first solution S1,

c) adding water to said first solution S1 in order to form a dilute solution S1d,

d) mixing said dilute solution S1d and said suspension Sp1 at a temperature comprised between 10°C and the reflux temperature of said second solvent, and

e) homogenizing said mixture until said first colloidal sol containing said first functionalized powder is obtained.

12. The method according to claim 10 or claim 11, wherein said step for functionalization of said nth ($n \geq 2$) powder with formation of an nth ($n \geq 2$) colloidal sol containing said nth functionalized powder ($n \geq 2$) comprise the following steps:

f) preparing an nth ($n \geq 2$) solution Sn of said agent bearing a carboxyl or carboxylate function in said Zth ($Z \geq n+1$) solvent (SO_2),

g) preparing a suspension Spn by dispersing said nth powder ($n \geq 2$) into said nth ($n \geq 2$) solution Sn,

h) adding water to said nth ($n \geq 2$) solution Sn in order to form an nth dilute solution ($n \geq 2$), Snd,

i) mixing said nth ($n \geq 2$) dilute solution Snd and said suspension Spn at a temperature comprised between 10°C and the reflux temperature of said Zth ($Z \geq n+1$) alcohol solvent and

j) homogenizing said mixture until said nth ($n \geq 2$) colloidal sol is obtained containing said nth functionalized powder ($n \geq 2$).

13. The method according to any of claims 1 to 9, wherein said first powder is functionalized in a functionalization solvent Sf, optionally in the presence of water and wherein said first colloidal sol is formed by the steps:

a) preparing a suspension Sp1 by dispersing said first functionalized powder into said second solvent SO_1.

b) adding water to said second solvent SO_1 in order to form a dilute solution S_1d,

c) mixing said dilute solution S1d and said suspension Sp1 at a temperature comprised between 10°C and the reflux temperature of said second solvent SO1,

d) homogenizing said mixture until an intermediate colloidal sol containing said first functionalized powder is obtained and,

e) adding to said intermediate colloidal sol a solution containing an agent bearing a carboxyl or carboxylate function in a third solvent, preferably an alcoholic solvent in order to form said first colloidal sol SOL1.

14. The method according to claim 13, when it depends on claim 3, wherein said nth powder ($n \geq 2$) is functionalized in a functionalization solvent Sf, optionally in the presence of water and wherein said first colloidal sol is formed by the steps:

f) preparing a suspension Spn by dispersing said nth powder ($n \geq 2$) in said Zth ($Z \geq n+1$) solvent (SOZ),

g) adding water to said Zth solvent ($Z \geq n+1$) in order to form a dilute solution Snd,

h) mixing said dilute solution Snd and said suspension Spn at a temperature comprised between 10°C and the reflux temperature of said Zth solvent ($Z \geq n+1$),

i) homogenizing said mixture until an intermediate colloidal sol of a solution containing said nth functionalized powder is obtained,

j) adding to said intermediate colloidal sol a solution containing an agent bearing a carboxyl or carboxylate function in a third solvent, preferably an alcohol solvent in order to form said nth colloidal sol SOLn.

15. The method according to any of claims 1 to 14, wherein said first alcohol solvent, said second solvent, said third solvent and said Zth ($Z \geq n+1$) solvent are selected independently of each other from the group consisting of water and of organic alcohols, either

saturated or unsaturated with a linear chain, comprising at least one alcohol function, and preferably selected from the group of methoxyethanol, ethanol, ethylene glycol, 1-propanol, methanol, n-butanol, 2-phenylethanol and 2-propanol and mixtures thereof and may be either identical or different.

16. The method according to any of claims 1 to 15, wherein said first alcohol solvent comprises an additive, preferably selected from the group of ethylene glycol, polyethylene glycol 200, polyethylene glycol 400, polyethylene glycol 1500, polyethylene glycol 10,000 and polyethylene glycol 1,500,000, ethoxylated natural fatty alcohols, preferably based on stearyl alcohol, more particularly Brij® S10, Pluronic F120®, sodium dodecylbenzene sulfonate and 4-hydroxybenzoic acid as well as mixtures thereof.

17. The method according to any of claims 1 to 16, wherein said functionalization solvent is selected from the group consisting of ethylene glycol, polyethylene glycol 200, polyethylene glycol 400, polyethylene glycol 1500, polyethylene glycol 10,000 and polyethylene glycol 1,500,000, ethoxylated natural fatty alcohols, preferably based on stearyl alcohol, more particularly Brij® S10, Pluronic F120®, and sodium dodecylbenzene sulfonate, para-hydroxybenzoic acid, as well as mixtures thereof.

18. The method according to any of claims 1 to 17, wherein said agent bearing a carboxyl or carboxylate function is selected from the group of monofunctional or polyfunctional carboxylic acids, optionally having alcohol chains and/or optionally benzene rings and/or having saturated or unsaturated carbon chains, preferably, said agent bearing a carboxyl or carboxylate function is 4-hydroxybenzoic acid.

19. A material comprising a substrate and at least one coating based on powder characterising that said coating consists of said powder and exhibits adherence to said substrate greater than 17 N/mm^2 according to the ASTM4541 standard.

20. The material according to claim 19, further comprising an nth coating ($n \geq 2$) based on an nth powder, wherein said nth coating consists of said nth powder.

21. The material according to claim 19 or 20, wherein said powder is a powder comprising an alkaline metal oxide, an earth-alkaline metal oxide, a transition metal oxide, a low metal oxide, a metalloid oxide, a lanthanide oxide, an actinide oxide, preferably a metal oxide and/or a silicon oxide, more preferentially comprising one or more oxides selected from the group of lithium, sodium, cerium, titanium, vanadium, chromium, molybdenum, manganese, iron, cobalt, palladium, copper, zinc, cadmium, aluminum, silicon, tin and lead oxides and combinations thereof, such as mixed oxides of cobalt and lithium, of iron and manganese, of lithium and of titanium, and the like.

22. The material according to any of claims 19 to 21, wherein said substrate is selected from the group consisting of a metal, of glass or quartz, of a ceramic support, or of any other material coated with titanium dioxide and silicon oxides.

23. The material according to claim 22, wherein said metal is selected from the group consisting of steel, in particular low, medium or high carbon steel, either rolled or not, coated or not, shaped or not, flat or shaped stainless steel, platinum, optionally deposited on another support, aluminum, either rolled or not, optionally shaped, more particularly, said metal is selected from the group of sheet-coated steel, pre-painted steel, sheet aluminum or steel coated with a titanium dioxide layer.

24. The material according to claim 22, wherein said glass or quartz is selected from the group consisting of an alkaline glass or not, either flat or shaped such as in the form of a tube, threads or fibers, quartz in the form of a sheet, a tube, threads or further fibers and the like.

In an advantageous alternative according to the invention, said first alcohol solvent comprises an additive, preferably selected from the group of ethylene glycol, polyethylene glycol 200, polyethylene glycol 400, polyethylene glycol 1500, polyethylene glycol 10000 and polyethylene glycol 15,00000, ethoxylated natural fatty acids, preferably based on stearyl alcohol, more particularly Brij® S10, Pluronic F127®, sodium dodecylbenzene sulfonate and 4-hydroxybenzoic acid as well as mixtures thereof.

According to a preferential embodiment, said functionalization solvent is selected from the group consisting of ethylene glycol, polyethylene glycol 200, polyethylene glycol 400, polyethylene glycol 1500, polyethylene glycol 10000 and polyethylene glycol 15,00000, ethoxylated natural fatty acids, preferably based on stearyl alcohol, more particularly Brij® S10, Pluronic F127®, and sodium dodecylbenzene sulfonate, para-hydroxybenzoic acid, as well as mixtures thereof.

Preferentially, said agent bearing a carboxyl or carboxylate function is a carboxylic acid or the associated carboxylate selected from the group of monofunctional or polyfunctional carboxylic acids, optionally having alcohol chains and/or optionally benzene rings and/or having saturated or unsaturated carbon chains, preferably, said agent bearing a carboxyl or carboxylate function is 4-hydroxybenzoic acid.

Advantageously, said agent bearing a carboxyl or carboxylate function is a carboxylic amino acid, in particular tyrosine.

Other embodiments of the method according to the invention are indicated in the appended claims.

The object of the invention is also a composite material, for example obtained with the method according to the present invention.

In particular, the present invention relates to a material comprising a substrate and at least one coating based on powder characterized in that said coating consists of said powder and has an adhesion to said substrate of more than 17 N/mm^2 according to the ASTM4541 standard.

Advantageously, the material includes according to the present invention, an nth coating ($n \geq 2$) based on an nth powder, in which said nth coating consists of said nth powder.

In the material according to the invention, preferably, said powder is a powder comprising an alkaline metal oxide, an earth-alkaline metal oxide, a transition metal oxide, a low metal oxide, a metalloid oxide, a lanthanide oxide, an actinide oxide, preferably, a metal

CLAIMS

1. A method for manufacturing a composite material comprising a substrate and a coating based on powder, comprising

a) functionalization of the substrate comprising a treatment of a surface of said substrate with a first solution containing at least one first solvent selected from the group consisting of water and of organic alcohols, either saturated or unsaturated with a linear chain, comprising at least one alcohol function, and preferably selected from the group of methoxyethanol, ethanol, ethylene glycol, 1-propanol, methanol, n-butanol, 2-phenylethanol and 2-propanol and mixtures thereof,

b) formation of a first stable colloidal sol,

c) at least one application of at least one layer of said first colloidal sol on the functionalized substrate,

d) drying of said at least one layer of said first colloidal sol and

e) formation of a first coating layer formed with said first colloidal sol, adhering to said substrate, by heating to a temperature above 50°C and below 500°C, characterized in that the method further comprises:

before the formation of said first stable colloidal sol, functionalization of a first powder by an agent bearing a carboxyl or carboxylate function and in that said first stable colloidal sol is based on said first powder, functionalized by an agent bearing a carboxyl or carboxylate function in a second solvent, said coating being formed with said first uniformly distributed powder.

2. The method according to claim 1, wherein said steps c) and d) are repeated alternately a predetermined number of times corresponding to the number of layers of said first powder in order to form said first coating.

3. The method according to claim 1 or claim 2, further comprising the steps:

a) functionalization of an nth powder ($n \geq 2$) and formation of an nth ($n \geq 2$) colloidal sol containing said nth ($n \geq 2$) powder, functionalized in a Zth ($Z \geq n+1$) solvent,

b) application of at least one layer of said nth colloidal sol of said nth powder on the substrate coated with said (n -1)th coating,

c) drying of said at least one layer of said nth colloidal sol and,

d) optionally formation of a coating layer formed with said nth colloidal sol of said nth powder, adhering to said (n-1)th coating, by heating to a temperature above 50°C and below 500°C.

4. The method according to claim 3, wherein said steps b) and c) are alternately repeated a predetermined number of times corresponding to the number of layers of said nth powder in order to form said nth coating.

5. The method according to any of claims 1 to 4, wherein said first and/or said nth colloidal sol contains water.

6. The method according to any of claims 1 to 5, wherein said powder is a powder comprising an alkaline oxide, an earth-alkaline oxide, a transition metal oxide, a low metal oxide, a metalloid oxide, a lanthanide oxide, an actinide oxide, preferably a metal oxide and/or a silicon oxide, more preferentially comprising one or several oxides selected from the group of lithium, sodium, cerium, titanium, vanadium, chromium, molybdenum, manganese, iron, cobalt, palladium, copper, zinc, cadmium, aluminum, silicon, tin and lead oxides and combinations thereof, such as mixed oxides of cobalt and lithium, of iron and manganese, of lithium and titanium, and the like.

7. The method according to any of the preceding claims, wherein said substrate is selected from the group consisting of metal, glass or quartz, a ceramic support, or any other material coated with titanium dioxide and silicon oxides.

8. The method according to claim 7, wherein said metal is selected from the group consisting of steel, in particular low, medium or high carbon steel, either rolled or not, coated or not, shaped or not, flat or shaped stainless steel, platinum, optionally deposited on another support, aluminum, rolled or not, optionally shaped, more particularly, said metal is selected from the group of sheet-coated steel, pre-painted steel, sheet aluminum or steel coated with a titanium dioxide layer.

9. The method according to claim 7, wherein said glass or quartz is selected from the group consisting of either alkaline or not glass, flat or shaped glass such as

in the form of a tube, threads or fibers, quartz in the form of a sheet, of a tube, of threads or further of fibers and the like.

10. The method according to any of claims 1 to 9, wherein said first and/or said nth colloidal sol is formed in the presence of an agent bearing a carboxyl or carboxylate function.

11. The method according to claim 10, wherein said step for functionalization of said first powder with formation of said first colloidal sol containing said first functionalized powder comprises the steps:

a) preparing a first solution S1 of said agent bearing a carboxyl or carboxylate function in said second solvent (SO1), which is selected from organic alcohols either saturated or unsaturated with a linear chain, comprising at least one alcohol function,

b) preparing a suspension Sp1 by dispersing said first powder into said first solution S1,

c) adding water to said first solution S1 in order to form a dilute solution S1d,

d) mixing said dilute solution S1d and said suspension Sp1 at a temperature comprised between 10°C and the reflux temperature of said second solvent, and

e) homogenizing said mixture until said first colloidal sol containing said first functionalized powder is obtained.

12. The method according to claim 10 or claim 11 wherein said method depends on claim 3 to 9 and not 1 to 2, wherein said step for functionalization of said nth ($n \geq 2$) powder with formation of an nth ($n \geq 2$) colloidal sol containing said nth functionalized powder ($n \geq 2$) comprise the following steps:

a) preparing an nth ($n \geq 2$) solution Sn of said agent bearing a carboxyl or carboxylate function in said Zth ($Z \geq n+1$) solvent (SOz),

b) preparing a suspension Spn by dispersing said nth powder ($n \geq 2$) into said nth ($n \geq 2$) solution Sn,

c) adding water to said nth ($n \geq 2$) solution Sn in order to form an nth dilute solution ($n \geq 2$), Snd,

d) mixing said nth ($n \geq 2$) dilute solution Snd and said suspension Spn at a temperature comprised between 10°C and the reflux temperature of said

Zth (Z ≥ n+1) solvent selected from the group consisting of water and of organic alcohols, either saturated or unsaturated with a linear chain, comprising at least one alcohol function, and preferably selected from the group of methoxyethanol, ethanol, ethylene glycol, 1-propanol, methanol, n-butanol, 2-phenylethanol and 2-propanol and mixtures thereof and

e) homogenizing said mixture until said nth (n ≥ 2) colloidal sol is obtained containing said nth functionalized powder (n ≥ 2).

13. The method according to any of claims 1 to 9, wherein said first powder is functionalized in a functionalization solvent Sf, optionally in the presence of water and wherein said first colloidal sol is formed by the steps:

a) preparing a suspension Sp1 by dispersing said first functionalized powder into said second solvent SO_1.

b) adding water to said second solvent SO_1 in order to form a dilute solution S_1d,

c) mixing said dilute solution S1d and said suspension Sp1 at a temperature comprised between 10°C and the reflux temperature of said second solvent SO1,

d) homogenizing said mixture until an intermediate colloidal sol containing said first functionalized powder is obtained and,

e) adding to said intermediate colloidal sol a solution containing an agent bearing a carboxyl or carboxylate function in a third solvent, preferably an alcoholic solvent in order to form said first colloidal sol SOL1.

14. The method according to claim 13, wherein said method depends on claim 3 to 9 and not 1 to 2, wherein said nth powder (n ≥ 2) is functionalized in a functionalization solvent Sf, optionally in the presence of water and wherein said nth colloidal sol is formed by the steps:

a) preparing a suspension Spn by dispersing said nth powder (n ≥ 2) in said Zth (Z ≥ n+1) solvent (SOZ),

b) adding water to said Zth solvent (Z ≥ n+1) in order to form a dilute solution Snd,

c) mixing said dilute solution Snd and said suspension Spn at a temperature comprised between 10°C and the reflux temperature of said Zth solvent (Z ≥ n+1),

d) homogenizing said mixture until an intermediate colloidal sol of a solution containing said nth functionalized powder is obtained,

e) adding to said intermediate colloidal sol a solution containing an agent bearing a carboxyl or carboxylate function in a third solvent, preferably an alcohol solvent in order to form said nth colloidal sol SOLn.

15. The method according to any of claims 1 to 14, wherein, said second solvent, is selected independently of each other from the group consisting of water and of organic alcohols, either saturated or unsaturated with a linear chain, comprising at least one alcohol function, and preferably selected from the group of methoxyethanol, ethanol, ethylene glycol, 1-propanol, methanol, n-butanol, 2-phenylethanol and 2-propanol and mixtures thereof and may be either identical or different.

16. The method according to any of claims 3 to 14, wherein said third solvent is selected independently of each other from the group consisting of water and of organic alcohols, either saturated or unsaturated with a linear chain, comprising at least one alcohol function, and preferably selected from the group of methoxyethanol, ethanol, ethylene glycol, 1-propanol, methanol, n-butanol, 2-phenylethanol and 2-propanol and mixtures thereof and may be either identical or different.

17. The method according to any of claims 13 or 14, wherein said Zth (Z ≥ n+1) solvent is selected independently of each other from the group consisting of water and of organic alcohols, either saturated or unsaturated with a linear chain, comprising at least one alcohol function, and preferably selected from the group of methoxyethanol, ethanol, ethylene glycol, 1-propanol, methanol, n-butanol, 2-phenylethanol and 2-propanol and mixtures thereof and may be either identical or different.

18. The method according to any of claims 1 to 15, wherein said first alcohol solvent comprises an additive, preferably selected from the group of ethylene glycol, polyethylene glycol 200, polyethylene glycol 400, polyethylene glycol 1500, polyethylene glycol 10,000 and polyethylene glycol 1,500,000, ethoxylated natural

fatty alcohols, preferably based on stearyl alcohol, more particularly Brij® S10, Pluronic F127®, sodium dodecylbenzene sulfonate and 4-hydroxybenzoic acid as well as mixtures thereof.

19. The method according to any of claims 13 to 18, wherein said functionalization solvent is selected from the group consisting of ethylene glycol, polyethylene glycol 200, polyethylene glycol 400, polyethylene glycol 1500, polyethylene glycol 10,000 and polyethylene glycol 1,500,000, ethoxylated natural fatty alcohols, preferably based on stearyl alcohol, more particularly Brij® S10, Pluronic F127®, and sodium dodecylbenzene sulfonate, para-hydroxybenzoic acid, as well as mixtures thereof.

20. The method according to any of claims 1 to 19, wherein said agent bearing a carboxyl or carboxylate function is selected from the group of monofunctional or polyfunctional carboxylic acids, optionally having alcohol chains and/or optionally benzene rings and/or having saturated or unsaturated carbon chains, preferably, said agent bearing a carboxyl or carboxylate function is 4-hydroxybenzoic acid.

21. A material comprising a substrate and at least one coating based on powder characterising that said coating consists of said powder and exhibits adherence to said substrate greater than 17 N/mm^2 according to the ASTM4541 standard.

22. The material according to claim 21, further comprising an nth coating ($n \geq 2$) based on an nth powder, wherein said nth coating consists of said nth powder.

23. The material according to claim 21 or 22, wherein said powder is a powder comprising an alkaline metal oxide, an earth-alkaline metal oxide, a transition metal oxide, a low metal oxide, a metalloid oxide, a lanthanide oxide, an actinide oxide, preferably a metal oxide and/or a silicon oxide, more preferentially comprising one or more oxides selected from the group of lithium, sodium, cerium, titanium, vanadium, chromium, molybdenum, manganese, iron, cobalt, palladium, copper, zinc, cadmium, aluminum, silicon, tin and lead oxides and combinations thereof, such as mixed oxides of cobalt and lithium, of iron and manganese, of lithium and of titanium, and the like.

24. The material according to any of claims 21 to 23, wherein said substrate is selected from the group consisting of a metal, of glass or quartz, of a ceramic support, or of any other material coated with titanium dioxide and silicon oxides.

25. The material according to claim 24, wherein said metal is selected from the group consisting of steel, in particular low, medium or high carbon steel, either rolled or not, coated or not, shaped or not, flat or shaped stainless steel, platinum, optionally deposited on another support, aluminum, either rolled or not, optionally shaped, more particularly, said metal is selected from the group of sheet-coated steel, pre-painted steel, sheet aluminum or steel coated with a titanium dioxide layer.

26. The material according to claim 24, wherein said glass or quartz is selected from the group consisting of an alkaline glass or not, either flat or shaped such as in the form of a tube, threads or fibers, quartz in the form of a sheet, a tube, threads or further fibers and the like.