CLAIMS

1. Particle, essentially in the form of a homogeneous sphere or a fraction of a homogeneous sphere, consisting essentially of a complex, in particular a salt, between an acid or a corresponding anion and at least one metal or a corresponding metal cation,
said acid or corresponding anion being selected from the group comprising 2-hydroxy-4-methyl-thiobutanoic acid (HMTBA), methionine, aspartic acid, the alginic acids, the pectinic acids, and the corresponding anions, in particular 2-hydroxy-4-methyl-thiobutanoate, methioninate, aspartate, the alginates and the pectinates,
said metal or metal cation being divalent or trivalent,
said particle having an amorphous fraction the mass of which represents at least 50%, in particular at least 70%, more particularly at least 90%, of the total mass of said particle,
said particle being substantially devoid of uncomplexed acid or anion and of uncomplexed metal or metal cation.

2. Particle according to claim 2, wherein the ratio of the mass of said uncomplexed acid or anion and/or of said at least one uncomplexed metal or cation to the total mass of said particle is below 20%, and in particular is in the range from 0 to 5%, more particularly from 0 to 1%.

3. Particle according to either of claims 1 and 2, wherein said complex has the following formula (Ia):

$$(Acid)_nM \qquad (Ia)$$

where M represents said metal,
n being equal to 2 when said metal is divalent and to 3 when said metal is trivalent,
said complex being in particular a salt, more particularly a salt of formula $(HMTBA)_2Ca$, $(HMTBA)_2Mg$, $(HMTBA)_2Fe$, $(HMTBA)_2Mn$, $(HMTBA)_2Zn$, $(HMTBA)_2Cu$, $(HMTBA)_3Fe$, $(HMTBA)_3Al$, $(methionine)_2Ca$, $(methionine)_2Mg$, $(methionine)_2Fe$, $(methionine)_2Mn$, $(methionine)_2Zn$, $(methionine)_2Cu$, $(methionine)_3Fe$, $(methionine)_3Al$, $(aspartic\ acid)_2Ca$, $(aspartic\ acid)_2Mg$, $(aspartic\ acid)_2Fe$, $(aspartic\ acid)_2Mn$, $(aspartic\ acid)_2Zn$, $(aspartic\ acid)_2Cu$, $(aspartic\ acid)_3Fe$, or $(aspartic\ acid)_3Al$, even more particularly a salt of formula $(HMTBA)_2Ca$, $(HMTBA)_2Mg$, $(HMTBA)_2Fe$, $(HMTBA)_2Mn$, $(HMTBA)_2Zn$, $(HMTBA)_2Cu$, $(methionine)_2Ca$, $(methionine)_2Mg$,

(methionine)$_2$Fe, (methionine)$_2$Mn, (methionine)$_2$Zn, (methionine)$_2$Cu, (aspartic acid)$_2$Ca, (aspartic acid)$_2$Mg, (aspartic acid)$_2$Fe, (aspartic acid)$_2$Mn, (aspartic acid)$_2$Zn or (aspartic acid)$_2$Cu.

4. Particle according to any one of claims 1 to 3, wherein said metal or corresponding cation is selected from the group comprising Mg, Be, Ca, Sr, Ba, Mn, Fe, Co, Ni, Cu, Zn, Pt, B, Al, Ga, In, in particular Mg, Ca, Fe, Mn, Cu, Zn and the corresponding cations, in particular Mg^{2+}, Be^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+}, Mn^{2+}, Fe^{2+}, Fe^{3+}, Co^{2+}, Co^{3+}, Ni^{2+}, Ni^{3+}, Cu^{2+}, Zn^{2+}, Pt^{2+}, Al^{3+}, Ga^{3+}, In^{3+}, more particularly Mg^{2+}, Ca^{2+}, Fe^{2+}, Fe^{3+}, Mn^{2+}, Cu^{2+} and Zn^{2+},

in particular in which said metal or corresponding cation is selected from the group comprising Mg, Ca, Cu and the corresponding cations, in particular Mg^{2+}, Ca^{2+} and Cu^{2+}.

5. Particle according to any one of claims 1 to 4, consisting essentially of a salt between an anion of an acid and at least one metal cation, in particular:

- said anion being 2-hydroxy-4-methyl-thiobutanoate and said cation being Ca^{2+}, or
- said anion being methioninate or 2-hydroxy-4-methyl-thiobutanoate and said cation being selected from the group comprising Mg^{2+}, Ca^{2+}, Fe^{2+}, Fe^{3+}, Zn^{2+}, Mn^{2+} and Cu^{2+}, in particular Mg^{2+} and Ca^{2+}.

6. Pulverulent composition of particles, said particles being as defined in any one of claims 1 to 5,

the granulometric size of said particles being in the range from 10 to 3000 µm, in particular from 20 to 300 µm, in granulometric average [Dv(0.5)], and/or

said composition having a flowability index that is in the range from 4 to 18 [Flodex index], and/or

said composition being such that, for a substantial portion of said composition, a particle of said portion is agglomerated with at least one other particle of said portion.

7. Method for preparing a pulverulent composition of particles according to any one of claims 1 to 6, consisting essentially of a complex, in particular a salt, between an acid or a corresponding anion and at least one metal or a corresponding metal cation, said method comprising a step of bringing said acid into contact with a mineral source of said metal or

corresponding cation in a spray-drying tower in order to obtain the formation of said complex, in particular of said salt, and initiate its precipitation,

said acid or corresponding anion being selected from the group comprising 2-hydroxy-4-methyl-thiobutanoic acid (HMTBA), methionine, aspartic acid, the alginic acids, the pectinic acids, and the corresponding anions, in particular 2-hydroxy-4-methyl-thiobutanoate, methioninate, aspartate, the alginates and the pectinates,

said metal or metal cation being divalent or trivalent,

said particle having an amorphous fraction the mass of which represents at least 50%, in particular at least 70%, more particularly at least 90%, of the total mass of said particle.

8. Method according to claim 7, comprising a spraying step, during which precipitation of said complex, in particular of said salt, takes place,

the contacting and spraying steps in particular being carried out using the same device, in particular a device comprising a rotating spraying element, contacting being followed immediately by spraying.

9. Method according to either of claims 7 and 8, comprising a step of spray-drying of said complex, in particular of said salt, during which precipitation of said complex, in particular of said salt, proceeds until there is complete solidification of the particle.

10. Method according to any one of claims 7 to 9, comprising the following steps:

- bringing said acid into contact with a mineral source of said metal or corresponding cation in a spray-drying tower in order to obtain the formation of said complex, in particular of said salt, and initiate its precipitation;
- spraying said complex, in particular said salt, undergoing precipitation, during which said precipitation continues, obtaining an ensemble of sprayed particles;
- spray-drying said ensemble of sprayed particles, during which said precipitation continues until there is complete solidification of the particle, to obtain a stable pulverulent composition;
- recovery of said pulverulent composition;

said method in particular comprising the following steps:

- bringing said acid into contact with a mineral source of said metal or corresponding cation in a spray-drying tower, using a device that allows said

contacting, in order to obtain the formation of said complex, in particular of said salt, and initiate its precipitation;

- spraying said complex, in particular said salt, undergoing precipitation, during which said precipitation takes place, using a spraying device, obtaining an ensemble of sprayed particles, said spraying immediately following the contacting, said spraying device being identical to that used for contacting, in particular a device comprising a rotating spraying element;
- spray-drying said ensemble of sprayed particles, during which said precipitation continues until there is complete solidification of the particle, to obtain a stable pulverulent composition;
- recovery of said pulverulent composition.

11. Method according to any one of claims 7 to 10, wherein:

- said contacting takes place by mixing an aqueous medium, in particular an aqueous solution, containing said acid, and an aqueous medium, in particular a solution or an aqueous suspension containing said metal or cation, and/or
- the contacting of said acid with a mineral source of said metal or corresponding cation is carried out continuously, said continuous contacting in particular being carried out in a device such as static or dynamic mixers, in particular kneaders, extruders, and mixers without an internal component, such as ultrasonic mixers.

12. Method according to any one of claims 7 to 11, wherein said complex is of the following formula (Ia):

$$(Acid)_nM \qquad (Ia)$$

where M represents said metal,

said complex being in particular a salt, more particularly a salt of formula $(HMTBA)_2Ca$, $(HMTBA)_2Mg$, $(HMTBA)_2Fe$, $(HMTBA)_2Mn$, $(HMTBA)_2Zn$, $(HMTBA)_2Cu$, $(HMTBA)_3Fe$, $(HMTBA)_3Al$, $(methionine)_2Ca$, $(methionine)_2Mg$, $(methionine)_2Fe$, $(methionine)_2Mn$, $(methionine)_2Zn$, $(methionine)_2Cu$, $(methionine)_3Fe$, $(methionine)_3Al$, $(aspartic\ acid)_2Ca$, $(aspartic\ acid)_2Mg$, $(aspartic\ acid)_2Fe$, $(aspartic\ acid)_2Mn$, $(aspartic\ acid)_2Zn$, $(aspartic\ acid)_2Cu$, $(aspartic\ acid)_3Fe$, or $(aspartic\ acid)_3Al$, even more particularly a salt of formula $(HMTBA)_2Ca$, $(HMTBA)_2Mg$, $(HMTBA)_2Fe$, $(HMTBA)_2Mn$, $(HMTBA)_2Zn$, $(HMTBA)_2Cu$, $(methionine)_2Ca$, $(methionine)_2Mg$,

(methionine)$_2$Fe, (methionine)$_2$Mn, (methionine)$_2$Zn, (methionine)$_2$Cu, (aspartic acid)$_2$Ca, (aspartic acid)$_2$Mg, (aspartic acid)$_2$Fe, (aspartic acid)$_2$Mn, (aspartic acid)$_2$Zn or (aspartic acid)$_2$Cu.

13. Method according to any one of claims 7 to 12, wherein said metal or corresponding cation is selected from the group comprising Mg, Be, Ca, Sr, Ba, Mn, Fe, Co, Ni, Cu, Zn, Pt, B, Al, Ga, In, in particular Mg, Ca, Fe, Mn, Cu, Zn and the corresponding cations, in particular Mg^{2+}, Be^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+}, Mn^{2+}, Fe^{2+}, Fe^{3+}, Co^{2+}, Co^{3+}, Ni^{2+}, Ni^{3+}, Cu^{2+}, Zn^{2+}, Pt^{2+}, Al^{3+}, Ga^{3+}, In^{3+}, more particularly Mg^{2+}, Ca^{2+}, Fe^{2+}, Fe^{3+}, Mn^{2+}, Cu^{2+} and Zn^{2+},

in particular in which said metal or corresponding cation is selected from the group comprising Mg, Ca, Cu and the corresponding cations, in particular Mg^{2+}, Ca^{2+} and Cu^{2+}.

14. Method according to any one of claims 7 to 13, wherein said particles consist essentially of a salt between an anion of an acid and at least one metal cation, in particular:

- said anion being 2-hydroxy-4-methyl-thiobutanoate and said cation being Ca^{2+}, the source of Ca^{2+} being selected from lime, milk of lime, slaked lime, calcium hydrogen carbonate and calcium carbonate, or being $Ca(OH)_2$, or
- said anion being methioninate or 2-hydroxy-4-methyl-thiobutanoate and said cation being selected from the group comprising Mg^{2+}, Ca^{2+}, Fe^{2+}, Fe^{3+}, Zn^{2+}, Mn^{2+} and Cu^{2+}, the source of said cation being selected from oxide, hydroxide, an aqueous solution of hydroxide and the carbonate of said cation.

15. Method according to any one of claims 7 to 14, comprising an additional step of agglomeration, or in which said spray-drying tower is a multiple effect spray-drying tower, said step of reacting said acid with said mineral metal source also comprising agglomeration.

CLAIMS

1. Particle, in the form of a homogeneous sphere or a fraction of a homogeneous sphere, consisting essentially of a complex, between an acid or a corresponding anion and at least one metal or a corresponding metal cation,

said acid or corresponding anion being selected from the group comprising 2-hydroxy-4-methyl-thiobutanoic acid (HMTBA), methionine, aspartic acid, the alginic acids, the pectinic acids, and the corresponding anions,

said metal or metal cation being divalent or trivalent,

said particle having an amorphous fraction the mass of which represents at least 50%, of the total mass of said particle,

said particle being substantially devoid of uncomplexed acid or anion and of uncomplexed metal or metal cation,the ratio of the mass of said uncomplexed acid or anion and/or of said at least one uncomplexed metal or cation to the total mass of said particle being below 20%.

2. Particle according to claim 1, wherein the complex is a salt.

3. Particle according to claim 1 or claim 2, wherein the acid or corresponding anion are selected from the group consisting of 2-hydroxy-4-methyl-thiobutanoate, methioninate, aspartate, the algininates, and the pectinates.

4. Particle according to any one of the preceding claims, wherein the mass of the amorphous fraction of which represents at least 70%, of the total mass of said particle.

5. Particle according to any one of claims 1 to 3, wherein the mass of the amorphous fraction of which represents at least 90%, of the total mass of said particle.

6. Particle according to any one of the preceding claims, wherein the ratio of the mass of said uncomplexed acid or anion and/or of said at least one uncomplexed metal or cation to the total mass of said particle is in the range of 0 to 5%

7. Particle according to any one of claims 1 to 5, wherein the ratio of the

mass of said uncomplexed acid or anion and/or of said at least one uncomplexed metal or cation to the total mass of said particle is in the range of 0 to 1%.

8. Particle according to any one of the preceding claims, wherein said complex has the following formula (Ia):

$$(Acid)_nM \qquad (Ia)$$

where M represents said metal,

n being equal to 2 when said metal is divalent and to 3 when said metal is trivalent,

said complex being in particular a salt, more particularly a salt of formula $(HMTBA)_2Ca$, $(HMTBA)_2Mg$, $(HMTBA)_2Fe$, $(HMTBA)_2Mn$, $(HMTBA)_2Zn$, $(HMTBA)_2Cu$, $(HMTBA)_3Fe$, $(HMTBA)_3Al$, $(methionine)_2Ca$, $(methionine)_2Mg$, $(methionine)_2Fe$, $(methionine)_2Mn$, $(methionine)_2Zn$, $(methionine)_2Cu$, $(methionine)_3Fe$, $(methionine)_3Al$, $(aspartic\ acid)_2Ca$, $(aspartic\ acid)_2Mg$, $(aspartic\ acid)_2Fe$, $(aspartic\ acid)_2Mn$, $(aspartic\ acid)_2Zn$, $(aspartic\ acid)_2Cu$, $(aspartic\ acid)_3Fe$, or $(aspartic\ acid)_3Al$, even more particularly a salt of formula $(HMTBA)_2Ca$, $(HMTBA)_2Mg$, $(HMTBA)_2Fe$, $(HMTBA)_2Mn$, $(HMTBA)_2Zn$, $(HMTBA)_2Cu$, $(methionine)_2Ca$, $(methionine)_2Mg$, $(methionine)_2Fe$, $(methionine)_2Mn$, $(methionine)_2Zn$, $(methionine)_2Cu$, $(aspartic\ acid)_2Ca$, $(aspartic\ acid)_2Mg$, $(aspartic\ acid)_2Fe$, $(aspartic\ acid)_2Mn$, $(aspartic\ acid)_2Zn$ or $(aspartic\ acid)_2Cu$.

9. Particle according to any one of claims 1 to 8, wherein said metal or corresponding cation is selected from the group comprising Mg, Be, Ca, Sr, Ba, Mn, Fe, Co, Ni, Cu, Zn, Pt, B, Al, Ga, In, in particular Mg, Ca, Fe, Mn, Cu, Zn and the corresponding cations, in particular Mg^{2+}, Be^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+}, Mn^{2+}, Fe^{2+}, Fe^{3+}, Co^{2+}, Co^{3+}, Ni^{2+}, Ni^{3+}, Cu^{2+}, Zn^{2+}, Pt^{2+}, Al^{3+}, Ga^{3+}, In^{3+}, more particularly Mg^{2+}, Ca^{2+}, Fe^{2+}, Fe^{3+}, Mn^{2+}, Cu^{2+} and Zn^{2+},

in particular in which said metal or corresponding cation is selected from the group comprising Mg, Ca, Cu and the corresponding cations, in particular Mg^{2+}, Ca^{2+} and Cu^{2+}.

10. Particle according to any one of claims 1 to 9, consisting essentially of a salt between an anion of an acid and at least one metal cation, in particular:

- said anion being 2-hydroxy-4-methyl-thiobutanoate and said cation being Ca^{2+}, or

- said anion being methioninate or 2-hydroxy-4-methyl-thiobutanoate and said cation being selected from the group comprising Mg^{2+}, Ca^{2+}, Fe^{2+}, Fe^{3+}, Zn^{2+}, Mn^{2+} and Cu^{2+}, in particular Mg^{2+} and Ca^{2+}.

11. Pulverulent composition of particles, said particles being as defined in any one of claims 1 to 10,

the granulometric size of said particles being in the range from 10 to 3000 μm, in particular from 20 to 300 μm, in granulometric average [Dv(0.5)], and/or

said composition having a flowability index that is in the range from 4 to 18 [Flodex index], and/or

said composition being such that, for a substantial portion of said composition, a particle of said portion is agglomerated with at least one other particle of said portion.

12. Method for preparing a pulverulent composition of particles according to any one of claims 1 to 11, consisting essentially of a complex, in particular a salt, between an acid or a corresponding anion and at least one metal or a corresponding metal cation, said method comprising a step of bringing said acid into contact with a mineral source of said metal or corresponding cation in a spray-drying tower in order to obtain the formation of said complex, in particular of said salt, and initiate its precipitation,

said acid or corresponding anion being selected from the group comprising 2-hydroxy-4-methyl-thiobutanoic acid (HMTBA), methionine, aspartic acid, the alginic acids, the pectinic acids, and the corresponding anions, in particular 2-hydroxy-4-methyl-thiobutanoate, methioninate, aspartate, the alginates and the pectinates,

said metal or metal cation being divalent or trivalent,

said particle having an amorphous fraction the mass of which represents at least 50%, in particular at least 70%, more particularly at least 90%, of the total mass of said particle.

13. Method according to claim 12, comprising a spraying step, during which precipitation of said complex, in particular of said salt, takes place,

the contacting and spraying steps in particular being carried out using the same device, in particular a device comprising a rotating spraying element, contacting being followed immediately by spraying.

14. Method according to either of claims 12 or 13, comprising a step of spray-drying of said complex, in particular of said salt, during which precipitation of said complex, in particular of said salt, proceeds until there is complete solidification of the particle.

15. Method according to any one of claims 12 to 14, comprising the following steps:

- bringing said acid into contact with a mineral source of said metal or corresponding cation in a spray-drying tower in order to obtain the formation of said complex, in particular of said salt, and initiate its precipitation;
- spraying said complex, in particular said salt, undergoing precipitation, during which said precipitation continues, obtaining an ensemble of sprayed particles;
- spray-drying said ensemble of sprayed particles, during which said precipitation continues until there is complete solidification of the particle, to obtain a stable pulverulent composition;
- recovery of said pulverulent composition;

said method in particular comprising the following steps:

- bringing said acid into contact with a mineral source of said metal or corresponding cation in a spray-drying tower, using a device that allows said contacting, in order to obtain the formation of said complex, in particular of said salt, and initiate its precipitation;
- spraying said complex, in particular said salt, undergoing precipitation, during which said precipitation takes place, using a spraying device, obtaining an ensemble of sprayed particles, said spraying immediately following the contacting, said spraying device being identical to that used for contacting, in particular a device comprising a rotating spraying element;
- spray-drying said ensemble of sprayed particles, during which said precipitation continues until there is complete solidification of the particle, to obtain a stable pulverulent composition;
- recovery of said pulverulent composition.

16. Method according to any one of claims 12 to 15, wherein:

- said contacting takes place by mixing an aqueous medium, in particular an aqueous solution, containing said acid, and an aqueous medium, in particular a solution or an aqueous suspension containing said metal or cation, and/or

- the contacting of said acid with a mineral source of said metal or corresponding cation is carried out continuously, said continuous contacting in particular being carried out in a device such as static or dynamic mixers, in particular kneaders, extruders, and mixers without an internal component, such as ultrasonic mixers.

17. Method according to any one of claims 12 to 16, wherein said complex is of the following formula (Ia):

$$(Acid)_nM \qquad (Ia)$$

where M represents said metal,

said complex being in particular a salt, more particularly a salt of formula $(HMTBA)_2Ca$, $(HMTBA)_2Mg$, $(HMTBA)_2Fe$, $(HMTBA)_2Mn$, $(HMTBA)_2Zn$, $(HMTBA)_2Cu$, $(HMTBA)_3Fe$, $(HMTBA)_3Al$, $(methionine)_2Ca$, $(methionine)_2Mg$, $(methionine)_2Fe$, $(methionine)_2Mn$, $(methionine)_2Zn$, $(methionine)_2Cu$, $(methionine)_3Fe$, $(methionine)_3Al$, $(aspartic\ acid)_2Ca$, $(aspartic\ acid)_2Mg$, $(aspartic\ acid)_2Fe$, $(aspartic\ acid)_2Mn$, $(aspartic\ acid)_2Zn$, $(aspartic\ acid)_2Cu$, $(aspartic\ acid)_3Fe$, or $(aspartic\ acid)_3Al$, even more particularly a salt of formula $(HMTBA)_2Ca$, $(HMTBA)_2Mg$, $(HMTBA)_2Fe$, $(HMTBA)_2Mn$, $(HMTBA)_2Zn$, $(HMTBA)_2Cu$, $(methionine)_2Ca$, $(methionine)_2Mg$, $(methionine)_2Fe$, $(methionine)_2Mn$, $(methionine)_2Zn$, $(methionine)_2Cu$, $(aspartic\ acid)_2Ca$, $(aspartic\ acid)_2Mg$, $(aspartic\ acid)_2Fe$, $(aspartic\ acid)_2Mn$, $(aspartic\ acid)_2Zn$ or $(aspartic\ acid)_2Cu$.

18. Method according to any one of claims 12 to 17, wherein said metal or corresponding cation is selected from the group comprising Mg, Be, Ca, Sr, Ba, Mn, Fe, Co, Ni, Cu, Zn, Pt, B, Al, Ga, In, in particular Mg, Ca, Fe, Mn, Cu, Zn and the corresponding cations, in particular Mg^{2+}, Be^{2+}, Ca^{2+}, Sr^{2+}, Ba^{2+}, Mn^{2+}, Fe^{2+}, Fe^{3+}, Co^{2+}, Co^{3+}, Ni^{2+}, Ni^{3+}, Cu^{2+}, Zn^{2+}, Pt^{2+}, Al^{3+}, Ga^{3+}, In^{3+}, more particularly Mg^{2+}, Ca^{2+}, Fe^{2+}, Fe^{3+}, Mn^{2+}, Cu^{2+} and Zn^{2+},

in particular in which said metal or corresponding cation is selected from the group comprising Mg, Ca, Cu and the corresponding cations, in particular Mg^{2+}, Ca^{2+} and Cu^{2+}.

19. Method according to any one of claims 12 to 18, wherein said particles consist essentially of a salt between an anion of an acid and at least one metal cation, in particular:

- said anion being 2-hydroxy-4-methyl-thiobutanoate and said cation being Ca^{2+}, the source of Ca^{2+} being selected from lime, milk of lime, slaked lime, calcium hydrogen carbonate and calcium carbonate, or being $Ca(OH)_2$, or

- said anion being methioninate or 2-hydroxy-4-methyl-thiobutanoate and said cation being selected from the group comprising Mg^{2+}, Ca^{2+}, Fe^{2+}, Fe^{3+}, Zn^{2+}, Mn^{2+} and Cu^{2+}, the source of said cation being selected from oxide, hydroxide, an aqueous solution of hydroxide and the carbonate of said cation.

20. Method according to any one of claims 12 to 19, comprising an additional step of agglomeration, or in which said spray-drying tower is a multiple effect spray-drying tower, said step of reacting said acid with said mineral metal source also comprising agglomeration.