METHOD AND APPARATUS FOR PROCESSING MATERIAL

FIELD

Some variations relate to processing a composition by using magnetically responsive particles and by using a magnetic transfer probe.

BACKGROUND

A composition may comprise a target substance and a liquid medium. The target substance may be separated from the liquid medium by using magnetically responsive particles. The particles may be arranged to selectively bind to the target substance. The particles may be collected and lifted from a vessel by using a magnetic transfer probe. The target substance bound to the particles may be collected and separated from the liquid medium together with the particles.

SUMMARY

An object is to provide a method for processing a composition. An object is to provide a method for collecting a target substance. An object is to provide a method for transferring a target substance. An object is to provide a method for enriching a target substance. An object is to provide a method for purifying a target substance. An object is to provide an apparatus for processing a composition. An object is to provide an apparatus for collecting a target substance. An object is to provide an apparatus for transferring a target substance. An object is to provide an apparatus for enriching a target substance. An object is to provide an apparatus for purifying a target substance.

~~According to an aspect, there is provided a method of claim 1.~~

~~Further aspects are defined in the other claims.~~

According to a~~n~~ first aspect of the present invention, there is provided a method for processing a composition (MX1) by using a magnetic transfer probe (100), the transfer probe (100) comprising a shield (120) and a probe magnet (MAG1) movable inside the shield (120),

the method comprising:

- providing a first composition (MX1) in a vessel (VES1), wherein the composition (MX1) comprises a first liquid (LIQ1) and a plurality of magnetically responsive particles (P1), wherein the particles (P1) are arranged to selectively interact with a target substance (M1),
- positioning the transfer probe (100) into the vessel (VES1) so as to collect the particles (P1) from the first composition (MX1),
- removing the collected particles (P1) together with the transfer probe (100) from the vessel (VES1) by causing a relative vertical movement between the transfer probe (100) and the vessel (VES1), and
- releasing the collected particles (P1) from the shield (120) to a release location (LOC2) by causing a relative vertical movement between the probe magnet (MAG1) and the shield (120),

wherein the probe magnet (MAG1) is a permanent magnet, which comprises a cylindrical portion (SRF0) and a convex bottom portion (CNX1) adjoining the cylindrical portion (SRF0), the magnet has an axis of symmetry (AX1), the axis of symmetry (AX1) intersects the bottom portion (CNX1) at an intersection point (Q1), the intersection point (Q1) and the circular lower boundary (CIR2) of the cylindrical portion (SRF0) define a reference cone (REF0), and the bottom portion (CNX1) protrudes with respect to the reference cone (REF0).

According to a second aspect of the present invention, there is provided an apparatus 500, comprising:

- a support (SUP1) for holding a vessel (VES1) for containing a composition (MX1), which comprises a first liquid (LIQ1) and magnetically responsive particles (P1),
- a transfer probe (100), which comprises a shield (120) and a probe magnet (MAG1) movable inside the shield (120),
- a first actuator (ACU1) for causing relative vertical movement between the probe magnet (MAG1) and the shield (120),
- a second actuator (ACU2) for causing relative vertical movement between the transfer probe (100) and the vessel (VES1),

wherein the apparatus (500) is arranged:
- to position the transfer probe (100) into the vessel (VES1) so as to collect the particles (P1) from the first composition (MX1),
- to remove the collected particles (P1) together with the transfer probe (100) from the vessel (VES1) by moving the transfer probe (100) upwards and/or by moving the vessel (VES1) downwards, and
- to release the collected particles (P1) from the shield (120) to a release location (LOC2) by moving the probe magnet (MAG1) upwards with respect to the shield (120) and/or by moving the shield (120) downwards with respect to the probe magnet (MAG1),
wherein the probe magnet (MAG1) is a permanent magnet, which comprises a cylindrical portion (SRF0) and a convex bottom portion (CNX1) adjoining the cylindrical portion (SRF0), the magnet has an axis of symmetry (AX1), the axis of symmetry (AX1) intersects the bottom portion (CNX1) at an intersection point (Q1), the intersection point (Q1) and the circular lower boundary (CIR2) of the cylindrical portion (SRF0) define a reference cone (REF0), and the bottom portion (CNX1) protrudes with respect to the reference cone (REF0).

The method comprises using the transfer probe to collect and/or process magnetically responsive particles of the composition. The transfer probe comprises a permanent probe magnet. The probe magnet comprises a cylindrical portion and a convex bottom portion. The probe magnet having the convex bottom may allow operation in a very small volume of the composition. The convex bottom portion of the magnet may be e.g. a hemisphere or a truncated hemisphere.

A composition may comprise a liquid component and magnetically responsive particles. The composition may be contained in a vessel. The transfer probe

CLAIMS

1. A method for processing a composition ~~(MX1)~~ by using a magnetic transfer probe ~~(100)~~, the transfer probe ~~(100)~~ comprising a shield ~~(120)~~ and a probe magnet ~~(MAG1)~~ movable inside the shield ~~(120)~~,
the method comprising:
- providing a first composition ~~(MX1)~~ in a vessel ~~(VES1)~~, wherein the composition ~~(MX1)~~ comprises a first liquid ~~(LIQ1)~~ and a plurality of magnetically responsive particles ~~(P1)~~, wherein the particles ~~(P1)~~ are arranged to selectively interact with a target substance ~~(M1)~~,
- positioning the transfer probe ~~(100)~~ into the vessel ~~(VES1)~~ so as to collect the particles ~~(P1)~~ from the first composition ~~(MX1)~~,
- removing the collected particles ~~(P1)~~ together with the transfer probe ~~(100)~~ from the vessel ~~(VES1)~~ by causing a relative vertical movement between the transfer probe ~~(100)~~ and the vessel ~~(VES1)~~, and
- releasing the collected particles ~~(P1)~~ from the shield ~~(120)~~ to a release location ~~(LOC2)~~ by causing a relative vertical movement between the probe magnet ~~(MAG1)~~ and the shield ~~(120)~~,
wherein the probe magnet ~~(MAG1)~~ is a permanent magnet, which comprises a cylindrical portion ~~(SRF0)~~ and a convex bottom portion ~~(CNX1)~~ adjoining the cylindrical portion ~~(SRF0)~~, the magnet has an axis of symmetry ~~(AX1)~~, the axis of symmetry ~~(AX1)~~ intersects the bottom portion ~~(CNX1)~~ at an intersection point ~~(Q1)~~, the intersection point ~~(Q1)~~ and the circular lower boundary ~~(CIR2)~~ of the cylindrical portion ~~(SRF0)~~ define a reference cone ~~(REF0)~~, and the bottom portion ~~(CNX1)~~ protrudes with respect to the reference cone ~~(REF0)~~.

2. The method of claim 1, wherein the surface ~~(SRF1)~~ of the convex bottom portion ~~(CNX1)~~ has maximum distance ~~(e_3)~~ from the reference cone ~~(REF0)~~ at a circular region ~~(CIR3)~~, wherein said maximum distance ~~(e_3)~~ is greater than or equal to 10% of the radius ~~(a_1)~~ of the cylindrical portion ~~(SRF0)~~.

3. The method of claim 1 or 2, wherein the surface ~~(SRF1)~~ of the convex bottom portion ~~(CNX1)~~ has maximum distance ~~(e_3)~~ from the reference cone ~~(REF0)~~ at a circular region ~~(CIR3)~~, wherein the radius ~~(r_3)~~ of said circular region ~~(CIR3)~~ is in the range of 10% to 90% of the radius ~~(a_1)~~ of the cylindrical portion ~~(SRF0)~~.

4. The method according to any of the claims 1 to 3, wherein the surface ~~(SRF1)~~ of the convex bottom portion ~~(CNX1)~~ has maximum distance ~~(e_3)~~ from the reference cone ~~(REF0)~~ at a circular region ~~(CIR3)~~, wherein the vertical position of said circular region ~~(CIR3)~~ is in the range of 10% to 90% of the height ~~(h_1)~~ of the convex bottom portion ~~(CNX1)~~.

5. The method according to any of the claims 1 to 4, wherein the ratio ~~(~~of the height ~~(h_1)~~ of the convex bottom portion ~~(CNX1)~~ to the radius ~~(a_1)~~ of the cylindrical portion ~~(SRF0)~~ is in the range of 0.5 to 2.0, advantageously in the range of 0.7 to 1.5.

6. The method according to any of the claims 1 to 5, wherein the convex bottom portion ~~(CNX1)~~ is a hemisphere or a truncated hemisphere.

7. The method according to any of the claims 1 to 6, wherein the convex bottom portion ~~(CNX1)~~ is a half spheroid, a truncated half spheroid, a truncated cone, or a combination of two or more conical portions with different taper angles ~~(α_k, α_{k+1})~~.

8. The method according to any of the claims 1 to 7, wherein the diameter ~~(D_{MAG1})~~ of the probe magnet ~~(MAG1)~~ in the range of 1 mm to 8 mm.

9. The method according to any of the claims 1 to 8, comprising releasing the collected particles ~~(P1)~~ from the shield ~~(120)~~ to a liquid ~~(LIQ2)~~ in a second vessel ~~(VES2)~~, wherein the volume of the liquid ~~(LIQ2)~~ in the second vessel ~~(VES2)~~ is in the range of 5 µl to 50 µl, advantageously in the range of 5 µl to 15 µl.

10. The method according to any of the claims 1 to 9, comprising releasing the collected particles ~~(P1)~~ from the shield ~~(120)~~ to a surface ~~(SRF2)~~.

11. The method according to any of the claims 1 to 10, wherein the particles are ferromagnetic particles, ferrimagnetic particles, or superparamagnetic particles, and wherein the size of the particles is in the range of 50 nm to 10 µm.

12. An apparatus ~~500~~, comprising:
- a support ~~(SUP1)~~ for holding a vessel ~~(VES1)~~ for containing a composition ~~(MX1)~~, which comprises a first liquid ~~(LIQ1)~~ and magnetically responsive particles ~~(P1)~~,
- a transfer probe ~~(100)~~, which comprises a shield ~~(120)~~ and a probe magnet ~~(MAG1)~~ movable inside the shield ~~(120)~~,
- a first actuator ~~(ACU1)~~ for causing relative vertical movement between the probe magnet ~~(MAG1)~~ and the shield ~~(120)~~,
- a second actuator ~~(ACU2)~~ for causing relative vertical movement between the transfer probe ~~(100)~~ and the vessel ~~(VES1)~~,
wherein the apparatus ~~(500)~~ is arranged:
- to position the transfer probe ~~(100)~~ into the vessel ~~(VES1)~~ so as to collect the particles ~~(P1)~~ from the first composition ~~(MX1)~~,
- to remove the collected particles ~~(P1)~~ together with the transfer probe ~~(100)~~ from the vessel ~~(VES1)~~ by moving the transfer probe ~~(100)~~ upwards and/or by moving the vessel ~~(VES1)~~ downwards, and
- to release the collected particles ~~(P1)~~ from the shield ~~(120)~~ to a release location ~~(LOC2)~~ by moving the probe magnet ~~(MAG1)~~ upwards with respect to the shield ~~(120)~~ and/or by moving the shield ~~(120)~~ downwards with respect to the probe magnet ~~(MAG1)~~,
wherein the probe magnet ~~(MAG1)~~ is a permanent magnet, which comprises a cylindrical portion ~~(SRF0)~~ and a convex bottom portion ~~(CNX1)~~ adjoining the cylindrical portion ~~(SRF0)~~, the magnet has an axis of symmetry ~~(AX1)~~, the axis of symmetry ~~(AX1)~~ intersects the bottom portion ~~(CNX1)~~ at an intersection point ~~(Q1)~~, the intersection point ~~(Q1)~~ and the circular lower boundary ~~(CIR2)~~ of the cylindrical portion ~~(SRF0)~~ define a reference cone ~~(REF0)~~, and the bottom portion ~~(CNX1)~~ protrudes with respect to the reference cone ~~(REF0)~~.

13. The apparatus ~~(500)~~ of claim 12, wherein the convex bottom portion ~~(CNX1)~~ is a hemisphere or a truncated hemisphere.

14. The apparatus ~~(500)~~ of claim 12 or 13, wherein the diameter ~~(D_{MAG1})~~ of the probe magnet ~~(MAG1)~~ is in the range of in the range of 1 mm to 8 mm.

15. The apparatus ~~(500)~~ according to any of the claims 12 to 14, comprising an array of probe magnets ~~(MAG1a, MAG1b)~~, wherein at least one magnet ~~(MAG1a)~~ of the array has an inverted magnetic orientation with respect to at least one second magnet ~~(MAG1b)~~ of the array.