CLAIMS

1. Method of spray-drying a high-viscosity fluid (4) using a spraying device, the method comprising:

- providing a nozzle plate (8) wherein at least one nozzle (14) is provided, said nozzle plate (8) having an inner main surface (10) and an outer main surface (12), the at least one nozzle (14) extending through the nozzle plate (8) from the inner main surface to the outer main surface;
- providing the high-viscosity fluid (4) in a reservoir (6) that is in fluidum connection with the at least one nozzle (14);
- pressurizing the high-viscosity fluid (4) in the reservoir (6), wherein the fluid (4) flows, as a result of said pressurizing, towards the nozzle plate (8), thus creating a pressure difference over the at least one nozzle (14) so that the fluid (4) flows out of the at least one nozzle (14), thereby passing the outer main surface (12) after passing the inner main surface (10);
- wherein the fluid flowing out of the nozzle (14) forms a jet that breaks up into droplets (18); and
- at least partially drying the droplets (18) in a drying medium, such as air, to become particles;
- wherein a cross-sectional area (A_1) of the at least one nozzle (14) in the inner main surface (10) exceeds a cross-sectional area (A_2) of the at least one nozzle (14) in the outer main surface (12) thereby decreasing a pressure difference over the at least one nozzle needed for spraying the high-viscosity fluid.

2. Method according to claim 1, wherein an area ratio, being equal to the cross-sectional area of the at least one nozzle in the inner main surface divided by the cross-sectional area of the at least one nozzle in the outer main surface, is at least five and/or is at most fifty.

3. Method according to claim 1 or 2, wherein the at least one nozzle comprises a substantially non-widening, e.g. cylindrical, part that extends

from the outer main surface, and comprises a substantially widening, e.g. frustoconical, part that extends from the substantially non-widening part to the inner main surface.

4. Method according to claim 3, wherein a pressure difference ratio, being equal to a pressure difference over the substantially widening part divided by a pressure difference over the substantially non-widening part, is at most 1, preferably at most 0.5, more preferably at most 0.3, e.g. at most 0.2.

5. Method according to one of claims 1-4, wherein, during pressurizing, the pressure difference over the at least one nozzle is kept at at most 15 bar, preferably at at most 12 bar.

6. Method according to one of claims 1-5, further comprising the step of generating dynamic pressure variations in the fluid (4) near the nozzle (14) that propagate through the nozzle (14) and cause a controlled breakup of the fluid jet flowing out of the nozzle (14), the broken up fluid jet forming substantially mono-disperse droplets (18).

7. Apparatus for spray-drying of a high-viscosity fluid (4), the apparatus comprising:

- a reservoir (6) for containing the high-viscosity fluid (4);
- a nozzle plate (8) that is in fluidum connection with the reservoir (6), has an inner main surface (10) and an outer main surface (12), and is provided with at least one nozzle (14) extending through the nozzle plate (8) from the inner main surface (10) to the outer main surface (12); and
- drying means;
- the apparatus being arranged for pressurizing the fluid (4) in the reservoir (6) so that, in use, the fluid (4) flows towards the nozzle plate (8), thus creating a pressure difference over the at least one nozzle (14) so that the fluid (4) flows out of the at least one nozzle (14), thereby passing the outer main surface (12) after passing the inner main surface (10); wherein

the fluid flowing out of the nozzle (14) forms a jet that breaks up into droplets (18); wherein the drying means is arranged for causing and/or allowing the droplets (18) to dry to become particles

- wherein a cross-sectional area (A_1) of the at least one nozzle (14) in the inner main surface (10) exceeds a cross-sectional area (A_2) of the at least one nozzle (14) in the outer main surface (12) thereby decreasing a pressure difference over the at least one nozzle needed for spraying the high-viscosity fluid.

8. Apparatus according to claim 7, wherein an area ratio, being equal to the cross-sectional area of the at least one nozzle in the inner main surface divided by the cross-sectional area of the at least one nozzle in the outer main surface, is at least five and/or is at most fifty.

9. Apparatus according to claim 8, wherein the at least one nozzle comprises a substantially non-widening, e.g. cylindrical, part that extends from the outer main surface, and comprises a substantially widening, e.g. frustoconical, part that extends from the substantially non-widening part to the inner main surface.

10. Apparatus according to claim 8 or 9, wherein a length of the substantially non-widening part of the at least one nozzle, measured along an outflow direction of the high-viscosity fluid through said non-widening part, is at least equal to three times a diameter of the at least one nozzle in the outer main surface (12).

11. Apparatus according to one of claims 7-10, comprising pressurizing means for pressurizing the fluid in the reservoir so that the fluid flows towards the nozzle plate and out of the at least one nozzle, thereby passing the outer main surface after passing the inner main surface.

12. Apparatus according to claim 11, wherein the pressurizing means are arranged for keeping a pressure difference over the at least one nozzle at at most 15 bar, preferably at at most 12 bar.

13. Apparatus according to one of claims 7-12, further comprising a pressure varying means (50) in the fluid (4) near the nozzle, the pressure varying means arranged for generating dynamic pressure variations in the fluid (4) near the nozzle (14) that propagate through the nozzle (14) and cause a controlled breakup of the fluid jet flowing out of the nozzle (14), the broken up fluid jet forming substantially mono-disperse droplets (18).

14. Apparatus according to one of claims 7-13, wherein the pressure varying means (50) comprises a pressure focusing member arranged such that an end of the pressure focusing member facing the nozzle (14) is placed at a distance of 2-1000 µm from the outflow opening and wherein the pressure focussing member and/or the nozzle plate are arranged for vibrating with respect to each other for varying the pressure adjacent the outflow opening.

15. Product produced by means of a method according to one of claims 1-6 and/or an apparatus according to one of claims 7-14.

CLAIMS

1. Method of spray-drying a high-viscosity fluid (4) using a spraying device, the method comprising:

– providing a nozzle plate (8) wherein at least one nozzle (14) is provided, said nozzle plate (8) having an inner main surface (10) and an outer main surface (12), the at least one nozzle (14) extending through the nozzle plate (8) from the inner main surface to the outer main surface;

– providing the high-viscosity fluid (4) in a reservoir (6) that is in fluidum connection with the at least one nozzle (14);

– pressurizing the high-viscosity fluid (4) in the reservoir (6), wherein the fluid (4) flows, as a result of said pressurizing, towards the nozzle plate (8), thus creating a pressure difference over the at least one nozzle (14) so that the fluid (4) flows out of the at least one nozzle (14), thereby passing the outer main surface (12) after passing the inner main surface (10); wherein the fluid flowing out of the nozzle (14) forms a jet that breaks up into droplets (18); and

– at least partially drying the droplets (18) in a drying medium, such as air, to become particles;

– wherein a cross-sectional area (A_1) of the at least one nozzle (14) in the inner main surface (10) exceeds a cross-sectional area (A_2) of the at least one nozzle (14) in the outer main surface (12) thereby decreasing a pressure difference over the at least one nozzle needed for spraying the high-viscosity fluid.

2. Method according to claim 1, wherein an area ratio, being equal to the cross-sectional area of the at least one nozzle in the inner main surface divided by the cross-sectional area of the at least one nozzle in the outer main surface, is at least five and/or is at most fifty.

3. Method according to claim 1 or 2, wherein the at least one nozzle comprises a substantially non-widening, e.g. cylindrical, part that extends

from the outer main surface, and comprises a substantially widening, e.g. frustoconical, part that extends from the substantially non-widening part to the inner main surface.

4. Method according to claim 3, wherein a pressure difference ratio, being equal to a pressure difference over the substantially widening part divided by a pressure difference over the substantially non-widening part, is at most 1, preferably at most 0.5, more preferably at most 0.3, e.g. at most 0.2.

5. Method according to one of claims 1-4, wherein, during pressurizing, the pressure difference over the at least one nozzle is kept at at most 15 bar, preferably at at most 12 bar.

6. Method according to one of claims 1-5, further comprising the step of generating dynamic pressure variations in the fluid (4) near the nozzle (14) that propagate through the nozzle (14) and cause a controlled breakup of the fluid jet flowing out of the nozzle (14), the broken up fluid jet forming substantially mono-disperse droplets (18).

7. Apparatus for spray-drying of a high-viscosity fluid (4), the apparatus comprising:

- a reservoir (6) for containing the high-viscosity fluid (4);
- a nozzle plate (8) that is in fluidum connection with the reservoir (6), has an inner main surface (10) and an outer main surface (12), and is provided with at least one nozzle (14) extending through the nozzle plate (8) from the inner main surface (10) to the outer main surface (12); and
- drying means;
- the apparatus being arranged for pressurizing the fluid (4) in the reservoir (6) so that, in use, the fluid (4) flows towards the nozzle plate (8), thus creating a pressure difference over the at least one nozzle (14) so that the fluid (4) flows out of the at least one nozzle (14), thereby passing the outer main surface (12) after passing the inner main surface (10); wherein

the fluid flowing out of the nozzle (14) forms a jet that breaks up into droplets (18); wherein the drying means is arranged for causing and/or allowing the droplets (18) to dry to become particles

– wherein a cross-sectional area (A_1) of the at least one nozzle (14) in the inner main surface (10) exceeds a cross-sectional area (A_2) of the at least one nozzle (14) in the outer main surface (12) thereby decreasing a pressure difference over the at least one nozzle needed for spraying the high-viscosity fluid.

8. Apparatus according to claim 7, wherein an area ratio, being equal to the cross-sectional area of the at least one nozzle in the inner main surface divided by the cross-sectional area of the at least one nozzle in the outer main surface, is at least five and/or is at most fifty.

9. Apparatus according to claim 8, wherein the at least one nozzle comprises a substantially non-widening, e.g. cylindrical, part that extends from the outer main surface, and comprises a substantially widening, e.g. frustoconical, part that extends from the substantially non-widening part to the inner main surface.

10. Apparatus according to claim 8 or 9, wherein a length of the substantially non-widening part of the at least one nozzle, measured along an outflow direction of the high-viscosity fluid through said non-widening part, is at least equal to three times a diameter of the at least one nozzle in the outer main surface (12).

11. Apparatus according to one of claims 7-10, comprising pressurizing means for pressurizing the fluid in the reservoir so that the fluid flows towards the nozzle plate and out of the at least one nozzle, thereby passing the outer main surface after passing the inner main surface.

12. Apparatus according to claim 11, wherein the pressurizing means are arranged for keeping a pressure difference over the at least one nozzle at at most 15 bar, preferably at at most 12 bar.

13. Apparatus according to one of claims 7-12, further comprising a pressure varying means (50) in the fluid (4) near the nozzle, the pressure varying means arranged for generating dynamic pressure variations in the fluid (4) near the nozzle (14) that propagate through the nozzle (14) and cause a controlled breakup of the fluid jet flowing out of the nozzle (14), the broken up fluid jet forming substantially mono-disperse droplets (18).

14. Apparatus according to one of claims 7-13, wherein the pressure varying means (50) comprises a pressure focusing member arranged such that an end of the pressure focusing member facing the nozzle (14) is placed at a distance of 2-1000 μm from the outflow opening and wherein the pressure focussing member and/or the nozzle plate are arranged for vibrating with respect to each other for varying the pressure adjacent the outflow opening.