CLAIMS

1. A column device for generating microdroplets, characterized in comprising:

a hollow tubular body having at least one inlet port and at least one outlet port opposite to the at least one inlet port; and

a three-dimensional periodic cavity structure mounted within the hollow tubular body and selected from the group consisting of

a three-dimensional ordered microstructure formed by a packed assembly of monodisperse spheres having diameter less than 1.3 millimeters (mm) and

an inverse structure of the three-dimensional ordered microstructure,

adapted to allow a disperse system of a continuous phase and a dispersed phase immiscible with the continuous phase and consisting of one or more macro-droplets to be fed in through the at least one inlet port, flow through the three-dimensional periodic cavity structure, and be discharged through the at least one outlet port, whereby as the disperse system enters and flows through the three- dimensional periodic cavity structure, the continuous phase applies shear stress to the one or more macro-droplets and divides them into microdroplets dispersed in the continuous phase; and

wherein the three-dimensional periodic cavity structure has a length of greater than or equal to 1 cm along flow direction of the disperse system.

2. The column device of claim 1, characterized in that the microdroplets satisfy Equation (5) after being cured:

$$Dv50 = A\ln(\text{flow rate}) + B \quad (5)$$

where Dv50 represents the median value of the particle size distribution of the cured microdroplets, the flow rate refers to the velocity at which the disperse system passes through the three-dimensional periodic cavity structure, A is a slope of Dv50 relative to the flow rate and ranges from -10 to -30 μm/ln(mL/min), and B is an intercept.

3. The column device of claim 2, characterized in that the slope A ranges from -12 to -25 μm/ln(mL/min).

4. The column device of claim 1, characterized in that the three-dimensional periodic cavity structure has a length of greater than or equal to 2 cm along the flow direction of the disperse system.

5. The column device of claim 4, characterized in that the three-dimensional periodic cavity structure has a length of greater than or equal to 3 cm along the flow direction of the disperse system.

6. The column device of claim 1, characterized in that the three-dimensional periodic cavity structure is a three-dimensional ordered microstructure formed by a packed assembly of spheres,

wherein at least 50% of the spheres in the three-dimensional periodic cavity structure are in a close-packed arrangement.

7. The column device of claim 5, characterized in that the three-dimensional periodic cavity structure is a three-dimensional ordered microstructure formed by a packed assembly of spheres, wherein at least 60% or at least 70% of the spheres in the three-dimensional periodic cavity structure are in a close-packed arrangement.

8. The column device of claim 2, characterized in that the cured microdroplets further satisfy Equation (6):

$$Y = aX + b. \quad (6)$$

where Y represents the dispersity of the particle size distribution of the microdroplets, X represents the flow rate of the disperse system, a is a slope of Y relative to X and ranges between 0.005 and 0.009 min/mL, and b is an intercept.

9. The column device of claim 8, characterized in that the slope a ranges between 0.006 and 0.008 min/mL.

10. A method for generating microdroplets using a column device, characterized in that the column device comprises:

a hollow tubular body having at least one inlet port and at least one outlet port opposite to the at least one inlet port; and

a three-dimensional periodic cavity structure mounted within the hollow tubular body and selected from the group consisting of a three-dimensional ordered microstructure formed by a packed assembly of spheres and an inverse structure of the three-dimensional ordered microstructure, so that a disperse system is allowed to be fed in through the at least one inlet port;

wherein the three-dimensional periodic cavity structure has a length of greater than or equal to 1 cm along flow direction of the disperse system;

the method comprising the steps of:

A) feeding the disperse system into the at least one inlet port, wherein the disperse system comprises a continuous phase and a dispersed phase immiscible with the continuous phase and consisting of one or more macro-droplets;

B) allowing the disperse system to pass through the three-dimensional periodic cavity structure, whereby as the disperse system enters and flows through the three- dimensional periodic cavity structure, the continuous phase applies shear stress to the one or more macro-droplets and divides them into microdroplets dispersed in the continuous phase and satisfying Equation (5) after being cured:

$$Dv50 = A\ln(\text{flow rate}) + B \quad (5)$$

where Dv50 represents the median value of the particle size distribution of the cured microdroplets, the flow rate refers to the velocity at which the disperse system passes through the three-dimensional periodic cavity structure, A is a slope of Dv50 relative to the flow rate and ranges from -10 to -30 μm/ln(mL/min), and B is an intercept; and

C) discharging the continuous phase and the microdroplets from the column device through the at least one outlet port.

11. The method of claim 10, characterized in further comprising, after the step C), a step of curing the microdroplets into microspheres.

12. The method of claim 10, characterized in that the disperse system is selected from the group consisting of water-in-oil emulsions and oil-in-water emulsions.

13. The method of claim 10, characterized in that the slope A ranges from -12 to -25 μm/ln(mL/min).

14. The method of claim 10, characterized in that the three-dimensional periodic cavity structure has a length of greater than or equal to 2 cm along the flow direction of the disperse system.

15. The method of claim 14, characterized in that the three-dimensional periodic cavity structure has a length of greater than or equal to 3 cm along the flow direction of the disperse system.

16. The method of claim 10, characterized in that the three-dimensional periodic cavity structure is a three-dimensional ordered microstructure formed by a packed assembly of spheres, wherein at least 50% of the spheres in the three-dimensional periodic cavity structure are in a close-packed arrangement.

17. The method of claim 16, characterized in that the three-dimensional periodic cavity structure is a three-dimensional ordered microstructure formed by a packed assembly of spheres, wherein at least 60% of the spheres in the three-dimensional periodic cavity structure are in a close-packed arrangement.

18. The method of claim 17, characterized in that the three-dimensional periodic cavity structure is a three-dimensional ordered microstructure formed by a packed assembly of spheres, wherein at least 70% of the spheres in the three-dimensional periodic cavity structure are in a close-packed arrangement.

19. The method of claim 10, characterized in that the cured microdroplets further satisfy Equation (6):

$$Y = aX + b. \quad (6)$$

where Y represents the dispersity of the particle size distribution of the microdroplets, X represents the flow rate of the disperse system, a is a slope of Y relative to X and ranges between 0.005 and 0.009 min/mL, and b is an intercept.

20. The method of claim 19, characterized in that the slope a ranges between 0.006 and 0.008 min/mL.

21. A column device for generating microdroplets, characterized in comprising:

a hollow tubular body having at least one inlet port and at least one outlet port opposite to the at least one inlet port; and

a three-dimensional periodic cavity structure mounted within the hollow tubular body and having a three-dimensional ordered porous microstructure comprising a plurality of spherical cavities each having diameter less than 1.3 millimeters (mm) and a plurality of pores interconnecting the spherical cavities,

wherein the plurality of spherical cavities are arranged such that the distances between the spherical cavities exhibit a regular periodicity, and

wherein the three-dimensional periodic cavity structure has a length of greater than or equal to 1 cm.

22. The column device of claim 21, wherein the spherical cavities are spaced apart from one another in an approximately equal distance.

23. The column device of claim 21, characterized in that the three-dimensional periodic cavity structure has a length of greater than or equal to 2 cm or a length of greater than or equal to 3 cm.

24. The column device of claim 21, wherein at least 50% of the spherical cavities in the three-dimensional periodic cavity structure are in a close-packed arrangement.

25. A method for fabricating the three-dimensional ordered porous microstructure of claim 21, the method comprising

filling an inverse opal material into interstitial voids of a template three-dimensional ordered microstructure formed from a plurality of monodisperse spheres to form an inverse structure; and

removing the template, thereby forming the three-dimensional ordered porous microstructure of claim 21.

26. The method of claim 25, wherein the inverse opal material is a metal or metal alloy, a metal oxide, or a polymer.

27. The method of claim 26, wherein

the metal or metal alloy is gold, silver, copper, nickel, platinum or a nickel-tungsten alloy;

the metal oxide is zinc oxide, silicon dioxide or cuprous oxide; or

the polymer is a polystyrene, a polyacrylate, a polymethacrylate, an acrylamide, a polypyrrole, a polyethylene, a polypropylene, a polyvinyl chloride or a silicone.

28. The method of claim 25, wherein the step of filling the inverse opal material into the interstitial voids of the template is performed by centrifugation, vacuum suction, pressure infiltration, sputtering, electroplating, chemical vapor deposition or atomic layer deposition.

29. The method of claim 28, wherein monomers and/or precursors of the polymer are filled in the voids and then cured *in situ*.