Claims

1. An apparatus for producing metal organic frameworks, comprising:

a tubular flow reactor comprising a heated tubular body into which, in use, precursor compounds which form the metal organic framework are fed and flow, said tubular body including at least one annular loop comprising a coil;

a flow restriction device comprising a back-pressure controller downstream of the tubular reactor for controlling the pressure within the tubular reactor; and

an apparatus for separating a metal organic framework (MOF) from a solution, comprising:

a housing having a reservoir capable of receiving a MOF containing solution;

a high frequency ultrasound transducer operatively connected to the reservoir and capable of applying megasonic frequencies of at least 400 kHz to the MOF containing solution, for separation of MOF from the MOF containing solution; and

an acoustic reflector surface spaced apart from the transducer within the housing configured to reflect said applied high frequency ultrasound from the high frequency transducer off the acoustic reflector surface, said acoustic reflector surface being spaced away from the high frequency ultrasound transducer such that a standing wave is formed through constructive interference,

wherein the precursor compounds are provided as at least one precursor solution fed into an inlet of the tubular reactor and heated during flow through the said tubular body.

2. An apparatus according to claim 1, further comprising an inline mixing arrangement wherein the precursor compounds are provided in at least two different precursor solutions containing different precursor compounds, the precursor solutions being mixed through inline mixing in a feed conduit fluidly connected to the inlet of the tubular body where the different precursor solutions are fed into the same inlet, the two or more precursor solutions being mixed at or proximate that inlet.

3. An apparatus according to claim 1, wherein the average radius of each annular loop is between 10 and 1000 mm.

4. An apparatus according to any one of claims 1-3, wherein the at least one annular loop form a tubular shaped coil radially centred about a central axis of the coil.

5. An apparatus according to any one of claims 1-4, wherein the length of the coil is greater than 50 mm.

6. An apparatus according to any one of claims 1-5, wherein the tubular flow reactor comprises a capillary tubular flow reactor.

7. An apparatus according to any one of claims 1-6, wherein the internal diameter of the tubular body is between 0.5 mm and 50 mm.

8. An apparatus according to any one of claims 1-7, wherein the tubular body is located inside a heated housing.

9. An apparatus according to any one of claims 1-8, wherein the tubular body is covered by or otherwise in contact with a heating arrangement, and the tubular body heats the precursor compounds to a temperature of between 20 and 200 ˚C.

10. An apparatus according to any one of claims 1-9, wherein the housing comprises a container including at least one wall position to contact the MOF containing solution, and the transducer is a high frequency ultrasound transducer that is positioned within the reservoir or in engagement with the at least one wall.

11. An apparatus according to any one of claims 1-10, wherein the high frequency ultrasound transducer comprises a plate transducer.

12. An apparatus according to any one of claims 1-11, wherein the housing includes at least one reflector surface designed to reflect the applied megasonic frequencies within the reservoir.

13. An apparatus according to any one of claims 1-12, wherein the high frequency ultrasound transducer is configured to provide an applied high frequency ultrasound of between 400 kHz to 4 MHz.

14. An apparatus according to any one of claims 1-13, wherein the high frequency ultrasound transducer is configured to provide an applied high frequency ultrasound of greater than 1 MHz.

15. A system for producing a metal organic framework (MOF), comprising:

an apparatus for forming a metal organic framework from precursor materials according to any one of claims 1-14; and

an apparatus for washing and/or purifying the metal organic framework, comprising: a housing having a reservoir capable of receiving a MOF containing solution from the reactor; and a high frequency ultrasound transducer operatively connected to the reservoir and capable of applying megasonic frequencies of at least 20 kHz to the MOF containing solution.

16. A process for producing metal organic frameworks, the process comprising:

introducing into an apparatus according to any one of claims 1 to 14 a solution comprising precursor compounds for forming the metal organic framework in solvent;

promoting a reaction within the tubular flow reactor to form the metal organic framework; and

applying a high frequency ultrasound of at least 20 kHz to a MOF containing solution sourced from the tubular flow reactor, such that any high frequency ultrasound applied within the MOF containing solution reflects off the acoustic reflector surface forming a standing wave through constructive interference, thereby separating the MOF material from solution as an aggregated sediment which settles out of the MOF containing solution.

17. A process according to claim 16, wherein the precursor compounds are provided in at least two different precursor solutions containing different precursor compounds, the precursor solution being mixed prior to introduction into the tubular body.

18. A process according to claim 16, wherein the precursor compounds are provided in at least two different precursor solutions containing different precursor compounds, the precursor solutions being mixed after introduction into the tubular body.

19. A process according to claim 16, wherein the yield of MOF from the apparatus is greater than 60%.