CLAIMS

1. A method comprising:

(i) providing an apparatus comprising an intake system, an injector, and a process system, wherein:

(a) the injector comprises a first injector conduit and a second injector conduit different from the first injector conduit;

(b) the injector can be in a first configuration providing a fluid communication between the first injector conduit and the intake system and a fluid communication between the second injector conduit and the process system, or in a second configuration providing a fluid communication between the first injector conduit and the process system and a fluid communication between the second injector conduit and the intake system, but not both at the same time; and

(c) the process system comprises a partitioner in fluid communication with the injector when the injector is in the second configuration;

(ii) flowing a first fluid from a source of the first fluid through a first intake conduit and into the first injector conduit when the injector is in the first configuration so that the first fluid occupies at least part of the first injector conduit;

(iii) changing the configuration of the injector from the first configuration to the second configuration;

(iv) flowing a second fluid that is substantially immiscible with the first fluid from a source of the second fluid through a first process conduit fluidly connected to the source of second fluid and the first injector conduit into the first injector conduit so that the second fluid displaces the first fluid from the first injector conduit into a second process conduit fluidly connected to the process system;

(v) flowing the first fluid from the injector and into a first partitioner conduit in the partitioner and flowing a third fluid that is substantially immiscible with the first fluid into a second partitioner conduit in the partitioner, wherein the partitioner produces a mixture comprising a plurality of partitions of the first fluid in the third fluid that flows out of an outlet of the partitioner;

(vi) while the injector is in the second configuration, flowing a fourth fluid substantially immiscible with the second and third fluids into the second injector conduit so that the fourth fluid occupies at least part of the second injector conduit;

(vii) changing the configuration of the injector from the second configuration to the first configuration;

(viii) while the injector is in the first configuration, flowing the second fluid into the second injector conduit so that it displaces the fourth fluid into the process system; and

(ix) flowing the fourth fluid into the partitioner and flowing the third fluid into the partitioner to produce a mixture comprising a plurality of partitions of the fourth fluid in the third fluid.

2. The method of claim 1, further comprising:

(vi) changing the injector from the second configuration to the first configuration; and
(vii) flowing a first cleaning fluid through the first injector conduit to remove some or all of first fluid that remains in the first injector conduit after step (iv) from the first injector conduit.

3. The method of claim 2, comprising serially repeating steps (ii)-(vii) for a plurality of fluids in addition to the first fluid, wherein each of the plurality of fluids can be the same as or different from the first fluid, and wherein each of the plurality of fluids is substantially immiscible with the second fluid and the third fluid, to produce a plurality of different mixtures each comprising a plurality of partitions of one of the fluids from the plurality of fluids in the third fluid from the partitioner.

4. The method of claim 3, wherein the plurality of fluids in addition to the first fluid comprises at least four different fluids.

5. The method of claim 1, wherein the partitioner produces the mixture comprising a plurality of partitions of the first fluid in the third fluid and said mixture comprises at least 100 partitions of the first fluid in the third fluid.

6. The method of claim 1, wherein the partitioner is electrically grounded during at least part of the production of the partitions.

7. The method of claim 1, wherein at least 95% of inner surfaces of sections of the first injector conduit, the first intake conduit, the second process conduit, and the partitioner, through which the first fluid flows, have greater affinity for the second and third fluids than for the first fluid.

8. The method of claim 7, wherein at least 99% of the inner surfaces have greater affinity for the second and third fluids than for the first fluid.

9. The method of claim 7, wherein the first fluid comprises an aqueous phase and the second and third fluids comprise a fluorinated oil, and wherein the inner surfaces comprise a fluorinated material.

10. The method of claim 1, further comprising flowing the mixture comprising a plurality of partitions of the first fluid in the third fluid through a conduit from the outlet of the partitioner through a reactor, wherein the reactor provides energy to initiate and/or promote one or more physical or chemical reactions in one or more of the partitions.

11. The method of claim 1, further comprising flowing the mixture comprising a plurality of partitions of the first fluid in the third fluid through a conduit from the outlet of the partitioner to a

detector conduit in a detector, wherein the detector conduit comprises an interrogation region, and wherein the detector detects at least one characteristic of at least a portion of the partitions as they flow in single file through the interrogation region.

12. The method of claim 11, wherein the detector comprises:

(a) a source of electromagnetic energy to provide electromagnetic energy to the interrogation region, wherein the interrogation region is configured for single file movement of partitions through the detector conduit,

(b) a detection element to detect electromagnetic energy emitted from a partition in the interrogation region; and

(c) an optical restriction positioned between the interrogation region and the detection element, wherein the optical restriction is configured and positioned such that when a first partition is passing through the interrogation region, not more than 25% of electromagnetic radiation reaching the detection element is from one or more partitions other than the first partition.

13. The method of claim 11, wherein:

the detector comprises:

(a) a source of electromagnetic energy to provide electromagnetic energy to the interrogation region, wherein the interrogation region is configured for single file movement of partitions through the detector conduit, and

(b) a detection element to detect electromagnetic energy emitted from a partition in the interrogation region; and

wherein the detector is configured to modulate output of the source of electromagnetic energy by a carrier periodic function to multiply the signal of the detection element by the carrier periodic function and to integrate the resultant product over multiple periods of the carrier periodic function.

14. The method of claim 1, wherein, in step (ii), an opening of the first intake conduit is positioned to be immersed in the first fluid to create a fluid connection for flow of the first fluid into the first injector conduit, wherein a major dimension of the opening of the first intake conduit is less than a characteristic dimension of any other conduit in the apparatus.

15. A method comprising:

(i) providing an apparatus comprising an intake system, an injector, and a process system, wherein:

(a) the injector comprises a first injector conduit;

(b) the injector can be in a first configuration providing a fluid communication between the first injector conduit and the intake system or in a second configuration providing a fluid communication between the first injector conduit and the process system, but not both at the same time; and

(c) the process system comprises a partitioner in fluid communication with the injector when the injector is in the second configuration;

(ii) flowing a first fluid from a source of the first fluid through a first intake conduit and into the first injector conduit when the injector is in the first configuration so that the first fluid occupies at least part of the first injector conduit;

(iii) changing the configuration of the injector from the first configuration to the second configuration;

(iv) flowing a second fluid that is substantially immiscible with the first fluid from a source of the second fluid through a first process conduit fluidly connected with the source of the second fluid and the first injector conduit into the first injector conduit so that the second fluid displaces the first fluid from the first injector conduit into a second process conduit fluidly connected to the process system; and

(v) flowing the first fluid from the injector and into a first partitioner conduit in the partitioner and flowing a third fluid that is substantially immiscible with the first fluid into a second partitioner conduit in the partitioner wherein the partitioner produces a mixture comprising a plurality of partitions of the first fluid in the third fluid that flows out of an outlet of the partitioner, wherein the partitioner is electrically grounded during at least part of the production of the partitions.

16. The method of claim 15, further comprising:

(vi) changing the injector from the second configuration to the first configuration; and

(vii) flowing a first cleaning fluid through the first injector conduit to remove some or all of the first fluid that remains in the first injector conduit after step (iv) from the first injector conduit.

17. The method of claim 15, wherein the injector further comprises a second injector conduit, different from the first injector conduit, wherein the injector is configured so that the second injector conduit is in fluid communication with the process system when the injector is in the first configuration or in fluid communication with the intake system when the injector is in the second configuration, but not both at the same time, and wherein the method further comprises:

(vi) while the injector is in the second configuration, flowing a fourth fluid substantially immiscible with the second and third fluids into the second injector conduit so that the fourth fluid occupies at least part of the second injector conduit;

(vii) changing the configuration of the injector from the second configuration to the first configuration;

(viii) while the injector is in the first configuration, flowing the second fluid into the second injector conduit so that it displaces the fourth fluid into the process system; and

(ix) flowing the fourth fluid into the partitioner and flowing the third fluid into the partitioner to produce a mixture comprising a plurality of partitions of the fourth fluid in the third fluid.

18. The method of claim 15, further comprising flowing the mixture comprising a plurality of partitions of the first fluid in the third fluid through a conduit from the outlet of the partitioner through a reactor, wherein the reactor provides energy to initiate and/or promote one or more physical or chemical reactions in one or more of the partitions.

19. The method of claim 15, further comprising flowing the mixture comprising a plurality of partitions of the first fluid in the third fluid through a conduit from the outlet of the partitioner to a detector conduit in a detector, wherein the detector conduit comprises an interrogation region, and wherein the detector detects at least one characteristic of at least a portion of the partitions as they flow in single file through the interrogation region.

20. The method of claim 15, wherein, in step (ii), an opening of the first intake conduit is positioned to be immersed in the first fluid to create a fluid connection for flow of the first fluid into the first injector conduit, wherein a major dimension of the opening of the first intake conduit is less than a characteristic dimension of any other conduit in the apparatus.

CLAIMS

1. A system for producing a serial flow emulsion comprising

(i) an intake system to sequentially transport a plurality of separate samples or portions of samples from a series of sample containers;

(ii) a process system, wherein the process system comprises a partitioner to generate a plurality of partitions in a continuous phase from each of the samples; and

(iii) an injector positioned between the intake system and the process system, wherein the injector is configured to be in fluid communication with the intake system, or to be in fluid communication with the process system, but not both simultaneously.

2. The system of claim 1 further comprising a reactor fluidly connected to the partitioner to initiate or modulate one or more reactions in one or more of the partitions.

3. The system of claim 2 wherein the reactor comprises a conduit fluidly connected to the partitioner through which partitions flow, wherein the reactor comprises at least two different thermal zones, and wherein the conduit repeatedly contacts the at least two different thermal zones.

4. The system of claim 2 further comprising a detector fluidly connected to the reactor to detect a characteristic of one or more of the partitions.

5. The system of claim 4 wherein the detector comprises at least one of

(a) an optical restriction that limits the amount of electromagnetic radiation that reaches a detection element in the detector from an interrogation region in the detector where partitions are detected to less than 10% of the electromagnetic radiation that would reach the detection element without the optical restriction;

(b) an interrogation region comprising a conduit wherein partitions flow in single file through the conduit, and wherein the cross-sectional area of the conduit is less than 90% of the average spherical cross-sectional area of the partitions;

(c) an excitation source to provide electromagnetic radiation to the interrogation region and a system to provide lock-in amplification of the excitation source;

(d) a system to separate partitions prior to the interrogation region of the detector.

6. The system of claim 4 wherein the detector comprises at least two of

(a) an optical restriction that limits the amount of electromagnetic radiation that reaches a detection element in the detector from an interrogation region in the detector where partitions are detected to less than 10% of the electromagnetic radiation that would reach the detection element without the optical restriction;

(b) an interrogation region comprising a conduit wherein partitions flow in single file through the conduit, and wherein the cross-sectional area of the conduit is less than 90% of the average spherical cross-sectional area of the partitions;

(c) an excitation source to provide electromagnetic radiation to the interrogation region and a system to provide lock-in amplification of the excitation source;

(d) a system to separate partitions prior to the interrogation region of the detector.

7. The system of claim 1 wherein the intake system is configured to provide a sample comprising a first fluid to the process system and the process system is configured to provide a second fluid to the system after the first fluid, and wherein at least 80, 90, 95, 96, 97, 98, 99, 99.5, 99.9, 99.99% surfaces of all components of the system that come into contact with the sample or portions of the sample have greater affinity for the second fluid than for the first fluid.

8. A method comprising

(i) transporting a first sample comprising a first dispersed phase from a first sample container into an intake system;

(ii) flowing the first sample from the intake system to an injector that is fluidly connected to the injection system but not to a process system;

(iii) repositioning the injector so that it is fluidly connected to the process system but not the intake system;

(iv) flowing the first sample from the injector into the process system;

(v) partitioning the first sample into a plurality of partitions of the first dispersed phase in a continuous phase;

(vi) repositioning the injector so that it is fluidly connected to the injection system but not to the process system;

(vii) transporting a second sample comprising a second dispersed phase from a first second container into the intake system and into the injector;

(viii) repositioning the injector so that it is fluidly connected to the process system but not the intake system;

(ix) flowing the second sample from the injector into the process system; and

(x) partitioning the second sample into a plurality of partitions of the second dispersed phase in the continuous phase.

9. The method of claim 8 further comprising flowing the partitions through a detector fluidly connected to the reactor to detect one or more of the partitions.

10. The method of claim 9 wherein the detector comprises at least one of

(a) an optical restriction that limits the amount of electromagnetic radiation that reaches a detection element in the detector from an interrogation region in the detector where partitions are detected to less than 10% of the electromagnetic radiation that would reach the detection element without the optical restriction;

(b) an interrogation region comprising a conduit wherein partitions flow in single file through the conduit, and wherein the cross-sectional area of the conduit is less than 90% of the average spherical cross-sectional area of the partitions;

(c) an excitation source to provide electromagnetic radiation to the interrogation region and a system to provide lock-in amplification of the excitation source;

(d) a system to separate partitions prior to the interrogation region of the detector.

11. The method of claim 9 wherein the detector comprises at least two of

(a) an optical restriction that limits the amount of electromagnetic radiation that reaches a detection element in the detector from an interrogation region in the detector where partitions are detected to less than 10% of the electromagnetic radiation that would reach the detection element without the optical restriction;

(b) an interrogation region comprising a conduit wherein partitions flow in single file through the conduit, and wherein the cross-sectional area of the conduit is less than 90% of the average spherical cross-sectional area of the partitions;

(c) an excitation source to provide electromagnetic radiation to the interrogation region and a system to provide lock-in amplification of the excitation source;

(d) a system to separate partitions prior to the interrogation region of the detector.

12. The method of claim 8 further comprising performing a reaction in at least a portion of the partitions.

13. The method of claim 12 wherein the portion of the partitions comprise at least one nucleic acid per partition, and the reaction is a polymerase chain reaction (PCR).

14. The method of claim 8 wherein the samples comprise a first fluid and the process system provides a second fluid to the system after the first fluid, and wherein at least 80, 90, 95, 96, 97, 98, 99, 99.5, 99.9, 99.99% surfaces of all components of the system that come into contact with the sample or portions of the sample have greater affinity for the second fluid than for the first fluid.

15. The method of claim 14 where the first fluid comprises first or second dispersed phase and the second fluid comprises continuous phase.

16. A system comprising a detector for detecting one or more partitions in a flowing series of partitions comprising

(i) a conduit configured to flow the partitions within the conduit in single file, comprising an interrogation region wherein partitions are detected;

(ii) a detection element for detecting the electromagnetic radiation emitted by the partitions in the interrogation region, if present; and

(iii) an optical restriction configured and positioned between the interrogation region and the detection element so that only a portion of the electromagnetic radiation from the interrogation region that can be detected by the detection element is actually detected.

17. The system of claim 16 wherein the portion of electromagnetic radiation that can be detected due to the optical restriction is less than 10% of the amount that would be detected without the optical restriction.

18. The system of claim 16 wherein the interrogation region has a cross-sectional area equal to or less than 90% of the average spherical cross-sectional area of the partitions.

19. The system of claim 16 wherein the interrogation region has a cross-sectional area equal to or less than 50% of the average spherical cross-sectional area of the partitions.

20. The system of claim 16 further comprising (iv) an excitation source for supplying electromagnetic radiation to the interrogation region.

21. The system of claim 20 comprising a plurality of excitation sources, each of which supplies electromagnetic radiation to the interrogation region.

22. The system of claim 21 wherein the excitation source or sources comprises a lock-in amplifier.

23. The system of claim 16 further comprising a partitioner fluidly connected to the detector, wherein the partitioner is configured to generate partitions of dispersed phase in a continuous phase from a sample, wherein the partitioner is configured to produce partitions of an average volume of 0.05-50 nL.

24. The system of claim 16 further comprising a partition separation system configured to add a separation fluid to the flow of partitions prior to the interrogation region of the detector.

25. The system of claim 16 further comprising a partitioner for creating the partitions.

26. The system of claim 25 further comprising

(i) an intake system to sequentially transport a plurality of separate samples or portions of samples from a series of sample containers;

(ii) a process system, wherein the process system comprises the partitioner to generate a plurality of partitions in a continuous phase from each of the samples; and

(iii) an injector positioned between the intake system and the process system, wherein the injector is configured to be in fluid communication with the intake system, or to be in fluid communication with the process system, but not both simultaneously.