CONDUIT CONTACTOR AND METHOD OF USING THE SAME

TECHNICAL FIELD OF THE DISCLOSURE

The present disclosure generally relates to a conduit contactor for facilitating chemical reactions and/or chemical extractions between immiscible liquids.

BACKGROUND OF THE DISCLOSURE

One method of reacting immiscible liquids, e.g., an aqueous phase and an organic phase, includes creating dispersions of one phase in the other to generate small droplets with a large surface area where mass transfer and reaction can occur. After mixing the reactants, separation of the phases is needed for product purity and quality. However, when using dispersion methods, separation of phases can be difficult and time consuming.

Alternative methods have been employed using fiber reactors or conduit contactors, in which fibers or films disposed within a conduit provide increased surface area to facilitate reaction between the immiscible liquids while avoiding agitation of the immiscible liquids and the resultant forming of dispersions/emulsions that are difficult to separate. Examples of conduit contactors are described in U.S. Patent Nos. 7,618,544 and 8,128,825, both of which are incorporated herein in their entireties.

However, conduit contactors are generally expensive to build and maintain, wherein a large portion of this cost is associated with the fibers or films used to create increased surface area for mass transfer or reaction. As such, there remains a need for an efficient and cost-effective conduit contactor.

BRIEF SUMMARY OF THE DISCLOSURE

According to a first aspect of the present disclosure, there is provided a conduit contactor for conducting chemical reactions or chemical extractions between immiscible liquids including: a conduit having a hollow interior, a first open end, and a second open end opposite the first open end; a separator in fluid communication with and proximate the second open end; and a plurality of fibers disposed within the conduit, wherein a total surface area of the fibers per volume of the hollow interior of the conduit is 150 cm^2/cm^3 or greater.

According to a second aspect of the present disclosure, there is provided a method of conducting chemical reactions or chemical extractions between immiscible liquids including: providing a conduit contactor including: a conduit having a hollow interior, a first open end, and a second open end opposite the first open end; a separator in fluid communication with and proximate the second open end; and a plurality of fibers disposed within the conduit, wherein a total surface area of the fibers per volume of the hollow interior of the conduit is 150 cm^2/cm^3 or greater; introducing a first liquid into the conduit and onto the fibers; introducing a second liquid into the conduit such that the second liquid contacts the first liquid, wherein the second liquid is immiscible with the first liquid; (i) extracting at least one component from the first liquid into the second liquid, (ii) extracting at least one component from the second liquid into the first liquid, or (iii) reacting at least one component from the first liquid with at least one component from the second liquid; and receiving the first and second liquids into the separator.

According to a third aspect of the present disclosure, there is provided a system for facilitating chemical reactions or chemical extractions between immiscible liquids including: a conduit having a hollow interior, a first open end, and a second open end opposite the first open end; a separator in fluid communication with and proximate the second open end; and a plurality of fibers disposed within the conduit, wherein a total surface area of the fibers per volume of the hollow interior of the conduit is 150 cm^2/cm^3 or greater; a first fluid supply for introducing a first liquid into the conduit and onto the fibers; and a second fluid supply for introducing a second liquid into the conduit such that the second liquid contacts the first liquid; wherein the first liquid and the second liquid are immiscible.

According to embodiments of the present disclosure, a conduit contactor is provided having improved efficiency and decreased cost of production. Traditionally, it was thought that maximizing surface area of fiber material within the conduit contactor could achieve more complete reaction between the immiscible liquids. However, the present inventors have surprisingly found that by reducing the amount of fiber material within the conduit contactor to a certain degree, the conduit contactor is able to more efficiently facilitate chemical extractions and/or chemical reactions between immiscible liquids introduced into the conduit contactor.

The utilization of this discovery provides an enormous benefit in terms of cost of constructing and maintaining such conduit contactors because the fiber material used therein can account for upwards of half of the total construction cost. Moreover, the

CLAIMS

What is claimed is:

1. A conduit contactor for conducting chemical reactions or chemical extractions between immiscible liquids comprising:

a conduit having a hollow interior, a first open end, and a second open end opposite the first open end;

a separator in fluid communication with and proximate the second open end; and

a plurality of fibers disposed within the conduit,

wherein a total surface area of the fibers per volume of the hollow interior of the conduit is from 100 cm^2/cm^3 to 490 cm^2/cm^3.

2. The conduit contactor of claim 1, wherein a total surface area of the fibers per volume of the hollow interior of the conduit is from 125 cm^2/cm^3 to 450 cm^2/cm^3.

3. The conduit contactor of claim 1, wherein a total surface area of the fibers per volume of the hollow interior of the conduit is from 150 cm^2/cm^3 to 435 cm^2/cm^3.

4. The conduit contactor of claim 1, wherein a length of the conduit and the fibers is from 0.25 m to 10 m.

5. The conduit contactor of claim 1, wherein an average diameter of the hollow interior of the conduit is from 0.5 cm to 3 m.

6. The conduit contactor of claim 1, wherein an average diameter of the fibers is from 5 μm to 150 μm.

7. A method of conducting chemical reactions or chemical extractions between immiscible liquids comprising:

providing a conduit contactor comprising:

a conduit having a hollow interior, a first open end, and a second open end opposite the first open end;

a separator in fluid communication with and proximate the second open end; and

a plurality of fibers disposed within the conduit,

wherein a total surface area of the fibers per volume of the hollow interior of the conduit is from 100 cm^2/cm^3 to 490 cm^2/cm^3;

introducing a first liquid into the conduit and onto the fibers;

introducing a second liquid into the conduit such that the second liquid contacts the first liquid, wherein the second liquid is immiscible with the first liquid;

(i) extracting at least one component from the first liquid into the second liquid, (ii) extracting at least one component from the second liquid into the first liquid, or (iii) reacting at least one component from the first liquid with at least one component from the second liquid; and

receiving the first and second liquids into the separator.

8. The method according to claim 7, wherein a total surface area of the fibers per volume of the hollow interior of the conduit is from 125 cm^2/cm^3 to 450 cm^2/cm^3.

9. The method according to claim 7, wherein a total surface area of the fibers per volume of the hollow interior of the conduit is from 150 cm^2/cm^3 to 435 cm^2/cm^3.

10. The method according to claim 7, further comprising pre-heating the conduit contactor to a temperature of 15°C to 100°C prior to introducing the first liquid.

11. The method according to claim 7, wherein a length of the conduit and the fibers is from 0.25 m to 10 m.

12. The method according to claim 7, wherein an average diameter of the hollow interior of the conduit is from 0.5 cm to 3 m.

13. The method according to claim 7, wherein an average diameter of the fibers is from 5 μm to 150 μm.

14. The method according to claim 7, wherein the first liquid is introduced at a first rate and the second liquid is introduced at a second rate, wherein a ratio of the first rate to the second rate is from 2:1 to 1:10.

15. The method according to claim 14, wherein the ratio of the first rate to the second rate is from 1:1 to 3:1.

16. A system for facilitating chemical reactions or chemical extractions between immiscible liquids comprising:

a conduit having a hollow interior, a first open end, and a second open end opposite the first open end;

a separator in fluid communication with and proximate the second open end; and

a plurality of fibers disposed within the conduit,

wherein a total surface area of the fibers per volume of the hollow interior of the conduit is from 100 cm^2/cm^3 to 490 cm^2/cm^3;

a first fluid supply for introducing a first liquid into the conduit and onto the fibers; and

a second fluid supply for introducing a second liquid into the conduit such that the second liquid contacts the first liquid;

wherein the first liquid and the second liquid are immiscible.

17. The system according to claim 16, wherein a total surface area of the fibers per volume of the hollow interior of the conduit is from 125 cm^2/cm^3 to 450 cm^2/cm^3.

18. The system according to claim 16, wherein a total surface area of the fibers per volume of the hollow interior of the conduit is from 150 cm^2/cm^3 to 435 cm^2/cm^3.

19. The system according to claim 16, wherein the first fluid supply is configured to introduce the first liquid into the conduit at a first rate and the second fluid supply is configured to introduce the second liquid into the conduit at a second rate, wherein a ratio of the first rate to the second rate is from 2:1 to 1:10.

~~20. The system according to claim 19, wherein the ratio of the first rate to the second rate is from 1:1 to 3:1.~~

1. A conduit contactor for conducting chemical reactions or chemical extractions between immiscible liquids comprising:

a conduit having a hollow interior, a first open end, and a second open end opposite the first open end;

a separator in fluid communication with and proximate the second open end; and

a plurality of fibers disposed within the conduit,

wherein a total surface area of the fibers per volume of the hollow interior of the conduit is 150 cm^2/cm^3 or greater.

2. The conduit contactor of claim 1, wherein a total surface area of the fibers per volume of the hollow interior of the conduit is from 180 cm^2/cm^3 to 490 cm^2/cm^3.

3. The conduit contactor of claim 1, wherein a total surface area of the fibers per volume of the hollow interior of the conduit is from 200 cm^2/cm^3 to 435 cm^2/cm^3.

4. The conduit contactor of claim 1, wherein a length of the conduit and the fibers is from 0.25 m to 10 m.

5. The conduit contactor of claim 1, wherein an average diameter of the hollow interior of the conduit is from 0.5 cm to 3 m.

6. The conduit contactor of claim 1, wherein an average diameter of the fibers is from 5 µm to 150 µm.

7. A method of conducting chemical reactions or chemical extractions between immiscible liquids comprising:

providing a conduit contactor comprising:

a conduit having a hollow interior, a first open end, and a second open end opposite the first open end;

a separator in fluid communication with and proximate the second open

end; and

a plurality of fibers disposed within the conduit,

wherein a total surface area of the fibers per volume of the hollow interior of the conduit is 150 cm^2/cm^3 or greater;

introducing a first liquid into the conduit and onto the fibers;

introducing a second liquid into the conduit such that the second liquid contacts the first liquid, wherein the second liquid is immiscible with the first liquid;

(i) extracting at least one component from the first liquid into the second liquid, (ii) extracting at least one component from the second liquid into the first liquid, or (iii) reacting at least one component from the first liquid with at least one component from the second liquid; and

receiving the first and second liquids into the separator.

8. The method according to claim 7, wherein a total surface area of the fibers per volume of the hollow interior of the conduit is from 180 cm^2/cm^3 to 490 cm^2/cm^3.

9. The method according to claim 7, wherein a total surface area of the fibers per volume of the hollow interior of the conduit is from 200 cm^2/cm^3 to 435 cm^2/cm^3.

10. The method according to claim 7, further comprising pre-heating the conduit contactor to a temperature of 15°C to 100°C prior to introducing the first liquid.

11. The method according to claim 7, wherein a length of the conduit and the fibers is from 0.25 m to 10 m.

12. The method according to claim 7, wherein an average diameter of the hollow interior of the conduit is from 0.5 cm to 3 m.

13. The method according to claim 7, wherein an average diameter of the fibers is from 5 µm to 150 µm.

14. The method according to claim 7, wherein the first liquid is introduced at a first

rate and the second liquid is introduced at a second rate, wherein a ratio of the first rate to the second rate is from 2:1 to 1:10.

15. The method according to claim 14, wherein the ratio of the first rate to the second rate is from 1:1 to 3:1.

16. A system for facilitating chemical reactions or chemical extractions between immiscible liquids comprising:

a conduit having a hollow interior, a first open end, and a second open end opposite the first open end;

a separator in fluid communication with and proximate the second open end; and

a plurality of fibers disposed within the conduit,

wherein a total surface area of the fibers per volume of the hollow interior of the conduit is 150 cm^2/cm^3 or greater;

a first fluid supply for introducing a first liquid into the conduit and onto the fibers; and

a second fluid supply for introducing a second liquid into the conduit such that the second liquid contacts the first liquid;

wherein the first liquid and the second liquid are immiscible.

17. The system according to claim 16, wherein a total surface area of the fibers per volume of the hollow interior of the conduit is from 180 cm^2/cm^3 to 490 cm^2/cm^3.

18. The system according to claim 16, wherein a total surface area of the fibers per volume of the hollow interior of the conduit is from 200 cm^2/cm^3 to 435 cm^2/cm^3.

19. The system according to claim 16, wherein the first fluid supply is configured to introduce the first liquid into the conduit at a first rate and the second fluid supply is configured to introduce the second liquid into the conduit at a second rate, wherein a ratio of the first rate to the second rate is from 2:1 to 1:10.

20. The system according to claim 19, wherein the ratio of the first rate to the second rate is from 1:1 to 3:1.