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(54) Process and apparatus for producing microcapsules

Vorrichtung und Verfahren zum herstellen von Mikrokapseln

Procédé et appareil pour la production de micro-capsules

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Description

Technical Field

[0001] The present invention relates to a process and apparatus for producing a microemulsion and microcapsules in water, oil, and chemically inert liquid.

Background Art

[0002] Conventionally, apparatuses for producing a microemulsion (containing microspheres) and microcapsules have been used in steps of manufacturing chemicals and some processes have been proposed. There are the following processes (see, for example, PCT Japanese Translation Patent Application Publication No. 8-508933): a process in which a second solution is dropped in a first solution, a process in which a first solution is dropped in the air from the inside portion of a double tube and a second solution is dropped from the outside portion thereof, and so on. Among processes for scattering droplets in the air, there is a process for ejecting droplets using piezoelectric elements used for inkjet printers and so on.

[0003] On the other hand, a technique in which monodispersed microdroplets are prepared with laboratory equipment is disclosed in Japanese Unexamined Patent Application Publication No. 2000-84384. However, in this technique, there is a problem in that the rate of preparing such microdroplets is low and the microdroplets cannot be covered with surfactants or microcapsule shells. Furthermore, only microdroplets having a diameter three times larger than the width of microchannels can be prepared. GB-A-2097692 describes a method for combining chemical reagents and to an apparatus for use therein.

[0004] EP-A-0512693 describes a process for preparing microcapsules.

[0005] EP-A-0964001 describes a process for preparing microencapsulated polymers.

[0006] The present invention seeks to provide an improved process and apparatus for producing microcapsules.

[0007] According to one aspect of the present invention, there is provided a process for producing microcapsules as defined in claim 1 hereinafter.

[0008] According to another aspect of the present invention, there is provided an apparatus for producing microcapsules as defined in claim 3 hereinafter.

Brief Description of the Drawings

[0009]

FIG. 1 is a plan view showing a microdroplet-producing apparatus.

FIG. 2 is an illustration showing microdroplet-producing processes.

FIG. 3 is a plan view showing a microcapsule-producing apparatus according to an embodiment of the present invention.

FIG. 4 is an illustration showing a microcapsule-producing process according to an embodiment of the present invention.

FIG. 5 is a plan view showing a microcapsule-producing apparatus.

FIG. 6 is an illustration showing a microcapsule-producing process.

FIG. 7 is an illustration showing the particle size obtained by varying the height of the continuous phases and dispersion phases.

FIG. 8 is an illustration showing a mechanism for ejecting a dispersion phase, a shell-forming phase, or a content-forming phase placed in a microdroplet-producing apparatus.

FIG. 9 is an illustration showing a mechanism for ejecting a dispersion phase, a shell-forming phase, or a content-forming phase placed in a microdroplet-producing apparatus.

FIG. 10 is an illustration showing a mechanism for ejecting a dispersion phase, a shell-forming phase, or a content-forming phase placed in a microdroplet-producing apparatus.

FIG. 11 is an illustration showing a mechanism for opening or closing a dispersion phase-feeding port of a microdroplet-producing apparatus.

FIG. 12 is an illustration showing a mechanism for opening or closing a dispersion phase-feeding port of a microdroplet-producing apparatus.

FIG. 13 is an illustration showing a mechanism for opening or closing a dispersion phase-feeding port of a microdroplet-producing apparatus.

FIG. 14 is an illustration showing a microcapsule-forming apparatus according to a fourteenth embodiment of the present invention.

[0010] FIG. 1 is a plan view showing an apparatus for producing microdroplets which does not form part of the invention, and FIG. 2 is an illustration showing processes for producing such microdroplets. FIG. 2(a) is an illustration showing a microdroplet-producing process (No. 1), FIG. 2(b) is another illustration showing a microdroplet-producing process (No. 2), FIG. 2(b-1) is a fragmentary sectional view thereof, and FIG. 2(b-2) is the sectional view of FIG. 2(b-1) taken along the line A-A.

[0011] In these figures, reference numeral 1 represents a main body of the microdroplet-producing apparatus, reference numeral 2 represents a microchannel in which a continuous phase flows and which is disposed in the main body 1, reference numeral 3 represents a dispersion phase-feeding channel placed such that the dispersion phase-feeding channel 3 and the microchannel 2 cross, reference numeral 4 represents a dispersion phase-feeding port, reference numeral 5 represents the continuous phase (for example, oil), reference numeral 6 represents a dispersion phase (for example, water), reference numeral 7 represents a microdroplet, and reference numeral 8 represents hydrophobic film.

[0012] In the above configuration, the dispersion phase 6 is fed to the continuous phase 5 flowing in the microchannel 2 in such a manner that flows of the dispersion phase 6 and the continuous phase 5 cross each other, as shown in FIG. 2. Part of the continuous phase 5 extends through each dispersion phase-feeding port 4, thereby producing the microdroplets 7 having a diameter smaller than the width of the dispersion phase-feeding channel 3.

[0013] For example, microdroplets having a diameter of about 25 μm can be obtained when the pressure of the dispersion phase (water) 6 is set to 2.45 kPa, the pressure of the continuous phase (oil containing 70% of oleic acid) 5 is set to 4.85 kPa, and the microchannel 2 and the dispersion phase-feeding channel 3 have a width of 100 μm and a height of 100 μm. When the pressure of the continuous phase is set to 5.03 kPa, microdroplets having a diameter of about 5 μm can be obtained.

[0014] As shown in FIGS. 2(b-1) and 2(b-2), in order to readily form the microdroplets 7 (in order to readily repelling the microdroplets), the hydrophobic films 8 are preferably disposed on portions of the inner walls of the microchannel 2, in which the continuous phase 5 flows, and the dispersion phase-feeding channel 3, wherein the portions are disposed at the vicinity of the junction of the flows of the continuous phase (for example, oil) 5 and the dispersion phase (for example, water) 6.

[0015] Since the continuous phase 5 contains oil and the dispersion phase 6 contains water, the hydrophobic films 8 are preferably used. However, when the continuous phase contains water and the dispersion phase contains oil, hydrophilic films are preferably used.

[0016] FIG. 3 is a plan view showing an apparatus for producing microcapsules according to an embodiment, and FIG. 4 is an illustration showing a process for producing such microcapsules.

[0017] In these figures, reference numeral 11 represents a main body of the microcapsule-producing apparatus, reference numeral 12 represents a microchannel in which a continuous phase flows and which is disposed in the main body 11, reference numeral 13 represents a shell-forming phase-feeding channel placed such that the shell-forming phase-feeding channel 13 and the microchannel 12 cross, reference numeral 14 represents a content-forming phase-feeding channel placed such that the content-forming phase-feeding channel 14 and the microchannel 12 cross, reference numeral 15 represents a shell-forming phase-feeding port, reference numeral 16 represents a content-forming phase-feeding port, reference numeral 17 represents the continuous phase (for example, water), reference numeral 18 represents a shell-forming phase, reference numeral 19 represents a content-forming phase, and reference numeral 20 represents a microcapsule.

[0018] In the above configuration, the shell-forming phase 18 and the content-forming phase 19 are fed to the continuous phase 17 flowing in the microchannel 12 in such a manner that flows of the shell-forming phase 18 and the content-forming phase 19 join the flow of the continuous phase 17, as shown in FIG. 4. The shell-forming phase 18 is fed from positions upstream to positions for feeding the content-forming phase 19 in such a manner that shell-forming phase 18 forms a thin layer.

[0019] FIG. 5 is a plan view showing an apparatus for producing microcapsules, and FIG. 6 is an illustration showing a process for producing such microcapsules.

[0020] In these figures, reference numeral 31 represents a main body of the microcapsule-producing apparatus, reference numeral 32 represents a first microchannel in which a continuous phase flows and which is disposed in the main body 31, reference numeral 33 represents a second microchannel in which another continuous phase flows and which is disposed in the main body 31, reference numeral 34 represents a first continuous phase (for example, oil), reference numeral 35 represents a second continuous phase (for example, oil), reference numeral 36 represents the junction of flows of the first continuous phase 34 and the second continuous phase 35, reference numeral 37 represents a content-forming phase-feeding channel, reference numeral 38 represents a content-forming phase (for example, water), reference numeral 39 represents a microdroplet (for example, water spheres), reference numeral 40 represents a third microchannel in which another continuous phase flows and which is disposed in the main body 31, reference numeral 41 represents a fourth microchannel in which another continuous phase flows and which is disposed in the main body 31, reference numeral 42 represents a third continuous phase (for example, water), reference numeral 43 represents a fourth continuous phase (for example, water), reference numeral 44 represents the junction of flows of the third continuous phase 42 and the fourth continuous phase 43, reference numeral 45 represents a shell-forming phase, reference numeral 46 represents a shell-forming microdroplet, and reference numeral 47 represents a microcapsule.

[0021] In the above configuration, the content-forming phase 38 is fed to the continuous phases 34 and 35 flowing in the first and second microchannels 32 and 33, respectively, in such a manner that the flow of the content-forming phase 38 joins the flows of the continuous phases 34 and 35. Thereby, the microdroplets 39 for forming contents are formed.

[0022] Subsequently, the shell-forming phase 45 containing the first and second continuous phases 34 and 35 mixed together is fed to the continuous phases 42 and 43 flowing in the third and fourth microchannels 40 and 41 in such a manner that the flow of the shell-forming phase 45 joins the junction of the flows of the third and fourth continuous phases 42 and 43. Thereby, a coating for forming a shell is formed on each microdroplet 39 for forming a content, thereby forming each microcapsule 47.

[0023] The microcapsule 47 contains the single microdroplet 39. However, the microcapsule 47 may contain a plurality of the microdroplets 39.

[0024] FIG. 7 shows the particle size obtained by varying the height (which can be converted into the pressure) of the continuous phases and dispersion phases, when the first and second microchannels 32 and 33 and the content-forming phase-feeding channel 37 have a width of 100 μm and a height of 100 μm and the channel in which the microdroplets 39 are present have a width of 500 μm and a height of 100 μm. It is clear that the particle size can be controlled by varying the height (which can be converted into the pressure) of the continuous phases and dispersion phases.

[0025] FIG. 8 is an illustration showing a mechanism for ejecting a dispersion phase, a shell-forming phase, or a content-forming phase placed in a microdroplet-producing apparatus. FIG. 8(a) is an illustration showing such a situation that piezoelectric actuators are expanded and therefore such a phase is not ejected, and FIG. 8(b) is an illustration showing such a situation that the piezoelectric actuators are contracted to eject the phase.

[0026] In these figures, reference numeral 51 represents a substrate, reference numeral 52 represents a driven plate, reference numeral 53 represents rubber, reference numeral 54 represents the piezoelectric actuators each disposed at the corresponding ends of the driven plate 52, reference numerals 55a-55d represent a plurality of feeding ports, and reference numerals 56a-56d represent a plurality of channels arranged for a single dispersion phase. A back pressure is applied to the bottom portion of the dispersion phase.

[0027] As shown in FIG. 8(a), a plurality of the channels 56a-56d are arranged, and the dispersion phase can be ejected therefrom at the same time when the piezoelectric actuators 54 are contracted, as shown in FIG. 8(b)

[0028] Various actuators may be used instead of the above piezoelectric actuators.

[0029] FIG. 9 is an illustration showing a mechanism for ejecting a dispersion phase, a shell-forming phase, or a content-forming phase placed in a microdroplet-producing apparatus. FIG. 9(a) is an illustration showing such a situation that a bimorph actuator is not warped and therefore such a phase is not ejected, and FIG. 9(b) is an illustration showing such a situation that the bimorph actuator is warped, thereby ejecting the phase.

[0030] In these figures, reference numeral 61 represents the bimorph actuator, reference numeral 62 represents a fixed plate, reference numeral 63 represents rubber, reference numerals 64a-64d represent a plurality of feeding ports, and reference numerals 65a-65d represent a plurality of channels arranged for a single dispersion phase. A back pressure is applied to the bottom portion of the dispersion phase.

[0031] As shown in FIG. 9(a), a plurality of the channels 65a-65d are arranged, and the dispersion phase can be ejected therefrom at the same time by the operation (upward warping) of the bimorph actuator 61, as shown in FIG. 9(b.

[0032] FIG. 10 is an illustration showing a mechanism for ejecting a dispersion phase, a shell-forming phase, or a content-forming phase placed in a microdroplet-producing apparatus. FIG. 10(a) is an illustration showing such a situation that an electrostrictive polymer is not energized and therefore such a phase is not ejected, and FIG. 10(b) is an illustration showing such a situation that the electrostrictive polymer is energized (contracted), thereby ejecting the phase.

[0033] In these figures, reference numeral 71 represents a substrate, reference numeral 72 represents a driven plate, reference numeral 73 represents the electrostrictive polymer, reference numerals 74a-74d represent a plurality of feeding ports, and reference numerals 75a-75d represent a plurality of channels arranged for a single dispersion phase. A back pressure is applied to the bottom portion of the dispersion phase.

[0034] As shown in FIG. 10(a), a plurality of the channels 75a-75d are arranged, and the dispersion phase can be ejected therefrom at the same time by the operation (contraction) of the electrostrictive polymer 73, as shown in FIG. 10(b).

[0035] FIG. 11 is an illustration showing a mechanism for opening or closing a dispersion phase-feeding port of a microdroplet-producing apparatus. FIG. 11(a) is an illustration showing such a situation that piezoelectric actuators are not energized (contracted) and therefore gates for a phase are opened, and FIG. 11(b) is an illustration showing such a situation that the piezoelectric actuators are energized (expanded) and thereby the gates for the phase are closed.

[0036] In these figures, reference numeral 81 represents a substrate,' reference numeral 82 represents rubber, reference numeral 83 represents a driven plate, reference numeral 84 represents the piezoelectric actuators, reference numeral 85 represent a fixed plate, and reference numerals 86a-86d represent a plurality of the gates.

[0037] As shown in these figures, a plurality of the gates 86a-86d are arranged, and all the gates for the phase can be closed by the operation of the two piezoelectric actuators 84 disposed at both sides.

[0038] Various actuators may be used instead of the above actuators.

[0039] FIG. 12 is an illustration showing a mechanism for opening or closing a dispersion phase-feeding port of a microdroplet-producing apparatus. FIG. 12(a) is an il-

lustration showing such a situation that a bimorph actuator is not energized (not warped), and therefore gates for a phase are opened, and FIG. 12(b) is an illustration showing such a situation that the bimorph actuator is energized (warped downward) and thereby the gates for the phase are closed.

[0040] In these figures, reference numeral 91 represents a substrate, reference numeral 92 represents rubber, reference numeral 93 represents the bimorph actuator, and reference numerals 94a-94d represent a plurality of the gates.

[0041] As shown in these figures, a plurality of the gates 94a-94d are arranged, and all the gates can be closed at the same time by the operation of the bimorph actuator 93.

[0042] FIG. 13 is an illustration showing a mechanism for opening or closing a dispersion phase-feeding port of a microdroplet-prdducing apparatus. FIG. 13(a) is an illustration showing such a situation that an electrostrictive polymer is not energized and therefore gates for a phase are opened, and FIG. 13(b) is an illustration showing such a situation that the electrostrictive polymer is energized (contracted) and thereby the gates for the phase are closed.

[0043] In these figures, reference numeral 101 represents a substrate, reference numeral 102 represents a driven plate, reference numeral 103 represents the electrostrictive polymer, and reference numerals 104a-104d represent a plurality of the gates.

[0044] As shown in FIG. 13(a), a plurality of the gates 104a-104d are opened when the electrostrictive polymer 103 is not energized (expanded). As shown in FIG. 13 (b), a plurality of the gates 104a-104d are closed at the same time when the electrostrictive polymer 103 is energized (contracted).

[0045] FIG. 14 is an illustration showing a microcapsuleforming apparatus. FIG. 14(a) is a schematic view showing the total configuration of the microcapsule-forming apparatus, and FIG. 14(a-1) is the left side elevational view thereof, FIG. 14(a-2) is a schematic plan view thereof, FIG. 14(a-3) is the right side elevational view thereof. FIG. 14(b) is an illustration showing a first junction, and FIG. 14(C) is an illustration showing a second junction.

[0046] In these figures, reference numeral 141 represents a main body of the microcapsule-forming apparatus, reference numeral 142 represents a microchannel in which a dispersion phase (for example, water) flows, reference numeral 143 represents a microchannel in which a first continuous phase (for example, oil) flows, reference numeral 144 represents a microchannel in which a second continuous phase (for example, water) flows, reference numeral 145 represents the first junction at which flows of the dispersion phase and the first continuous phase are joined together, reference numeral 146 represents the second junction at which flows of the dispersion phase, the first continuous phase, and the second continuous phase are joined together, reference numeral 147 represents the first continuous phase, reference numeral 148 represents the dispersion phase, reference numeral 149 represents an emulsion (for example, water), reference numeral 150 represents the second continuous phase, and reference numeral 151 represents formed microcapsules. The microcapsules 151 can contain one or more emulsions 149.

[0047] The present invention is not limited to the above embodiments, and various modifications may be performed within the scope of the present invention. The present invention covers such modifications.

[0048] As described above in detail, according to the present invention, microcapsules can be rapidly formed in a simple manner.

Industrial Applicability

[0049] According to a process and apparatus for producing microcapsules according to embodiments of the present invention, an emulsion and microcapsules can be rapidly formed in a simple manner. Such a process and apparatus are fit for the field of drug production and biotechnology.

Claims

1. A process for producing microcapsules comprising the steps of:

   feeding a continuous phase (17) into a first microchannel (12);
   feeding a shell-forming phase (18) into a second microchannel (13), the second microchannel (13) joining the first microchannel (12); and
   feeding a content-forming phase (19) into a third microchannel (14), the third microchannel (13) joining the first microchannel (12) at a position downstream of and in the vicinity of the second microchannel (13),
   to thereby form microcapsules (20) in the continuous phase (17), the microcapsules (20) being formed of the shell-forming phase (18) encapsulating the content-forming phase (19).

2. A process according to claim 1, wherein the shell-forming phase (18) is fed from positions upstream to positions for feeding the content-forming phase (19) in such a manner that the shell-forming phase (19) forms a thin layer to form microcapsules (20).

3. An apparatus for producing microcapsules comprising:

   (a) a first microchannel (12);
   (b) a second microchannel (13) formed so as to join the first microchannel (12);
   (c) a third microchannel (14) formed so as to join the first microchannel (12) at a position down-

stream of and in the vicinity of the second microchannel (13); and
(d) a feed arrangement to feed a continuous phase (17) into the first microchannel (12), a feed arrangement to feed a shell-forming phase (18) into the second microchannel (13), and a feed arrangement to feed a content-forming phase (19) into the third microchannel (14), such that, in use, microcapsules (20) are formed in the continuous phase (17), the microcapsules (20) being formed of the shell-forming phase (18) encapsulating the content-forming phase (19).

4. An apparatus according to claim 3, wherein the a feed arrangement to feed the shell-forming phase (18) is configured to feed the shell-forming phase (18) from positions upstream to positions for feeding the content-forming phase(19) in such a manner that the shell-forming phase (18) forms a thin layer.

5. An apparatus according to claim 3, wherein the a feed arrangement to feed the shell-forming phase (18) and content-forming phase (19) each include a substrate (51), a driven plate (52), an elastic member (53) disposed between the substrate (51) and the driven plate (52), and an actuator (54) for driving the driven plate (52), to thereby feed the shell-forming phase (18) and the content-forming phase (19) at the same time.

6. An apparatus according to claim 3 further comprising films (8) disposed on portions of inner wall surfaces of the first microchannel (12) in which the continuous phase (17) flows and the third microchannel (14) for feeding the content-forming phase (19), for readily forming the microcapsules (20), wherein the portions include the junction point of the flows of the continuous phase (17) and the content-forming phase (19) and the vicinity of the junction point.

Patentansprüche

1. Verfahren zum Herstellen von Mikrokapseln, umfassend die folgenden Schritte:

Einspeisen einer kontinuierlichen Phase (17) in einen ersten Mikrokanal (12);
Einspeisen einer schalenbildenden Phase (18) in einen zweiten Mikrokanal (13), wobei der zweite Mikrokanal (13) mit dem ersten Mikrokanal (12) verbunden ist; und
Einspeisen einer inhaltsbildenden Phase (19) in einen dritten Mikrokanal (14), wobei der dritte Mikrokanal (13) mit dem ersten Mikrokanal (12) an einer Position unterhalb und in der Nähe des zweiten Mikrokanals (13) verbunden ist,
um dadurch Mikrokapseln (20) in der kontinuierlichen Phase (17) zu bilden, wobei die aus der schalenbildenden Phase (18) gebildeten Mikrokapseln (20) die inhaltsbildende Phase (19) einkapseln.

2. Verfahren nach Anspruch 1, wobei die schalenbildende Phase (18) von Positionen oberhalb von Positionen zum Einspeisen der inhaltsbildenden Phase (19) auf eine solche Weise eingespeist wird, dass die schalenbildende Phase (19) eine dünne Schicht zum Ausbilden von Mikrokapseln (20) bildet.

3. Vorrichtung zum Herstellen von Mikrokapseln, umfassend:

(a) einen ersten Mikrokanal (12);
(b) einen zweiten Mikrokanal (13), der dazu ausgebildet ist, mit dem ersten Mikrokanal (12) verbunden zu werden;
(c) einen dritten Mikrokanal (14), der dazu ausgebildet ist, mit dem ersten Mikrokanal (12) an einer Position unterhalb und in der Nähe des zweiten Mikrokanals (13) verbunden zu werden; und
(d) einer Einspeisungsanordnung zum Einspeisen einer kontinuierlichen Phase (17) in den ersten Mikrokanal (12), einer Einspeisungsanordnung zum Einspeisen einer schalenbildenden Phase (18) in den zweiten Mikrokanal (13) und einer Einspeisungsanordnung zum Einspeisen einer inhaltsbildenden Phase (19) in den dritten Mikrokanal (14) so, dass im Gebrauch Mikrokapseln (20) in der kontinuierlichen Phase (17) gebildet werden, wobei die aus der schalenbildenden Phase (18) gebildeten Mikrokapseln (20) die inhaltsbildende Phase (19) einkapseln.

4. Vorrichtung nach Anspruch 3, wobei die Einspeisungsanordnung zum Einspeisen der schalenbildenden Phase (18) dazu konfiguriert ist, die schalenbildende Phase (18) von Positionen oberhalb von Positionen zum Einspeisen der inhaltsbildenden Phase (19) auf eine solche Weise einzuspeisen, dass die schalenbildende Phase (18) eine dünne Schicht bildet.

5. Vorrichtung nach Anspruch 3, wobei die Einspeisungsanordnung zum Einspeisen der schalenbildenden Phase (18) und der inhaltsbildenden Phase (19) jeweils ein Substrat (51), eine angetriebene Platte (52), ein zwischen dem Substrat (51) und der angetriebenen Platte (52) angeordnetes elastisches Element (53) und eine Betätigungsvorrichtung (54) zum Antreiben der angetriebenen Platte (52) beinhalten, um dadurch die schalenbildende Phase (18) und die inhaltsbildende Phase (19) gleichzeitig einzuspeisen.

6. Vorrichtung nach Anspruch 3, weiterhin umfassend Filme (8), die auf Bereichen von Innenwandflächen des ersten Mikrokanals (12), in dem die kontinuierliche Phase (17) fließt, und des dritten Mikrokanals (14) zum Einspeisen der inhaltsbildenden Phase (19) angeordnet sind, um die Mikrokapseln (20) ohne weiteres auszubilden, wobei die Bereiche den Verbindungspunkt der Flüsse der kontinuierlichen Phase (17) und der inhaltsbildenden Phase (19) und die Umgebung des Verbindungspunkts einschließen.

Revendications

1. Un processus de production de microcapsules comprenant les opérations suivantes :

   le passage d'une phase continue (17) dans un premier microcanal (12) ;
   le passage d'une phase de formation de coque (18) dans un deuxième microcanal (13), le deuxième microcanal (13) rejoignant le premier microcanal (12) ; et
   le passage d'une phase de formation de contenu (19) dans un troisième microcanal (14), le troisième microcanal (13) rejoignant le premier microcanal (12) à un endroit situé en aval et proche du deuxième microcanal (13),
   afin de former des microcapsules (20) dans la phase continue (17), les microcapsules (20) étant formées par la phase de formation de coque (18) qui encapsule la phase de formation de contenu (19).

2. Un processus conformément à la revendication 1, dans lequel la phase de formation de coque (18) va d'endroits en amont à des endroits de passage de la phase de formation de contenu (19) de manière telle que la phase de formation de coque (19) forme une couche fine pour la formation de microcapsules (20).

3. Un appareil de production de microcapsules comprenant :

   (a) Un premier microcanal (12) ;
   (b) Un deuxième microcanal (13) formé de façon à rejoindre le premier microcanal (12) ;
   (c) Un troisième microcanal (14) formé de façon à rejoindre le premier microcanal (12) à un endroit en aval et proche du deuxième microcanal (13) ; et
   (d) Un dispositif permettant de faire passer une phase continue (17) dans le premier microcanal (12), un dispositif permettant de faire passer une phase de formation de coque (18) dans le deuxième microcanal (13) et un dispositif permettant de faire passer une phase de formation de contenu (19) dans le troisième microcanal (14), de façon telle que, en cours d'utilisation, des microcapsules (20) soient formées pendant la phase continue (17), les microcapsules (20) étant formées par la phase de formation de coque (18) qui encapsule la phase de formation de contenu (19).

4. Un appareil conformément à la revendication 3, dans lequel le dispositif permettant le passage de la phase de formation de coque (18) est configuré de façon à faire passer la phase de formation de coque (18) d'endroits situés en amont à des endroits de passage de la phase de formation de contenu (19) de manière telle que la phase de formation de coque (18) forme une couche fine.

5. Un appareil conformément à la revendication 3, dans lequel le dispositif permettant le passage de la phase de formation de coque (18) et le dispositif permettant le passage de la phase de formation de contenu (19) contiennent chacun un substrat (51), une plaque entraînée (52), un membre élastique (53) placé entre le substrat (51) et la plaque entraînée (52), et un dispositif d'actionnement (54) pour entraîner la plaque entraînée (52), de façon à ce que le passage de la phase de formation de coque (18) et le passage de la phase de formation de contenu (19) aient lieu en même temps.

6. Un appareil conformément à la revendication 3, comprenant également des films (8) disposés sur des portions des surfaces des parois intérieures du premier microcanal (12) dans lequel la phase continue (17) passe et du troisième microcanal (14) pour le passage de la phase de formation de contenu (19), afin de former facilement les microcapsules (20), dans lequel les portions comprennent le point de jonction des flux de la phase continue (17) et de la phase de formation de contenu (19) ainsi que les environs du point de jonction.

FIG. 1

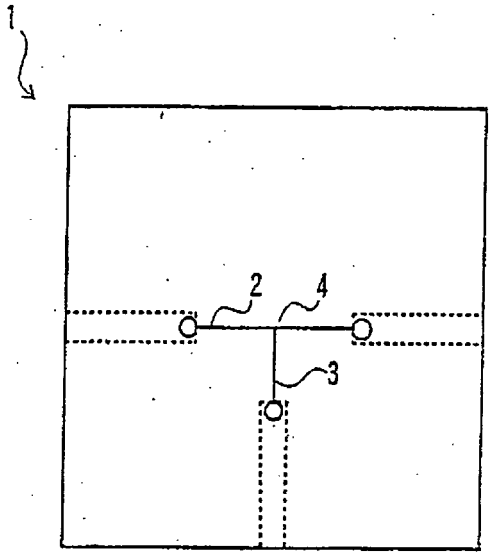


FIG. 2

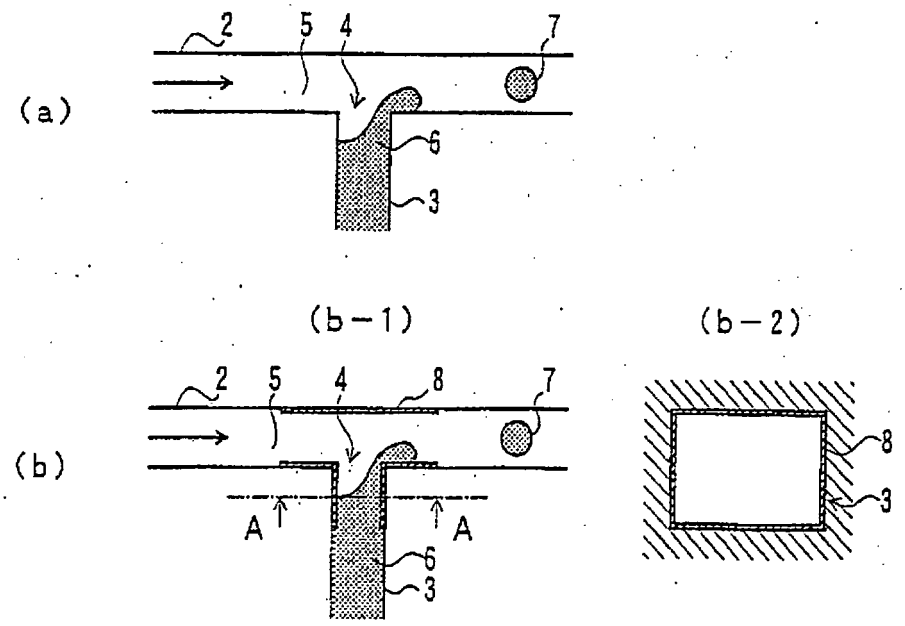


FIG. 3

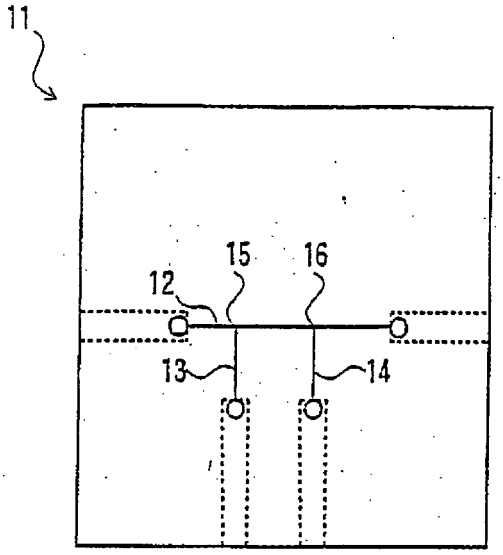


FIG. 4

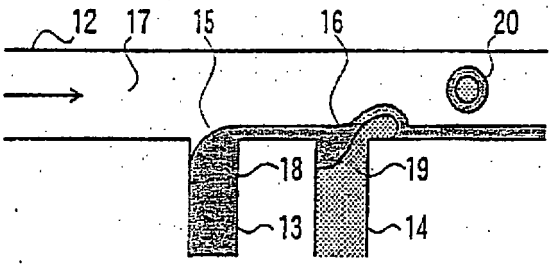


FIG. 5

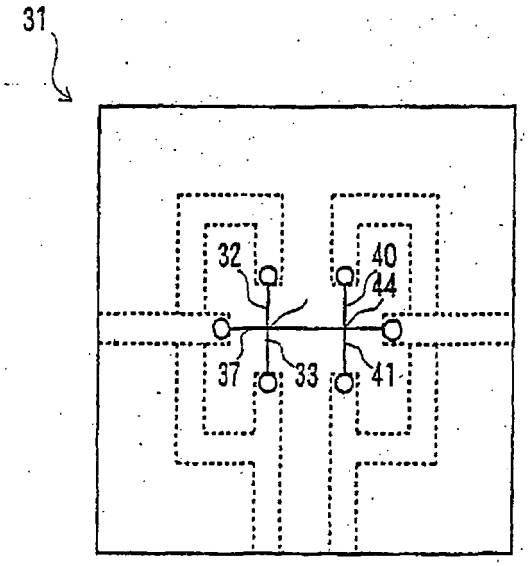
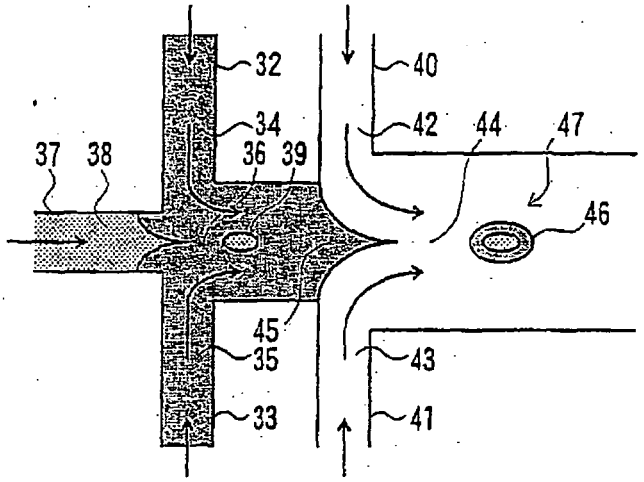


FIG. 6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41

FIG. 7

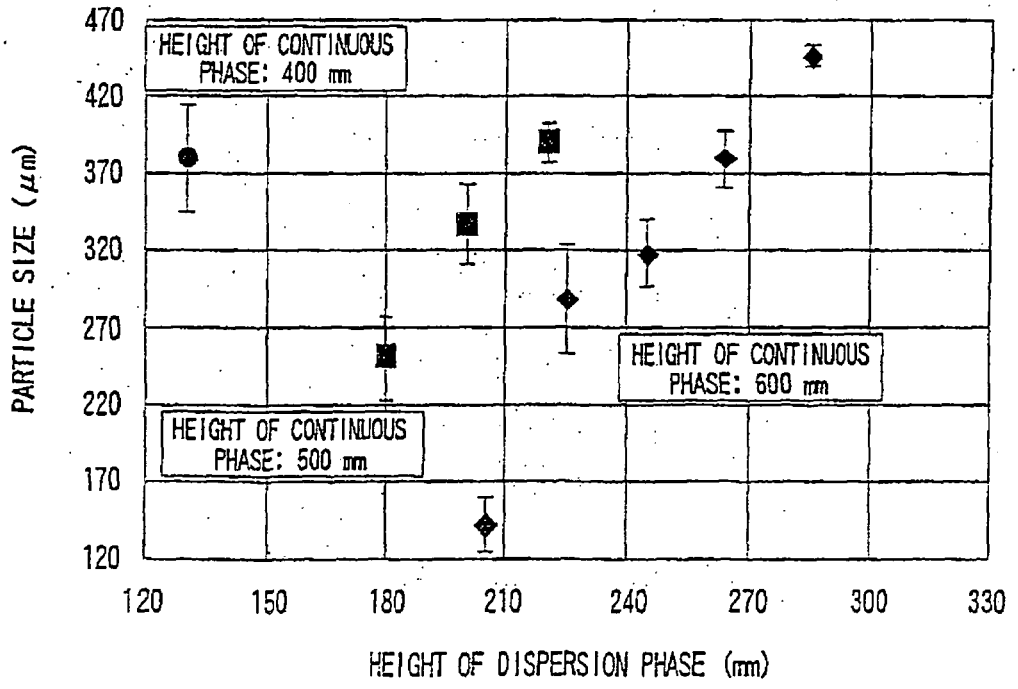

470
420
370
320
270
220
170
120
PARTICLE SIZE (μm)
HEIGHT OF CONTINUOUS PHASE: 400 mm
HEIGHT OF CONTINUOUS PHASE: 600 mm
HEIGHT OF CONTINUOUS PHASE: 500 mm
120
150
180
210
240
270
300
330
HEIGHT OF DISPERSION PHASE (mm)

FIG. 8

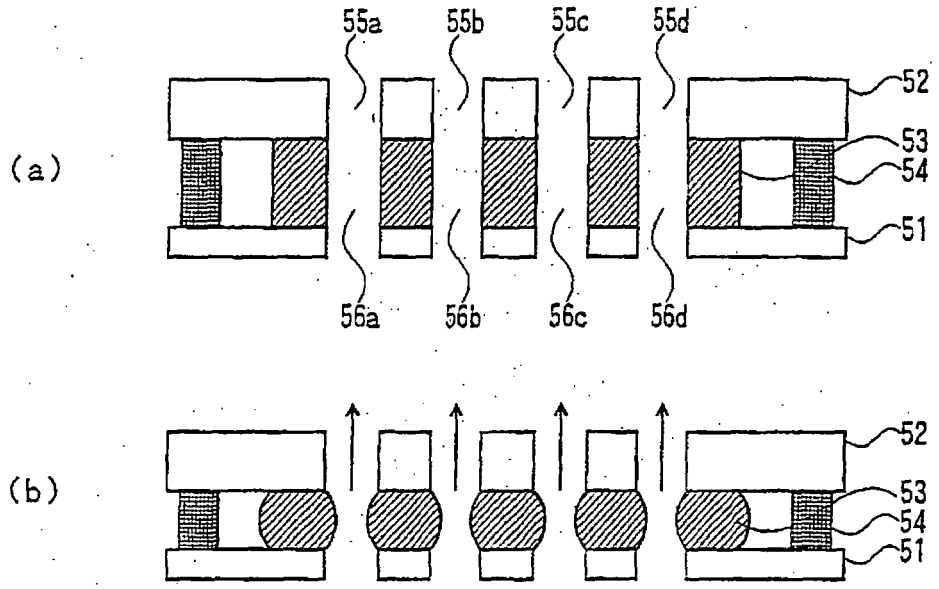

(a)
55a
55b
55c
55d
52
53
54
51
56a
56b
56c
56d
(b)
52
53
54
51

FIG. 9

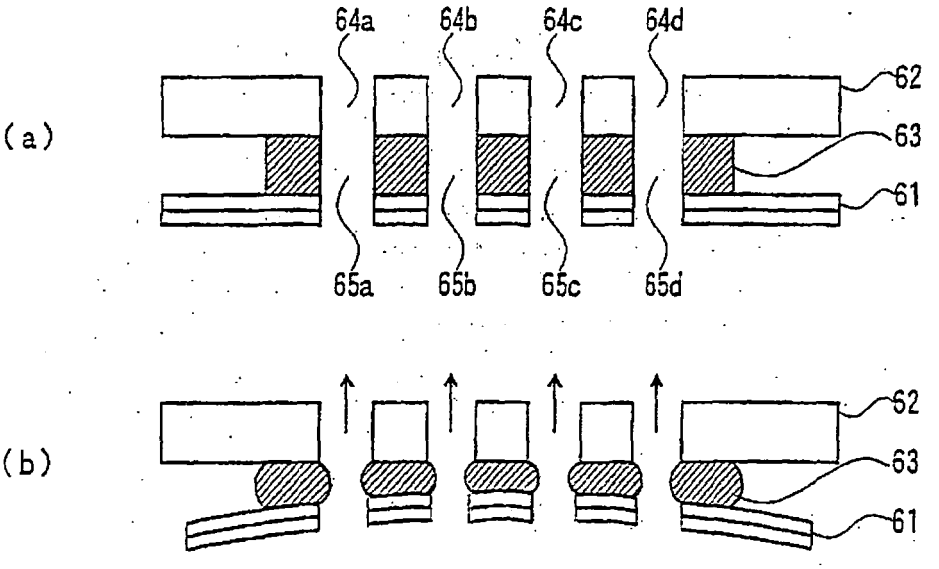

(a)
64a
64b
64c
64d
62
63
61
65a
65b
65c
65d
(b)
62
63
61

FIG. 10

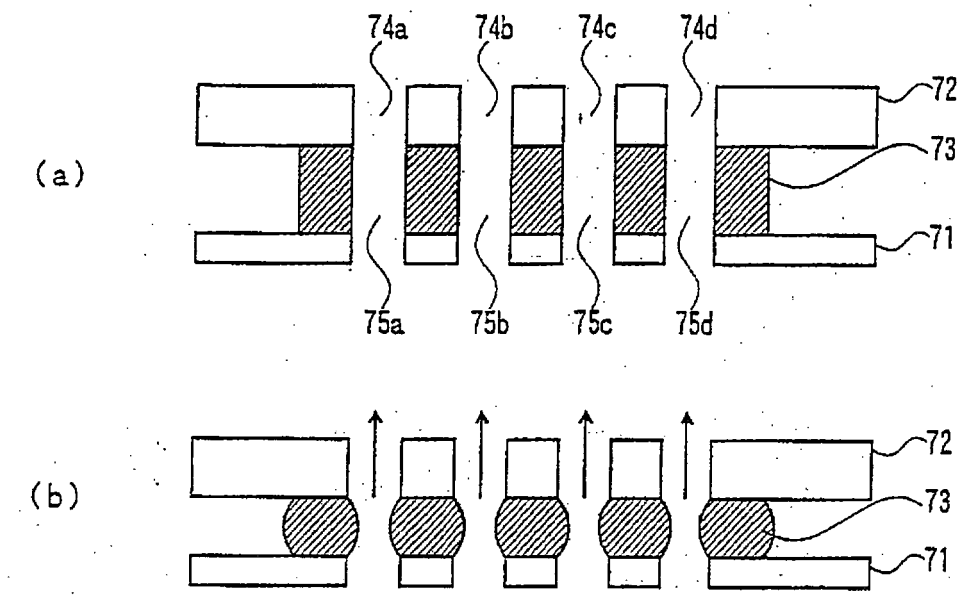

(a)
74a
74b
74c
74d
72
73
71
75a
75b
75c
75d
(b)
72
73
71

FIG. 11

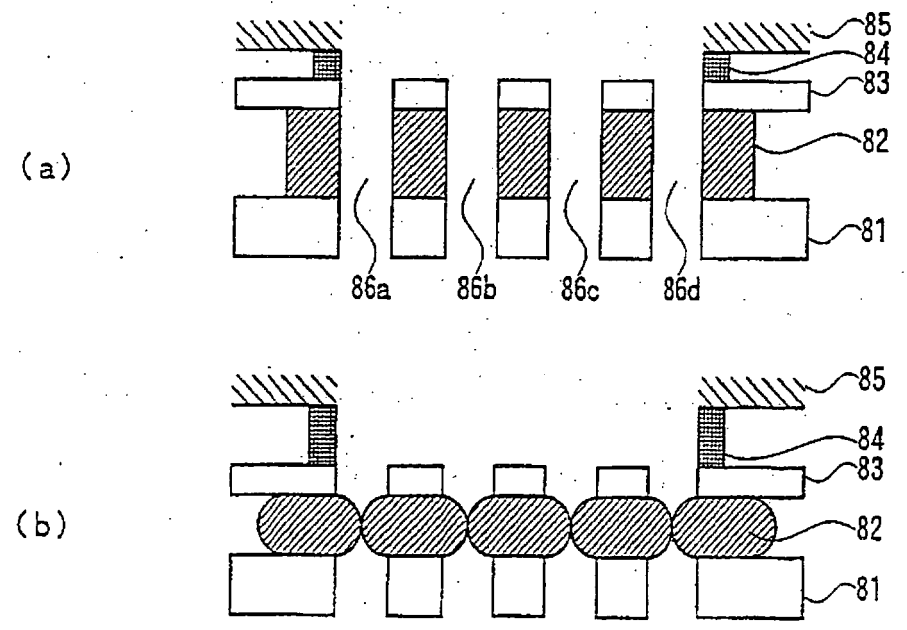
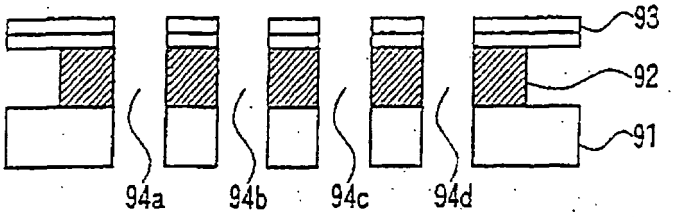

(a)
85
84
83
82
81
86a
86b
86c
86d
(b)
85
84
83
82
81

FIG. 12

(a)



(b)

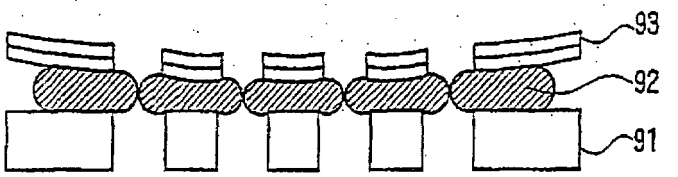
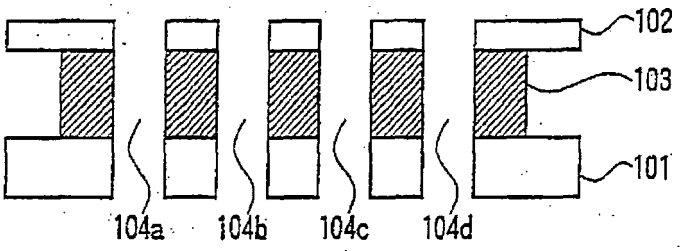


FIG. 13

(a)



(b)

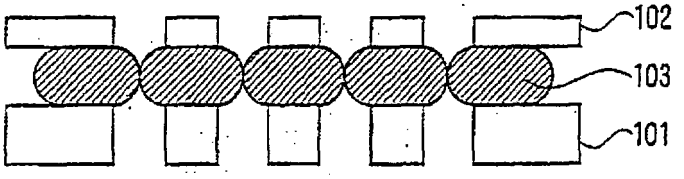
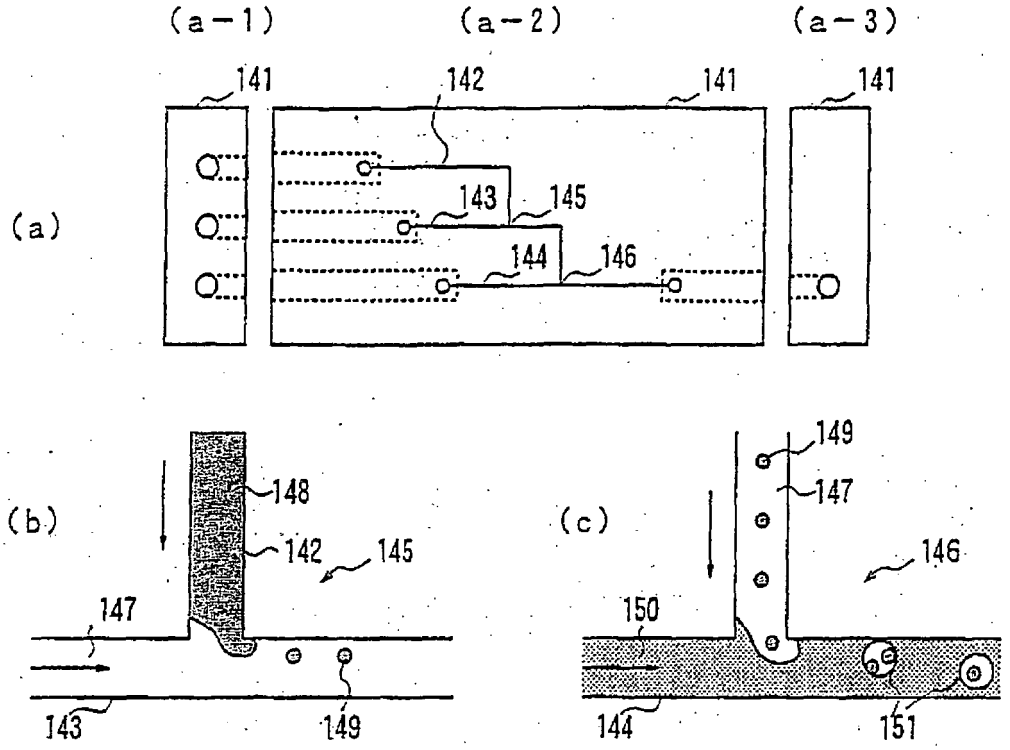


FIG. 14


(a-1)
(a-2)
(a-3)
141
142
141
141
(a)
143
145
144
146
(b)
148
142
145
147
143
149
(c)
149
147
146
150
144
151

REFERENCES CITED IN THE DESCRIPTION

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