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(54) **Use of micro mixers for generating foam**

(57) A method for producing a foam using a static micro mixer and a micro mixer for producing a foam are disclosed in this application. The micro mixer is provided with at least one disk (1) which has at least one inlet opening (2) for the introduction of at least one feed stream into a linking channel (3) at least partially provided in a surface of the disk and at least one outlet opening (4) for the outflow of the feed stream from the linking channel (3) into a mixing zone (5) provided in the disk (1). The inlet opening (2) is connected with the outlet opening (4) in a communicating manner by means of the linking channel (3). The disk (1) is adapted to be provided with a cover (15) such that the linking channel (3) is defined as a space between the surface of the disk (1) and the cover (15). The linking channel (3) before opening into the mixing zone (5) is divided by microstructure dividers (6) into sub channels (7). The micro mixer is formed such that a tenside solution as a first feed stream is supplied through the inlet opening (2) into the mixing zone (5), a gas as a second feed stream is supplied into the mixing zone (5), and a foam is produced within the mixing zone (5) by mixing the tenside solution and the gas.

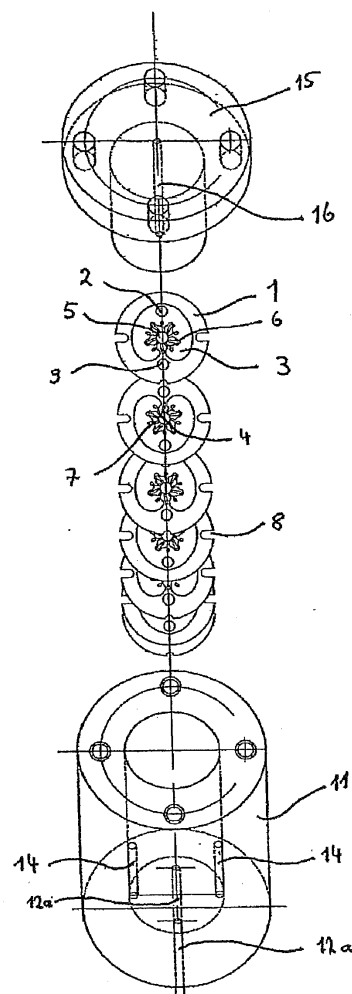


Fig. 3

Description

[0001] The present invention relates to micro mixers and more particularly to disk-shaped components for static micro mixers for generating foam.

[0002] The objective of mixing at least two fluids is to attain a uniform distribution of the two fluids within a certain time such as a short time. In dynamic mixers, the mixing takes place by use of mechanically actuated agitators which cause turbulent flow conditions. Dynamic mixers have the drawback that because of the required mechanical components they cannot be readily reduced in size. In static mixers, the mixing takes place without the use of movable parts. These mixers can be reduced in size to give so-called static micro mixers of which various embodiments are known. Static micro mixers have the advantage that the size of the components can be reduced and that therefore they can be integrated into other systems such as heat exchangers and reactors. By cooperation between two or more components interconnected in a narrow space, additional possibilities exist in terms of process optimization. The very narrow distribution of mixing times achievable in static micro mixers offers many possibilities of optimization of chemical reactions in terms of selectivity and yield. It is possible to achieve mixing times between 1 second and a few milliseconds, the mixing of gases taking place even much faster. The application potential of micro mixers ranges from liquid-liquid and gas-gas mixing to the formation of liquid-liquid emulsions, gas-liquid dispersions and thus also to multiphase reactions and phase-transfer reactions for the time being.

[0003] US 2008/0106968 A1 discloses a static micro mixer for mixing a liquid/gaseous combustible medium.

[0004] The object of the present invention is to provide a method and a device for mixing at least two fluids for foaming, which process and device are adapted to avoid releasing gases, particularly of volatile organic compounds, during foaming of a tenside solution.

[0005] This object is solved by the present invention in that a micro mixer is used, which is provided with at least one disk. The disk is provided with at least one inlet opening, a linking channel, at least one outlet opening, which opens into a mixing zone. The inlet opening and the outlet opening are connected in a communicating manner such that two feed streams may be supplied into the mixing zone where mixing occurs. Using such a disk in micro mixer prevents releasing of gases when foaming of a tenside solution.

[0006] These and other advantages and features of the various embodiments of the invention disclosed herein, will be made more apparent from the description, drawings and claims that follow.

[0007] Summarizing the ideas of the present invention, the following items are preferred:

Item 1: A method for producing a foam uses a static micro mixer. The micro mixer is provided with at least

one disk which has at least one inlet opening for the introduction of at least one feed stream into a linking channel at least partially provided in a surface of the disk and at least one outlet opening for the outflow of the feed stream from the linking channel into a mixing zone provided the disk. The inlet opening is connected with the outlet opening in a communicating manner by means of the linking channel. The disk is adapted to be provided with a cover such that the linking channel is defined as a space between the surface of the disk and the cover. The linking channel before opening into the mixing zone is divided by microstructure dividers into sub channels. The method comprises the steps of:

- supplying a tenside solution as a first feed stream through the inlet opening into the mixing zone,
- supplying a gas as a second feed stream into the mixing zone, and
- producing a foam within the mixing zone by mixing the tenside solution and the gas.

Item 2: The method of item 1, wherein the tenside solution and the gas are supplied in a turbulent manner into the mixing zone.

Item 3: The method of item 1, wherein the flow velocity at which the first and second feed streams are supplied into the mixing zone is greater than the flow velocity of the foam within the mixing zone.

Item 4: The method of item 1, wherein the widths of the sub channels being in the millimeter to submillimeter range and being smaller than the width of the mixing zone.

Item 5: The method of item 1, wherein the widths of the sub channels at their opening into the mixing zone are from 1 μm to 2 mm.

Item 6: The method of item 1, wherein a means for conveying the foam out of the mixing zone is provided within the mixing zone.

Item 7: The method of item 6, wherein the means for conveying the foam is a screw conveyor.

Item 8: The method of item 1, wherein the micro mixer is provided with a plurality of disks, which are provided as a stack.

Item 9: The method of item 8, wherein the plurality of disks are superposed on one another and the first feed stream and the second feed stream are supplied into the mixing zone through the inlet openings of different disks.

Item 10: The method of item 1, wherein the disk is provided with at least two inlet openings for supplying at least two different feed streams, each inlet opening being connected with the mixing zone through the linking channel.

Item 10: A static micro mixer for producing a foam, wherein the micro mixer has a housing and is provided with at least one disk which has at least one inlet opening for the introduction of at least one feed stream into a linking channel at least partially provided in a surface of the disk and at least one outlet opening for the outflow of the feed stream from the linking channel into a mixing zone provided in the disk, wherein the inlet opening is connected with the outlet opening in a communicating manner by means of the linking channel, and wherein the disk is adapted to be provided with a cover such that the linking channel is defined as a space between the surface of the disk and the cover, wherein the linking channel before opening into the mixing zone is divided by microstructure dividers into sub channels, wherein the micro mixer is formed such that a tenside solution as a first feed stream is supplied through the inlet opening into the mixing zone, a gas as a second feed stream is supplied into the mixing zone, and a foam is produced within the mixing zone by mixing the tenside solution and the gas.

The disks can be from 10 to 1000 μm thick. The height of the channels is preferably less than 1000 μm and most preferably less than 250 μm . For example, the disk may be 1000 μm thick and the channels may have a height of 750 μm . The wall thickness of the built-in microstructure components and of the channel bottom is preferably less than 100 μm and most preferably less than 70 μm .

[0008] The mixing zone is preferably a through hole extending through the disk in a direction perpendicular to a plane defined by the disk. The mixing zone may be formed in a central position completely enclosed by the disk.

[0009] The linking channel and sub channels disposed on the disks can be provided in any suitable shape. Both the disks and each linking channel disposed thereon can vary in height, width and thickness so as to also be able to convey different media and different quantities. The basic shape of the disks can be of any suitable shape, for example it can be round or circular or else elliptical or angular, for example rectangular or square. The disk shape can also be optimized in terms of simple fabrication or in terms of minimum weight or minimum unused surface. The outlet openings of the sub channels can be arranged in any desired manner from a straight line to any geometric form. For example, the outlet openings can be arranged on a circular line, particularly when the mixing zone is completely enclosed by the plane of the disk. Two or more than two components can be conveyed in such a disk and mixed in identical or different quantity

ratios. The sub channels can be disposed at any angle to each other or relative to the line on which the outlet openings into the mixing zone are disposed. Several sub channels, each conveying, for example, a first component, can be arranged side by side, and in the adjacent section of the same disk there can be arranged side by side several sub channels conveying, for example, a second component. However, the components can, by means of additional through-holes and additional sub channels in the disks, be configured so that the first and second components alternate from sub channel to sub channel in the same disk.

[0010] At their entrance to the mixing zone, the sub channels preferably have a width in the range from 1 μm to 2 mm and a length in the range from 10 μm to 10 mm and most preferably a width in the range from 5 μm to 250 μm and a length in the range from 250 μm to 5 mm.

[0011] The linking channel can have a variable width. Preferably, the ratio of the greatest width of the linking channel and/or the width of the inlet opening to the width of the sub channels at their outlet opening into the mixing zone is greater than 2 and most preferably greater than 5. The ratio of the width of the mixing zone to the width of the sub channels is preferably greater than 2 and most preferably greater than 5.

[0012] The linking channel between the inlet and outlet openings is preferably formed by an indentation. The inlet opening and/or outlet opening or the mixing zone, however, can also be disposed at the edge of the disk or be in the form of recesses at the edge of the disk.

[0013] The term "sub channels" also includes division of the feed stream into part streams by built-in microstructure dividers just before the outflow of said feed stream into the mixing zone. The dimensions, particularly the lengths and widths of these built-in parts, can be in the range of millimeters or preferably smaller than 1 mm. The sub channels are preferably shortened to the length that is absolutely needed for flow control and, hence, for a certain throughput they require comparatively low pressures. The length-to-width ratio of the sub channels is preferably in the range from 1:1 to 20:1, particularly from 8:1 to 12:1 and most preferably about 10:1. The built-in microstructure dividers are preferably configured in such a way that the flow velocity of the feed stream at the outlet opening into the mixing zone is greater than at the inlet opening into the linking channel and preferably also greater than the flow velocity of the product stream through the mixing zone.

[0014] The term "flow velocity" is to be understood as a velocity of the feed streams and the product stream given in meter per second and is used to differentiate between a velocity of a flowing fluid and its volume flow rate given in litre per hour.

[0015] The term "height" is to be understood as a dimension perpendicular to a plane defined by the top or bottom surface of the disk. The term "length" of the linking channel and the sub channels is to be understood as a dimension parallel to the plane defined by the top or bot-

tom surface of the disk and in a direction from the inlet opening to the outlet opening and vice versa. The term "width" of the linking channel and the sub channels is to be understood as a dimension parallel to the plane defined by the top or bottom surface of the disk and perpendicular to the length.

[0016] The outlet openings are the ends of the sub channels opening into the mixing zone. The outlet openings are in the form of, for example, round or angular, for example rectangular, recesses. In the case of an enclosed mixing zone, the elliptical or circular shape is preferred. The sub channel can taper off in the form of nozzles in the direction of the mixing zone. The sub channels can be linear or bent in the shape of a spiral. The sub channels can enter into the mixing zone at a right angle relative to the circumferential line of the mixing zone or at an angle different from 90°. When in the event that the angle is different from a right angle a stack of several mixer disks is formed, preferably the disks with opposite deviation from a right angle are adjacent to each other. Similarly, when a stack of several mixer disks is formed, then, in the event that the course of the sub channels is spiral-shaped, disks with oppositely oriented direction of spiral rotation are preferably adjacent to each other.

[0017] In the following, by the term "fluid" is meant a gaseous or liquid substance or a mixture of such substances that can contain one or more solid, liquid or gaseous dissolved or dispersed substances.

[0018] The term "mixing" also includes the processes of dissolving, dispersing and emulsifying. Hence, the term "mixture" comprises solutions, liquid-liquid emulsions and gas-liquid and solid-liquid dispersions.

[0019] In another example, there are present at least two inlet openings for at least two different feed streams, each inlet opening being connected with the mixing zone through a linking channel. In this case, there are preferably two outlet openings for two different feed streams on opposite sides of the mixing zone.

[0020] Suitable materials of construction for the disks are, for example, metals, particularly corrosion-resistant metals, such as, for example, stainless steel, as well as glasses, ceramic materials or plastic materials. The disks can be fabricated by techniques for producing microstructures on surfaces, techniques that in and of themselves are known, for example by etching or milling of metals or by embossing or injection-molding of plastics.

[0021] The static micro mixer of the invention has a housing with at least two inlets for fluids and at least one outlet for fluids. In the housing may be located at least one disk of the invention arranged in a stack. Stacks can be formed from any number of disks permitting a through-flow commensurate with the height of the stack. To ensure the same pressure throughout the mixer, in the case of greater lengths the fluid can be introduced at several points. Grooves or ribs can be used for purposes of stacking and aligning. The disks are superposed on one another so that the inlet openings form subsidiary channels for introducing a particular feed stream and the outlet

openings or the mixing zones together form a main channel for removing the product stream, the main channels and subsidiary channels extending through the stack. Overall, a micro mixer can have, for example, at least 5, 10, 100 or even more than 1000 sub channels and it consists of a stack of disks having several sub channels.

[0022] Preferably, each part stream of a first feed flowing from an outlet opening of a disk into the mixing zone is directly adjacent to a part stream of a second feed flowing from an outlet opening of an adjacent disk into the mixing zone. In the mixing zone, the mixing takes place by diffusion and/or turbulence. Particularly, the first feed is a tenside solution or surfactant and the second feed is a gas, e.g. air, carbon dioxide, nitrogen or the like, so that a foam is generated in the mixing zone, e.g. a cosmetic or chemical foam such as a shaving foam or hair mousse. Further, in contrast to conventional foaming processes, no additional solvents or volatile organic compounds are necessary for such a foaming process. The particular characteristics of the tenside solution and the gas may be arbitrarily chosen for a respective purpose. This means, the concentration of the tenside solution and the gas, the pressure with which these are supplied into the mixing zone, the velocity or flow velocity at which these are supplied into the mixing zone, the exact composition of the tenside solution and the gas, and other parameters, e.g. temperature, may be defined or determined by the skilled person depending on the individual application of the resulting foam and its characteristics. The size of the micro mixer may be individually set. No greenhouse gases are inevitably released during a foaming process of the invention.

[0023] The term "tenside solution" is to be understood as a solution of compounds that lower the surface tension of a liquid, the interfacial tension between two liquids, or that between a liquid and a solid. The "tenside solution" may for example be water containing or water based. Tensides or surfactants are usually organic compounds that are amphiphilic, meaning they contain both hydrophobic groups (their tails) and hydrophilic groups (their heads). Therefore, a surfactant molecule contains both a water insoluble (or oil soluble) component and a water soluble component. Surfactant molecules will migrate to the water surface, where the insoluble hydrophobic group may extend out of the bulk water phase, either into the air or, if water is mixed with an oil, into the oil phase, while the water soluble head group remains in the water phase. This alignment and aggregation of surfactant molecules at the surface acts to alter the surface properties of water at the water/air or water/oil interface. Because air is not hydrophilic, surfactants are also foaming agents to varying degrees. Foaming results as the tensides or surfactants form a film composed of two layer, wherein the hydrophobic ends form the two surfaces and the hydrophilic ends extend into the film.

[0024] In another example of the micro mixer, the linking channels of the disks are formed by indentations. Before they end in the mixing zone, the linking channels

are divided into sub channels by microstructure dividers disposed on the disks. In an alternative embodiment, the linking channels of the disks are formed as recesses in the disks, the disks being arranged as intermediate disks between a cover disk and a bottom disk, and the linking channels, before they end in the mixing zone are divided into sub channels by microstructure dividers disposed on the cover disk and/or bottom disk.

[0025] The flow velocity of the feed stream or feed streams in the linking channel may be greater than the flow velocity of the product mixture within the mixing zone. Particularly, the flow velocity may be set such that turbulence is created in the mixing zone and the mixing and foaming in the mixing zone takes place at least partly as a result of turbulence.

[0026] Particularly, by supplying a solution of tensides into the mixing zone, the above micro mixers are well adapted for producing a foam if a second component supplied into the mixing zone is a gas, e.g. air, carbon dioxide, nitrogen or the like. Thus, foams free of volatile organic compounds may be produced which are particularly suitable for cosmetics or other chemical products. This means, the foams may be generated from reactive chemical components without that the components have to evaporate a gas during their reaction.

[0027] In order to further convey the foam produced within the mixing zone, a rotating means, such as a helical component, may be provided, which is adapted to convey the foam out of the mixing zone similar to a screw conveyor. Alternatively, a vibrating sharp edged disc may be provided within the mixing zone, which cuts or shears the bubbles off from the outlet openings.

[0028] The particulars of the method of the present invention are that the tenside solution and the gas may be supplied in a turbulent manner into the mixing zone. The flow velocity at which the first and second feed streams are supplied into the mixing zone may be greater than the flow velocity of the foam within the mixing zone. The widths of the sub channels may be in the millimeter to submillimeter range and may be smaller than the width of the mixing zone. The widths of the sub channels at their opening into the mixing zone are from 1 μm to 2 mm. A means for conveying the foam out of the mixing zone may be provided within the mixing zone. The means for conveying the foam may be a screw conveyor. The micro mixer may be provided with a plurality of disks, which are provided as a stack. The plurality of disks components may superposed on one another and the first feed stream and the second feed stream may be supplied into the mixing zone through the inlet openings of different disks. The disks may be provided with at least two inlet openings for supplying at least two different feed streams, each inlet opening being connected with the mixing zone through the linking channel.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] In the following, exemplary embodiments of the

components and micro mixers of the invention are explained by reference to the drawings.

FIG. 1a-b shows mixing disks with two inlet openings for two feed streams and wherein the inlet opening and outlet opening are enclosed,

FIG. 1c shows a mixing disk with a single inlet opening and wherein the inlet opening and outlet opening are enclosed,

FIG. 1d shows a mixing disk with enclosed inlet opening, through-flow opening and outlet opening,

FIG. 2 shows a longitudinal section of the schematic structure of a static micro mixer that can be used for generating foam, and

FIG. 3 shows a micro mixer with a housing and a stack of several mixing disks.

DETAILED DESCRIPTION OF THE EMBODIMENTS OF THE INVENTION

[0030] One embodiment of a component for a micro mixer of the invention is shown in FIG. 1a and FIG. 1b. The component is a disk 1. The disks 1 have two inlet openings 2. The inlet openings 2 are through holes extending through the disk 1 in a direction perpendicular to a plane defined by the disk 1. Each inlet opening 2 is connected with one linking channel 3 formed for example by an indentation in the surface of the disk 1 and extends parallel to the plane defined by the surface of the disk 1. The linking channel 3 may be shaped in a bent manner such as a spiral. Further, the disk 1 comprises outlet openings 4 which are provided at ends of the linking channels 3. Thus, the inlet openings 2 are connected with the outlet openings 4 in a communicating manner. The disk 1 also comprises a mixing zone 5 which is formed as a through hole extending through the disk 1 in a direction perpendicular to the plane defined by the disk 1. The mixing zone 5 is in a central position of the disk 1. By a multiplicity of microstructure dividers 6, each linking channel 3 is divided into a multiplicity of sub channels 7. Through the outlet openings 4, the sub channels 7 open into the mixing zone 5. Particularly, the outlet openings 4 are arranged on a circular line around the mixing zone 5. Preferably, the outlet openings 4 are disposed opposite each other having the mixing zone 5 therebetween. The microstructure dividers 6 are bent, for example, in the form of spirals, the spirals shown in FIG. 1a and FIG. 1b having an opposite sense of rotation. The microstructure dividers 6, however, can also be linear or unbent.

[0031] When the disks 1 are round, they may have recesses 8 at the edge which can cooperate or engage with fixing elements 14 in a housing 11 to prevent torsion or slipping. The disks 1, however, can also be angular, preferably quadrangular, for example in the shape of a

square. In this case, the recesses and fixing elements may be omitted.

[0032] Through the two inlet openings 2 two different feed streams can be introduced into the linking channel 3. Each feed stream can flow within one linking channel 3 towards the outlet openings 4. The feed streams may then enter the mixing zone 5 through the two outlet openings 4 which serve as an outflow of the feed streams from linking channel 3. Particularly, the disk 1 may be provided with a cover 15 (Fig. 3) such that the linking channel 3 is defined as a space between the cover 15 and the disk 1. The cover 15 may be cover disk without the provision of any inlet openings and linking channels or may be another disk 1 which is disposed with its bottom surface on the above explained disk 1. The bottom surface of such a disk 1 is the side facing away from the linking channel, i.e. the side without any indentation..

[0033] FIG. 2 shows the schematic structure of an embodiment of a static micro mixer in longitudinal section. A housing 11 is provided with two fluid inlets 12a. The housing 11 contains a stack of several disks 1 of the invention. The inlet openings 2 of the disks 1 can be closed and opened by means of a closure 13a which is may be displaceable perpendicularly to the plane defined by the surface of the disk 1. The micro mixer can be used as a reactor for producing a foam from a tenside solution and a gas.

[0034] For example, the micro mixer preferably has a stack of several disks 1 superposed on one another, with the disks 1 of the kind shown in FIG. 1a alternating with disks 1 of the kind shown in FIG. 1b and giving rise to an arrangement consisting of an alternating layer structure. In this manner, two different feed streams can be fed to the mixing zone 5 directly adjacent and over and under one another. In the stack, the disks 1 are, superposed on one another in such a way that the inlet openings 2 form subsidiary channels for introducing a particular feed stream, and the mixing zones 5 form a main channel for removing the product stream. The mixing zone 5 can be located within the housing 11, and the foam can be removed through an appropriate fluid outlet 16 (Fig. 3), e.g. by means of the above described screw conveyor. It is to be noted that any other means suitable for conveying the foam out of the mixing zone may be applied. Each feed stream is supplied by means of a fluid inlet 12a into a respective inlet opening 2. Each feed stream flows within the respective linking channel 3 and enters the mixing zone 5 through the outlet openings 4. Within the mixing zone 5, the two feed streams are mixed and form a foam.

[0035] In FIG. 3 is shown as an example a possible embodiment of a micro mixer of the invention in an exploded view. The housing 11 contains a stack of the disks 1. Shown as an example is a stack of several disks of an alternative kind, wherein the sub channels 7 and the additional sub channels 13 lead to the mixing zone 5 in parallel and inclined at identical angles. It is to be appreciated that the explanation applies to the disks 1 shown in Figs. 1a and 1b as well. The micro mixer has the stack

of several superposed disks 1 wherein the disks 1 alternate giving rise to an alternating layer structure in that the angle formed between the sub channels 7 and the circumferential line of the mixing zone 5 has an opposite deviation of 90°. In this manner, two different feed streams can be introduced into the mixing zone 5 directly adjacent and over and under each other at opposite angles. The disks 1 are positioned so that the recesses 8 cooperate or engage with the fixing elements 14 so as to prevent the twisting of the disks 1. The housing has two fluid inlets 12a for introducing the feed streams. The housing can be closed with a cover 15 containing a fluid outlet 16.

[0036] One feed stream supplied into the mixing zone 5 may be a tenside solution and the second feed stream supplied into the mixing zone 5 may be a gas, e.g. air, carbon dioxide or nitrogen or the like. Thus, a foam will be generated in the mixing zone 5 without releasing volatile organic compounds. For the purpose of removing the bubbles from the outlet openings 4, a means for cutting or shearing the bubbles off may be provided. This means may be composed of a rotating means, which may be helically formed similar to a screw conveyor and rotates close to the outlet openings 4 within the mixing zone. Thereby, the foam may be conveyed out of the mixing zone 5 and the main channel towards an outlet of the micro mixer which will be described later. Alternatively, a disk having a sharp edge may be provided within the mixing zone which cuts the bubbles off by means of vibrating.

[0037] It is explicitly stated that other disks of the invention can also be used, in which case optionally the shape of the housing, the number and position of the inlets and outlets of the fluid etc must be correspondingly adapted. Such examples are explained below in more detail.

[0038] Another embodiment is shown in FIG. 1c. The disk has a single enclosed inlet opening 2 which is connected with a linking channel 3 formed by an indentation in the surface of the disk 1. The linking channel 3 has the shape of an egg. The linking channel 3 is divided by a multiplicity of microstructure dividers 6 into a multiplicity of sub channels 7. The sub channels 7 open through the outlet openings 4 into the mixing zone 5. The outlet openings 4 are arranged on a circular line around the mixing zone 5. The mixing zone 5 and the inlet opening 2 are configured as through-holes in the disk 1. The microstructure dividers are bent, for example, in the shape of a spiral. The microstructure dividers, however, can also be linear, unbent or have any other geometric shape.

[0039] A micro mixer using the disks 1 shown in Fig. 1c preferably has a stack of several components superposed on one another. In the stack, the disks 1 are disposed above one another in a manner such that the inlet openings 2 form a subsidiary channel for introducing a feed stream, and the mixing zones 5 form a main channel into which a second feed stream may be supplied and the resulting product stream may be removed therefrom.

This embodiment is also well suited, for example, for foaming tenside solutions. To this end, the tenside solution to be treated with the gas may be introduced through the subsidiary channel formed by the superposed inlet openings 2 and the gas to be dispersed within the tenside solution for generating a foam is introduced through the central main channel formed by the superposed mixing zones 5. Advantageously, the stack of disks 1 can be configured as an alternating layer structure wherein disks 1 with spiral-shaped microstructure dividers 6 of opposite sense of rotation are alternately disposed one above the other. It is also possible to use only a single type of disk. The microstructure dividers are then preferably linear and shaped so that the sub channels form nozzles. Summarizing, the second embodiment differs from the first embodiment in that each disk 1 comprises a single inlet opening 2 for the inflow of a first feed stream and a second feed stream may be directly supplied into the mixing zone 5. It is to be appreciated that a micro mixer using the disks 1 of the ones shown in Fig. 1c requires an adaption of one of the fluid inlets 12a shown in Fig. 3 such that the second feed stream may be directly supplied into the mixing zone 5.

[0040] Another embodiment is shown in FIG. 1d. The disk 1 has an inlet opening 2, a mixing zone 5 and a flow-through opening 9. The inlet opening 2 is connected with a linking channel 3 formed by an indentation in the surface of the disk 1. The linking channel 3 is similarly shaped like the linking channel 3 of the disk 1 shown in Fig. 1c but is smaller. The linking channel 3 is divided into a multiplicity of sub channels 7 by a multiplicity of microstructure dividers 6. The sub channels 7 open through the outlet openings 4 into the mixing zone 5. The outlet openings 4 are arranged on a circular line around the mixing zone 5. The mixing zone 5, inlet opening 2 and flow-through opening 9 are configured as through-holes in the disk 1. The microstructure dividers 6 are, for example, bent in the form of spirals. The microstructure dividers 6, however, can also be linear, unbent or have any other geometric shape. With an additional built-in component 10 such as a triangular or trapezoid protrusion in the linking channel 3, the flow conditions in the linking channel 3 can be optimized. When the disks 1 are round, they may have at their edges recesses 8 that can cooperate or engage with fixing elements 14 in a housing 11 to prevent twisting or slipping of the disks. A micro mixer may have a stack of several disks 1 of the kind shown in FIG. 1d and disposed above one another alternately twisted by 180°. In this manner, two different feed streams can be introduced into the mixing zone 5 directly adjacent and above and under one another. In the stack, the disks 1 are superposed on one another in a manner such that the inlet openings 2 and the flow-through openings 9 alternate and form two subsidiary channels for introducing two feed streams, the mixing zones 5 forming a main channel for removing the product stream which is a foam in the present invention. Advantageously, the stack of disks 1 can have a configuration with an alter-

nating layer structure wherein disks 1 with spiral-shaped microstructure dividers 6 of opposite sense of rotation are disposed alternately one above the other. A single type of disk 1, however, can also be used. The microstructure dividers 6 may be linear and configured in such a way that the sub channels form nozzles. Accordingly, the third embodiment differs from the first embodiment, in that the feed streams are supplied into the mixing zone 5 not in the same but in different disks 1.

[0041] The disks may alternatively be formed in a manner as disclosed by US 2008/0106968 A1, the whole content of which concerning the design of the disks is explicitly incorporated by reference in this application.

[0042] The dimensions and values disclosed herein are not to be understood as being strictly limited to the exact numerical values recited. Instead, unless otherwise specified, each such dimension is intended to mean both the recited value and a functionally equivalent range surrounding that value. For example, a dimension disclosed as "40 mm" is intended to mean "about 40 mm."

Claims

1. Method for producing a foam using a static micro mixer, wherein the micro mixer is provided with at least one disk (1) which has at least one inlet opening (2) for the introduction of at least one feed stream into a linking channel (3) at least partially provided in a surface of the disk (1) and at least one outlet opening (4) for the outflow of the feed stream from the linking channel (3) into a mixing zone (5) provided in the disk (1), wherein the inlet opening (2) is connected with the outlet opening (4) in a communicating manner by means of the linking channel (3), and wherein the disk (1) is adapted to be provided with a cover (15) such that the linking channel (3) is defined as a space between the surface of the disk (1) and the cover (15), wherein the linking channel (3) before opening into the mixing zone (5) is divided by microstructure dividers (6) into sub channels (7), wherein the method comprises the steps of:
 - supplying a tenside solution as a first feed stream through the inlet opening into the mixing zone (5),
 - supplying a gas as a second feed stream into the mixing zone (5), and
 - producing a foam within the mixing zone (5) by mixing the tenside solution and the gas.
2. The method of claim 1, wherein the tenside solution and the gas are supplied in a turbulent manner into the mixing zone (5).
3. The method of claim 1, wherein the flow velocity at which the first and second feed streams are supplied into the mixing zone (5) is greater than the flow ve-

locity of the foam within the mixing zone (5).

4. The method of claim 1, wherein the widths of the sub channels (7) being in the millimeter to submillimeter range and being smaller than the width of the mixing zone (5). 5
5. The method of claim 1, wherein the widths of the sub channels (7) at their opening into the mixing zone (5) are from 1 μm to 2 mm. 10
6. The method of claim 1, wherein a means for conveying the foam out of the mixing zone (5) is provided within the mixing zone (5). 15
7. The method of claim 6, wherein the means for conveying the foam is a screw conveyor.
8. The method of claim 1, wherein the micro mixer is provided with a plurality of disks, which are provided as a stack. 20
9. The method of claim 8, wherein the plurality of disks are superposed on one another and the first feed stream and the second feed stream are supplied into the mixing zone (5) through the inlet openings of different disks. 25
10. The method of claim 1, wherein the disk is provided with at least two inlet openings (2) for supplying at least two different feed streams, each inlet opening (2) being connected with the mixing zone (5) through the linking channel (3). 30
11. Static micro mixer for producing a foam, wherein the micro mixer has a housing (11) and is provided with at least one disk (1) which has at least one inlet opening (2) for the introduction of at least one feed stream into a linking channel (3) at least partially provided in a surface of the disk and at least one outlet opening (4) for the outflow of the feed stream from the linking channel (3) into a mixing zone (5) provided in the disk (1), wherein the inlet opening (2) is connected with the outlet opening (4) in a communicating manner by means of the linking channel (3), and wherein the disk (1) is adapted to be provided with a cover (15) such that the linking channel (3) is defined as a space between the surface of the disk (1) and the cover (15), wherein the linking channel (3) before opening into the mixing zone (5) is divided by micro-structure dividers (6) into sub channels (7), wherein the micro mixer is formed such that a tenside solution as a first feed stream is supplied through the inlet opening (2) into the mixing zone (5), a gas as a second feed stream is supplied into the mixing zone (5), and a foam is produced within the mixing zone (5) by mixing the tenside solution and the gas. 35 40 45 50 55

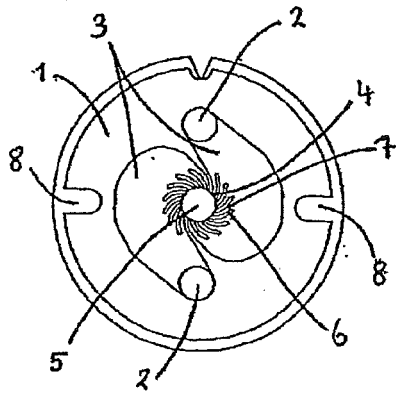


Fig. 1a

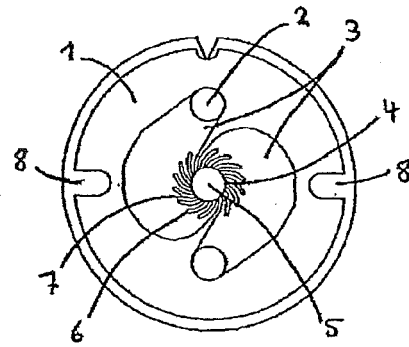


Fig. 1b

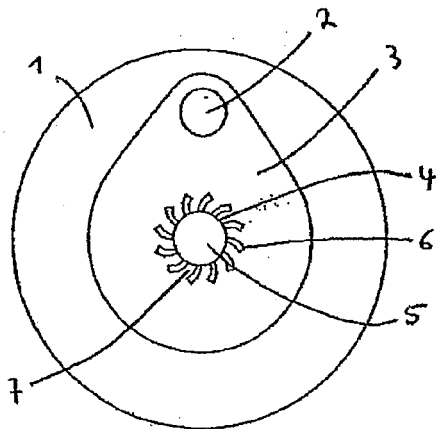


Fig. 1c

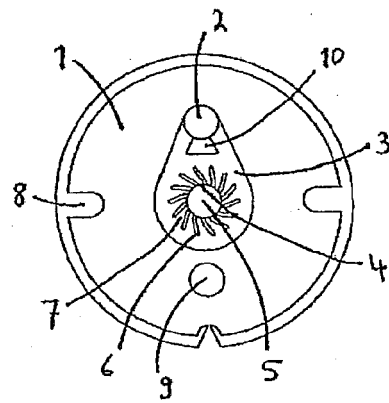
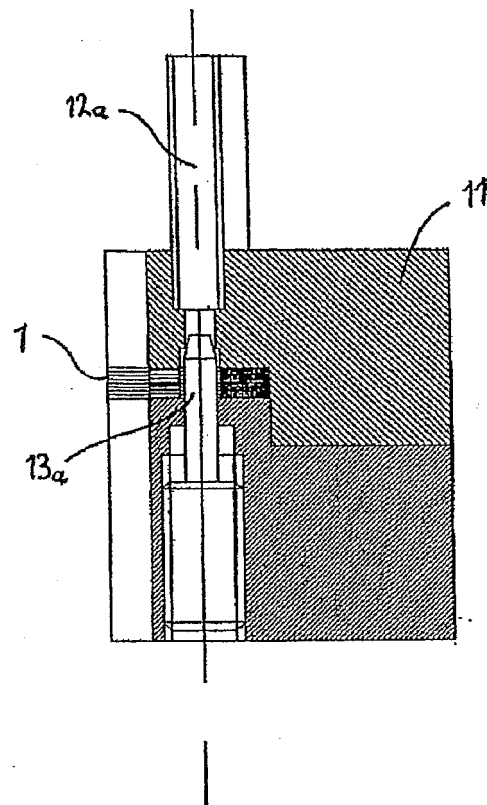


Fig. 1d

Fig. 2



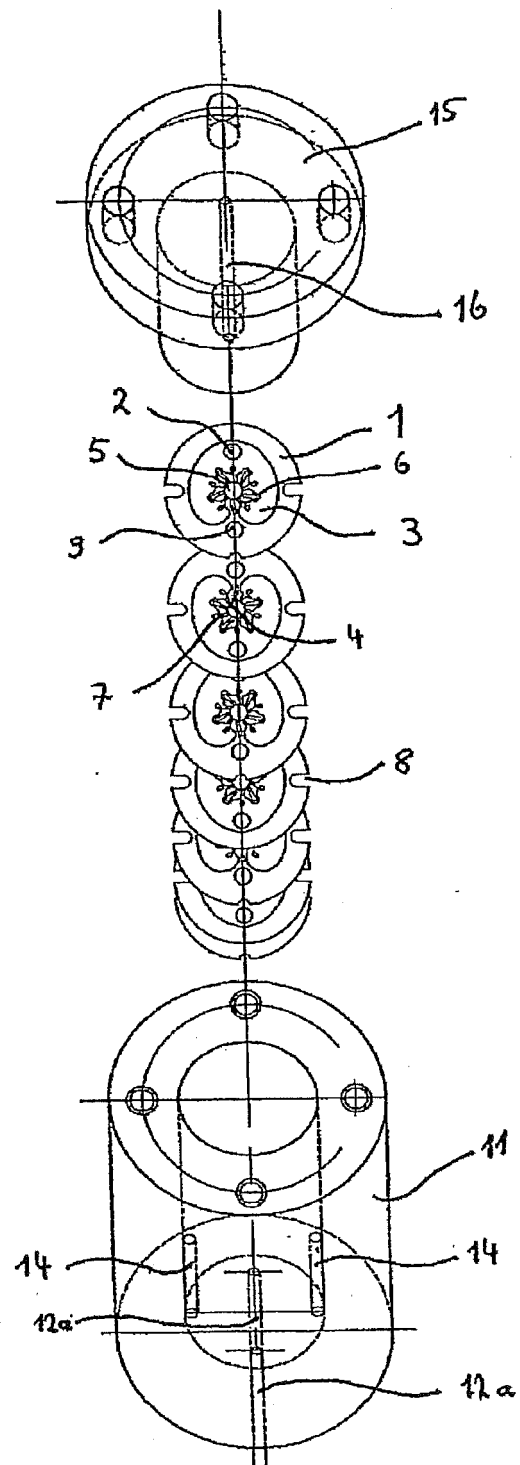


Fig. 3



EUROPEAN SEARCH REPORT

Application Number
EP 14 17 0225

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X A	WO 2005/018785 A1 (WELLA AG [DE]; SCHANZ GERHARD [DE]; SENDELBACH GERHARD [DE]) 3 March 2005 (2005-03-03) * page 1, line 5 - line 10 * * page 3, line 10 - page 4, line 11 * * page 6, line 1 - line 19 * * page 7, line 9 - line 22 * * page 8, line 1 - line 25 * * page 9, line 23 - page 10, line 20 * * page 13, line 15 - page 14, line 23 * * page 32, line 23 - line 24 * * page 33, line 29 - page 34, line 4 * * claims 13,14,18,19 * * figures 1a,6a,9 * ----- -/--	1-6,8-11 7	TECHNICAL FIELDS SEARCHED (IPC) B01F
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 12 November 2014	Examiner Real Cabrera, Rafael
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03.82 (P04C01)



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	* paragraph [0018] - paragraph [0019] *		
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	* paragraph [0050] *		
	* figures *		

The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
Place of search		Date of completion of the search	Examiner
The Hague		12 November 2014	Real Cabrera, Rafael
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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