(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 992 949 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
09.03.2016 Bulletin 2016/10

(21) Application number: **14183318.6**

(22) Date of filing: **03.09.2014**

(51) Int Cl.:
B01F 5/06 *(2006.01)* ***B01F 11/02*** *(2006.01)*
B01F 13/10 *(2006.01)* ***B01F 15/02*** *(2006.01)*
B01F 3/08 *(2006.01)*

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

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(54) Method for producing aqueous emulsions or suspensions

(57) The present invention proposes an apparatus (20) for mixing a first liquid (12) and at least a second liquid (14) by producing shear and/or cavitation. Said apparatus (20) comprises a premixing chamber (38), wherein a first liquid (12) and at least a second liquid (14) are mixed to form a premix (44), said premixing chamber (38) comprising an inlet (40) from a feed line (32) for a first liquid (12) and at least one inlet (42) from a feed line (34) for at least a second liquid (14). The apparatus (20) further comprises a spray element (64) with an orifice (66) therein forming the outlet (68) of the premixing chamber (38), wherein said orifice (66) is configured to discharge the premix (44) from the premixing chamber (38) in a jet (70) and produce shear or cavitation in the premix jet (70). The apparatus (20) further comprises a mixing chamber (72) with an outlet (74), the mixing chamber (72) collecting the jet (70) exiting the premixing chamber (38) as a mix (24) and discharging the mix (24) through the outlet (74). The feed line (32) for the first liquid (12) at least partially comprises a material (36) with a specific thermal conductivity of less than 15 W/(m*K). The present invention also proposes to use the apparatus (20) to produce an aqueous emulsion or suspension.

The present invention further proposes a method for the production of an aqueous emulsion or suspension.

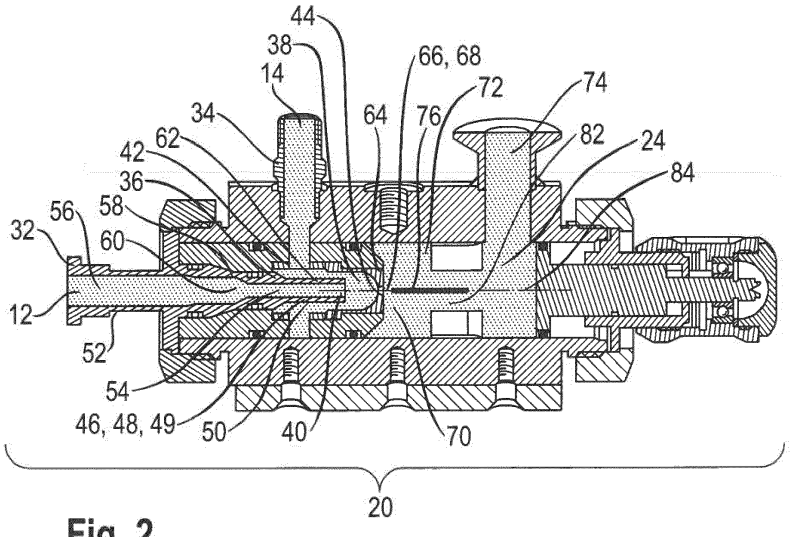

Fig. 2

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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a method of making aqueous emulsions or suspensions and, more particularly, to a method of making aqueous emulsion or suspensions with a homogenizer of the shear/cavitation type. The present invention further relates to an apparatus for the preparation of aqueous emulsion or suspensions.

[0002] Disperse preparations of the emulsion or suspension type play a prominent role in the preparation of cosmetics, pharmaceutical products and foods. The optimization of the production process, especially with regard to saving time and energy, is therefore of particular importance. A review of modem methods of producing semisolid and liquid emulsions is given in the article in SOFW-Journal, volume 124, 5/98, pages 308 to 313, as well as in the article in SÖFW-Journal, volume 118, 5/92, pages 287 to 296. With regard to the temperatures at which they are carried out, the methods can be divided into hot/hot, hot/cold and cold/cold methods.

[0003] The standard method of preparing emulsions is the hot/hot method, in which the fatty phase is heated to about 75° C and combined with the water phase, which has also been heated to about 75° C. Subsequently, the excess energy, which was supplied in the form of heat, is removed with the expenditure of much time. This method is therefore very time-consuming and cost-intensive.

[0004] In order to reduce the energy consumption and shorten the production time, so-called hot/cold and cold/cold methods have been developed. For the hot/cold method, for example, the hot oily phase is added to the emulsifying tank and is emulsified with water, which has a lower temperature than the oil phase. Often, the prerequisites for this method were a very slow addition of water to avoid crystallization by shock cooling, as well as a sufficiently high proportion of fat to prevent a drop in temperature to below the solidification point during the addition of water.

[0005] The WO 95/13787 discloses that, for producing emulsions, it is possible to mix the fatty phase and the aqueous phase at ambient temperature, however, only under the condition that, first of all, a suitable emulsifier is present and, secondly, that the fatty phase is an oil of moderate polarity. For emulsifying oils with a high or low polarity at room temperature, it is necessary that additional metal soaps be present. To begin with, these metal soaps must be dissolved in the oil at elevated temperatures and subsequently cooled; this is also time-consuming and cost- intensive.

[0006] US 6,479,041 B2 describes a method for producing aqueous emulsions or suspensions, in which a liquid phase is added to a supply tank, which is connected to a homogenizer having a stator, a rotor mounted rotatably in the stator and an additional connection, through which a second phase, which is to be homogenized, can be added directly onto the rotor and comes into contact with the previously added phase only in the toothed rings of the rotor. When the homogenizer is started, subsequently the second phase, which is insoluble in the previously added phase and is to be homogenized, is supplied in liquid form through the additional connection. At least one of the two phases is an aqueous phase and at least one of the two phases is not heated. The process suffers from the disadvantage that, when the hot phase is a molten component, often crystallization of the hot phase occurs. This is especially problematic when the emulsification process is stopped or is a discontinuous process, since an interruption of the emulsification process often results in the necessity of a cleaning operation of the homogenizer in which crystallized material must be removed. Further, during the starting process of the homogenizer, the two phases are not supplied with the target ratio as the motors driving the pumps and the homogenizer, respectively, have to start up. Thus, during the starting process of the homogenizer, a homogenous product may not be produced and, therefore, the amounts of the product produced during the starting process are disposed.

[0007] Emulsions or suspensions, produced by conventional methods, frequently also have the disadvantage that the emulsified or suspended particles have a particle size, which is not uniform enough or too large. This is associated with an effective surface area, which is too small for many applications. Moreover, the emulsion or suspension is not dispersed optimally.

[0008] US 8,517,595 B2 describes an apparatus and method for mixing by producing shear and/or cavitation, and components for the apparatus. Further apparatuses and methods for producing cavitation are described in U.S. Pat. Nos. 3,399,031; 4,675,194; 5,026,167; and 5,837,272. One particular apparatus for producing hydrodynamic cavitation is known as a SONOLATOR® high pressure homogenizer, which is manufactured by Sonic Corp. of Stratford, Conn., U.S.A. The SONOLATOR® high pressure homogenizer directs liquid under pressure through an orifice into a chamber having a knife-like blade therein. The liquid is directed at the blade, and the action of the liquid on the blade causes the blade to vibrate at sonic or ultrasonic frequencies. This produces hydrodynamic cavitation in the liquid in the area around the blade.

[0009] While the preparation of emulsions and dispersions via shear or cavitation or a mixture of both is well established and produces consistently good results, the method has several drawbacks, especially with regard to the preparation of emulsions with the hot/cold method when the hot component is a melt.

[0010] This method, as explained above, necessarily comprises the contact of the molten hot material with the cold aqueous component, which results in rapid cooling of the melt and successive formation of a well-mixed dispersion. This is generally a smooth process in a continuous state. Problems, however, arise once the process

is interrupted, be it intentionally or due to failure of a component. As soon as the constant stream of hot, molten material diminishes, the supply of heat decreases and the molten material tends to solidify and crystallize on those surfaces which have a temperature below the melting point of the material. Such a solidification results in an interruption of the process and often necessitates disassembly and cleaning of the apparatus for removal of the solidified material.

[0011] An apparatus used for the preparation of emulsions in the hot/cold method generally is made of steel components due to the high pressure and temperature conditions the apparatus is subjected to. While the steel components have been known to be reliable construction elements for high-pressure homogenizers, they suffer from the disadvantage of a high thermal conductivity, being one of the reasons for the problems described above.

SUMMARY OF THE INVENTION

[0012] It was therefore an object of the invention to make available a simplified, broadly applicable apparatus and method for producing suspensions or emulsions, which is not time-consuming and cost-intensive and, at the same time, not subject to the limitations named above and does not adversely affect significantly or even improves the desired properties of the product produced. It was further an object of the invention to make available a method and apparatus for producing suspensions or emulsions, which allows for unintended or intended discontinuities or interruptions in the production process without the necessity to stop the production process for cleaning the apparatus.

[0013] The object of the invention is solved by an apparatus for mixing a first liquid and at least a second liquid by producing shear and/or cavitation, said apparatus comprising a premixing chamber. The premixing chamber is configured in that at least a first liquid and at least a second liquid are mixed to form a premix. The premixing chamber comprises an inlet from a feed line for a first liquid and at least one inlet from a feed line for at least a second liquid. The apparatus further comprises a spray element with an orifice therein forming the outlet of the premixing chamber. The orifice is configured to discharge the premix from the premixing chamber in a jet and produce shear or cavitation in the premix jet. The apparatus further comprises a mixing chamber with an outlet. The mixing chamber is configured to collect the jet exiting the premix chamber as a mix and to discharge the mix through the outlet. The feed line for the first liquid at least partially comprises a material with a specific thermal conductivity of less than 15 W/(m*K).

[0014] With this construction of the apparatus, the first liquid and the second liquid may be premixed in the premix chamber. This premix corresponds to a first step for improving the mixing efficiency. As the premix is discharged through the orifice of the spray element, the premix is dispensed. Particularly, as the orifice is adapted to produce shear or cavitation in the premix jet, the first liquid and the second liquid are intensively mixed and collected within the mixing chamber. Thereafter, the so provided mix may be discharged from the outlet of the mixing chamber. As the feed line for the first liquid at least partially comprises a material with a comparable low specific thermal conductivity, this apparatus is advantageous particularly in cases the first liquid is a molten hot material which comes into contact with a cold material as the second liquid. The comparable low specific thermal conductivity prevents a rapid cooling of the melt, for example in case of a production interruption, an intermittent production or the like. Thus, if the constant stream of hot, molten material diminishes, the supply of heat does not significantly decrease and the molten material does not tend to solidify and crystallize on those surfaces which have a temperature below the melting point of the material.

[0015] Shear or shearing in the sense of the present invention refers to the occurrence of a shear strain, which is a deformation of a material substance in which parallel internal surfaces slide past one another. It is induced by a shear stress in the material.

[0016] Cavitation in the sense of the present invention is the formation of vapor cavities in a liquid, i.e. small liquid-free zones that are the consequence of forces acting upon the liquid. It usually occurs when a liquid is subjected to rapid changes of pressure that cause the formation of cavities where the pressure is relatively low. When subjected to higher pressure, the voids implode and can generate an intense shockwave. Such shockwaves are used to mix the premix consisting of the first liquid and the second liquid.

[0017] A spray element in the sense of the present invention is any device that facilitates dispersion of liquid or a mix of liquids into a spray. The spray element can be used for several purposes: e.g., to distribute a liquid over an area, to increase liquid surface area, and to create impact force on a solid surface. Particularly, the orifice of the spray element causes the formation of a jet of the liquid or mix of liquids.

[0018] Thermal conductivity in the sense of the present invention is the property of a material to conduct heat. Thermal conductivity is measured in Watts per Meter Kelvin (W/(m·K))

[0019] The feed line for the first liquid at least partially consists of a material with a specific thermal conductivity of less than 15 W/(m*K), preferably less than 5 W/(m*K) or less than 2 W/(m*K).

[0020] With this construction, the feed line may be at least partially made of a material having a low specific thermal conductivity. Thus, the above advantages concerning the prevention of a rapid cooling of the melt, for example in case of a production interruption, an intermittent production or the like, may be provided by a single constructional member.

[0021] The feed line for the first liquid may form a part of the wall of the premixing chamber.

[0022] With this construction, the portion of the feed

line having a low specific thermal conductivity is arranged close to or at the premixing chamber. Thus, the above advantages concerning the prevention of a rapid cooling of the melt, for example in case of a production interruption, an intermittent production or the like, may be provided directly at the location where the first liquid and the second liquid are premixed.

[0023] Suitable materials for the feed may be selected in that the feed line for the first liquid at least partially comprises glass, or mineral material or polymeric material or a mixture of two or more thereof.

[0024] For example, the feed line for the first liquid at least partially comprises a mineral material selected from quartz, concrete, or a thermoset or thermoplastic polymer such as polypropylene (PP), polyethylene (PE), polyvinyl chloride (PVC), polyoxybenzylmethylenglycolanhydride, poly(etherketone)s (PEK), poly(etheretherketone)s (PEEK), poly(etherketoneketone)s (PEKK), poly(etheretheretherketone)s (PEEEK), poly(etheretherketoneketone)s (PEEKK) or poly(etherketonetherketonketon)s (PEKEKK).

[0025] The apparatus may be designed in that at least a part of the feed line for the first liquid forms part of the boundary of the premixing chamber.

[0026] With this construction, the portion of the feed line having a low specific thermal conductivity is arranged as close as possible to the premixing chamber by means of forming a part thereof. Thus, the above advantages concerning the prevention of a rapid cooling of the melt, for example in case of a production interruption, an intermittent production or the like, may be provided directly at the location where the first liquid and the second liquid are premixed.

[0027] The feed line for the first liquid may comprise a front portion facing the premixing chamber and a rear portion facing away from the premixing chamber. The front portion may be made of a material with a specific thermal conductivity of less than 15 W/(m*K), preferably 5 W/(m*K) or less than 5 W/(m*K) or 2 W/(m*K) or less than 2 W/(m*K). It can be especially preferred to use a material having a thermal conductivity of 1 W/(m*K) or less, or 0,5 W/(m*K) or less or 0,3 W/(m*K) or less. The following list of polymeric materials which can be used to form at least a part of the feed line for the first liquid shall serve as an overview of typical ranges for thermal conductivities of polymers that can be used according to the invention (all thermal conductivities in parentheses are given in W/(m · K)). Suitable polymers are polymers selected from the group of poly(etherketone)s (PEK), poly(etheretherketone)s (PEEK), poly(etherketoneketeone)s (PEKK), poly(etheretheretherketone)s (PEEEK), poly(etheretherketoneketone)s (PEEKK) or poly(etherketonetherketonketon)s (PEKEKK) (all 0,23 - 0,27), Polyethylenterephthalate (PET 0,24) Polyurethane (PUR 0,245), Polyimide (PI 0,37 - 0,52), Polyetherimide (PEI 0,24), Polytetrafluoroethylene (PTFE 0,25), Polyvinylchloride (PVC 0,17), Polyamide (PA 0,25 - 0,35), Polypropylene (PP 0,23), Polycarbonate 0,20), Epoxyresin (EP 0,20), Polymethylmethacrylat (PMMA 0,19), Polyethylene (PE 0,33 - 0,57), Polystyrene (PS 0,17), Polysiloxane (Silicone 0,2 - 0,3).

[0028] With this construction, that portion of the feed line facing the premixing chamber comprises a material having a low specific thermal conductivity. Thus, the above advantages concerning the prevention of a rapid cooling of the melt, for example in case of a production interruption, an intermittent production or the like, may be provided directly close to or at a location where the first liquid and the second liquid are premixed.

[0029] The front portion may comprise a first inner diameter and the rear portion may comprise a second inner diameter. The first inner diameter may be smaller than the second inner diameter.

[0030] With this construction, the dynamic pressure of the first liquid is increased which improves the mixing efficiency within the premixing chamber.

[0031] The front portion may comprise a wall thickness of 1 mm to 20 mm, preferably of 2 mm to 6 mm.

[0032] Depending on the specific thermal conductivity of the material for the front portion, the wall thickness may be decreased. In other words, if the material for the front portion has a low specific thermal conductivity, the wall thickness may be decreased if compared to a material having a higher specific thermal conductivity.

[0033] The mixing chamber may comprise a vibrating blade or it may not comprise a vibrating blade.

[0034] If the mixing chamber comprises a vibrating blade, the premix is directed at the blade, and the action of the premix on the blade causes the blade to vibrate at sonic or ultrasonic frequencies. This produces hydrodynamic cavitation in the premix in the area around the blade. Thus, the mix is prepared via shear or cavitation and consistently good results regarding the mixing efficiency are produced.

[0035] Alternatively, the vibrating blade may be omitted.

[0036] This construction may be preferred in cases the premix is fed into the mixing chamber in an intermittent or pulsating manner.

[0037] The apparatus may comprise a first displacement pump for feeding the first liquid through the feed line for the first liquid and a second displacement pump for feeding the second liquid through the feeding line for the second liquid.

[0038] With this construction, predetermined volumes of the first liquid and the second liquid may be conveyed.

[0039] A displacement pump in the sense of the present invention is any pump that makes a fluid move by trapping a fixed amount and forcing (displacing) that trapped volume into a discharge pipe or the like.

[0040] Particularly, the first displacement pump and the second displacement pump may be adapted to feed the first liquid and the second liquid in pulsating strokes.

[0041] With this construction, the mix may be conveyed in predetermined doses. Thereby, this construction provides the basis of a direct portioning process of the mix,

which can result in a direct filling process. A direct filling process is to be understood as a filling process wherein the mix may be directly filled into corresponding container without being temporarily stored in a tank or any other storing container.

[0042] The first displacement pump and the second displacement pump may be adapted to feed the first liquid and the second liquid where one stroke can take 0.5 to 25 seconds.

[0043] With this construction, the mix may be conveyed in fast subsequent, predetermined doses. Thereby, this construction provides the basis of a fast direct filling process of the mix. Further, it is to be noted that the value for the feed concerns one stroke and the time is related to the pressure and the amount of the product. Needless to say, the more pressure and less volume the shorter is the time/stroke.

[0044] The first displacement pump and the second displacement pump may be each adapted to provide an operating pressure within 5 to 500 bar, preferably within 20 to 180 bar.

[0045] This construction ensures that the first liquid and the second liquid are reliably premixed due to the rapid pressure increase.

[0046] Preferably, the first displacement pump and/or the second displacement pump is a piston pump or a plunger pump. For example, the first displacement pump and/or the second displacement pump is a metering pump.

[0047] With this construction, a direct filling process is possible, wherein volumes of the respective mixes to be filled are exactly predetermined. With other words, the volumes of each mix filled into a corresponding container are substantially identical.

[0048] A piston pump in the sense of the present invention is a type of displacement pump where a high-pressure seal reciprocates with a piston during operation of the pump.

[0049] A plunger pump in the sense of the present invention is a type of displacement pump where a high-pressure seal is stationary and a smooth cylindrical plunger slides through the seal during operation of the pump.

[0050] A metering pump in the sense of the present invention is a type of pump that moves a precise volume of liquid in a specified time period providing an accurate flow rate. Delivery of fluids in precise adjustable flow rates is defined as metering.

[0051] The first displacement pump and the second displacement pump may be each adapted to feed a volume of 1 ml to 4,000 ml, preferably 2 ml to 250 ml per stroke.

[0052] Suitable displacement pumps are available, e.g., from Teledyne Technologies Incorporated, Thousand Oaks, California, USA.

[0053] With this construction, the direct filling of cosmetics, pharmaceutical products and foods is possible.

[0054] The object of the invention is solved by a method for the production of an aqueous emulsion or suspension, wherein a hydrophobic liquid phase is brought into contact with an aqueous phase in a premixing chamber to form a premix. The premixing chamber comprises an inlet from a feed line for a first liquid and at least one inlet from a feed line for at least a second liquid. The premix is forced to leave the premixing chamber through a spray element with an orifice therein forming the outlet of the premixing chamber. The orifice is configured to spray the premix in a jet and produce shear or cavitation in the premix jet. The hydrophobic liquid phase and the aqueous phase have a temperature difference of at least 10°C.

[0055] With this method, the hydrophobic liquid phase and the aqueous phase may be premixed in the premix chamber. This premix corresponds to a first step for improving the mixing efficiency. As the premix is discharged through the orifice of the spray element, the premix is dispersed. Particularly, as the orifice is adapted to produce shear or cavitation in the premix jet, the hydrophobic liquid phase and the aqueous phase are intensively mixed. As the hydrophobic liquid phase and the aqueous phase have a temperature difference of at least 5°C, preferably at least 10°C, a cooling device is not necessary as the hydrophobic liquid phase within the mix may be cooled by the aqueous phase.

[0056] An emulsion in the sense of the present invention is a mixture of two or more components, one of which forms a continuous phase, and the other of which is distributed throughout the continuous phase. Two liquids can form different types of emulsions. As an example, oil and water can form, first, an oil-in-water emulsion, wherein the oil is the dispersed phase, and water is the dispersion medium. Second, they can form a water-in-oil emulsion, wherein water is the dispersed phase and oil is the external phase. Multiple emulsions are also possible, including a "water-in-oil-in-water" emulsion and an "oil-in-water-in-oil" emulsion.

[0057] A suspension in the sense of the present invention is a heterogeneous mixture of a liquid containing solid particles that are sufficiently large for sedimentation. The internal phase (solid) is dispersed throughout the external phase (fluid) through mechanical agitation, with the use of certain excipients or suspending agents. The term solid particles is used as with the present invention one of the two liquids may be a melt, which may crystallize or solidify within the mix and, therefore form solid particles.

[0058] The premix may leave the premixing chamber with a pressure of at least 5 bar, preferably at least 30 or at least 50 bar. This allows to convey the premix even if the premix has a high viscosity.

[0059] The pressure in the premix chamber may vary intermittently.

[0060] Thereby, the premix may be conveyed in pulsating strokes. Thus, this method provides the basis of a direct filling process of a mix made of the hydrophobic liquid phase and the aqueous phase. A direct filling process is to be understood as a filling process wherein the

mix may be directly filled into corresponding container without being temporarily stored in a tank or any other storing container.

[0061] The object of the invention is solved by use of an apparatus as described above to produce an aqueous emulsion or suspension.

[0062] With this use, the first liquid may be a hydrophobic liquid phase and the second liquid may be an aqueous phase. The hydrophobic liquid phase may be brought into contact with the aqueous phase in the premixing chamber to form the premix. The premix may be forced to leave the premixing chamber through the spray element with the orifice therein forming the outlet of the premixing chamber. The orifice may be configured to spray the premix in a jet and produce shear or cavitation in the premix jet. The first liquid and the second liquid may have a temperature difference of at least 5°C, preferably at least 10°C.

[0063] With this use, the hydrophobic liquid phase and the aqueous phase may be premixed in the premix chamber. This premix corresponds to a first step for improving the mixing efficiency. As the premix is discharged through the orifice of the spray element, the premix is dispensed. Particularly, as the orifice is adapted to produce shear or cavitation in the premix jet, the hydrophobic liquid phase and the aqueous phase are intensively mixed. As the hydrophobic liquid phase and the aqueous phase preferably have a temperature difference of at least 10°C, a cooling device is not necessary as the hydrophobic liquid phase within the mix may be cooled by the aqueous phase. As the feed line for the first liquid at least partially comprises a material with a comparable low specific thermal conductivity, this apparatus is advantageous particularly in cases the first liquid is a molten hot material which comes into contact with a cold material as the second liquid. The comparable low specific thermal conductivity prevents a rapid cooling of the melt, for example in case of a production interruption, an intermittent production or the like. Thus, if the constant stream of hot, molten material diminishes, the supply of heat does not significantly decrease and the molten material does not tend to solidify and crystallize on those surfaces which have a temperature below the melting point of the material.

[0064] Emulsions or dispersion which can be produced with a method and apparatus according to the invention, generally have two phases, an "aqueous phase" and a "non-aqueous phase", often also called an "oil phase". It is within the scope of the invention to produce emulsions of the O/W type as well as of the W/O type.

[0065] An "aqueous phase" according to the invention can comprise water as well as mixtures of water with water-soluble solvents, such as low molecular weight alcohols, for example, ethanol or isopropanol or polyols, such as ethylene glycol, diethylene glycol, butylene glycol or glycerin.

[0066] The particles, of the disperse phase generally have a particle size of, for example, about 0.1 μm to about 10 μm, and a large effective surface.

[0067] Often the oil phase exists in solid form at room temperature and is emulsified in the molten state. Such phases are waxes or wax-like materials, such as natural waxes, which can be regenerated (insect wax, animal wax and plant wax), fossil waxes (crude oil wax, brown coal wax, peat wax or ozokerites), synthetic waxes (Fischer-Tropsch wax, polyethylene wax or amide wax), higher melting paraffins, esters, fats, long-chain carboxylic acids or long-chain alcohols, each having a melting or solidifying point above room temperature.

[0068] The temperatures of the aqueous phase and of the hot melt supplied ideally are selected so that the resulting temperature of the mixture is below the crystallization or solidification point of the substance, which is to be homogenized into the previously added phase. For example, if the temperature of the molten wax is 70°C to 90° C. and the temperature of the aqueous phase is 10° to 25° C.

[0069] Upon mixing of both phases, a mixture with a temperature between 10° and 40° C. can be attained, depending on the respective amounts mixed. The wax suspension obtained can then immediately after mixing be filled into containers, ready for use, without the need for a subsequent protracted cooling and without the danger of a subsequent time-delayed change in the viscosity or consistency, since the crystallization effects are concluded immediately.

[0070] In a special embodiment, the hot phase, which is to be homogenized, especially a molten wax or a melt of a substance, which has a wax-like consistency at room temperature, is homogenized without an emulsifier. If the phase, which is to be homogenized, is a liquid at room temperature, it is preferably added without being heated. Such a phase may be an oil or an oil-like material, such as naturally occurring oils (vegetable or animal fatty oils), which can be regenerated, synthetic oils, silicone oils, mineral oils, essential oils, water-insoluble, branched or linear aliphatic hydrocarbons, linear or branched alcohols, especially fatty alcohols as well as long-chain ethers or esters. Suitable hydrocarbons are, for example, liquid paraffins, squalane or squalane. Furthermore, esters of trihydric and multihydric alcohols, especially vegetable triglycerides, such as olive oil, almond oil, peanut oil, sunflower oil as well as synthetic triglycerides, such as C_2 to C_{10} fatty acid triglycerides or also jojoba oil, are suitable.

[0071] Furthermore, monoesters or diesters of the formula R_1-$COOR_2$, R_1-COO-R_3-$OOCR_1$ and R_2COO-R_3-$OOCR_2$, in which R_1 represents a C_8 to C_{22} alkyl group, R_2 a C_3 to C_{22} alkyl group and R_3 a C_2 to C_{16} alkylene group, are suitable as oil phase. Naturally occurring monoester mixtures and wax ester mixtures, such as those present in jojoba oil or sperm oils, and branched primary alcohols, such as those known under the name of Guerbet alcohols, are also suitable. In addition, materials, which are usually used as opacifying agents in cosmetic materials, are suitable as substances, which are to be homogenized. These are, in particular, those having the formula R_1-$COO(CHR_4CHR_5O)_n$-COR_6, wherein R_1

represents a C_8 to C_{22} alkyl group, R_4 and R_5 represent hydrogen or methyl and R_6 represents hydrogen or R_1 and n is a number between 1 and 12 and preferably 1, 2, 3 or 4. Diesters of glycol and fatty acids are preferred.

[0072] If the oil phase is a liquid at room temperature, it is particularly advantageous and saves time and energy, if neither of the phases is heated (cold/cold emulsification).

[0073] The method according to the invention can be carried out without an emulsifier. However, an emulsifier or a surfactant, as emulsifier, may also be present and preferably is introduced before the substance, which is to be homogenized, was supplied over the additional connection of the homogenizer. The emulsifier may be present in amounts of 0.5 to 30% by weight of the finished composition. Nonionic, anionic, cationic, amphoteric or zwitterionic emulsifiers are suitable. Suitable emulsifiers are listed, for example, in the "International Cosmetic Ingredient Dictionary and Handbook", 7th edition, volume 2, in the "Surfactants" section and especially in the "Surfactants-Emulsifier Agents".

[0074] Nonionic emulsifier are, for example, ethoxylated fatty alcohols, ethoxylated nonylphenols, monoglycerides and diglycerides of fatty acids, ethoxylated castor oil and ethoxylated, hydrogenated castor oil, fatty acid alkanolamides and ethoxylated fatty esters. Cationic emulsifiers are, for example, long-chain quaternary ammonium compounds such as those known under the CTFA name of "quaternium", for example, alkyltrimethylammonium salts of dialkyldimethylammonium salts with C_8 to C_{22} alkyl groups. Anionic emulsifiers are, for example, fatty alcohol sulfates, alkyl ether sulfates and alkylbenzenesulfonates. Amphoteric emulsifiers are, for example, the different known betaines, such as fatty acid amidoalkylbetaines and sulfobetaines and C_8 to C_{22} alkyl betaines.

[0075] The inventive method is also suitable for producing an opacifier composition for cosmetic materials. For this purpose, initially a concentrated alkyl ether sulfate, such as lauryl ether sulfate, is dissolved in electrolyte-free water, which has not been heated. Subsequently, a water-insoluble opacifying agent, such as a diester of ethylene glycol and fatty acid or of polyethylene glycol and fatty acid, for example, polyethylene glycol (3)-distearate, is homogenized in the liquid or molten state with the above mentioned water/ether sulfate mixture.

[0076] The method according to the invention is especially suitable for producing cosmetic and pharmaceutical materials. Since the emulsion or suspension produced pursuant to the invention is extremely fine and has a low viscosity, the further active and inactive ingredients can be incorporated significantly more easily and quickly than they can according to conventional methods, as a result of which the formulation times are clearly shortened.

[0077] It is also particularly advantageous to produce hair dyeing creams according to the inventive method, particularly hair dyeing creams for oxidizing hair dyes containing dye intermediates, which respond to oxidation. These hair dyeing creams are usually based on a wax-containing cream. With conventional methods of production, a hydrophobic, molten wax phase, heated to about 70° to 80° C, is emulsified at a temperature of 70° to 80° C. in an aqueous phase, containing the dye intermediates as well as any additional conventional additives. Subsequently, the emulsion must be cooled very slowly and with delay and stirring, in order to prevent uncontrolled crystallization of the wax (formation of wax specks). During this relatively long cooling, undesirable oxidation reactions may occur as a result of the oxygen stirred in from the air. In addition, there may be post-thickening, which may cause difficulties with the finished product.

[0078] The disadvantages of the conventional method of emulsifying are overcome by the method according to the invention. Time consuming and energy-consuming heating and cooling of the whole composition are not required. The danger of forming specks and of undesirable oxidation reactions is clearly reduced. Immediately after the wax phase is supplied, the dye composition obtained can be filled, as finished product, into containers without any further homogenizing steps, since cooling is not required and the consistency does not change due to post-thickening. Because of the much finer dispersion of the hydrophobic phase, a significantly larger specific surface area and, with that, a higher effectiveness of the raw materials is attained.

[0079] If the end product is a viscous composition, the desired final viscosity, especially in the case of O/W emulsions, frequently is obtained already by the homogenization. However, the desired final viscosity can also be adjusted (preferably at the end of the manufacturing process) by the addition of an electrolyte, such as sodium chloride, or of a different, thickening material, such as celluloses or cellulose derivatives.

[0080] Compositions, produced by conventional methods, frequently show the effect of post-thickening, which means that the final viscosity and consistency are developed only after a certain period of time. Compositions, produced by the method according to the invention, do not have this disadvantage. Instead, they have their final viscosity generally immediately at the conclusion of the manufacturing process or very shortly thereafter.

[0081] It has been observed that, compared to suspensions or emulsions produced by conventional means, the emulsions or suspensions produced pursuant to the invention, at the same concentration and using the same amount of hydrophobic materials, have advantageous properties. Physically, this is observed in a higher viscosity of the compositions produced pursuant to the invention. However, the application properties of the products are also improved. For example, for a hair care material, in the form of a pumpable foam, it was found that the feel and combability of the treated hair are better and the foam is creamier and softer than in the case of a product, not produced pursuant to the invention but hav-

ing the identical chemical composition. The improved consistency properties and application properties presumably are attributable to a better, finer dispersion of the internal phase or to a smaller particle diameter of the dispersed phase.

[0082] Summarizing the above, particular embodiments of the present invention are:

1. An apparatus for mixing a first liquid and at least a second liquid by producing shear and/or cavitation, said apparatus comprising:

- a premixing chamber, wherein a first and at least a second liquid are mixed to form a premix, said premixing chamber comprising an inlet from a feed line for a first liquid and at least one inlet from a feed line for at least a second liquid,
- a spray element with an orifice therein forming the outlet of the premixing chamber, wherein said orifice is configured to discharge the premix from the premixing chamber in a jet and produce shear or cavitation in the premix jet,
- a mixing chamber with an outlet, the mixing chamber collecting the jet exiting the premix chamber as a mix and discharging the mix through the outlet,

wherein the feed line for the first liquid at least partially comprises a material with a specific thermal conductivity of less than 15 W/(m*K).

2. Apparatus according to embodiment 1, characterized in that the feed line for the first liquid at least partially consists of a material with a specific thermal conductivity of less than 15 W/(m*K), preferably less than 5 W/(m*K) or less than 2 W/(m*K).

3. Apparatus according to embodiment 1or 2, characterized in that the feed line for the first liquid forms a part of a wall of the premixing chamber.

4. Apparatus according to one of the preceding embodiments, characterized in that the feed line for the first liquid at least partially comprises glass, or mineral material or polymeric material or a mixture of two or more thereof.

5. Apparatus according to one of the preceding embodiments, characterized in that the feed line for the first liquid at least partially comprises a mineral material selected from quartz, concrete, or a thermoset or thermoplastic polymer such as polypropylene (PP), polyethylene (PE), polyvinyl chloride (PVC), polyoxybenzylmethylenglycolanhydride, poly(etherketone)s (PEK), poly(etheretherketone)s (PEEK), poly(etherketonekteone)s (PEKK), poly(etheretheretherketone)s (PEEEK), poly(etheretherketoneketone)s (PEEKK) or poly(etherketonetherketonketon)s (PEKEKK).

6. Apparatus according to one of the preceding embodiments, characterized in that at least a part of the feed line for the first liquid forms part of a boundary of the premixing chamber.

7. Apparatus according to one of the preceding embodiments, characterized in that the feed line for the first liquid comprises a front portion facing the premixing chamber and a rear portion facing away from the premixing chamber, wherein the front portion is made of a material with a specific thermal conductivity of less than 15 W/(m*K), preferably less than 5 W/(m*K) or less than 2 W/(m*K).

8. Apparatus according to the preceding embodiment, characterized in that the front portion comprises a first inner diameter and the rear portion comprises a second inner diameter, wherein the first inner diameter is smaller than the second inner diameter.

9. Apparatus according to embodiment 7 or 8, characterized in that the front portion comprises a wall thickness of 1 mm to 20 mm, preferably of 2 mm to 6 mm.

10. Apparatus according to one of the preceding embodiments, characterized in that the mixing chamber comprises a vibrating blade or no vibrating blade.

11. Apparatus according to one of the preceding embodiments, characterized in that it comprises a first displacement pump for feeding the first liquid through the feed line for the first liquid and a second displacement pump for feeding the second liquid through the feeding line for the second liquid.

12. Apparatus according to the preceding embodiment, characterized in that the first displacement pump and the second displacement pump are adapted to feed the first liquid and the second liquid in pulsating strokes.

13. Apparatus according to the preceding embodiments, characterized in that the first displacement pump and the second displacement pump are adapted to feed the first liquid and the second liquid where one stroke can take 0.5 to 25 seconds.

14. Apparatus according to one of the preceding embodiments 11 to 13, characterized in that the first displacement pump and the second displacement pump are each adapted to provide an operating pressure within 5 to 500 bar, preferably within 20 to 180 bar.

15. Apparatus according to one of the preceding embodiments 11 to 14, characterized in that the first displacement pump and/or the second displacement pump is a piston pump or a plunger pump.

16. Apparatus according to one of the preceding embodiments 11 to 15, characterized in that the first displacement pump and/or the second displacement pump is a metering pump.

17. Apparatus according to one of the preceding embodiments 11 to 16, characterized in that the first displacement pump and the second displacement pump are each adapted to feed a volume of 1 ml to 4,000 ml, preferably 2 ml to 250 ml per stroke.

18. Method for the production of an aqueous emulsion or suspension, wherein a hydrophobic liquid phase is brought into contact with an aqueous phase in a premixing chamber to form a premix, said premixing chamber comprising an inlet from a feed line for a first liquid and at least one inlet from a feed line for at least a second liquid, the premix being forced to leave the premixing chamber through a spray element with an orifice therein forming the outlet of the premixing chamber, wherein said orifice is configured to spray the premix in a jet and produce shear or cavitation in the premix jet, characterized in that the hydrophobic liquid phase and the aqueous phase have a temperature difference of at least 10°C.

19. Method according to embodiment 18, characterized in that the premix leaves the premixing chamber with a pressure of at least 5 bar, preferably at least 30 or at least 50 bar.

20. Method according to embodiment 18 or 19, characterized in that the pressure in the premix chamber varies intermittently.

21. Use of an apparatus according to one of embodiments 1 to 17 to produce an aqueous emulsion or suspension.

22. Use according to the preceding embodiment, characterized in that the first liquid is a hydrophobic liquid phase and the second liquid is an aqueous phase, wherein the hydrophobic liquid phase is brought into contact with the aqueous phase in the premixing chamber to form the premix, the premix being forced to leave the premixing chamber through the spray element with the orifice therein forming the outlet of the premixing chamber, wherein said orifice is configured to spray the premix in a jet and produce shear or cavitation in the premix jet, wherein the first liquid and the second liquid have a temperature difference of at least 10°C.

BRIEF DESCRIPTION OF THE FIGURES

[0083] Further optional features and embodiments of the invention will be disclosed in more detail in the subsequent description of specific embodiments, preferably in conjunction with the dependent claims. Therein, the respective optional features may be realized in an isolated fashion as well as in any arbitrary feasible combination, as the skilled person will realize. The scope of the invention is not restricted by the specific embodiments. The embodiments are schematically depicted in the Figures. Therein, identical reference numbers in these Figures refer to identical or functionally comparable elements.

[0084] In the Figures:

Figure 1 shows an overview of a system for producing a mix of a first liquid and a second liquid,

Figure 2 shows a cross-sectional view of an apparatus for mixing a first liquid and at least a second liquid by producing shear and/or cavitation according to a first embodiment of the present invention,

Figure 3 shows a perspective view of a spray element of the apparatus for mixing a first liquid and at least a second liquid by producing shear and/or cavitation according to the first embodiment of the present invention, and

Figure 4 shows a cross-sectional view of an apparatus for mixing a first liquid and at least a second liquid by producing shear and/or cavitation according to a second embodiment of the present invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0085] Figure 1 shows an overview of a system 10 for producing a mix of a first liquid 12 and a second liquid 12. Particularly, the system 10 is adapted to produce an emulsion or suspension. Thus, the first liquid 12 may be an aqueous phase and the second liquid 14 may be a hydrophobic liquid phase. The first liquid 12 may be stored within at least one tank 16. Similar, the second liquid 14 may be stored within at least one tank 18. The at least one tank 16 for the first liquid 12 and the at least one tank 18 for the second liquid 14 are connected to an apparatus 20 for mixing a first liquid and at least a second liquid by producing shear and/or cavitation, which will be described in more detail below. The apparatus 20 is connected to a storing tank 22 for storing a mix 24 leaving the apparatus. The storing tank 22 may be used as a buffering tank for buffering the mix 24 in a filling process as will be explained in more detail below. The storing tank 22 may comprise an agitator 26 for agitating the mix 24 stored within the storing tank 22. The agitation process

may be used for preventing a separation of the respective components of the mix 24. The storing tank 22 may be connected to a filler (not shown in detail) for filling the mix into container, vessels, bottles or any other suitable receptacle. In order to feed the mix 24 from the storing tank 22 to the filler, the system 10 comprises a pump 28. The system 10 may additionally comprise a mill 30 for further dispersing the mix 24 before being supplied to the filler.

[0086] Figure 2 shows a cross-sectional view of the apparatus 20 for mixing the first liquid 12 and at least the second liquid 14 by producing shear and/or cavitation according to a first embodiment of the present invention. The apparatus 20 comprises a feed line 32 for the first liquid 12 and a feed line 34 for the second liquid 14. The feed line 32 for the first liquid 12 at least partially comprises a material 36 with a specific thermal conductivity of less than 15 W/(m*K). Particularly, the feed line 32 for the first liquid 12 at least partially consists of a material with a specific thermal conductivity of less than 15 W/(m*K), preferably less than 5 W/(m*K) or less than 2 W/(m*K), for example 0,5 W/(m*K). Preferably, the feed line 32 for the first liquid 12 at least partially comprises glass, or mineral material or polymeric material or a mixture of two or more thereof. For example, the feed line 32 for the first liquid 12 at least partially comprises a mineral material selected from quartz, concrete, or thermoset or thermoplastic polymer such as polypropylene (PP), polyethylene (PE), polyvinyl chloride (PVC), polyoxybenzylmethylenglycolanhydride, poly(etherketone)s (PEK), poly(etheretherketone)s (PEEK), poly(etherketonekteone)s (PEKK), poly(etheretheretherketone)s (PEEEK), poly(etheretherketoneketone)s (PEEKK) or poly(etherketonetherketonketon)s (PEKEKK).

[0087] The apparatus 20 further comprises a premixing chamber 38. The premixing chamber 38 comprises an inlet 40 from the feed line 32 for the first liquid 12 and at least one inlet 42 from the feed line 34 for the at least one second liquid 14. In the premixing chamber 38, the first liquid 12 and the at least one second liquid 14 are mixed to form a premix 44. At least a part 46 of the feed line 32 for the first liquid 12 forms part of a wall 48 of the premixing chamber 38. More particularly, at least a part 46 of the feed line 32 for the first liquid 12 forms part of a boundary 49 of the premixing chamber 38. For example, the feed line 32 for the first liquid 12 comprises a front portion 50 facing the premixing chamber 38 and a rear portion 52 facing away from the premixing chamber 38. The front portion 50 is made of the material 36 with a specific thermal conductivity of less than 15 W/(m*K), preferably less than 5 W/(m*K) or less than 2 W/(m*K). The front portion 50 comprises a first inner diameter 54 and the rear portion 52 comprises a second inner diameter 56. The first inner diameter 54 is smaller than the second inner diameter 56. Between the front portion 50 and the rear portion 52, a transition portion 58 may be provided. The transition portion 58 may be shaped in that a third inner diameter 60 gradually decreases from the rear portion 52 to the front portion 50. For example, the third inner diameter 60 may conically narrow. The front portion 50 comprises a wall thickness 62 of 1 mm to 20 mm, preferably of 2 mm to 6 mm.

[0088] The rear portion 52 may be made of metal. Needless to say, the feed line 32 for the first liquid may be made completely of the material 36 with a specific thermal conductivity of less than 15 W/(m*K), preferably less than 5 W/(m*K) or less than 2 W/(m*K).

[0089] The apparatus 20 further comprises a spray element 64 with an orifice 66 therein forming an outlet 68 of the premixing chamber 38. The orifice 66 is configured to discharge the premix 44 from the premixing chamber 38 in a jet 70 and to produce shear or cavitation in the premix jet 70.

[0090] Figure 3 shows a perspective view of the spray element 64 of the apparatus 20 for mixing a first liquid and at least a second liquid by producing shear and/or cavitation according to the first embodiment of the present invention. As can be taken from the illustration of Figure 3, the orifice 66 is formed similar to a cat exe. The interior of the orifice 66 is a hemispherical dome. The orifice 66 is made with a V-shaped cut from outside. The area of the orifice 66 is controlled by an angle of the V-shape, a radius of the dome and the depth of the cut.

[0091] Now, it is referred back to the illustration of Figure 2. The apparatus 20 further comprises a mixing chamber 72 with an outlet 74. The mixing chamber 72 collects the jet 70 exiting the premix chamber 38 as the mix 24 and discharges the mix 24 through the outlet 74. The mixing chamber 72 further comprises a vibrating blade 76. The mix 24 is directed at the blade 76. The action of the mix 24 on the blade 76 causes the blade 76 to vibrate at sonic or ultrasonic frequencies. Thereby, hydrodynamic cavitation in the mix 24 in the area around the blade 76 is produced, which increases the mixing efficiency.

[0092] Now, it is referred back to the illustration of Figure 1. In order to supply the first liquid 12 and the second liquid 14 from the tank 16 for the first liquid 12 and the tank 18 for the second liquid 14 to the apparatus 20, pumps are provided. In case the mixing process of the first liquid 12 and the second liquid 14 is a continuous process, i.e. a process for permanently filling the storing tank 22 without any interruption, in principle any pump may be applied which is adapted to convey a hydrophobic liquid phase and an aqueous phase.

[0093] In the present embodiment, the system 10 is configured to discontinuous fill the storage tank 22, i.e. the storage tank 22 is filled with subsequent quantities of the mix 24. For this reason, the apparatus 20 comprises a first displacement pump 78 for feeding the first liquid 12 through the feed line 32 for the first liquid 12 and a second displacement pump 80 for feeding the second liquid 14 through the feeding line 34 for the second liquid 14. The first displacement pump 78 and the second displacement pump 80 are adapted to feed the first liquid 12 and the second liquid 14 in pulsating or intermittent

strokes. More particularly, the first displacement pump 78 and the second displacement pump 80 are adapted to feed the first liquid 12 and the second liquid 14 where one stroke can take 0.5 to 25 seconds. In order to increase the mixing efficiency for the premix 44, the first displacement pump 78 and the second displacement pump 80 are each adapted to provide an operating pressure within 5 to 500 bar, preferably within 20 to 180 bar, for example, 100 bar. As such, the first displacement pump 78 and/or the second displacement pump 80 is a piston pump or a plunger pump. Particularly, the first displacement pump 78 and/or the second displacement pump 80 is a metering pump. For example, the first displacement pump 78 and the second displacement pump 80 are each adapted to feed a volume of 1 ml to 4,000 ml, preferably 2 ml to 250 ml per stroke, for example 80 ml. Basically, the apparatus 20 is adapted to provide flow rates of 1 ml/s to 4,000 ml/s. The more pressure and less volume the shorter is the time/stroke.

[0094] Now, a method for the production of an aqueous emulsion or suspension is described. The production is carried out using the apparatus 20. The first liquid 12 is a hydrophobic liquid phase and the second liquid 14 is an aqueous phase. By means of the first displacement pump 78 and the second displacement pump 80, the first liquid 12 and the second liquid 14 are supplied to the apparatus 20 through the feed line 32 for the first liquid 32 and the feed line 34 for the second liquid 14. The first liquid 12 and the second liquid 14 have a temperature difference of at least 10°C. Particularly, the first liquid 12 is a melt of the hydrophobic liquid phase which has a temperature that is 10 °C higher than the second liquid 14. As the front portion 50 of the feed line 32 for the first liquid 12 is made of the material 36, a crystallization of the hot hydrophobic liquid phase is reliably prevented even when the emulsification process is stopped or is a discontinuous process as described above as the material 36 having a low specific thermal conductivity prevents the hydrophobic liquid phase from being cooled by the cooler aqueous phase.

[0095] The first liquid 12 enters the premixing chamber 38 through the inlet 40 and the second liquid 14 enters the premixing chamber 38 through the inlet 42. Thereby, the hydrophobic liquid phase is brought into contact with the aqueous phase in the premixing chamber 38 to form the premix 44. The first displacement pump 78 and the second displacement pump 80 are adapted to feed the first liquid 12 and the second liquid 14 such that a pressure of 80 bar to 150 bar is present in the premixing chamber 38. As the first displacement pump 78 and the second displacement pump 80 supply the first liquid 12 and the second liquid 14 as subsequent separate quantities, the pressure in the premix chamber 38 varies intermittently. Subsequently, the premix 44 is forced to leave the premixing chamber 38 through the spray element 64 with the orifice 66 therein forming the outlet 68 of the premixing chamber 38. The premix 44 leaves 44 the premixing chamber 38 with a pressure of at least 5 bar, preferably at least 30 or at least 50 bar, for example 80 bar.

[0096] The orifice 66 sprays the premix 44 in a jet 70 and produces shear or cavitation in the premix jet 70 as the jet 70 leaving the orifice 66 impinges on the vibrating blade 76. With other words, the jet 70 is directed at the blade 76. The action of the jet 70 on the blade 76 causes the blade 76 to vibrate at sonic or ultrasonic frequencies. Thereby, the premix 44 is intensively mixed so as to form the mix 24. The mix 24 is collected within the mixing chamber 72. It is to be noted that a significant portion of the jet 70, after being intercepted by the blade 76, will exit directly from two holes 82 formed close to an axial center 84, both above and below the blade 76. This portion of the jet 70 will not recirculate in the mixing chamber 72. As the mixing chamber 72 comprises a large volume if compared to the premixing chamber 38, the pressure within the mixing chamber 72 decreases. For example, a pressure within the mixing chamber 72 may be 2 bar. Finally, the mix 24 is discharged through the outlet 74 and is conveyed towards the storage tank 22. It is explicitly stated that the storage tank 22 may be omitted and the mix discharged through the outlet may be directly filled into suitable containers such as bottles or receptacles. Further, due to the pressures present in the premixing chamber 38 and the mixing chamber 72, the vibrating blade 76 may be omitted. Figure 4 shows a cross-sectional view of an apparatus 20 for mixing a first liquid 12 and at least a second liquid 14 by producing shear and/or cavitation according to a second embodiment of the present invention. Hereinafter, only the differences from the apparatus 20 of the first embodiment will be described and like constructional members are indicated by like reference numerals.

[0097] The apparatus 20 according to the second embodiment may be basically applied to the system 10 shown in Figure 1. The apparatus 20 according to the second embodiment is adapted to provide flow rates less than the apparatus 20 according to the first embodiment. For example, the apparatus 20 according to the second embodiment is adapted to provide flow rates up to 5 gpm. The mixing chamber 72 of the apparatus 20 according to the second embodiment differs significantly in geometry from the mixing chamber 72 of the apparatus 20 according to the first embodiment. Particularly, the vibrating blade 76 is held by a blade holder 86. The premix jet 70 from the orifice 66, which is first intercepted by the vibrating blade 76, is forced to turn by the surface of the blade holder 86 to form recirculation. Then, the thus formed mix 24 exits the mixing chamber 72 by two narrow tunnels 88 formed at a top 90 and a bottom 92 of the blade holder 86.

[0098] 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. An apparatus (20) for mixing a first liquid (12) and at least a second liquid (14) by producing shear and/or cavitation, said apparatus (20) comprising:

   - a premixing chamber (38), wherein a first liquid (12) and at least a second liquid (14) are mixed to form a premix (44), said premixing chamber (38) comprising an inlet (40) from a feed line (32) for a first liquid (12) and at least one inlet (42) from a feed line (34) for at least a second liquid (14),
   - a spray element (64) with an orifice (66) therein forming the outlet (68) of the premixing chamber (38), wherein said orifice (66) is configured to discharge the premix (44) from the premixing chamber (38) in a jet (70) and produce shear or cavitation in the premix jet (70),
   - a mixing chamber (72) with an outlet (74), the mixing chamber (72) collecting the jet (70) exiting the premixing chamber (38) as a mix (24) and discharging the mix (24) through the outlet (74),

   wherein the feed line (32) for the first liquid (12) at least partially comprises a material (36) with a specific thermal conductivity of less than 15 W/(m*K).

2. Apparatus according to claim 1, **characterized in that** the feed line (32) for the first liquid (12) at least partially consists of a material (36) with a specific thermal conductivity of less than 15 W/(m*K), preferably less than 5 W/(m*K) or less than 2 W/(m*K).

3. Apparatus according to claim 1or 2, **characterized in that** the feed line (32) for the first liquid (12) forms a part of a wall (48) of the premixing chamber (38).

4. Apparatus according to one of the preceding claims, **characterized in that** the feed line (32) for the first liquid (12) at least partially comprises glass, or mineral material or polymeric material or a mixture of two or more thereof

5. Apparatus according to one of the preceding claims, **characterized in that** the feed line (32) for the first liquid (12) at least partially comprises a mineral material selected from quartz, concrete, or a thermoset or thermoplastic polymer such as polypropylene (PP), polyethylene (PE), polyvinyl chloride (PVC), polyoxybenzylmethylenglycolanhydride, poly(etherketone)s (PEK), poly(etheretherketone)s (PEEK), poly(etherketonekteone)s (PEKK), poly(etheretheretherketone)s (PEEEK), poly(etheretherketoneketone)s (PEEKK) or poly(etherketonetherketonketon)s (PEKEKK).

6. Apparatus according to one of the preceding claims, **characterized in that** at least a part of the feed line (32) for the first liquid (12) forms part of a boundary (49) of the premixing chamber (38).

7. Apparatus according to one of the preceding claims, **characterized in that** the feed line (32) for the first liquid (12) comprises a front portion (50) facing the premixing chamber (38) and a rear portion (52) facing away from the premixing chamber (72) (38), wherein the front portion (50) is made of a material (36) with a specific thermal conductivity of less than 15 W/(m*K), preferably less than 5 W/(m*K) or less than 2 W/(m*K).

8. Apparatus according to the preceding claim, **characterized in that** the front portion (50) comprises a first inner diameter (54) and the rear portion (52) comprises a second inner diameter (56), wherein the first inner diameter (54) is smaller than the second inner diameter (56).

9. Apparatus according to claim 7 or 8, **characterized in that** the front portion (50) comprises a wall thickness (62) of 1 mm to 20 mm, preferably of 2 mm to 6 mm.

10. Apparatus according to one of the preceding claims, **characterized in that** the mixing chamber (72) comprises a vibrating blade (76) or no vibrating blade (76).

11. Apparatus according to one of the preceding claims, **characterized in that** it comprises a first displacement pump (78) for feeding the first liquid (12) through the feed line (32) for the first liquid (12) and a second displacement pump (80) for feeding the second liquid (14) through the feeding line (34) for the second liquid (14).

12. Apparatus according to the preceding claim, **characterized in that** the first displacement pump (78) and the second displacement pump (80) are adapted to feed the first liquid (12) and the second liquid (14) in pulsating strokes.

13. Apparatus according to the preceding claims, **characterized in that** the first displacement pump (78) and the second displacement pump (80) are adapted to feed the first liquid (12) and the second liquid (14) where one stroke can take 0.5 to 25 seconds.

14. Apparatus according to one of the preceding claims 11 to 13, **characterized in that** the first displacement pump (78) and the second displacement pump (80) are each adapted to provide an operating pressure within 5 to 500 bar, preferably within 20 to 180 bar.

15. Apparatus according to one of the preceding claims 11 to 14, **characterized in that** the first displacement pump (78) and/or the second displacement pump (80) is a piston pump or a plunger pump.

16. Apparatus according to one of the preceding claims 11 to 15, **characterized in that** the first displacement pump (78) and/or the second displacement pump (80) is a metering pump.

17. Apparatus according to one of the preceding claims 11 to 16, **characterized in that** the first displacement pump (78) and the second displacement pump (80) are each adapted to feed a volume of 1 ml to 4,000 ml, preferably 2 ml to 250 ml per stroke.

18. Method for the production of an aqueous emulsion or suspension, wherein a hydrophobic liquid phase is brought into contact with an aqueous phase in a premixing chamber (38) to form a premix (44), said premixing chamber (38) comprising an inlet (40) from a feed line (32) for a first liquid (12) and at least one inlet (42) from a feed line (34) for at least a second liquid (14), the premix (44) being forced to leave the premixing chamber (38) through a spray element (64) with an orifice (66) therein forming the outlet (68) of the premixing chamber (38), wherein said orifice (66) is configured to spray the premix (44) in a jet (70) and produce shear or cavitation in the premix jet (70), **characterized in that** the hydrophobic liquid phase and the aqueous phase have a temperature difference of at least 10°C.

19. Method according to claim 18, **characterized in that** the premix (44) leaves the premixing chamber (38) with a pressure of at least 5 bar, preferably at least 20 or at least 50 bar.

20. Method according to claim 18 or 19, **characterized in that** the pressure in the premixing chamber (38) varies intermittently.

21. Use of an apparatus according to one of claims 1 to 17 to produce an aqueous emulsion or suspension.

22. Use according to the preceding claim, **characterized in that** the first liquid (12) is a hydrophobic liquid phase and the second liquid (14) is an aqueous phase, wherein the hydrophobic liquid phase is brought into contact with the aqueous phase in the premixing chamber (38) to form the premix (44), the premix (44) being forced to leave the premixing chamber (38) through the spray element (64) with the orifice (66) therein forming the outlet (68) of the premixing chamber (38), wherein said orifice (66) is configured to spray the premix (44) in a jet (70) and produce shear or cavitation in the premix jet (70), wherein the first liquid (12) and the second liquid (14) have a temperature difference of at least 10°C.

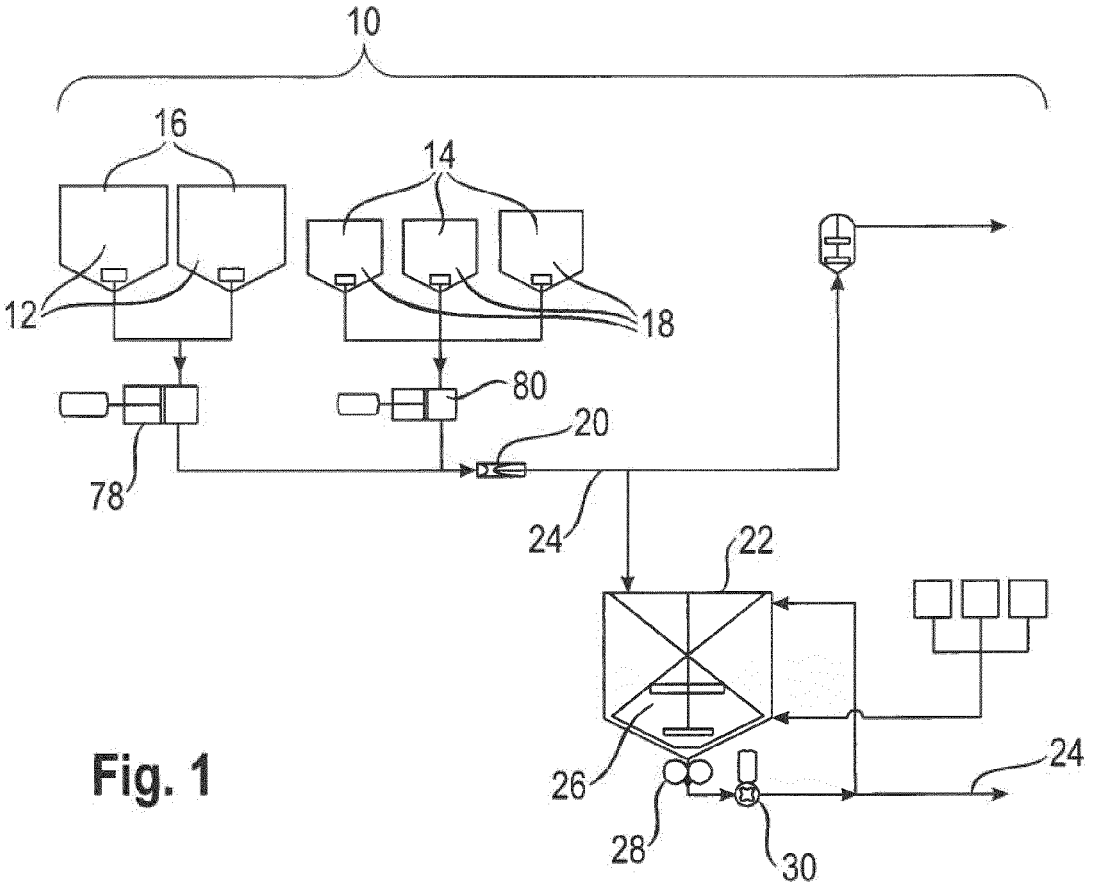
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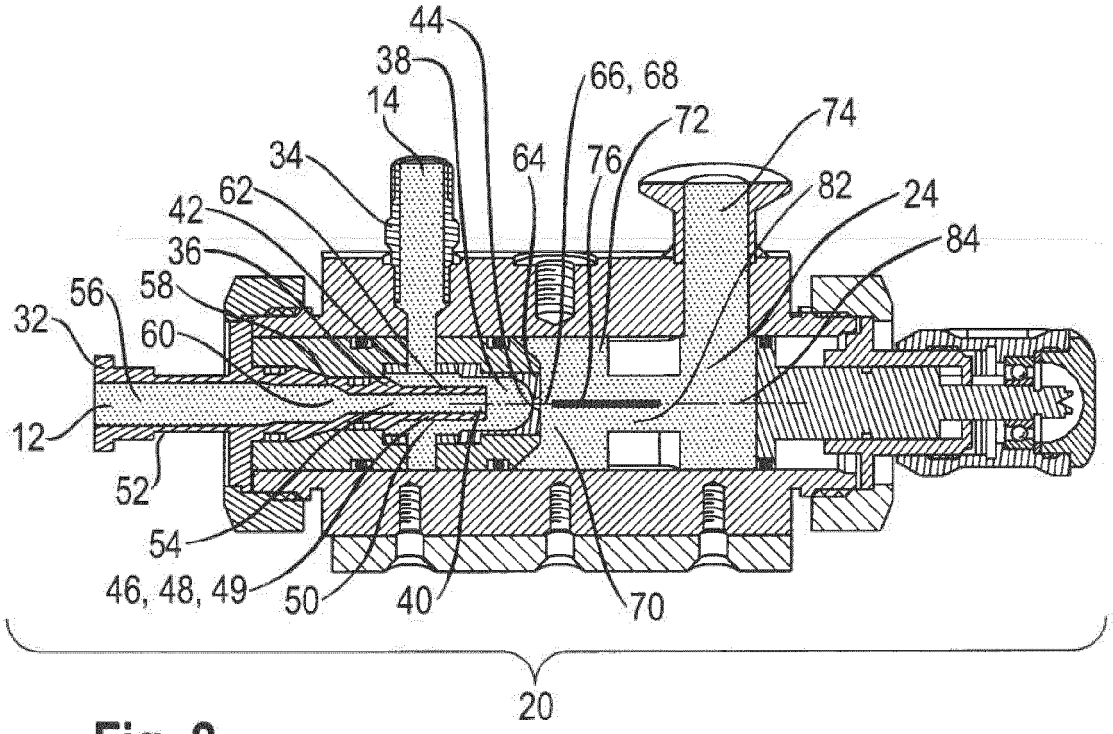
Fig. 1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70
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Fig. 2

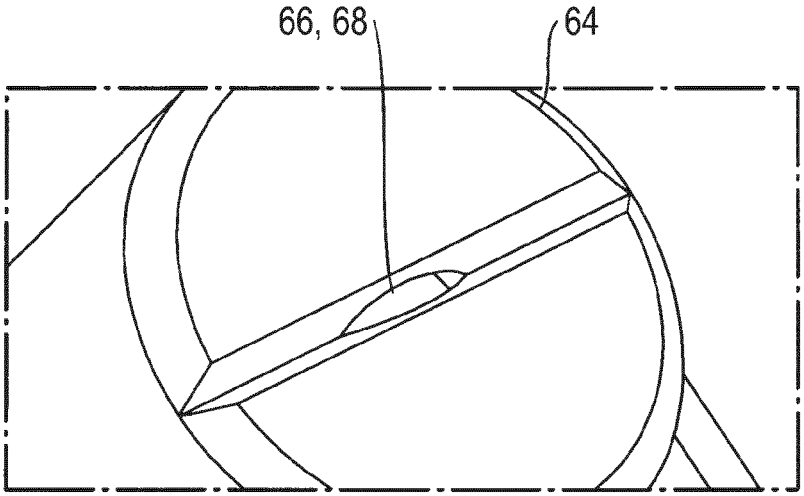
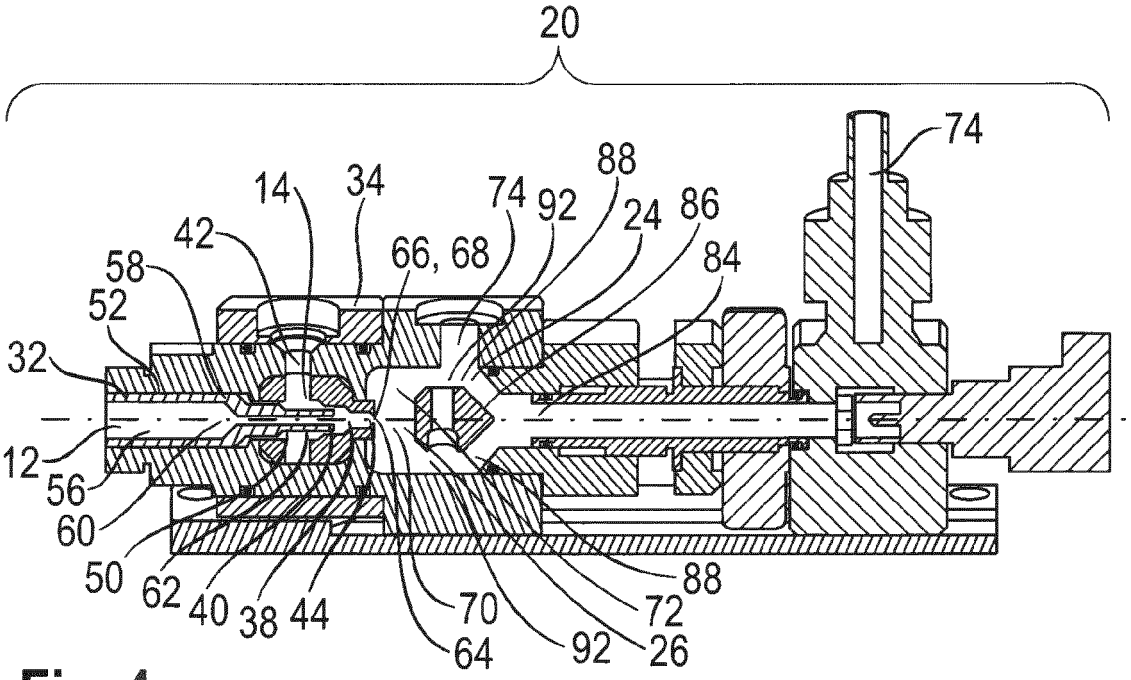

66, 68
64

Fig. 3


20
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88
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66, 68
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Fig. 4

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EUROPEAN SEARCH REPORT

Application Number
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Place of search	Date of completion of the search	Examiner
The Hague	17 February 2015	Zattoni, Federico

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