The present invention generally discloses a micropump for delivering liquids at low delivery rates. The micropump has a reservoir chamber containing a liquid which is to be delivered. A suction space comprising a saturated pump solution, a condensation space comprising a saturated solution, a diaphragm separating the suction space and the condensation space. The diaphragm is permeable to water vapour and impermeable to liquid water. The water vaporizes out of the suction space into the condensation space, resulting in an increase in volume of the saturated solution in the condensation space, thereby exerting a pressure on an impermeable wall such that the liquid is driven out of the reservoir chamber.
MICROPUMP FOR DELIVERING LIQUIDS AT LOW DELIVERY RATES IN A PUSH/PULL OPERATING MODE

REFERENCE TO RELATED APPLICATIONS


TECHNICAL FIELD

[0002] The invention generally relates to a micropump that delivers liquids at low delivery rates in a push/pull operating mode and which permits restricted control of the delivery rate.

BACKGROUND

[0003] It is generally known that micropumps are used to deliver gases. In such gas delivery micropumps, the problem of the formation of air bubbles/vapour bubbles which is typical of liquids does not occur. One of the disadvantages with the delivery devices which deliver gases or which operate with a gas buffer volume is the pronounced dependence of an enclosed volume of gas on the temperature and pressure. As a result, such pumps are not only dependent on the external temperature but also on the barometric pressure unless they are separated from the environment by encapsulation, requiring a high level of expenditure. An example of the micropump used to deliver liquids at very low flow rates is disclosed in DE 100 29 453 C2 and EP 1 363 020 A2.

[0004] The micropumps which are known from the prior art have the disadvantage that they permit a medium to be delivered only in the suction operating mode. However, for application in analysis systems with material-exchanging apparatuses such as, for example, diaphragm filters or microdialysers a push/pull operating mode is often desired. Furthermore, the prior art have the disadvantage of having a large overall volume which is necessary as a result of the use of a buffer volume or a fixed sorbent according.

[0005] As discussed above, the micropumps which are known from the prior art do not constitute a feasible approach to micropumps which permit largely constant delivery rates in the range less than 100 nl/min over relatively long time periods. Therefore, there is a need for a micropump that can permit constant delivery rates over a relatively long period in a push/pull operating mode.

SUMMARY

[0006] One of the objects of the present invention is a micropump which delivers liquids at low delivery rates in a push/pull operating mode. One of the other objects is a micropump that permits a restricted regulating possibility of the delivery rate. Yet another object is to have a micropump that is small in design and has low manufacturing costs.

[0007] In one embodiment, the micropump of the present invention is advantageously significantly smaller than the pump for very low flow rates which is known from DE 100 29 453 C2. This is possible as a result of the elimination of the sorbent and the complete utilization of the space available. In addition, a buffer vessel for holding distilled H₂O which is necessary for the operation of this sorbent pump is dispensed with. Since a liquid is used as a delivery medium, the micropump which is proposed according to the invention is independent of the external pressure, i.e. the ambient pressure, in terms of its pumping speed.

[0008] The micropump of the present invention has a reservoir chamber containing a liquid which is to be delivered: a suction space comprising a saturated pump solution, a condensation space comprising a saturated solution. A diaphragm separating the suction space and the condensation space. The diaphragm is permeable to water vapour and impermeable to liquid water. The water vaporizes out of the suction space into the condensation space, resulting in an increase in volume of the saturated solution in the condensation space, thereby exerting a pressure on an impermeable wall such that the liquid is driven out of the reservoir chamber.

[0009] These and other features and advantages of the present invention will be more fully understood from the following detailed description of the invention taken together with the accompanying claims. It is noted that the scope of the claims is definitely by the recitations therein and not by the specific discussion of the features and advantages set forth in the present description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The following detailed description of the embodiments of the present invention can be best understood when read in conjunction with the following drawings, where like structure is indicated with like reference numerals and in which:

[0011] FIG. 1 shows a schematic cross section through the micropump which is proposed according to the invention;

[0012] FIGS. 2.1 to 2.4 show schematic cross sections through vapour-permeable diaphragms;

[0013] FIG. 3 shows a cross section through a vapour-permeable diaphragm with a mechanical reinforcement; and

[0014] FIG. 4 shows a shaped, vapour-permeable diaphragm.

[0015] Skilled artisans appreciate that elements in the figures are illustrated for simplicity and clarity and have not necessarily been drawn to scale. For example, the dimensions of some of the elements in the figure may be exaggerated relative to other elements to help improve understanding of the embodiment(s) of the present invention.

[0016] In order that the invention may be more readily understood, reference is made to the following examples, which are intended to illustrate the invention, but not limit the scope thereof.

DETAILED DESCRIPTION

[0017] The following description of the preferred embodiment is merely exemplary in nature and is in no way intended to limit the invention or its application or uses.

[0018] Referring in particular to FIG. 1, a micropump configured as a microvapourizer pump for delivering small flows of liquid in simultaneous push/pull operating mode is generally shown and represented by reference numeral 10.
With continued reference to FIG. 1, the micropump 10 comprises an upper body 11, a central body 12 and a lower body 13. The upper body 11 and the central body 12 bear against one another along a first joint 14, while the central body 12 and the lower body 13 are in contact with one another along a second joint 15.

As shown in FIG. 1, the lower body 13 comprises a suction space 16. A feed line 17 is assigned to the suction space 16, together with a venting line containing a valve 18. Preferably, the suction space 16 is connected via the feed line 17 to a liquid source (not illustrated in FIG. 1).

The suction space 16 is filled with a saturated pump solution 19 and contains a depot 20 of crystals. The walls of the suction space 16 in the lower body 13 are of essentially rigid design, apart from a diaphragm 21 (as described in detail below).

With continued reference to FIG. 1, the micropump 10, further comprises a diaphragm 21. The diaphragm 21 is preferably permeable to water vapour and impermeable to liquid water. As shown, on the pressure side of the diaphragm 21 there is a further condensation space 27 which has at least one flexible wall. As shown, the diaphragm 21 separates the suction space 16 from a condensation space 27.

An upper side 25 of the diaphragm 21 faces the condensation space 27 which is formed in the central body 12, while under side 26 of the diaphragm 21 faces the suction space 16. The diaphragm 21 is clamped in the region of the joint 15 of the central body 12 and of the lower body 13 by means of two sealing O-rings 22, 23. The first O-ring 22 and the second O-ring 23 ensure there is a seal between the condensation space 27 and the suction space 16. Alternatively, it is also possible for the diaphragm 21 to be welded in, casted in or bonded in in the region of the joint 15 or to be attached in a seal-forming fashion between the suction space 16 and the condensation space 27 in some other way.

As shown in FIG. 1, below the diaphragm 21 there is a supporting structure 24 which supports the diaphragm 21 which is permeable to water vapour and impermeable to liquid water and prevents it from sagging downwards.

The diaphragm 21 is, for example, a PTFE flat diaphragm with a pore size of 0.2 µm. Instead of PTFE flat diaphragms, scaled, hydrophobic solubility diaphragms can also be used to separate the suction space 16 and the condensation space 27. For example such diaphragms contain a thin layer of silicone, made of interlinked polycrystalline ethylsiloxane which has a sufficiently high degree of permeability to water vapour.

With continued reference to FIG. 1, the upper body 11 of the micropump 10 also comprises a reservoir chamber 31. The condensation space 27 is separated from the reservoir chamber 31 by means of the impermeable diaphragm 28. The impermeable diaphragm 28 is impermeable to a salt solution in the condensation space 27 and the liquid in the reservoir chamber 31. The impermeable diaphragm 28 is clamped at clamping-in locations 33 in the region of the first joint 14 between the upper body 11 and the central body 12. The reservoir chamber 31 has an outlet 32 and contains the liquid which is to be pumped and which is connected by means of the outlet 32 to a liquid sink (not illustrated in FIG. 1).

The condensation space 27 formed in the central body 12 is bounded by the rigid walls of the central body 12 on the one hand and by the upper side 25 of the diaphragm 21 as well as by an impermeable diaphragm 28. The condensation space 27 contains a saturated solution, for example a saturated salt solution 29 and a depot of crystals 30. In the case of a saturated salt solution 29, the depot 30 is a depot of salt crystals.

All salts which have a lower vapour pressure as a saturated solution than the sucked-in solution, for example for example a solution of cooking salt, generates are suitable as crystals 30 promote the holding of water vapour by the condensation space 27. If substances are dissolved in the sucked-in solution, it is preferred if the salts used in the condensation space 27 are ones for which the vapour pressure of a saturated aqueous solution is lower than the vapour pressure of a sucked-in solution which is concentrated to saturation. Salts which are suitable for this are, for example NH₄Cl or LiCl.

Through the diaphragm 21 water vaporizes into the saturated salt solution 29 which is contained in the condensation space 27, and is always saturated owing to the depot 30 of salt crystals which is contained there. Due to the water vapour which passes through the diaphragm 21 the volume of the saturated salt solution 29 is increased. The enlargement of the volume of the saturated salt solution 29 contained in the condensation space 27 exerts a pressure on the impermeable diaphragm 28 and thus drives the liquid contained in the reservoir chamber 31 through the outlet 32 of a liquid sink.

In the overall view of the micropump 10 illustrated in FIG. 1, said micropump 10 continuously sucks liquid into the suction space 16 via the feed line 17 and continuously outputs liquid via the outlet 32. The streams of liquid which pass through the feed line 17 to the suction space 16 and the outlet 32 of the reservoir chamber 31 correspond to one another in a first approximation.

Once the impermeable diaphragm 28 separating the saturated salt solution 29 and the liquid contained within the reservoir chamber 31 is deflected in such a way that the liquid contained in the reservoir chamber 31 has been displaced through the outlet 32 the impermeable diaphragm 28 stays in this position and the micropump 10 is disposed of. The time period within which the liquid contained in the reservoir chamber 31 is completely driven out of said reservoir chamber 31 via outlet 32 is a period between 3 and 7 days. After the impermeable diaphragm 28 has been deflected and adopted a curvature opposite to the curvature as shown in FIG. 1, the liquid contained within the reservoir 31 has been completely driven out of said reservoir chamber 31 and the micropump 10 can be disposed of.

As a result of the diaphragm 21 water vaporizes out of the suction space 16 into the saturated salt solution 29 within the condensation space 27 and increases its volume. The increase in the saturated salt solution 29 within the condensation space 27 exerts a pressure on the impermeable diaphragm 28, which is impermeable to water vapour and liquid. As a result of the pressure on impermeable diaphragm 28 which is of flexible construction, liquid is driven out of the reservoir chamber 31.

Viewed in its entirety, the micropump 10 is used both to suck liquid into the suction space 16 and to force
liquid out of the reservoir chamber 31, with the two streams of liquid being the same in a first approximation. The micropump 10 is consequently a push/pull pump.

[0034] Instead of porous, hydrophobic PTFE flat diaphragms which can be used as diaphragms which are permeable to water vapour and impermeable to liquid water it is also possible to use hydrophobic diaphragms with relatively large pores. However, in such diaphragms the pressure difference which can be achieved is smaller and therefore the risk of a hydraulic short-circuit as a result of the ingress of liquid into the relatively large pores of the hydrophobic diaphragm is greater.

[0035] This risk which is associated with the use of porous diaphragms can be avoided by using sealed, hydrophobic solubility diaphragms. Such a sealed, hydrophobic solubility diaphragm may be fabricated from a film made of silicone. Surprisingly, it has been found that a thin layer of silicone, for example of interlinked polydimethylsiloxane, has a sufficiently high permeability to water vapour in order to be able to implement the micropump 10 proposed according to the invention.

[0036] In addition it is also possible to form such a sealed, hydrophobic solubility diaphragm, by means of a silicone film which is provided with a mechanical reinforcing structure. Such a mechanical reinforcing structure may be, for example, a monofil woven fabric. The monofil woven fabric is preferably a metallic woven fabric which is covered with a thin silicone layer in such a way that the meshes between the monofil threads are covered with a small silicone film.

[0037] A sealed, hydrophobic solubility diaphragm may, for example, be favourably obtained by covering a monofil woven fabric, preferably a metallic monofil woven fabric, with a thin silicone layer, in such a way that the meshes with the monofil woven fabric, i.e. the individual threads, are covered with a small, thin silicone film. This may also be implemented in an analogous fashion by an extremely thin perforated sheet metal plate, a nonwoven, a grill or else by means of a porous diaphragm.

[0038] With specific reference to FIG. 4, the abovementioned monofil woven fabric, which is preferably a wire fabric with metallic wires, can be shaped spherically in such a way that it becomes self-supporting and no further stabilizing elements are necessary to prevent sagging of a diaphragm which is produced in such a way.

[0039] A second embodiment of the vapour-permeable diaphragm 21 is shown in FIG. 2.1. The vapour-permeable diaphragm 21 which is illustrated in FIG. 2.1 is embodied as a microporous diaphragm and has an upper side 41 and an underside 42. With respect to the exemplary embodiment illustrated in FIG. 1, the upper side 41 faces the condensation space 27, while the underside 42 is oriented facing the suction space 16. In contrast, the vapour-permeable diaphragm 21 illustrated in FIG. 2.1 is impermeable to liquid water.

[0040] Yet another embodiment of the diaphragm 21 is shown in FIG. 2.2. As shown the diaphragm 21 is provided on its underside 42 with a silicone film 46. In contrast, the upper side 41 of the diaphragm 21 which is permeable to water vapour but impermeable to liquid water is formed without such a film. The silicone film 46 on the underside 42 of the diaphragm 21 faces the suction space 16 according to the embodiment variant of the micropump 10 according to the illustration in FIG. 1.

[0041] FIG. 2.3 shows another embodiment of the diaphragm 21 which is permeable to water vapour and impermeable to liquid water. The diaphragm 21 is coated with a silicone film 46 both on the underside 41 and on the upper side 42. The silicone film 46 on the upper side 41 and the underside 42 of the diaphragm 21 which is permeable to water vapour but impermeable to liquid water is held on both sides of a diaphragm structure which is formed with large pores.

[0042] In yet another embodiment as shown in FIG. 2.4 exhibits a diaphragm 21 which is permeable to water vapour but impermeable to liquid water and is formed as a silicone film 46. According to this embodiment, there is no need for a large-pore or fine-pore diaphragm structure and the diaphragm 21 which is permeable to water vapour and impermeable to liquid water is formed exclusively by the silicone film 46.

[0043] Referring in particular to FIG. 3, a cross section through the diaphragm 21 of FIG. 1 is shown. The diaphragm 21 as shown has an integrated mechanical reinforcement.

[0044] The diaphragm 21 illustrated in FIG. 3 is a sealed, hydrophobic solubility diaphragm which can be used as an alternative to hydrophobic pore diaphragms. Said diaphragm has a monofil woven fabric, indicated by the reinforcing threads 44 of a mechanical reinforcement 43. As shown, the diaphragm 21 has individual reinforcing threads 44 passing through it. The threads 44 extend perpendicularly to the plane of the drawing. Between the individual reinforcing threads 44 of the mechanical reinforcement 43 there are in each case sections which are covered with a thin silicone film 46. The mechanical reinforcement 43, which is embodied for example as a monofil wire fabric, can be shaped spherically in such a way that it assumes self-supporting properties and no further elements are necessary to prevent sagging of the diaphragm 21.

[0045] If an electric current is applied to the individual reinforcing threads 44 of the mechanical reinforcement 43, indicated by a supply voltage $U_{in}$ or if individual reinforcing threads 44 have an electric voltage $U_{in}$ applied to them, the pump rate of the micropump 10 can be increased. The application of an electric voltage to the reinforcing threads 44 of the mechanical reinforcement 43 causes the temperature to be increased locally and the transport rate of water or water vapour through the diaphragm 21.

[0046] The individual reinforcing threads 44 of the diaphragm 21 are preferably connected to earth, as indicated by reference symbols 45. The voltage supply of the individual reinforcing threads 44 is provided by a supply voltage, indicated by $U_{in}$ from a voltage source (not illustrated in more detail either).

[0047] Referring in particular to FIG. 4, a way of shaping the diaphragm 21 which is permeable to water vapour and impermeable to liquid water is shown. As shown, the diaphragm 21 has a mechanical reinforcing structure 43. In the embodiment shown in FIG. 4, the reinforcing structure 43 is constructed as an arrangement of monofil reinforcing threads 44 between which individual film sections of silicone 46 are located on the upper side 41 and the underside
42. The diaphragm 21 is formed in the shape of a hat. This may be brought about, for example, by shaping a flat, planar face of the diaphragm 21 by means of a tool, which is rounded in the form of a die so that the intrinsic rigidity is improved by lengths of the monofil reinforcing threads 44.

[0048] As has already been mentioned above, there may be substances contained in the solution sucked into the suction space 16 via the feedline 17. In this case, crystals 30, for example salt crystals, for which the vapour pressure of a saturated aqueous solution is lower than the vapour pressure of a sucked-in solution which has been concentrated to saturation are preferably used in the condensation space 27. Such concentration leading to saturation takes place, for example, within the suction space 16 if an NaCl solution is sucked in. In the process, NaCl crystals are formed on the diaphragm 21 on the suction side, i.e. on the underside 26. Surprisingly it has been found that it is now possible to use the pump principle of the micropump 10 according to FIG. 1 without destruction by the formation of crystals if from the beginning so much crystalline NaCl is placed in advance in the suction space 16 that when the suction space 16 is filled via the feedline 17 a saturated NaCl solution with a remaining crystal deposit 20 is formed. As a result of the sucking in, NaCl which is conveyed in is preferably deposited on the crystals of the crystal deposit 20 which are present in the suction space 16, without the underside 26 of the diaphragm 21 being blocked.

[0049] The propulsive force for the conveying by water is determined by the difference in water vapour pressure between two saturated salt solutions, i.e. within the suction space 16 and within the condensation space 27. Since this difference in water vapour pressure between the saturation solutions 29 and 19 is constant, the pump rate is constant as long as the external influencing conditions such as, for example, the temperature are kept constant. As mentioned above, the micropump 10 which is proposed according to the invention operates according to the push/pull operating mode, that is to say liquid is sucked in via the suction space 16 and liquid is forced out of the reservoir chamber 30, with the two said streams of liquid being identical in a first approximation. The micropump 10 consequently operates in the push/pull mode.

EXAMPLE

Micropump 10 With PTFE Diaphragm

[0050] In a reference example illustrating the method of functioning of the proposed pump principle for a micropump 10 for push/pull operating mode, a diaphragm filter holder made of acetal with a diameter of 25 mm from Novodirect, Kehl, Germany, Order number C13907 was equipped with a 25 mm disc of a PTFE diaphragm 21 with a 0.2 µm pore size. A sealing ring 24x2 mm made of silicone was positioned on the diaphragm 21 which was being used. A slurry of NH₄Cl in distilled water was prepared, and 600 µl of the crystal slurry was applied centrally to the PTFE diaphragm 21. The upper part of the filter holder was lined in the interior with a thin polyethylene film (thickness: 15 µm) and screwed in a seal-forming fashion to the lower part. The pump solution (0.9% NaCl in H₂O) was forced into the upper part through a connected hose and the hose was clamped off.

[0051] Salt crystals (cf. position 20) were poured into the suction space 16 under the diaphragm 21 through the hose opening in the lower part of the filter holder. Salt crystals 30 were poured into the space above the diaphragm 21 through the hose opening in the lower part of the filter holder. Saturated cooking salt solution was introduced using a spray. Excess air was removed by changing the pressure and by vibration. A hose which was filled with 0.9% NaCl solution was connected to the lower part of the prepared filter holder. The hose opened into a reservoir vessel with approximately 2 ml 0.9% NaCl solution, said vessel standing on a balance with a resolution of 0.000001 mg. The hose which was connected to the upper part of the filter holder was led into a further reservoir vessel with approximately 1 ml 0.9% NaCl in water which was located on a second balance. Both hoses were positioned in such a way that they were not in contact with the vessel. In order to protect against vaporization, both liquid volumes were coated with approximately 5 mm of mineral oil. The hose clamp was removed and after a run-in time of approximately 1 hour a continuous drop in weight of the first reservoir vessel occurred and there was a corresponding increase in weight of the other, second reservoir vessel. Changes in speed were converted in flow rates, from which an average flow of 48 ml per minute over a time period of 3 days was calculated.

EXAMPLE 2

Manufacture of a Silicone Diaphragm

[0052] A metal fabric, for example the mechanical reinforcement 43 illustrated in FIG. 3 which had individual reinforcing threads 44 running parallel to one another, comprised individual monofil wires with a diameter of 40 µm with a mesh width of 50 µm (manufacturer Carl Beisser GmbH, Magstadt, Germany) and was dipped into a solution of 50 g polydimethylsiloxane from Wacker-Chemie GmbH, Nünchritz, Germany) in 500 ml toluene. The metal fabric was then pulled out of the solution and was allowed to drip dry. After complete vaporization of the solvent at 60 °C, and a time period of approximately 12 hours, a diaphragm 21 which was permeable to water vapour and impermeable to liquid water, according to the illustration in FIG. 3, was completed.

EXAMPLE 3

Manufacture of a Spherical Silicone Diaphragm

[0053] A metal fabric, through the mechanical reinforcement 43 as in the illustration according to FIG. 3, comprising individual reinforcing threads 44 was pulled over a spherical shape with a diameter of 30 mm. The result was a structure which was configured in the shape of a hat and which was punched out of the metal fabric with a diameter of 40 mm. The metal fabric was dipped, similarly to example 2, in a silicone solution and then drip dried and dried at a temperature of 60° C. overnight.

EXAMPLE 4

Pump With a Reinforced Silicone Diaphragm

[0054] A micropump 10 according to the filter design specified with respect to example 1 was produced, but with the difference that a diaphragm according to example 2 was used. It was possible to detect an average flow through the
diaphragm 21 which was permeable to water vapour and impermeable to liquid water of 21 nl/min over a time period of 5 days.

EXAMPLE 5

Pump With Heated Silicone Diaphragm

[0055] A micropump 10 according to example 4 was produced, but with the difference that electrical contacts for making contact with the mechanical reinforcing fabric 43 were manufactured on two locations lying opposite one another on the diaphragm 21 which was permeable to water vapour and impermeable to liquid water. Current conductors were connected to the electrical contacts which were provided on the diaphragm which was permeable to water vapour and impermeable to liquid water. The current conductors were constructed in the form of sheathed copper leads and were bonded in a liquid-tight fashion into bores within the housing using cyanacrylate bonding agent. Such a test setup for a micropump 10 exhibited a virtually doubled average flow at 22° C. room temperature as soon as a heating current of 50 mA flowed through the reinforcing threads 44 of the mechanical reinforcement 43.

[0056] It is noted that terms like “preferably”, “commonly” and “typically” are not utilized herein to limit the scope of the claimed invention or to imply that certain features are critical, essential, or even important to the structure or function of the claimed invention. Rather, these terms are merely intended to highlight alternative or additional features that may or may not be utilized in a particular embodiment of the present invention.

[0057] For the purposes of describing and defining the present invention it is noted that the term “substantially” is utilized herein to represent the inherent degree of uncertainty that may be attributed to any quantitative comparison, value, measurement, or other representation. The term “substantially” is also utilized herein to represent the degree by which a quantitative representation may vary from a stated reference without resulting in a change in the basic function of the subject matter at issue.

[0058] Having described the invention in detail and by reference to specific embodiments thereof, it will be apparent that modification and variations are possible without departing from the scope of the invention defined in the appended claims. More specifically, although some aspects of the present invention are identified herein as preferred or particularly advantageous, it is contemplated that the present invention is not necessarily limited to these preferred aspects of the invention.

What is claimed is:

1. A micropump for delivering liquids at low delivery rates comprising:
   a reservoir chamber containing a liquid which is to be delivered, wherein the reservoir chamber is fed to a liquid sink;
   a suction space comprising a saturated pump solution;
   a condensation space comprising a saturated solution having a lower vapour pressure than the saturated pump solution;

2. The micropump according to claim 1, wherein the diaphragm is clamped between housing bodies of the micropump in the region of a joint.
3. The micropump according to claim 1, wherein the diaphragm is embodied as a hydrophobic microfiltration flat diaphragm.
4. The micropump according to claim 3, wherein the flat diaphragm has a pore size in the range between 0.05 μm to 1 μm.
5. The micropump according to claim 4, wherein the flat diaphragm has a pore size of 0.2 μm.
6. The micropump according to claim 1, wherein the diaphragm is embodied as a sealed, hydrophobic solubility diaphragm.
7. The micropump according to claim 1, wherein the diaphragm is provided with a mechanical reinforcement.
8. The micropump according to claim 7, wherein the diaphragm has a mechanical reinforcement which comprises monofil reinforcement threads.
9. The micropump according to claim 7, wherein the diaphragm comprises a silicone film on the upper and underside.
10. The micropump according to claim 7, wherein the diaphragm is embodied with a spherical formation as a self-supporting structure.
11. The micropump according to claim 9, wherein the silicone film is manufactured from interlinked polydimethylsiloxane.
12. The micropump according to claim 8, wherein a current can be applied to the mechanical reinforcement at the upper side and/or the underside of the diaphragm in order to influence the delivery rate.
13. The micropump according to claim 1, wherein the saturated solution in the condensation space is a salt solution and is accommodated in the condensation space in the salt depot.
14. The micropump according to claim 13, wherein the depot contains NH₄Cl or LiCl salts.
15. The micropump according to claim 1, wherein an NaCl solution is contained in the suction space.
16. The micropump according to claim 1, wherein the an impermeable wall is flexible and impermeable to the saturated solution in the condensation space and the liquid in the reservoir chamber.
17. A method of delivering liquids at low delivery rates using a micropump, the method comprising:
   containing a liquid to be delivered in a reservoir chamber, wherein the reservoir chamber is fed to a liquid sink;
   pumping a saturated pump solution into a suction space;
   pumping a saturated solution having a lower vapour pressure than the saturated pump solution into a condensation space;
separating the suction space and the condensation space by a diaphragm, such that the diaphragm is permeable to water vapour and impermeable to liquid water;

separating the condensation space and the reservoir chamber by an impermeable wall;

vaporizing water out of the suction space into the condensation space through the diaphragm;

increasing the volume of the saturated solution in the condensation space;

exerting a pressure on the impermeable wall; and

driving the liquid out of the reservoir chamber.

* * * * *