

# DATA SHEET FC Pump

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The FC Pump was developed for low power pumping of alcohols such as ethanol and methanol. Intended uses are indirect pumping using alcohols as driving liquid, and fuel cells.

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## Ordering Information

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## General

Osmotex' electroosmotic (EO) pumps have the following advantages:

- Very compact disc-shaped design, typical dimensions Ø15mm, thickness 2-4mm
- Do not create gas bubbles in flow path given a certain counter pressure (some versions)
- Reduced influence of electrochemistry
- Low power
- Silent
- Low cost, suitable for volume applications

Osmotex develops advanced EO pumps with strongly reduced influence of electrochemistry and bubble formation, when used in the correct way. Electrochemical reactions should still be considered when considering new liquids.

While Osmotex' standard products cover a wide range of power, flow rates, liquids and other conditions, Osmotex can also develop customized solutions when needed.

Standard pumps are delivered un-calibrated. Like for other EO pumps, the flow – pressure – voltage characteristics depends on the liquid used. Osmotex also offers robust solutions with flow-sensor feedback control.

## “Electrolysis – Free” Operation

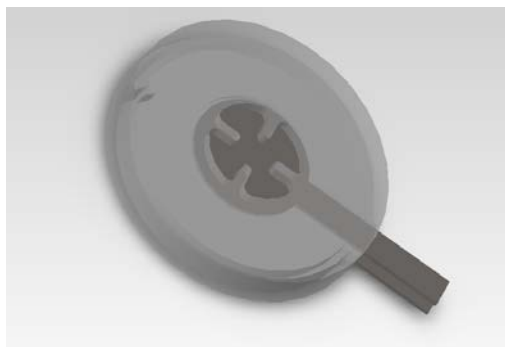
Osmotex' FC Pump include reversible electrodes to suppress un-desired electrochemical processes. As a result, the voltage (and hence the liquid flow) must be reversed at intervals of up to ca 6 hours. Although electrochemical reactions are never totally absent, this results in a smooth and bubble-free flow between the reversals. A flow rectifying valve system is offered to create a uni-directional flow (see below).

## Package and Measures

Shape: Circular disc  
Diameter: 14 mm  
Thickness: 1.8 mm

Despite different characteristics, all Osmotex micropumps are embedded in the same type compact plastic package (diameter 2cm, thickness 2mm to 4mm). These “Pump Cores” (figure 1) do not include fluidic and electric connectors.

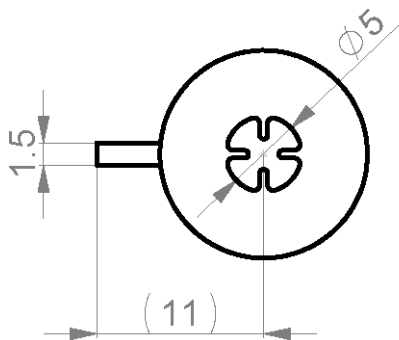
Osmotex also offers an evaluation package with fluidic and electric connectors (figure 1).



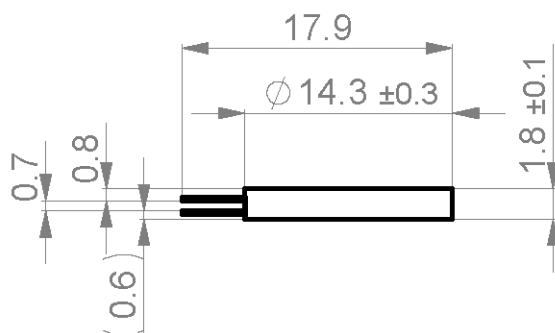
**Figure 1: Osmotex micropump “Core”. The liquid flow generated is perpendicular to the clover-shaped area in the disc center.**

## Geometry and Interfacing with Connectors

In the following is included information necessary to design fluidic and electrical connectors. The clover shaped area in the centre must be available for liquid flow, while the area around can be used for sealing. For example, a flat rubber gasket with diameter large enough to encircle the clover can be pressed against the Pump Core.



**Figure 2: Top/bottom view.**



**Figure 3: Side view.**

### Other Diameters

The standard version has electrode diameter 6mm (open flow diameter 5 mm as shown on figure). Osmotex also offer versions with diameters 4 and 8 mm, with maximum flow rates approximately half and double that of the standard version, respectively.

### Sealing

The micropump can be interfaced with fluidic connectors using a gasket, for example made of a rubber such as NBR, FKM or (for less deformation) EPDM. It is important that the rubber does not block the gas venting holes and that the gass is allowed to pass to the atmosphere.

## Geometry – Future Version with Integrated Electrical Connectors

Osmotex plans to launch a version of the micropump with electric connectors on the top face of the disc shaped Pump Core. This will provide a more compact design without leads sticking out from the periphery. The exact measures of the product might differ from the provisional measures presented in this section.

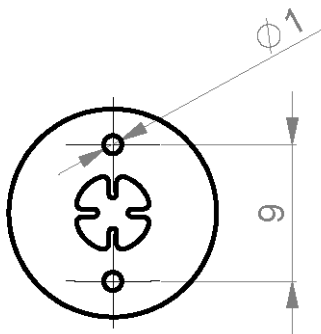


Figure 4: Top view, integrated connectors (provisional measures).

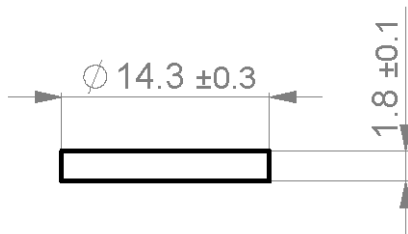
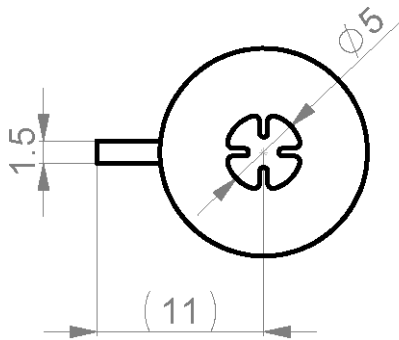


Figure 5: Side view, integrated connectors (provisional measures).



**Figure 6: Bottom view, integrated connectors (provisional measures).**

## Customized Solutions

Osmotex can engage in application specific development for producers of end user equipment. Our broad expertise in electrokinetics and microfluidics makes us ready to meet most challenges, whether the need is a simple pump with package, a robust design with flow rate feedback control, or the integration of several pumps on a chip.

## Application notes

### Filling and Flushing

The pump can be primed by using a syringe while taking care not to inject air to the pump or applying excessive pressure.

To obtain stable flow, there should be a constant water level in the inlet reservoir.

NB Electroosmotic pumps cannot suck air and are not self priming.

## Liquids

The pump has been tested for Methanol and Ethanol. Other polar organic liquids might show a similar performance, depending on their properties. For aqueous solutions it works similarly to the LS Electrolysis Free micropump (see corresponding data sheet).

## Precaution

The pump should not be run at higher voltages than 20V (15V for aqueous or higher conductivity solutions) and should never be allowed to run dry, as this could lead to breakdown of the electrodes and porous pump structure.

## Gas-free operation – Regeneration Modes

Osmotex FC Pump has palladium electrodes to avoid catalytic bubble formation. Hydrogen will under many circumstances act as the main positive current carrier, and the storage capability of palladium eliminates the formation of hydrogen bubbles at the cathode. The pump should always be operated with (very) low frequency AC voltage in order to avoid emptying or overfilling either hydrogen storing electrode. Further, the current should never be so high as to result in surface filling (over saturating the electrode surface with hydrogen, leading to damage). A dual polarity square pulse signal with variable duty-cycle can be used. In order to stay within these safe conditions, the current should be electronically monitored and voltage amplitude and direction adjusted as necessary (e.g. change direction of voltage before one electrode is over filled or emptied). A less sophisticated control system might be used (e.g. applying pulses of equal amplitude and duration but opposite sign), however the pump lifetime and performance will be reduced.

Max charge storage capacity of each electrode: ca 8 Coulomb (2.2 mAh).

Critical current for surface filling of hydrogen storing electrode: ca 40 mA

Recommended max current: 10 mA.

During the initial half-cycle, hydrogen will be generated and stored in the negative electrode (cathode). It is recommended to pre-fill with up to 80% of the total hydrogen storage capacity, and then move an amount of charge corresponding to 60% of the total charge in subsequent half-cycles of a low frequency square pulse signal. This leaves a margin of 20% from over-filling an electrode.

For example:

1. Apply 10 V until a total charge of 1.76 mAh has been transferred
2. Apply 10 V with opposite polarity until a charge of 1.32 mAh has been transferred
3. In subsequent use, reverse the polarity (and hence flow direction) every time a charge of 1.32 mAh has been transferred in one direction

Flow direction: towards positive electrode.

Osmotex electronic control unit OPC-20 handles the flow reversals automatically, and can simultaneously control a valve system assuring uni-directional flow in synchronization (see below).

## Appendix

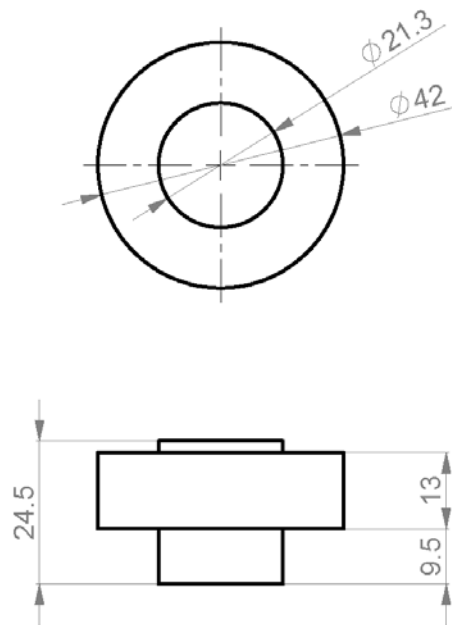
### Auxiliary Equipment

Osmotex can deliver the FC Pump embedded in an open reservoir evaluation package with standard fluidic and electrical connectors.

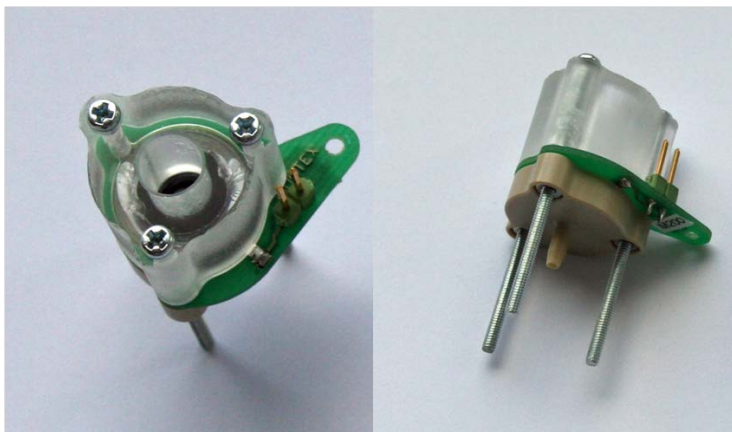
### Evaluation Package



**Figure 7: Closed evaluation package with fluidic and electric connectors (right) and its parts including the “Pump Core” (left). The fluidic connector has inner diameter 1.7 mm and outer 2.5 mm.**



**Figure 8: Osmotex' closed connector would fit into a cylinder as shown (top and side views).**



**Figure 9: Evaluation package with fluidic and electric connectors and open inlet reservoir. The fluidic connector has inner diameter 1.7 mm and outer 2.5 mm.**

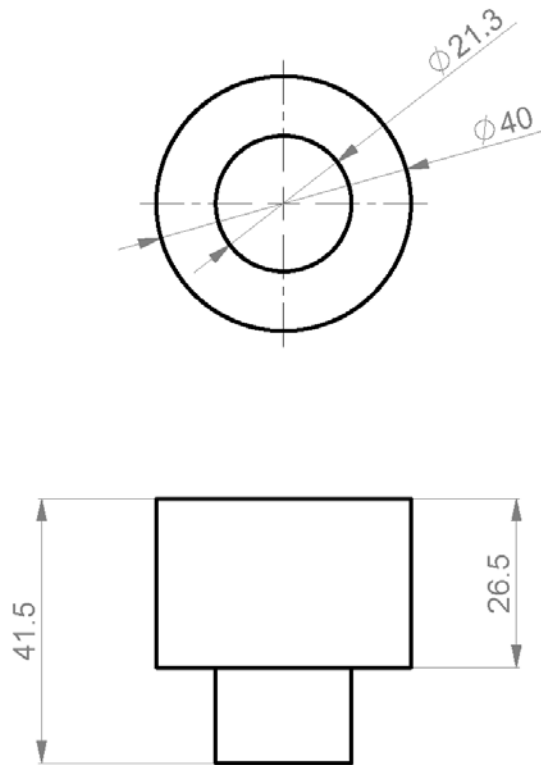


Figure 10: Osmotex' open reservoir connector would fit into a cylinder as shown (top and side views).

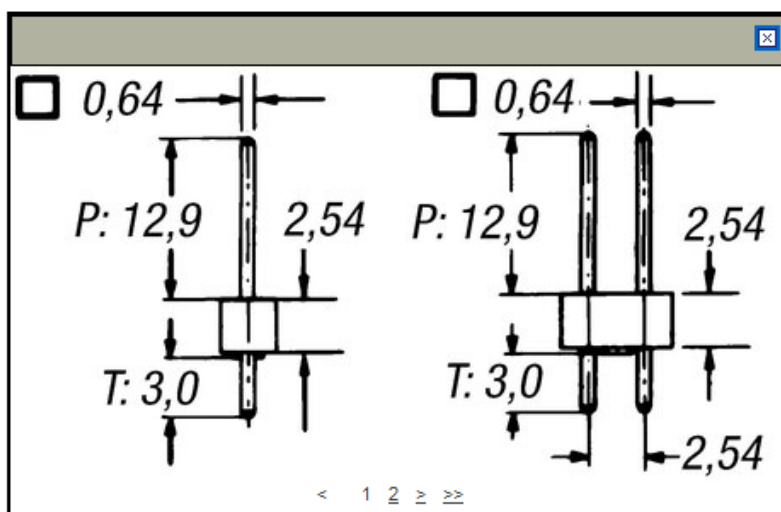


Figure 11: Electrical contact at connectors.

## Electronic Control Unit

Osmotex OPC-20 electronic controller can be used for the following purposes:

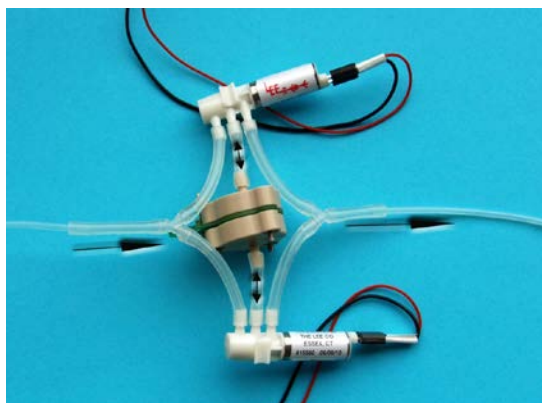
- Programmable power supply for micropump operation (USB interface to PC)
- Controlling the reversal rate for bubble-free operation
- Automatic control of the valve rectifier system
- Flow feedback control (with flow sensor) for high precision flow

## Flow Sensor Feedback Control System

Osmotex offers a solution with flow sensor for high accuracy pumping, see data section.

## Valve Flow Rectifier

As the bubble-free micropump needs flow reversals at certain intervals, Osmotex developed a flow rectifier giving a uni-directional flow to the application. On figure 12, the right-pointing arrows indicate the directed flow, while the smaller double arrows show the pumping back- and forth. It might be further adapted to an indirect pumping system which is not dependent on limited reservoirs. Although the use of small passive valves was demonstrated to work well for several hours, passive valves are only considered to be reliable enough with future high pressure versions of the pump core. At the moment, standard electromechanical valves are used. Being bi-stable, the valves are only actuated at the moment of switching, resulting in low power consumption (at the level of the pump's) and less mechanical wear. The valves are controlled in synchronization with the pump by Osmotex electronic control unit



**Figure 12: Flow-rectifying valve system.**

## Example Data

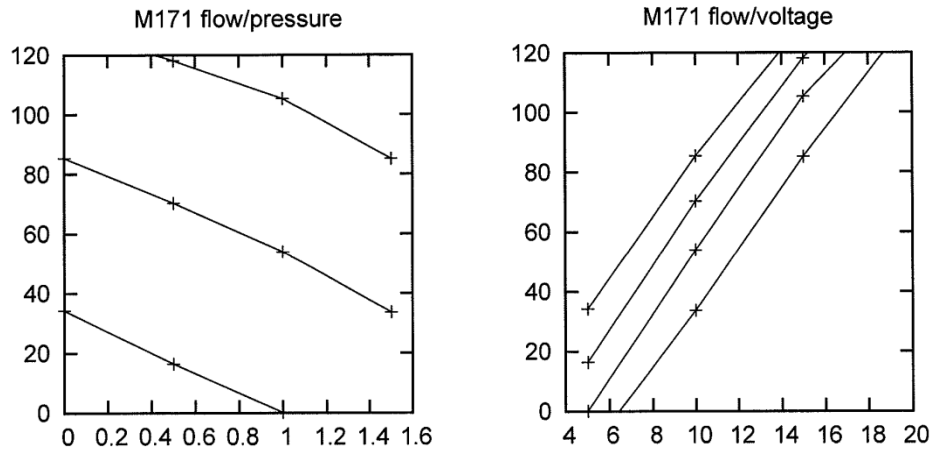
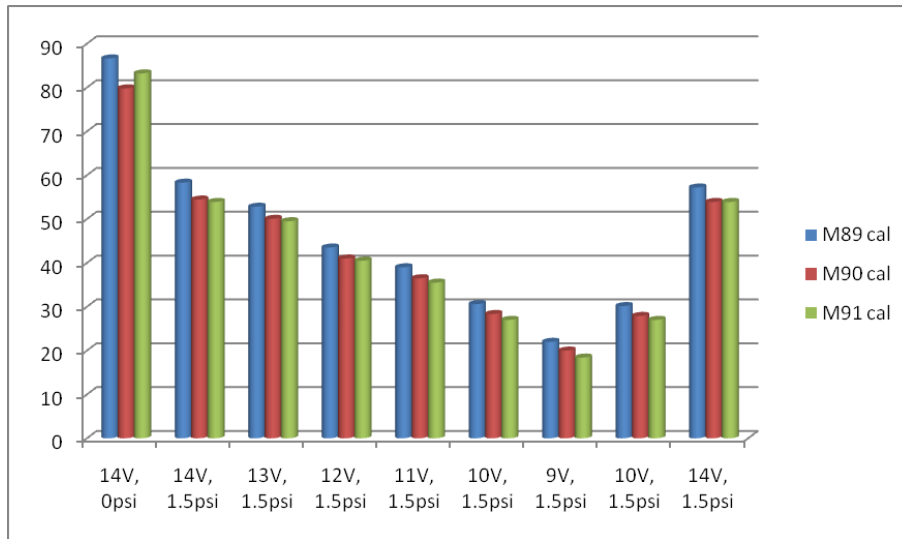
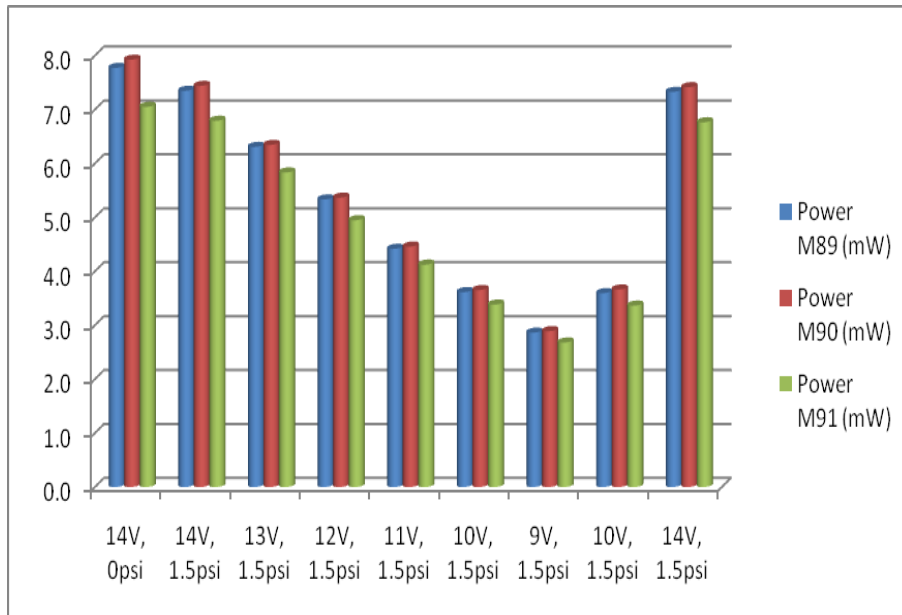


Figure 13: Left: Flow in  $\mu\text{l}/\text{min}$  vs pressure at 5, 10 and 15 V. Right: Flow vs voltage at 0, 1, 2, 3 PSI (0, 69, 138, 276 mBar).



**Figure 14: Comparison of flow rates for 3 micropumps (methanol).**



**Figure 15: Comparison of power consumption for 3 different pumps (methanol)**

## High-Accuracy Flow-Feedback System

Osmotex' feedback system is based on Sensirion Flow sensors.

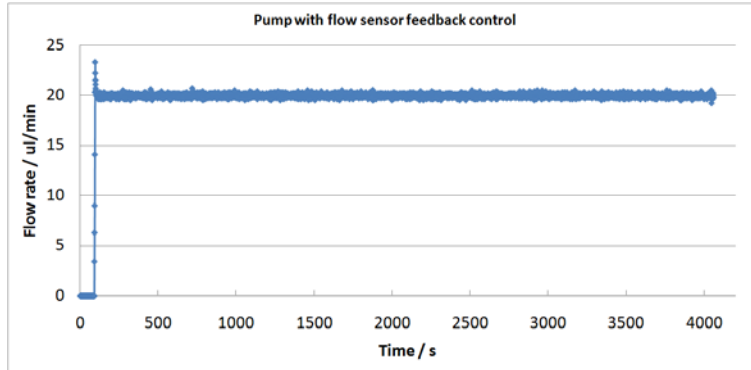


Figure 16: Flow sensor and high precision flow with feedback loop.