



OSMOFUSOR - osmotically driven fully MRI compatible infusor / drug applicator

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Problem and Proposal

Imaging Problem:

Most medical infusors are NOT MRI compatible (and the ones that are, still need to remain in a safe distance).

Patient Problem:

Low constant flow rates are difficult to achieve. Patients with continuous medication need may not be able to undergo a MRI examination.

Technical Challenge:

Non-magnetic pump/push drive mechanism required that does NOT need electrical power.

Proposed Solution:

Use an **osmotic drive** to push a conventional syringe. Natural principle that does NOT require any electrical components.

Desired Specifications:

Cheap, consumable, easy to use, easy connectivity to standard tubing, adjustable flow rate (0.5ml/h to 5ml/h preferably higher), non-magnetic, non-ferrous, no electrical components, fully MRI compatible (7T), can be placed directly next to the patient

MRI compatibility

Imaging Results

- Picture below shows MRI imaging phantom with OSMOFUSOR next to it (syringe and reservoir are visible on the right edge of the image) - imaging sequence on Siemens Allegra 3T syngo t2_tse_tra_448_5mm, 336 x 448, TE 98, TR 4600



- No magnetic attraction at all -- see bore of 3T MRI with OSMOFUSOR directly placed inside (bottom left)
- Slight reduction of S/N with OSMOFUSOR in operation (~4%) which could also be due to measurement error (placing ROI's)
- No artefacts visible and measurable
- Infusion worked without any problems

Results and Discussion

Results:

The OSMOFUSOR worked without any problems in the magnetic environment of up to 3T (see picture above right -- in magnet bore). Due the absence of any electronic components and the exclusive use of non-magnetic materials, and since osmotic gradient exchange is a natural physical principle, we do not believe that the system will perform any differently in 7T or even higher fields. The achievable flow rates are currently around 2ml/h.

Discussion:

We experienced some reduction in S/N of the MRI image with an OSMOFUSOR in operation. We are currently not sure of the reason. Some of the negative deviation could be a result of not perfectly matching the ROI on the spherical imaging phantom. Absolutely no imaging artefacts were seen and no magnetic attraction force experienced.

The device needs to be changed to accept larger syringes, but in general the design has the chance to be manufactured for relatively low-cost at volumes. The achievable flow-rates need to be increased to make the product a viable alternative.

Next Steps / Improvements:

Flow rates can be doubled / tripled by running two and three systems in parallel respectively or by including two or three of the current osmosis drives. The flow-rate with one system should be adjustable from 0.5ml/h to 5ml/h in 0.5ml/h steps in the next version of the device due at the beginning of next year. That would allow a maximum achievable flow rate of 15ml/h.

We will also try the systems for anaesthetic infusion of small MRI imaging in the coming months.

Other applications - also non-MRI related - are possible (e.g. Ultrasound Contrast Media, constant flow insulin infusion, transcatheter pumps, ...) and the drive could be a platform infusion device for low-flow-rate applications.

References

- Friebe, M., H. Adleff, B. Tombach. Metal and Electronic Free Fully MRI Compatible Medical Infusor Based on Osmotic Pressure. European Society for Magnetic Resonance in Medicine and Biology Congress, Poster Presentation, 2011.
- Patent applications US 2007/0088338 + US 2009/0129945 -- Osmotic Pump
- Patent application DE 10 2011 018604.2 -- Medical Infusor for application in strong magnetic environments

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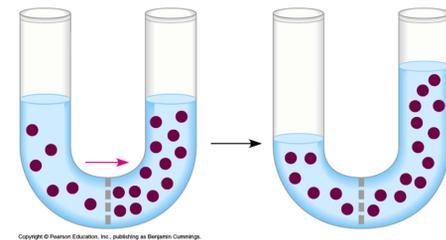
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The Osmotic drive -- OSMOFUSOR

Osmotic Actuation:



concentration gradient drives flow through membrane -- no power required

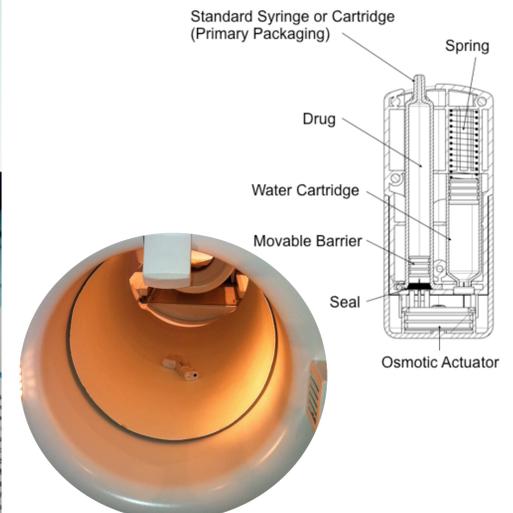
Common Osmotic Pumps:

- + pulse free flow
- + high pressure capability
- decreasing flow rate
- not adjustable

Our Osmotic Pumps:

- + pulse free flow
- + high pressure capability
- + compensate dilution of osmolytes
- + no decrease in flow rate**
- + controllable flow

- Manufactured a special infusor for MRI operation - replaced all non-MRI compatible materials
- Included an adjustable flow-rate dialer (changes the semi-permeable)
- Allows conventional syringes to be used (currently 2ml - next version additionally 10ml)

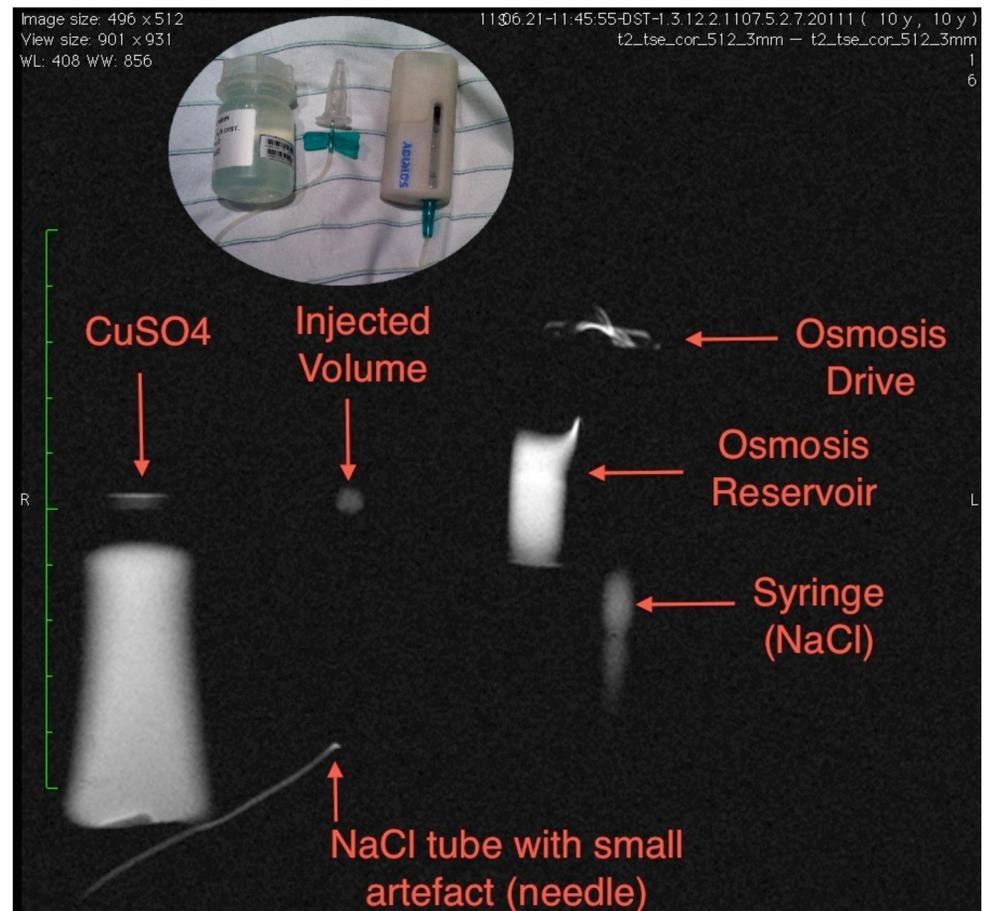


MRI picture of the test setup

The OSMOFUSOR placed next to a small imaging phantom (to provide the necessary load) - MRI image nicely shows the reservoir, the filled syringe (NaCl solution), the tubing to the little container for the injected volume, the osmotic drive and the needle.

The inserted photo on the MRI image below shows the setup placed on a pillow as used for the MRI imaging.

The infusion volume was about 2ml in one hour of MRI imaging, exactly what was pre-adjusted.



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