Supplementary Information

Magnetization of Magnetic Composite

The measurement of magnetization (emu) versus applied field (Oersted) were taken using SQUID magnetometer (Quantum Design, CA, USA) and were derived in SI units using the composite density. Fig SI-1shows the magnetization curve of the magnetic composite measured at both 23°C and 37°C.

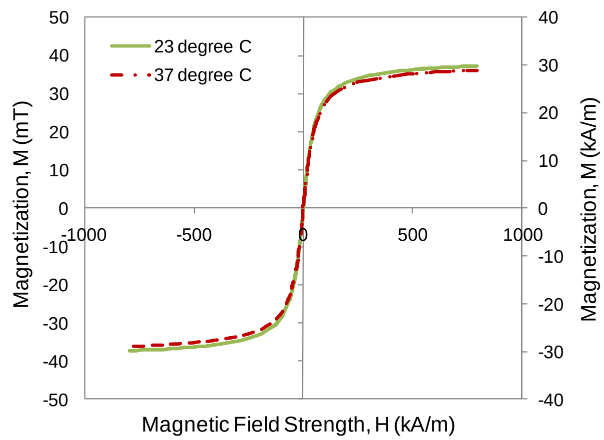

Fig SI-1 Magnetization of the magnetic composite material in 23°C and 37°C.

Magnetic Field Strength of the Permanent Magnet as a Function of Distance

The magnetic field of the permanent magnet was characterized as a function of the distance from the centre of the magnet using a F. W. Bell Gaussmeter (Sypris Test & Measurement, FL, USA).

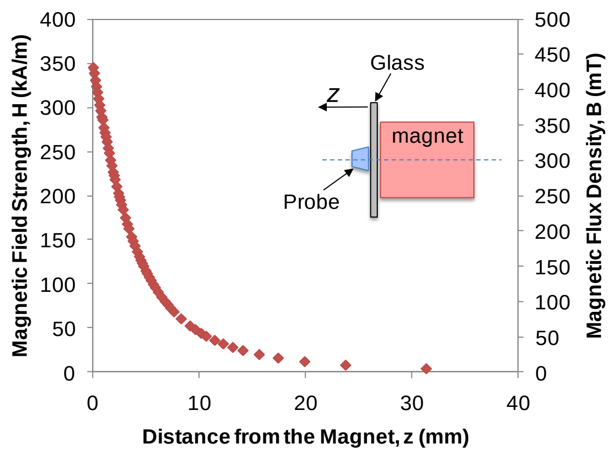

Fig. SI-2 Magnetic field strength of the permanent magnet as a function of the distance from the surface of the magnet (neodymium, diameter=½", thickness=¾").

Theoretical Magnetic Force on Membranes

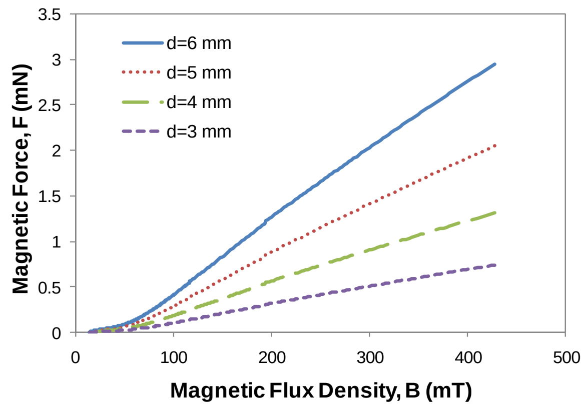

Fig. SI-3 Theoretical force exerted on membranes with a nominal thickness of 40 μm in the permanent magnet generated field.

Surface treatment of Magnetic PDMS Membrane

As shown in Fig SI-4-a and b, due to the non-wetting property of the magnetic PDMS surface, the capillary forces oppose the flow through the aperture and a portion of surface tension ($\sigma \cos \theta$) acts on the wall boundary of the flow front. The required pressure to overcome the surface tension can be determined using Young-Laplace equation[1]

$$\Delta P = \sigma \left(\frac{1}{R_1} + \frac{1}{R_2}\right) \quad (6)$$

where σ is the surface tension of fluid and R_1 and R_2 are the principal radii of curvature of the flow front. For the rectangular laser-cut apertures the width and height of the aperture are equal, thus $R_1 = R_2 = R$. From the geometrical relations (Fig SI-4-b) the curvature radius can be determined as

$$R = \frac{w}{2\cos(\pi - \theta)} \quad (7)$$

where w is the width of the aperture. Substituting Eq. (7) in (6) results in

$$\Delta P = \frac{4\,\sigma \cos(\pi - \theta)}{w} \quad (8)$$

For a circular aperture, w is replaced by the diameter of the aperture. Fig SI-4-c shows the required capillary break pressure versus aperture size in different contact angles while the surface tension, σ, for air-water interface is 0.072 N/m. It suggests that increasing the aperture size is not an effective way to decrease the required pressure for larger aperture sizes. Moreover, increasing the aperture size is not desired since it will increase background diffusion, i.e. leaking of drug from the reservoir. Fig SI-4-c also shows that reducing surface hydrophobicity leads to requiring smaller pressures to overcome capillary forces. As shown in Fig SI-4-a, in order for the fluid to flow through the aperture, the force that is provided by application of a magnetic field on the membrane should overcome the capillary force. However, according to previous analysis, our permanent magnet setup can provide pressures of up to ~110 Pa on the magnetic membrane which is not enough pressure for the fluid to flow even at aperture size of 400 μm.

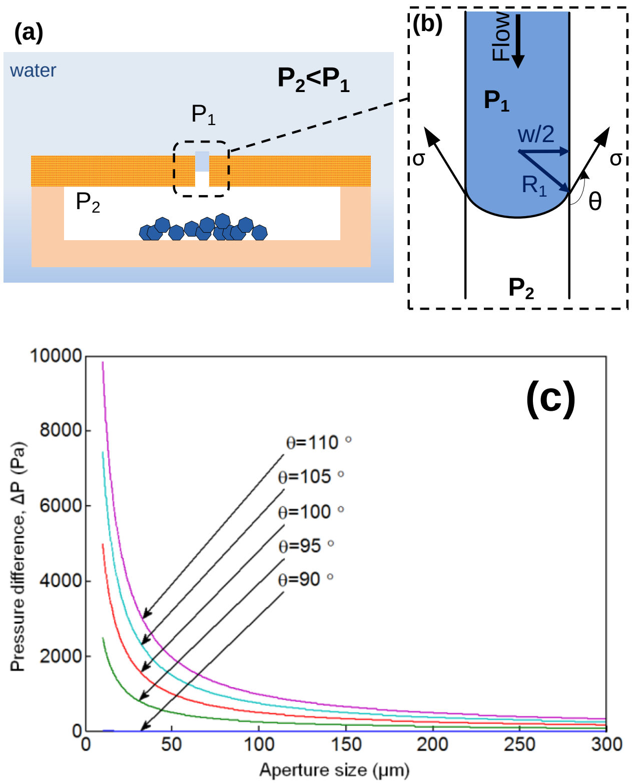

Fig SI-4 (a) Dry drug in a reservoir while immersed in water. An external pressure is needed to overcome capillary forces through the aperture to allow water go into the reservoir, (b) Pressure-driven flow with surface tension opposing the fluid flow, (c) capillary break pressure as a function of aperture size and contact angle

The Effect of Incubation Time in Surface Treatment

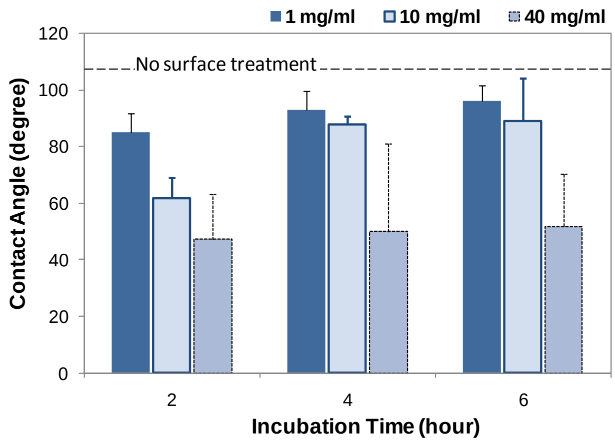

Fig. SI-5 The effect of incubation time and BSA solution concentration on the surface wettability of the magnetic PDMS material

Refernce

1. G. Frank, M. Rabold and P. Woias, *Journal of Micromechanics and Microengineering*, 2006, **16**, 1321-1330.