Electronic Supplementary Information - ESI

Miniature stick-packaging – an industrial technology for pre-storage and release of reagents in lab-on-a-chip systems

Thomas van Oordt*, Yanick Barb, Jan Smetana, Purav Shantilal Vora, Günter Roth, Roland Zengerle and Felix von Stetten*

*to whom correspondence should be addressed:
Email: *thomas.van.oordt@hsg-imit.de & vstetten@imtek.uni-freiburg.de

The supporting material includes:

(1) The influence of additional zirconium oxide beads in stick-packs on the burst pressure.

(2) A movie file showing release of water upon centrifugation (105 kPa 55 Hz) according to **Fig. 1** (stick-pack without constriction) and **Fig. 4**(stick-pack with constriction).

1) Zirconium oxide beads

Stick-packs can be equipped with additional beads (zirconium oxide, 1 mm diameter, Fritsch, Germany). On a centrifugal system the high density of the bead (6 g/cm³) causes additional pressure on the frangible seal and the stick-packs burst at a lower rotational frequency compared to those without beads. The shift of the frequency is measured with 7 mm wide stick-packs filled with 250 µl water with and without one additional bead. The results are compared to the theoretical shift of the frequency:

The centrifugal pressure difference along a liquid column (stick-pack) on a rotating disk with innermost radius r_1 and outermost radius r_2 is given by

$$p_{liquid} = \frac{1}{2}\rho(2\pi f)^2(r_2^2 - r_1^2) \qquad (1)$$

where ρ is the density of the liquid and f the spinning frequency. The additional force of a single zirconium oxide bead in the liquid is given by the expression

$$F = {}_{\Delta}\rho V(2\pi f)^2 r_2 \qquad (2)$$

where ${}_{\Delta}\rho$ is the difference of the densities (zirconium oxide and water) and V is the volume of the bead. To obtain the pressure we assume that during peeling about the half of the area of the bead is in contact with the frangible seal

$$p_{bead} = \frac{2F}{\pi d^2} = \frac{2\ {}_{\Delta}\rho V(2\pi f)^2 r_2}{\pi d^2} = \frac{{}_{\Delta}\rho d(2\pi f)^2 r_2}{3} \qquad (3)$$

where d is the diameter of the bead. At the burst pressure the total pressure on the seal of a stick-pack with one single bead is

$$p_{burst} = p_{liquid} + p_{bead} = \frac{1}{2}\rho(2\pi f)^2(r_2^2 - r_1^2) + \frac{{}_{\Delta}\rho d(2\pi f)^2 r_2}{3} \qquad (4)$$

and solved for the frequency:

$$f = \sqrt{\frac{p_{burst}}{\frac{1}{2}\rho(r_2^2 - r_1^2) + \frac{1}{3}\ {}_{\Delta}\rho d r_2}} \times \frac{1}{2\pi} \qquad (5)$$

The burst frequency of a water filled stick-pack on a centrifugal disk is measured and the burst pressure is then calculated according to eqn (1). Now the burst frequency of a stick-pack with the same seal strength but with an additional zirconium oxide bead can be estimated according to eqn (5). The change of the radial positions of the liquid column due to the additional bead is less than 0.5 % and can be therefore neglected.

The theoretical change of the burst frequency according to eqn (5) of strongly bonded stick-packs corresponds well with the measurements. The measured frequency drop is 6.9 Hz (STDV 2.1 Hz, n = 10) the calculated one is 5.6 Hz (r_1 = 3.2 cm, r_2 = 4.4 cm with a burst pressure of 116.9 kPa).