Supplementary Information

A. Flow during wet-out in strips with expansions of different widths

For a strip containing an expansion, the width of the expansion can be used to vary the transport time of the fluid front through the strip. Figure S1 shows a series of images of transport of the fluid front in strips with different width expansions. The transport time of the fluid front in the strip of constant width is shortest. The transport time of the fluid front is greatest in the strip containing the expansion to a greater width. Thus, an expansion in the width of an inlet leg can be used to vary the transport time of reagent delivered relative to other inlet legs.

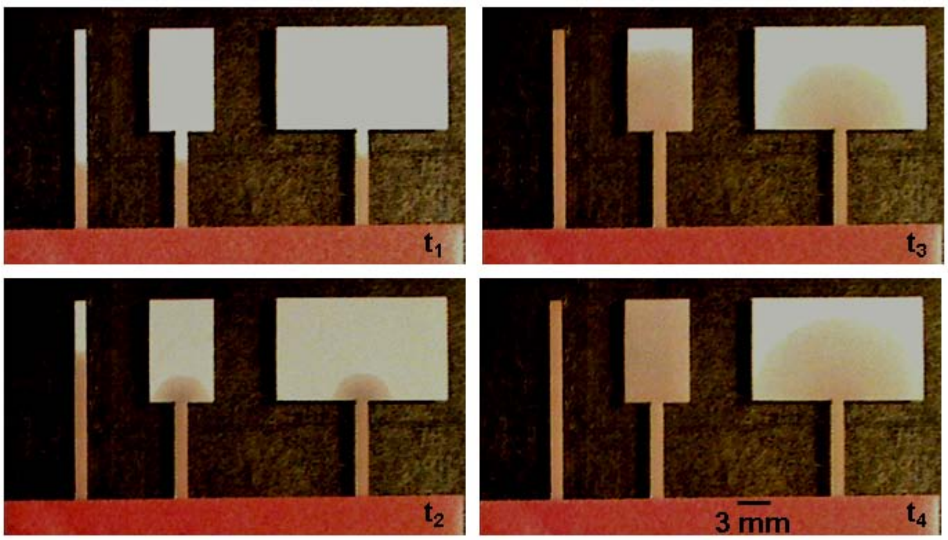

Figure S1. Transport of fluids during wet-out for strips with expansions of different widths. A constant width strip is also shown for comparison. The effect of an expansion of greater width is to slow the advancement of the fluid front through the strip relative to that in a strip with an expansion of smaller width.

B. Minimizing Transport Time in a Contraction

This can be understood through a straightforward analysis of transport based on the Washburn equation, assuming a simple velocity function in the first constant width segment that is consistent with the Washburn equation,

$$v(t) = \frac{v_0\sqrt{\tau}}{\sqrt{\tau+t}}\,, \qquad \text{(S1)}$$

where v_0 is the initial velocity, τ is the timescale over which the fluid column progression becomes linear, and the expression is valid for $0 < t < t_1$. It is assumed $t_1 \gg \tau$. The distance traveled in this section is described by,

$$d(t) = 2v_0\sqrt{\tau}\left[\sqrt{\tau + t} - \sqrt{\tau}\right]. \qquad \text{(S2)}$$

Assuming that the fluid front travels a distance d_1 to the end of the first segment of constant width at t_1,

$$d_1 = 2v_0\sqrt{\tau}\left[\sqrt{\tau + t_1} - \sqrt{\tau}\right], \qquad \text{(S3)}$$

and

$$t_1 = \left(\frac{d_1}{2v_0\sqrt{\tau}} + \sqrt{\tau}\right)^2 - \tau. \qquad \text{(S4)}$$

Analogous equations to (S2) though (S5), describe flow of the fluid front in the second segment of constant width. A velocity function consistent with Washburn behaviour at $t_1 \gg \tau$ is,

$$v'(t) = \frac{v_0'\sqrt{\tau}}{\sqrt{\tau + (t - t_1)}}, \qquad \text{(S5)}$$

where $v_0' = \frac{v_0\sqrt{\tau}}{\sqrt{\tau + t_1}}$ (here, the prime does not denote a derivative), and again τ is the timescale over which the behaviour becomes Washburn-like. The expression is valid for $t > t_1$, and the relative time is $t - t_1$. The distance traveled in the second segment of constant width is,

$$d(t) = d_1 + 2v_0'\sqrt{\tau}\left[\sqrt{\tau + t - t_1} - \sqrt{\tau}\right]. \qquad \text{(S6)}$$

Assuming that the fluid front travels a total distance d_T along both segments of constant widths in t_T,

$$d_T = d_1 + 2v_0'\sqrt{\tau}\left[\sqrt{\tau + t_T - t_1} - \sqrt{\tau}\right], \qquad \text{(S7)}$$

and

$$t_T = t_1 - \tau + \left(\frac{d_T - d_1}{2v_0'\sqrt{\tau}} + \sqrt{\tau}\right)^2. \qquad \text{(S8)}$$

Imposing $t_1 \gg \sqrt{\tau}$ and solving for the d_1 that minimizes t_T, results in,

$$d_1 = \frac{d_T}{2}. \qquad \text{(S9)}$$

C. Darcy's Law Flow in Strips of Two Constant Width Segments

For a strip composed of two constant width segments, with lengths L_1 and L_2, widths W_1 and W_2, and equal heights H, the volume of the strip is $V = L_1W_1H + L_2W_2H$ and the resistance of the strip is $R = \frac{\mu}{\kappa}\left(\frac{L_1}{HW_1} + \frac{L_2}{HW_2}\right)$. From equation (4), the transport time is proportional to,

$$\delta = (L_1W_1 + L_2W_2)\left(\frac{L_1}{W_1} + \frac{L_2}{W_2}\right). \qquad \text{(S10)}$$

Note that the expression is symmetric in L_1 and L_2. Assuming $\gamma = \frac{L_2}{L_1}$ and $\beta = \frac{W_2}{W_1}$, δ can be rewritten as,

$$\delta = L_1L_2\left(1 + \frac{1}{\beta\gamma}\right)(\beta + \gamma). \qquad \text{(S11)}$$

Taking the derivative with respect to β, results in,

$$\frac{d\delta}{d\beta} = L_1 L_2 \left(\frac{-(\beta+\gamma)}{\beta\gamma^2} + 1 + \frac{1}{\beta\gamma} \right). \qquad \text{(S12)}$$

Setting $\frac{d\delta}{d\beta} = 0$, and simplifying, results in $\gamma = 1$. This condition $L_1 = L_2$ corresponds to a local maximum, indicating that for any fixed non-equal width values, the greatest transport time can be obtained for equal length segments (and assuming the same $\frac{\mu}{\kappa\Delta P}$).

For $\gamma = 1$ or $L_1 = L_2 = L$, in the limit of $\beta \gg 1$, $\delta \sim L^2 \beta$, or $\delta \sim L^2 \frac{W_2}{W_1}$. Thus, longer transport times can be obtained by increasing the ratio in the widths of the segments (again assuming the same $\frac{\mu}{\kappa\Delta P}$).