A Simple Microfluidic Mixer Based on Suspensions

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Aim
Mixing in microfluidic devices is difficult, as flow is laminar. We solve this problem using fluctuations induced by the presence of sheared particles. It was recently shown that particles within a fluid greatly enhance transport properties in sheared non-Brownian suspensions.[1] We use this mechanism to create a highly efficient, active microfluidic mixer with a low pressure drop.

Methods
We design and construct a microfluidic chip (Figure 1) with a cylindrical mixing chamber, filled with 30-40% volume of glass particles. A small magnet is added to the chamber to drive the particles. Channel dimensions are chosen such that the glass particles are confined to the chamber. We pump a viscous fluid (\(\eta = 58\) mPas) in both inlets at equal rates. In one inlet, we add a dye to visualize mixing.

Mixing efficiency: Effect of driving rate
To evaluate mixing efficiency, we monitor intensity fluctuations in the outlet channel in the steady state. We measure the standard deviation \(\sigma\) of 45 pixels at different driving rates of the magnet. When the rate is set to zero, no mixing occurs (Figure 3a) and the standard deviation is maximized (\(\sigma_{\text{max}}\)). We define the mixing efficiency as \(\alpha = 1 - \frac{\sigma}{\sigma_{\text{max}}}\)[2]. The mixing efficiency is plotted as a function of driving rate in Figure 3b. The mixing efficiency is already maximized at very low driving rates.

Conclusion
We present a novel microfluidic mixer that is easy to fabricate and simple to use. The mixer features a single mixing chamber in which mixing-enhancing particles are driven by a moving magnet. The mixer is efficient for a range of driving rates and features a low pressure drop. These features make the mixer design compatible with soft chip material, and therefore ideal to incorporate in lab-on-a-chip devices.