Information on the position of each tube, reproducibility of mixing performance after opening and re-assembling, and the effect of deviations from the accurate alignment of the tubes

The photographs of the inner and outer tubes used to fabricate DTCF1-1 are shown in Fig. S1. The position of the inner tube in the outer tube of the accurately aligned DTCF1-1 is shown in Fig. S1(c). Once we fixed the desirable arrangement of each parts of DTCF-MX to realize the accurately alignment, we could reproduce the good mixing performance by using the DTCF-MX after opening the device and re-assembling (see Fig. S2(a) and S2(b)). On the other hand, the mixing performance became quite bad when the alignment of the inner and outer tubes was not accurate (see Fig. S2(c) and S2(d)). A solid, accurately aligned micromixer with the same design would be made by the usual microtechnologies. By using such micromixer, the disadvantage caused by displacement error would be overcome.

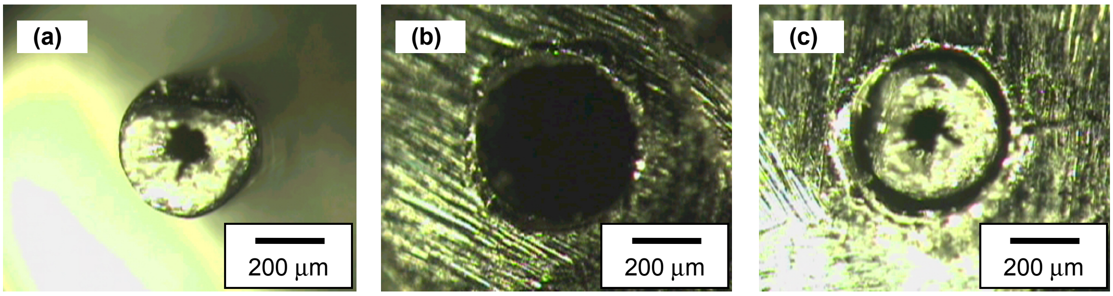

Fig. S1 Cross-sectional photographs of the inner tube (a), outer tube (b), and the position of inner tube of DTCF1-1 (c)

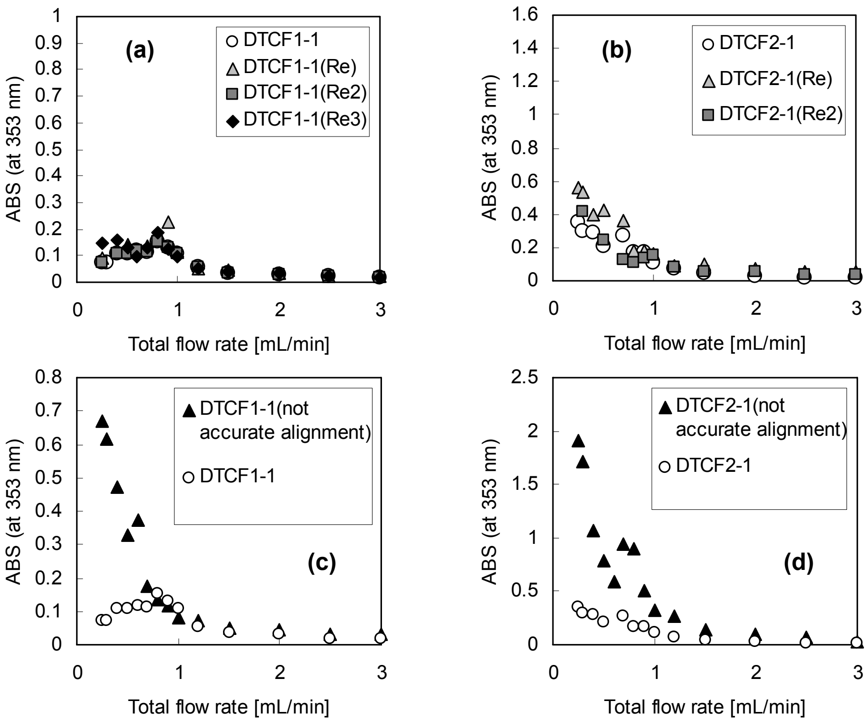

Fig. S2 Reproducibility (a, b) and effect of deviations from accurate alignment of tubes (c, d).

Pressure drop

We measured the pressure drops for DTCF-MXs, T-mixers and SSIMM with the HPLC pump. The pressure drops of each micromixer used in this study were same under the same experimental conditions. Such results were due to the large pressure drop in the tube used to connect the HPLC pump and the micromixers. The tube had 1.24×10^{-4} m of inner diameter and 0.2 m of length. In addition, we calculated the pressure drop for DTCF1-1 by using Hagen-Poiseuille equation because we found from the calculated Reynolds number that the flow in each zone of DTCF-MX was laminar. Figure S3(a) shows the experimental and calculated pressure drops for various total flow rates. Figure S3(b) shows the calculated pressure drops in each zone of DTCF1-1. As shown in Figure S3(a), the experimentally obtained pressure drops and the calculated ones were corresponding well. Furthermore, as shown in Figure S3(b), the pressure drop in the tube connecting HPLC pump and DTCF-MX is the largest. The results shown in Figure S3(b) also indicate that the pressure drops in each channel of DTCF-MX (i.e. inner tube, outer tube, and annulus between inner and outer tubes) are not particularly large.

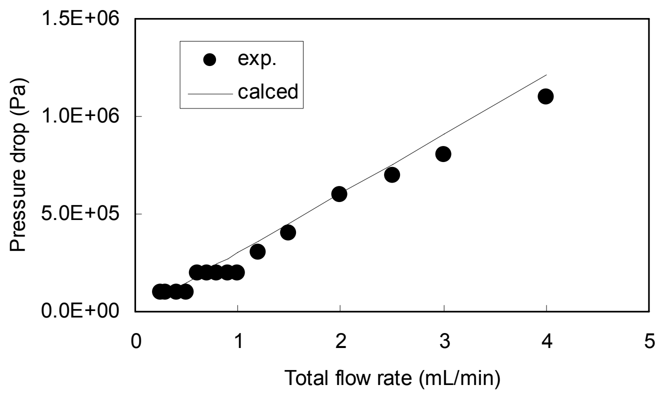

Fig. S3(a) Pressure drop measured and calculated with Hagen-Poiseuille equation.

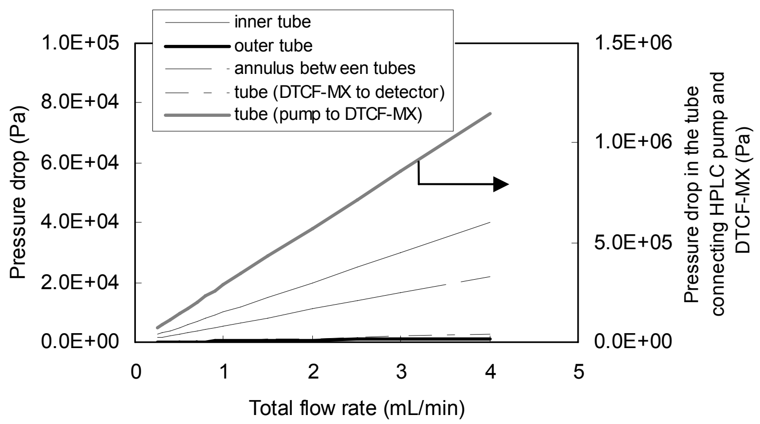

Fig. S3(b) Pressure drops at each zone calculated with Hagen-Poiseuille equation.

Table S1 Summary of shear rate at the mixing zone of DTCF-MX

total flow rate (mL/min)	Shear rate (s^{-1})		
	DTCF1-1	DTCF2-1	KM200-4-520
0.25	24.1	20.5	
0.3	28.9	24.6	
0.4	38.6	32.8	
0.5	48.2	41.0	50
0.6	57.9	49.2	
0.7	67.5	57.4	
0.8	77.2	65.6	
0.9	86.8	73.7	
1	96.5	81.9	
1.2	115.8	98.3	
1.5	144.7	122.9	
2	192.9	163.9	
2.5	241.2	204.9	
3	289.4	245.8	
4	385.9	327.8	401

Table S2 Summary of Reynolds numbers of DTCF-MX

total flow rate (mL/min)	DTCF1-1		DTCF2-1	
	Re(gap)	Re(exit)	Re(gap)	Re(exit)
0.25	6.2	11.1	6.0	11.1
0.3	7.4	13.3	7.2	13.3
0.4	9.9	17.7	9.6	17.7
0.5	12.3	22.1	12.0	22.1
0.6	14.8	26.5	14.4	26.5
0.7	17.3	31.0	16.8	31.0
0.8	19.8	35.4	19.2	35.4
0.9	22.2	39.8	21.5	39.8
1	24.7	44.2	23.9	44.2
1.2	29.6	53.1	28.7	53.1
1.5	37.0	66.3	35.9	66.3
2	49.4	88.4	47.9	88.4
2.5	61.7	110.5	59.9	110.5
3	74.1	132.7	71.8	132.7
4	98.8	176.9	95.8	176.9