Versatility and stability optimization of flowfocusing droplet generators via quality metric-driven design automation

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Device Description	Or (um)	OrL	W _d	Wc	E	A.R	Са	F.R.R
Orthogonal Device #1 (Figure 2)	75	1	2	2	2	1	.06-1.05	10-22
Orthogonal Device #2 (Figure 2)	75	1.5	2.5	2.5	3	1.5	.06-1.05	10-22
Orthogonal Device #3 (Figure 2)	75	2	3	3	4	2	.06-1.05	10-22
tOrthogonal Device #4 (Figure	75	2.5	3.5	3.5	5	2.5	.06-1.05	10-22
2)								
Orthogonal Device #5 (Figure 2)	75	3	4	4	6	3	.06-1.05	10-22
More Versatile (Figure 3)	75	3	2	2	4.5	1	.05-1.05	2-22
Less Versatile (Figure 3)	150	1	4	4	2	3	.05-1.05	2-22
More Versatile (Figure 4)	150	2	2	2	5	1	.05-1.05	2-22
Less Versatile (Figure 4)	175	1.5	2.5	2.5	2	1	.05-1.05	2-22
More stable (Figure 5)	175	3	2	2	3.5	1.5	.05-1.05	2-22
Less stable (Figure 5)	75	1	3.5	3.5	2	3	.05-1.05	2-22
More stable (Figure 6)	175	2.5	3	2.9	6	1	.05-1.05	2-22
Less stable (Figure 6)	175	3	3.3	3	2	1.5	.05-1.05	2-22

Supplementary Table 1: Overview of all droplet generators used in this study

Abbreviations: Or - orifice width; Or_L -normalized orifice length; W_d – normalized dispersed phase (water) input; W_c – normalized continuous phase (oil) input; E – Expansion ratio; A.R – Aspect ratio; Ca capillary number; F.R.R – Flow rate ratio

Supplementary Table 2: Correlation coefficients (R²) for design parameters and versatility scores in the dripping regime

	Or (um)	Or∟	W _d	Wc	E	A.R
Overall Score	-0.19	0.41	-0.13	-0.18	0.17	-0.51
Size Score	0.57	-0.06	-0.01	-0.20	-0.02	0.58
Rate Score	-0.53	0.39	-0.05	-0.03	0.012	-0.60

Interpreting R^2 values: -1.0 < R^2 < -0.7 – strong negative correlation; -0.7 < R^2 < -0.5 – moderate negative correlation; -0.5 < R^2 < -0.3 – weak negative correlation; -0.3 < R^2 < 0.3 – negligible correlation; 0.3 < R^2 < 0.5 – weak positive correlation; 0.5 < R^2 < 0.7 – moderate positive correlation; 0.7 < R^2 < 1.0 – strong positive correlation

Supplementary Table 3: Correlation coefficients (R²) for design parameters and versatility scores in the jetting regime

	Or (um)	OrL	W _d	Wc	E	A.R
Overall Score	-0.05	0.06	-0.58	0.33	-0.35	-0.05
Size Score	0.54	-0.15	-0.10	-0.23	0.66	0.26
Rate Score	-0.29	0.08	-0.46	0.3	-0.59	-0.18

Supplementary Table 4: Correlation coefficients (R²) for design parameters and stability scores in the dripping and jetting regime

	Or (um)	OrL	W _d	Wc	E	A.R	Са	F.R.R
Dripping	0.54	0.16	-0.10	0.09	0.09	0.06	-0.21	0.01
Jetting	0.47	0.02	-0.26	0.17	0.00	0.33	0.46	-0.06





Supplementary Figure S2: Distribution of versatility scores in both regimes (top), dripping regime (middle), and jetting regime (bottom).



Supplementary Figure S3: Diameter, generation rate, and overall versatility in the dripping regime.



Supplementary Figure S4: Main effect analysis of diameter, generation rate, and overall versatility in the jetting regime.



Supplementary Figure S5: Summary of flow rate combinations used for the more and less versatile devices in main figures 2 and 3



Supplementary Figure S6: Distribution of stability scores in both regimes (top), dripping regime (middle), and jetting regime (bottom).



Supplementary Figure S7: Main effect analysis of stability in the jetting regime.

Design Quality Metrics: Using 3 candidate designs, the versatility and stability metrics of each candidate generator was calculated. Output designs were ranked according to Stability. CLICK HERE to download the designs and quality metrics for all candidates. Below, you can see the performance ranges of the top-ranked devices regime (versatility) as well as how close the device is to a regime boundary (stability). More info on this methodology can be found here (Note: this link currently not * active, publication is in review). 0 **Droplet Generator Design:** 1 More Info Versatility (in both regimes): Stability: ٨ Fluid Properties **Overall score** Size score Rate score Stability score 33803.148 162.83 322.064 0.387 2 Example Datasets 350 0 µDrop Image Processing Tool Dripping letting Dripping ٠ 20.0 DAFD Solution 300 DAFD Solutio Meet the Team ł 17.5 250 15.0 Publications ate Ratio 200 12.5 Collaborate with Us 150 ▲ 인 10.0 100 7.5 50 5.0 2.5 100 150 Drop 200 Size 250 300 350 0.1 0.2 0.3 0.4 Capillary 0.5 0.6 v Number 0.7 0.8 0.9 50

Supplementary Figure S8: DAFD Quality metric design report. If specified by the user, upon completion of metrics-driven design automation, a companion report will be generated to contextualize the results for the user.



Supplementary Figure S9: Design space coverage of (a) the 25 orthogonal devices used in DAFD and (b) a selection of 5 of the orthogonal devices that can cover more than 99% of the design space.