Scientific contribution from Lonza –
Screening and classification of plate structures for enhanced mixing performance

FlowPlate® Reactor Technology to Control Multi-phase Reactions in Continuous-Flow Processing

Figure 1. FlowPlate patented LL-Triangle-Structure that shows a desirable Drop-Flow

The control of multi-phase reactions (liquid-liquid (LL)or gas-liquid) is of prime importance to enable broad application of flow technologies. The patented FlowPlate® Reactor Technology answers this challenge via a simple approach based on a deep understanding of reactor design and fluid mechanics. (Figure 1): During the development of a basic reactor structure for multi-phase applications, it was quickly realized that curvature is detrimental to mass transfer and, as a result, needs to be minimized. This work is nicely described in the following publication:
http://www.sciencedirect.com/science/article/pii/S1385894716305228

As seen in Figure 2, curvatures generate centrifugal forces which tend to separate phases, not mix them. Despite this, many microreactors or static mixers are designed using curvatures. Clearly this is a pitfall that needs to be avoided when dealing with multi-phase applications.

Figure 2. A typical unwanted Parallel-Flow pattern where the denser phase remains close to the wall

A key objective when developing a multi-phase structure is to generate the so-called drop flow (see Figure 1) at low pressure drop. This is exactly the case with the LL-Rhombus or LL-Triangle structures, though a preference is observed for the LL-Triangle. This is described in “Microreactor mixing-unit design for fast liquid—liquid reactions”
http://akademiai.com/doi/abs/10.1556/1846.2016.00026.

The next key question is how does such a structure behave with various solvents? This question is answered by Plouffe et al. who describe that interfacial tension has a substantial impact on mass transfer: the higher the value, the lower the mass transfer:
http://www.sciencedirect.com/science/article/pii/S1385894715014084

Finally, this research would not be complete without a scale-up study. Scale-up can be ensured at constant energy dissipation rate (pressure drop) when operating in the proper flow regime (e.g. Drop /Dispersed-Flow; see also Figure

3) The important conclusions are summarized here:
http://www.sciencedirect.com/science/article/pii/S0009250915007861

A- B-

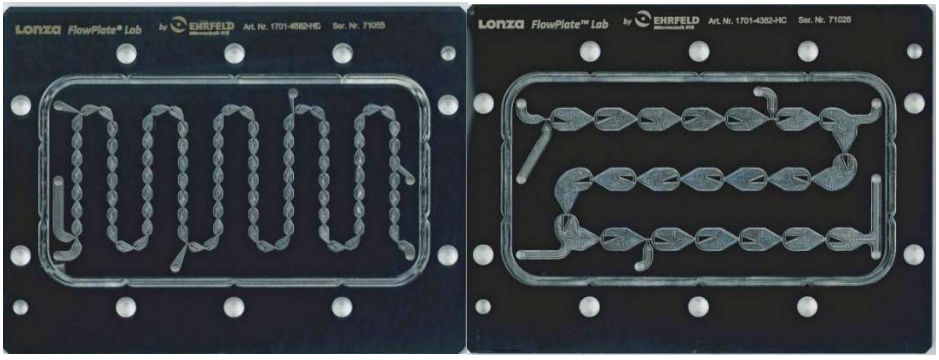

Figure 3. FlowPlate® Lab with LL-Triangle-Structure for small flow rate applications (A– 1–15 mL/min) and a scalable version at ten times this basic flow rate (B– 15-150 mL/min)

A video is also available showing a good-established drop flow:
https://www.youtube.com/watch?v=5-VEQyAPCBY

If you cannot access the publications linked to this article, please send us an email at: microreactor@lonza.com

If you have any questions, we will be pleased to answer them by phone, email or in a personal meeting. Visit us under www.ehrfeld.com to obtain an initial impression of our technology.

Or meet us in person at the next event:

9th Symposium on Continuous Flow Reactor Technology for Industrial Applications
14th-16th of November in Barcelona http://www.flowchemistrytks.com/

In case of further questions, please do not hesitate to contact us:
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