FLUIGENT PRESSURE CONTROL SYSTEMS & RAYDROP EMULSIFICATION EQUIPMENT - WATER IN OIL EMULSIONS

INTRODUCTION

Water in oil emulsions (W/O) form the basis manufacturing techniques widely used in the industrial and R&D environments to manufacture droplets (e.g. for compartmentalisation applications), hydrogel beads (e.g. alginate, agarose or polyacrylamide) and polymer beads (e.g. acrylic, vinyl and ethyl-based). Of particular importance, is the ability to produce high-quality, monodisperse droplets and the ability to do so reproducibly and at a viable production rate.

The combination of Fluigent pressure pump units and Raydrop microfluidic devices enable smooth fluid delivery, precision flowrate control, automation and reproducibility necessary to generate high quality water in oil emulsions.

In this application note, we present droplet generation data obtained using one of the most widely used water in oil emulsion systems – water in decane. We demonstrate the ability of Fluigent equipment coupled with Raydrop microfluidic devices to generate high quality emulsions with controlled droplet sizes and with high throughput.

MATERIALS AND METHODS

1. Reagents

Droplet Phase: Water (Mili Q)

Continuous phase: Decane + 2% (wt) SPAN 80

Reagent	Supplier	Catalogue number	Cas Number
Water	Ultrapure 18.2 MΩ – cm	-	7732-18-5
Decane	Sigma Aldrich	D901	124-18-5
SPAN 80	Sigma Aldrich	8.40123	1338-43-8

2. Microfluidic setup

The microfluidic setup was comprised of:

- 2x FlowEZ (2000 mbar) pressure pumps - *Microfluidic flow controller*

The Flow EZ is the most advanced flow controller for pressure-based fluid control. It can be combined with a Flow Unit to control pressure or flow rate. It can be used without a PC. Two Flow EZ with 2 bar of full-scale pressure are used in the setup presented here.

- 2x Flow units enabling flowrate control - *Flow sensor*

The Flow Unit is a flow sensor that allows real time flow rate measurement. By combining a Flow Unit with the Flow EZ, it is possible to switch from pressure control to flow rate control, allowing for the generation of highly monodispersed droplets over a long period of time. Two Flow Units M are used here to monitor and control the flow rates of the dispersed and continuous phase during the run.

- 1x RayDROP - *Droplet generator*

The RayDrop droplet and emulsion chip is used to control the generation of alginate droplet. The RayDrop is based on the alignment of two capillaries immersed in a pressurized chamber containing the continuous phase. The dispersed phase exits one of the capillaries through a 3D-printed nozzle, placed in front of the extraction capillary for collecting the droplets. This non-embedded implementation of an axisymmetric flow-focusing is referred to co-flow-focusing.

- *Optical microscope*

Fluigent high-speed camera is a package which contain all necessary instrument to have good optical instrument.

It contains:

- Microscope
- High speed camera
- Light controller

This package is connected with an USB 3.0 wire to a PC where the user can visualize its microfluidic device with the Pixelink Capture Software together with the Fluigent OxyGEN Software. The camera has been selected to reach rates up to 7028 fps which is ideal for droplet experiments.

3. Fluidic path

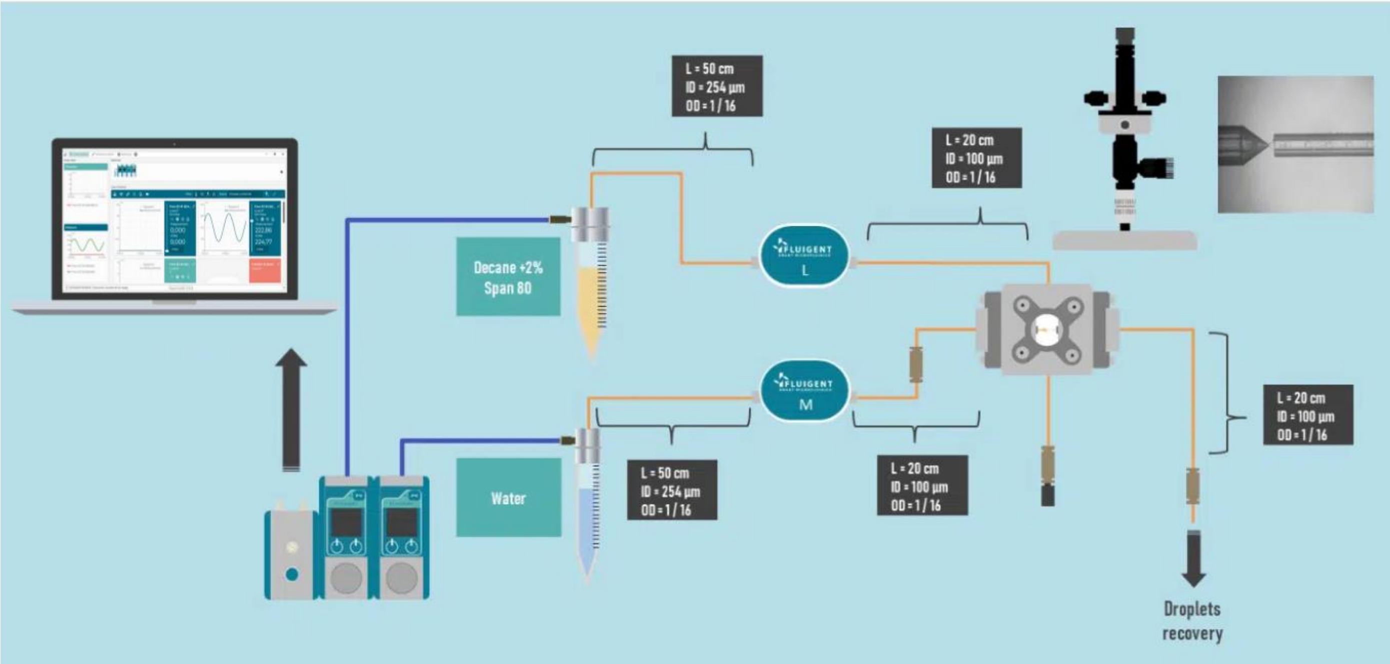

Figure 1: Scheme of the fluidic setup

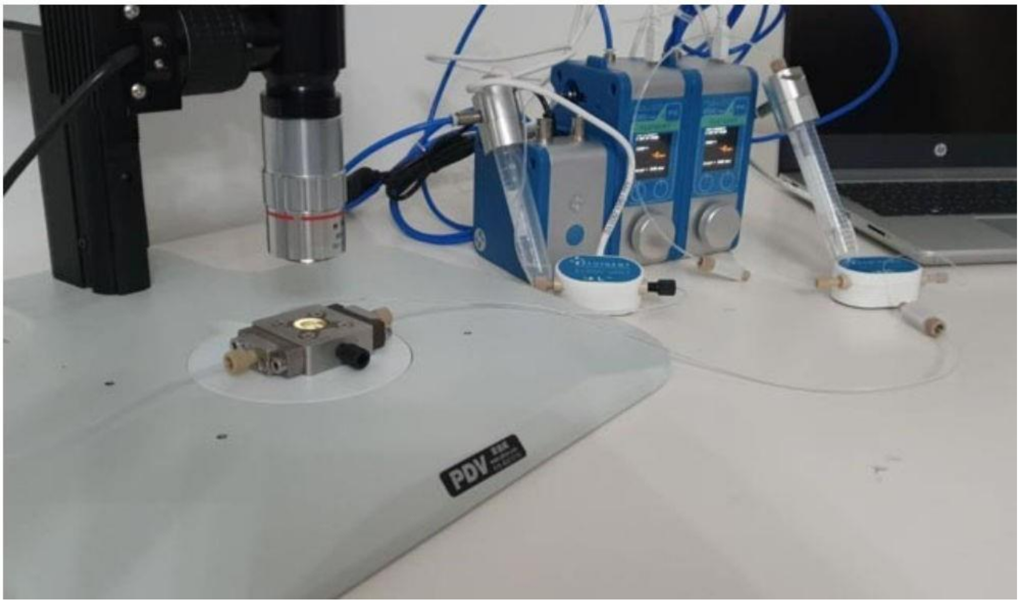

Figure 2: Pictures of the Fluigent equipment

RESULTS

Continuous phase flowrate (µl/min)	Droplet phase flowrate (µl/min)	Droplet diameter (µm)	Production rate (Hz)
100	5	71	445
100	10	75	754
100	15	87	725
50	5	85	259
50	10	91	422
50	15	92	613
25	5	89	225
25	10	93	396
25	15	94	575
15	15	94	575

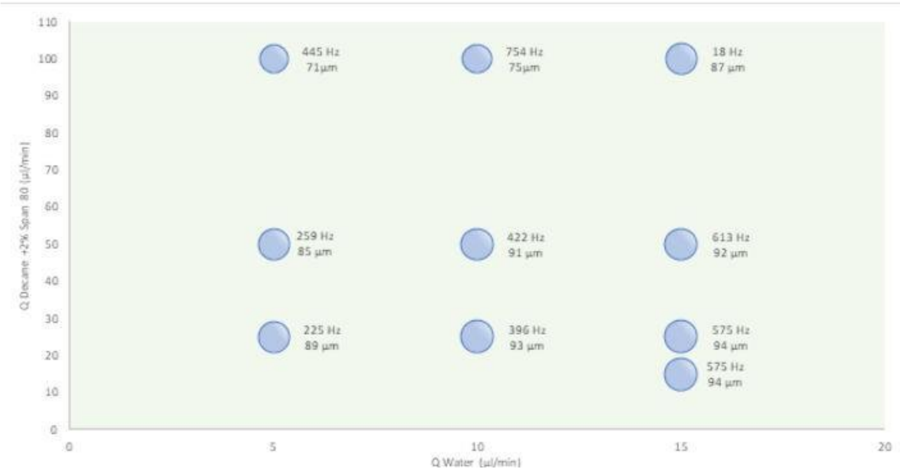

Figure 3: Droplet phase diagram

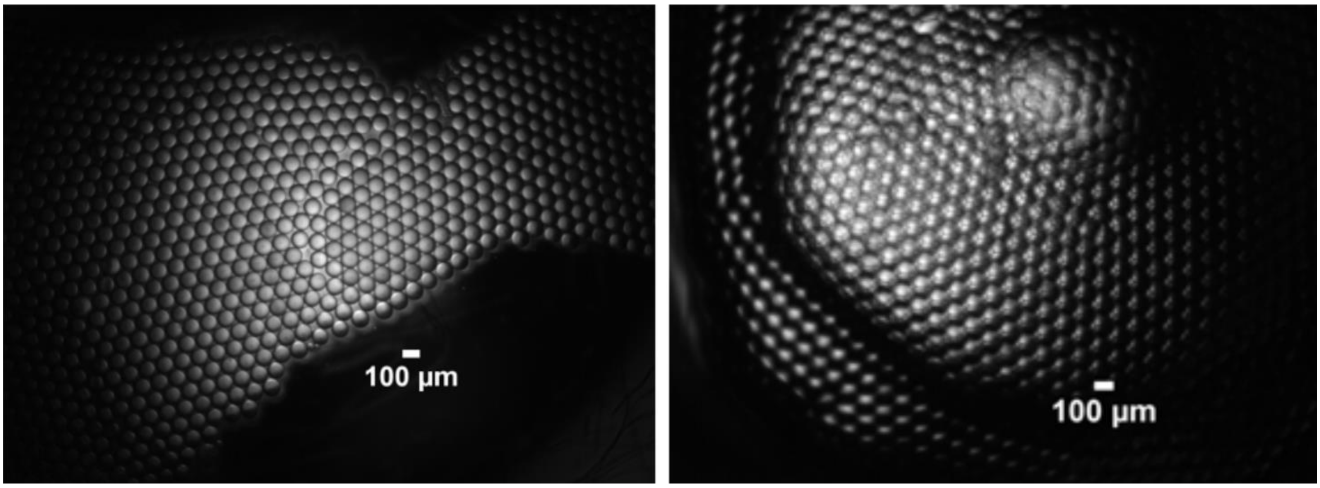

Figure 4: Images of water droplets in decane generated using Fluigent equipment and Raydrop microfluidic device

CONCLUSION

Fluigent pressure based flow controller units and Raydrop microfluidic device were successfully used to generate high-quality, monodisperse droplets of water in hydrocarbon oil. The droplet size was controlled in the range of 75 – 94 µm by adjusting the continuous and dispersed phase flowrates. Peak stable droplet production rate was recorded for 75 µm droplets at 754 Hz. The production techniques developed here can be extended to generation of hydrogel, protein or polymer beads by addition of suitable post processing steps.