

DTIP 2014

Double Emulsion Generation and Separation by Microfluidic Consecutive Flow Focusing

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Outline

Introduction

Liposomes, polymersomes

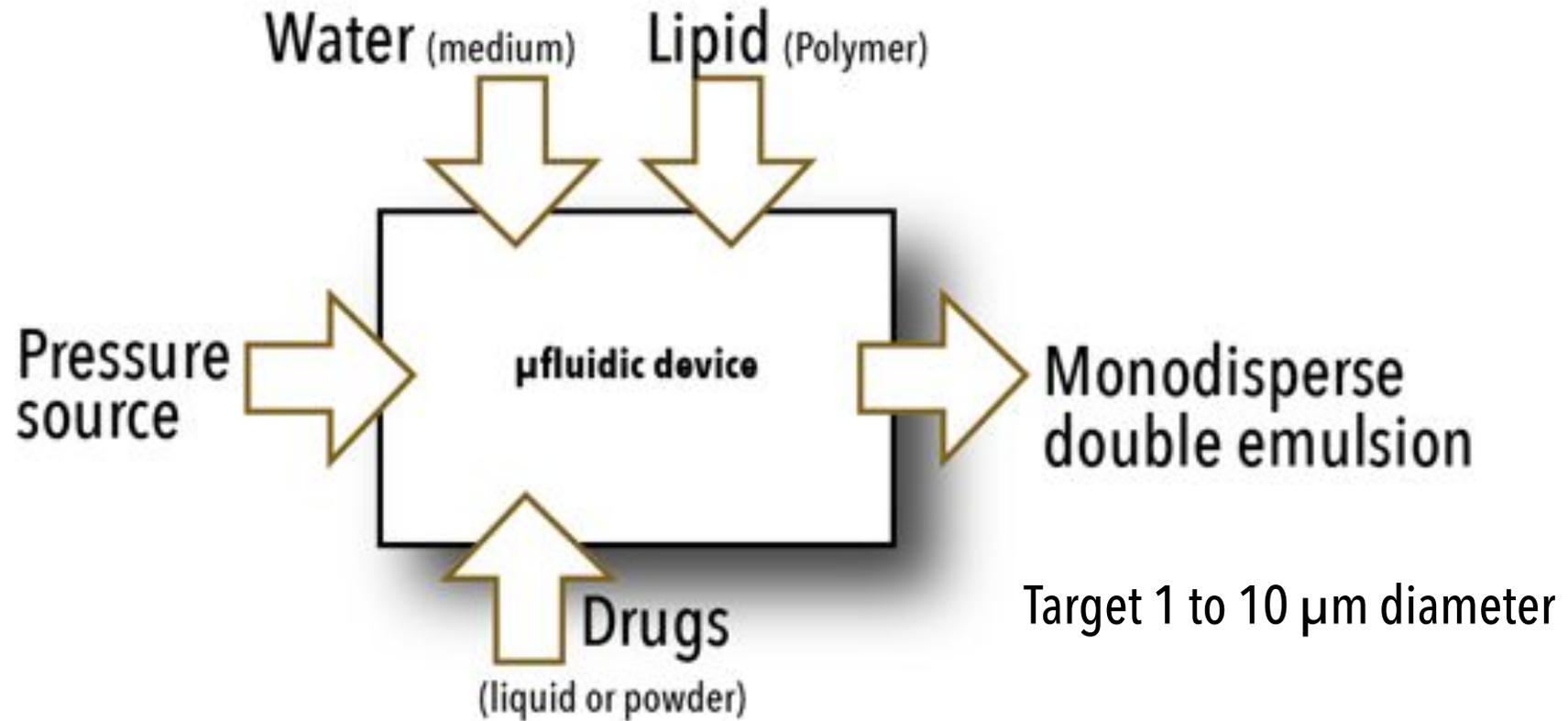
Microfluidic flow focusing

Experiments

Separation

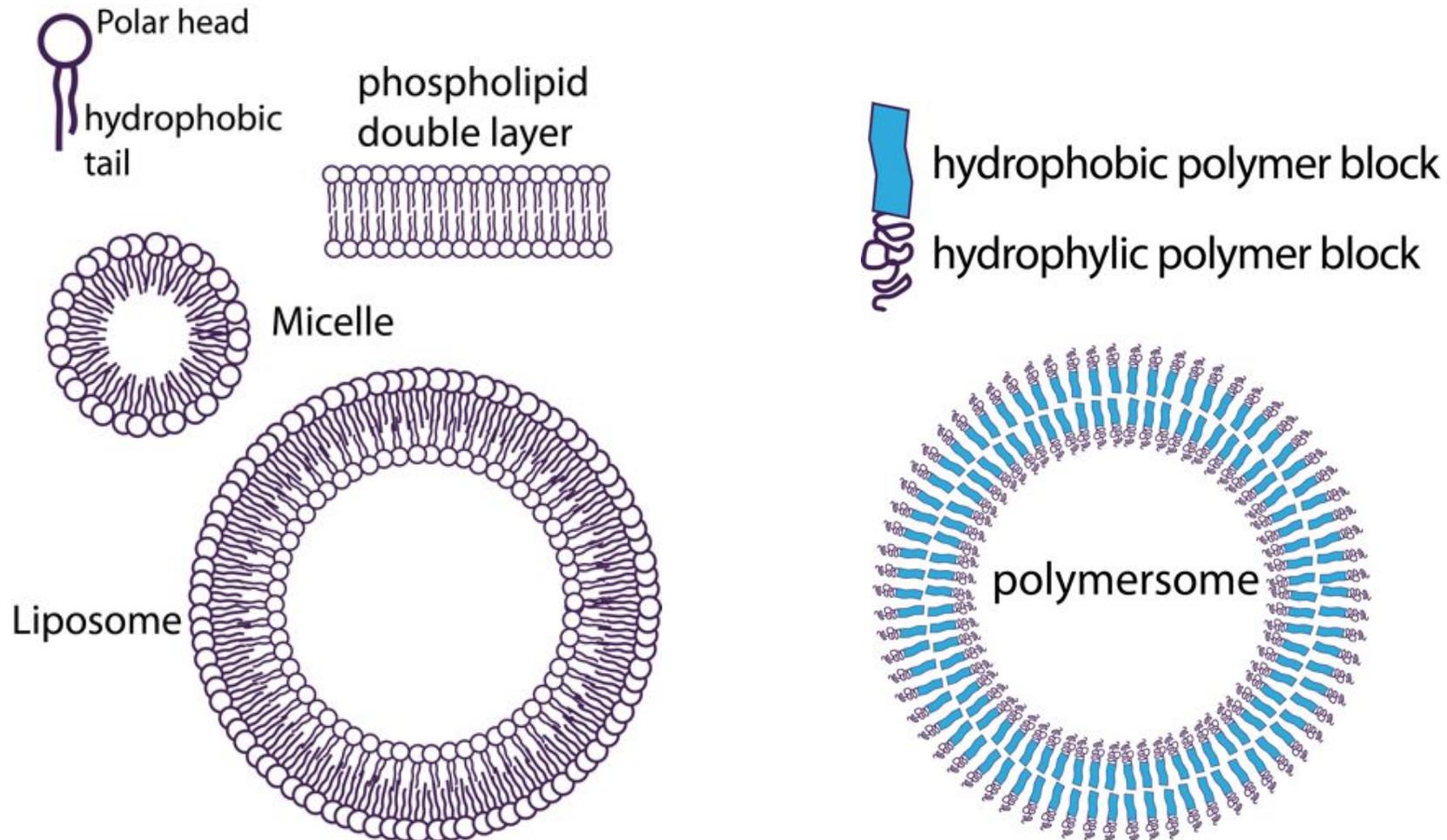
Conclusions

Goals



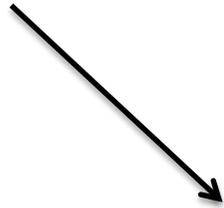
Double emulsion : Liposomes, Polymersomes

Amphiphilic molecules or grafted polymer blocks

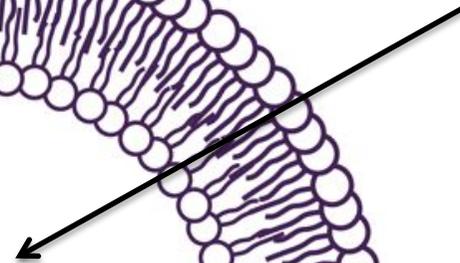


Pharmaceutical Vectorization

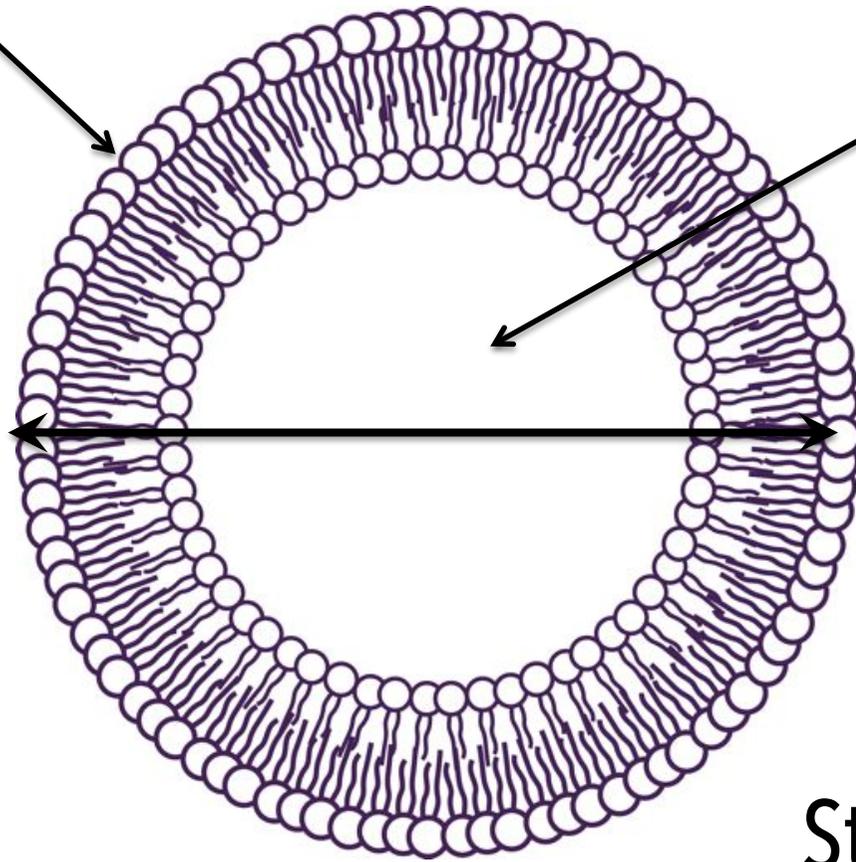
Labels



Drugs



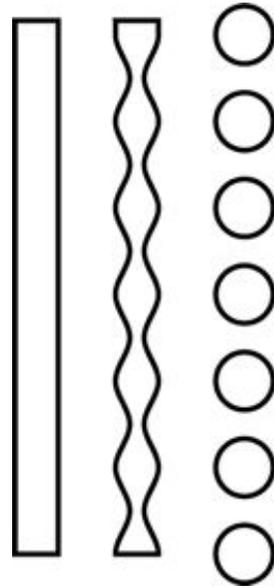
diameter



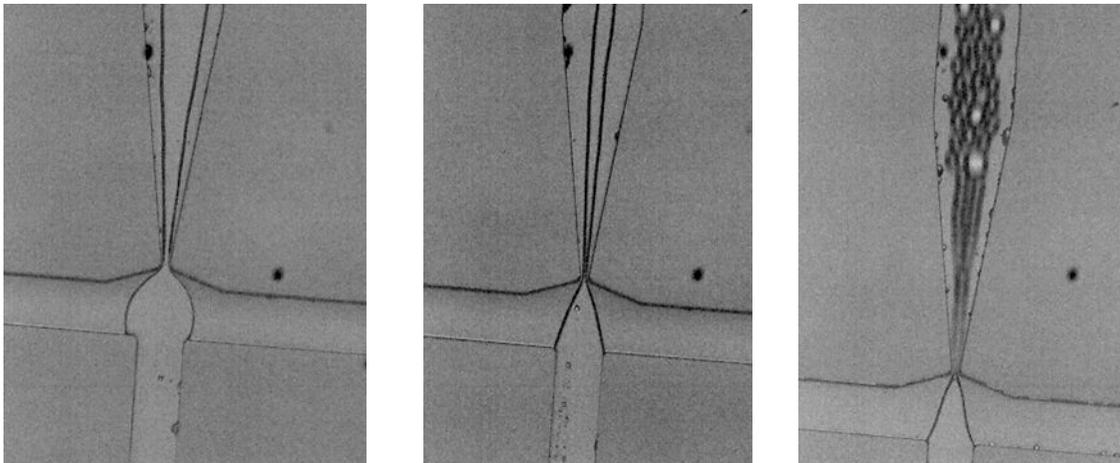
Stability
biodegradable

It starts with droplets....

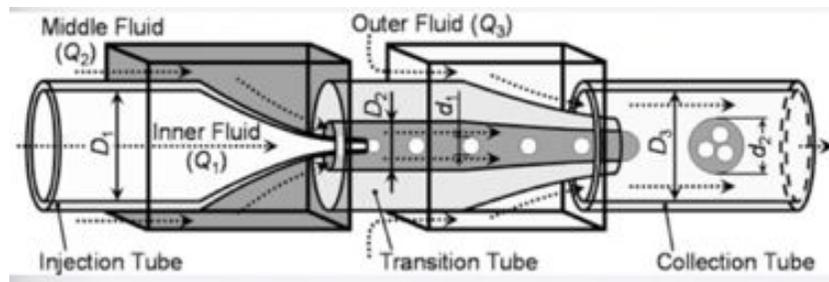
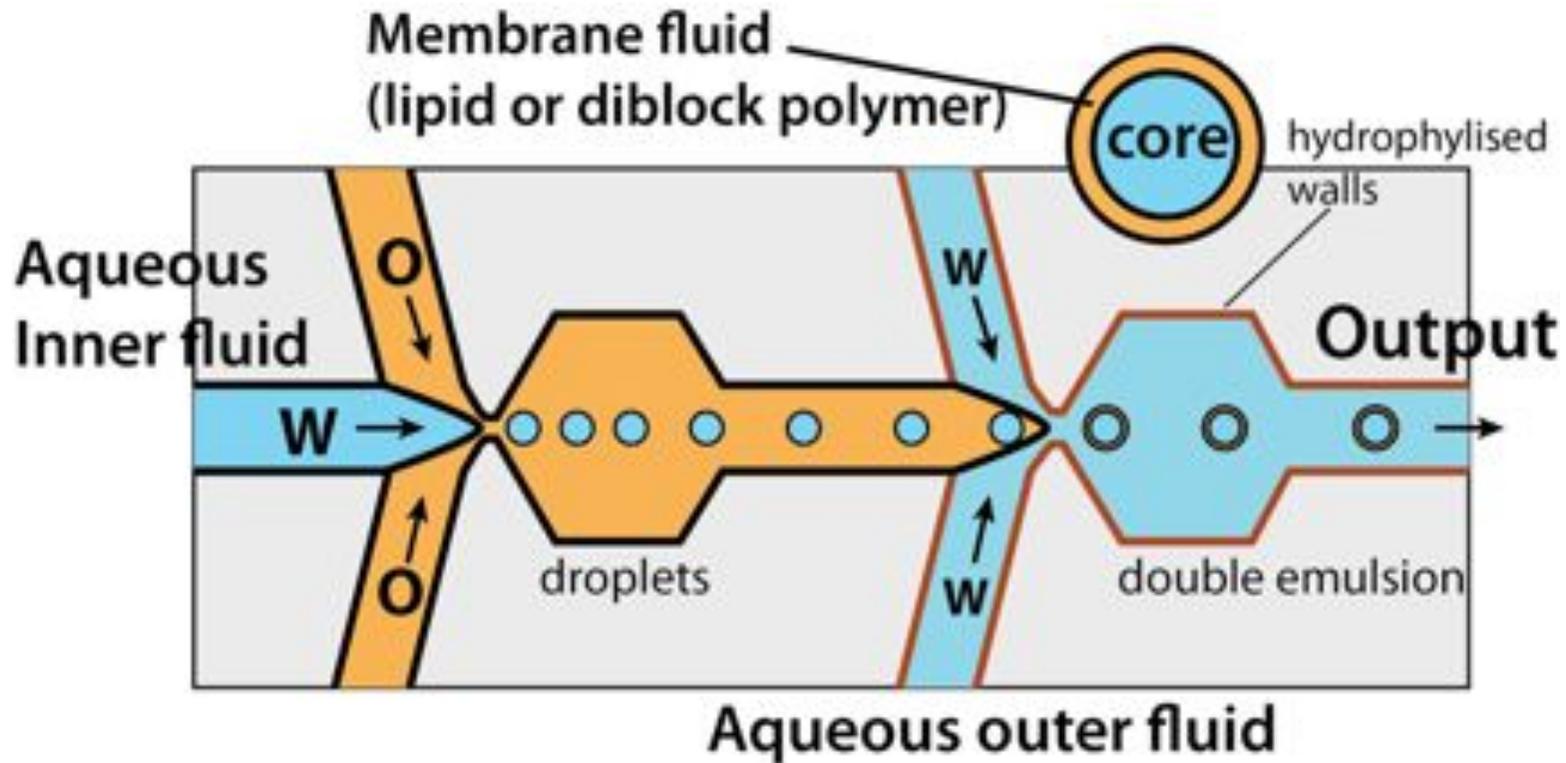
Rayleigh-Plateau instability
Surface tension
Liquid break-up



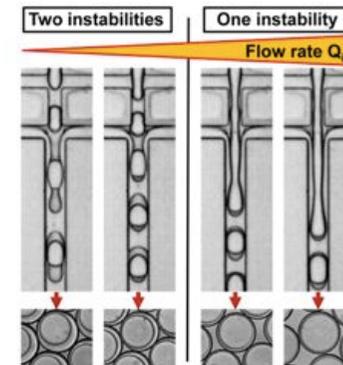
Microfluidic Flow focusing



Consecutive Flow focusing



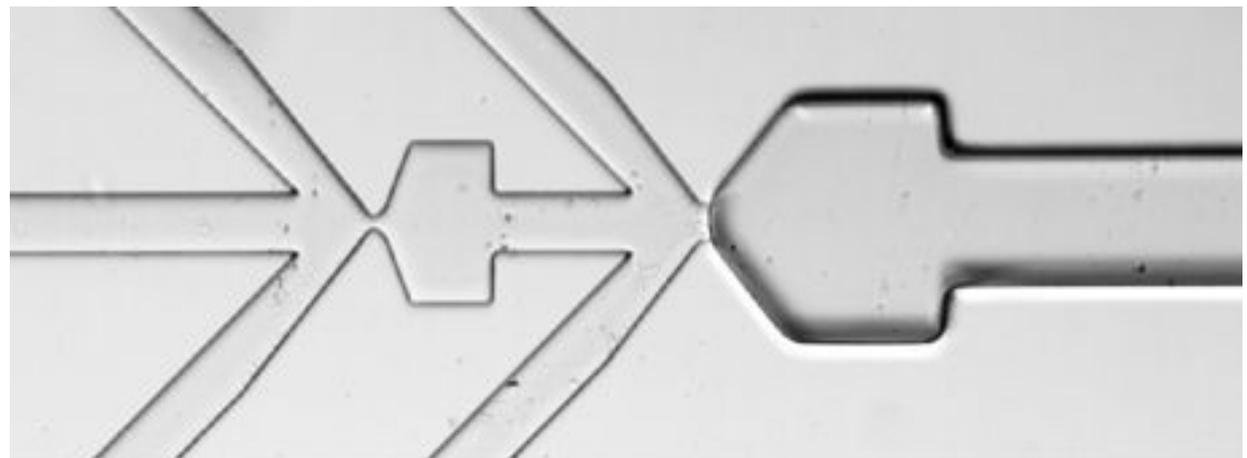
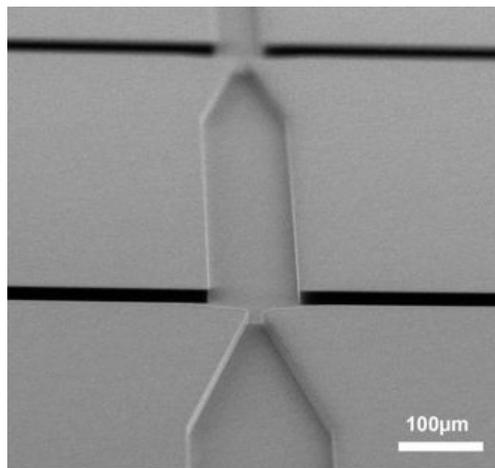
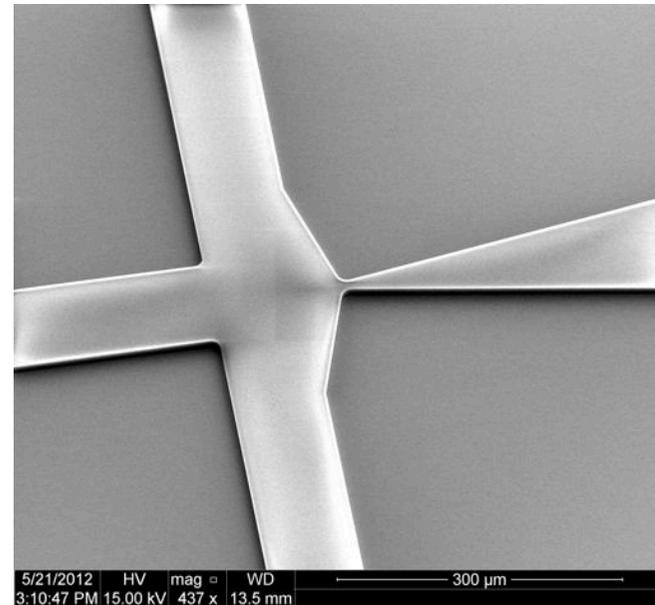
D.A. Weitz
Harvard



J. Thiele
U. Hambourg

Microfabrication

- Classic SU-8 on silicon replica molding
- Double thickness (10-100 μ m)
- Sol-gel inside protective coating



Experiment with lipids

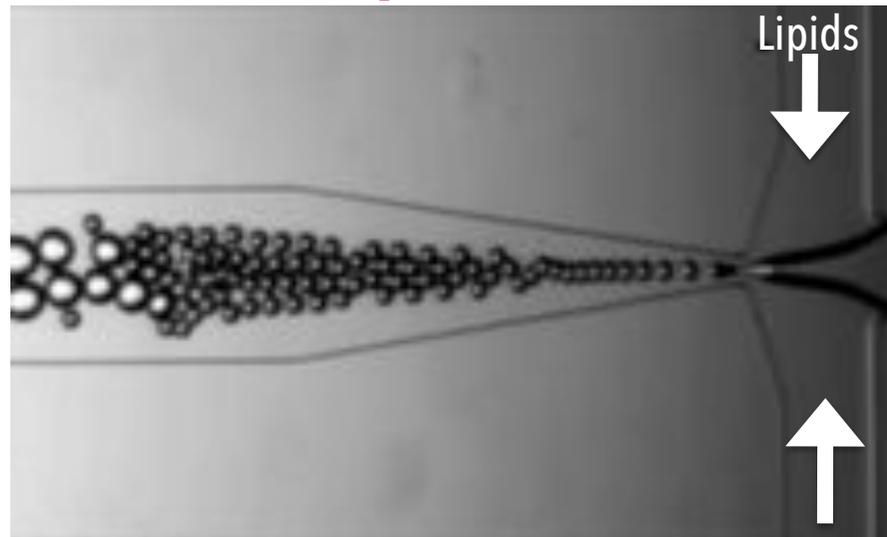
Input 1: DI water
+5% pluronic

Input 2: oleic acid

Input 3: DI water +
10% ethanol +
20% glycerol

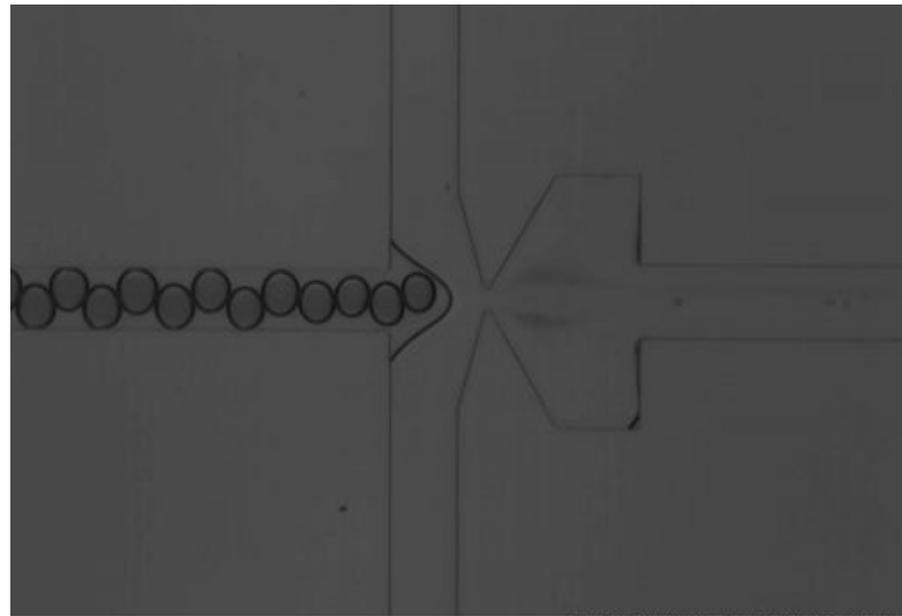
Elveflow OB1
Pressure controller
Pressure ratio :
1-3-10

Mikrotron High fps
camera, 40x



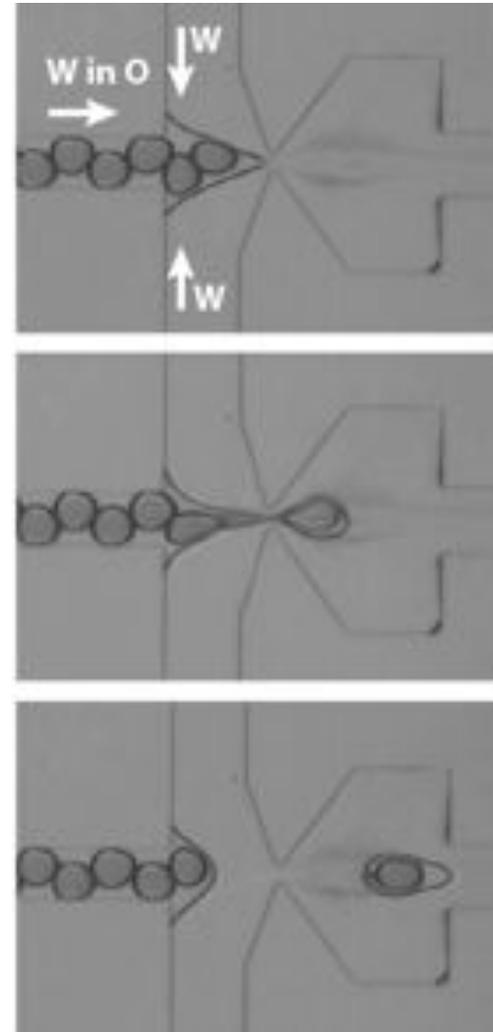
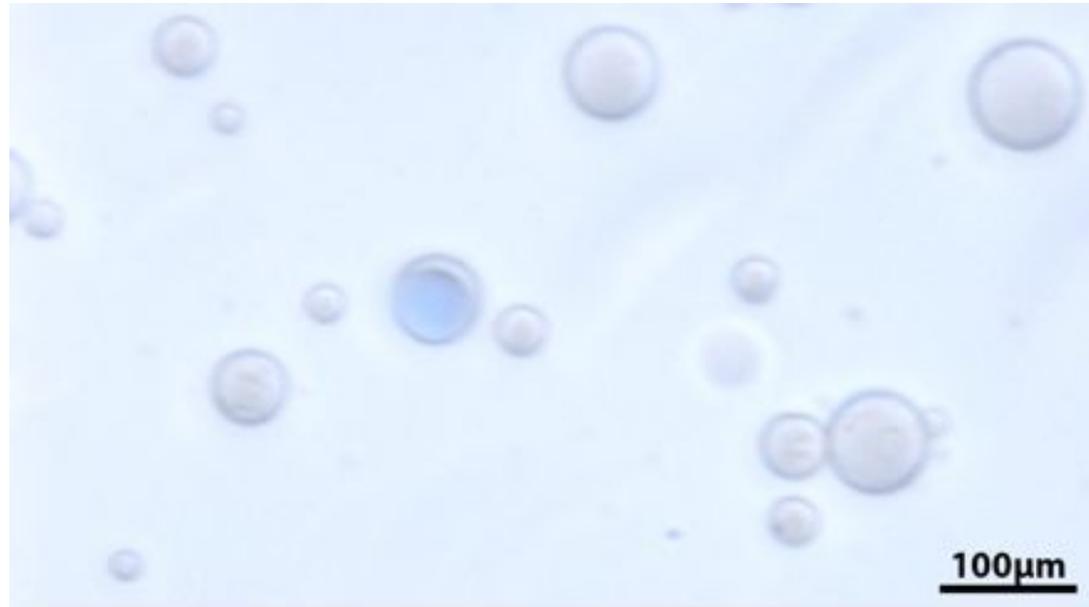
Dripping regime

1593 fps
shutter 15 μ s



Dynamic equilibrium : Very dependant to pressure conditions

Liposomes



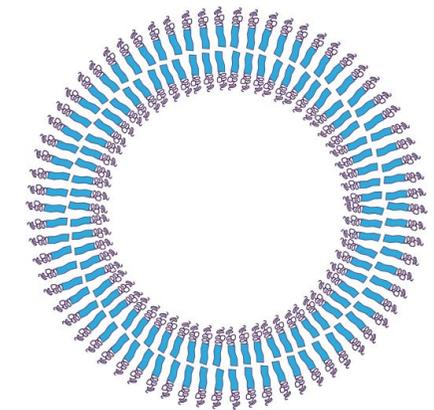
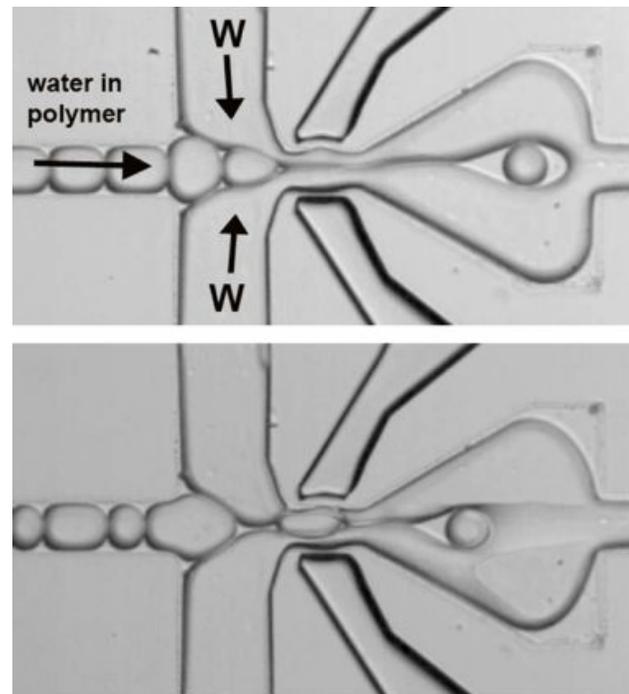
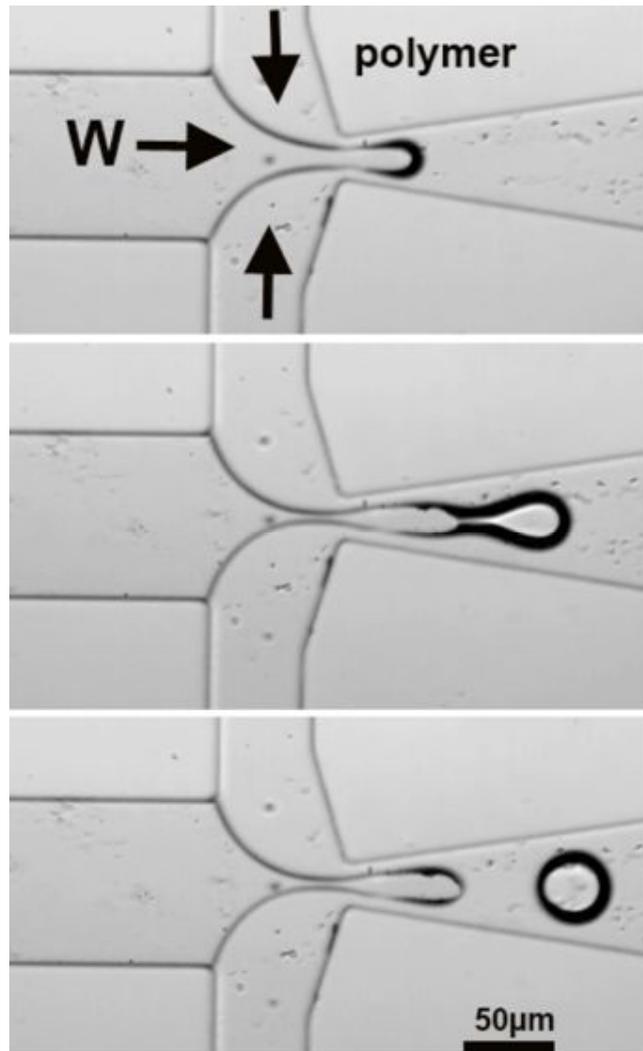
Solvation of the excess lipid

Polymersomes

Input 1: DI water

Input 2: poly(butadiene)-b-poly(ethylene oxide) 1mg/ml
(PB-b-PEO) in 50% toluene 50% DCM

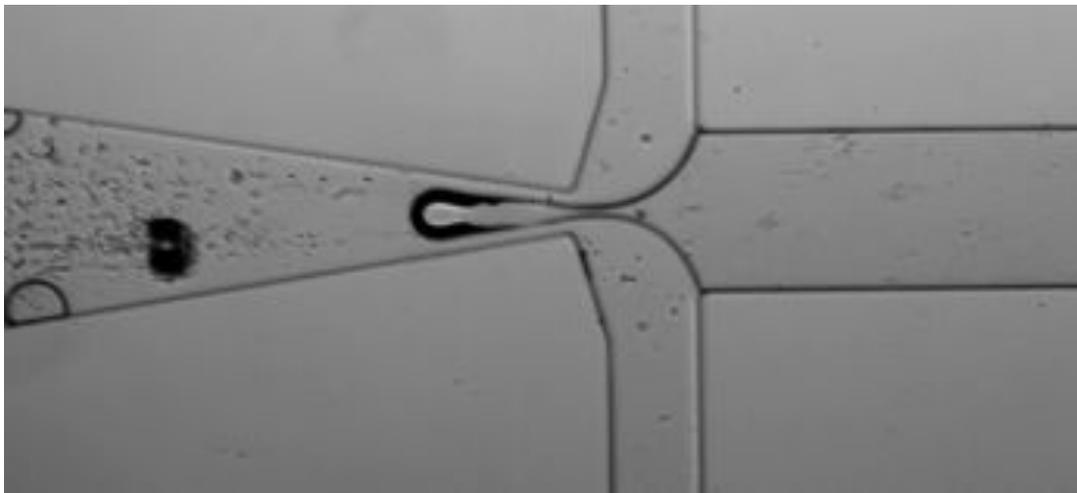
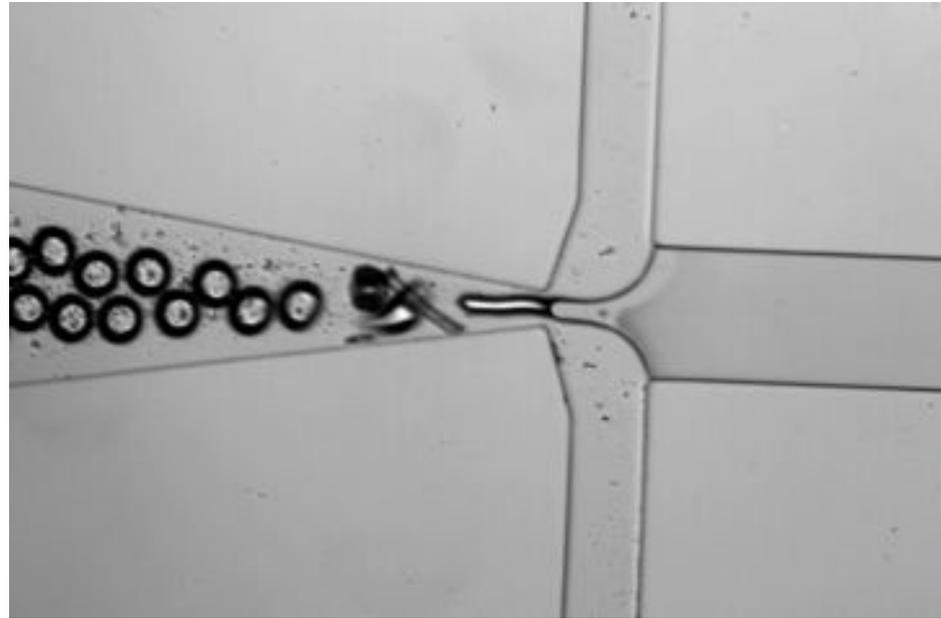
Input 3 : water + 5%PVA



Hydrophilisation of the output
Clogging of microchannels

Polymersomes

285fps
24 μ s shutter



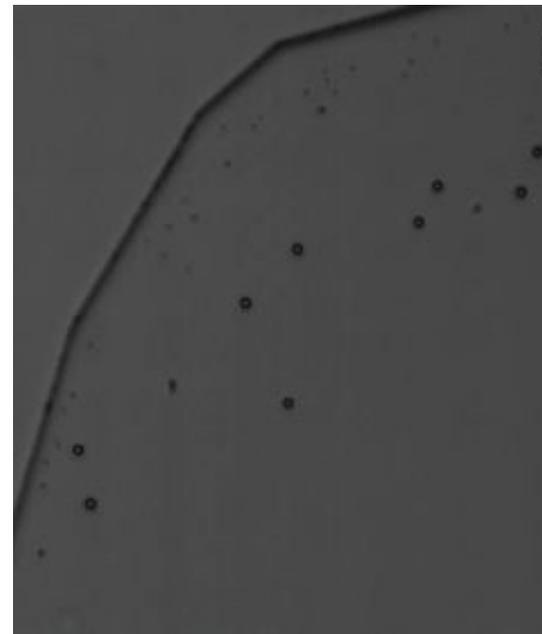
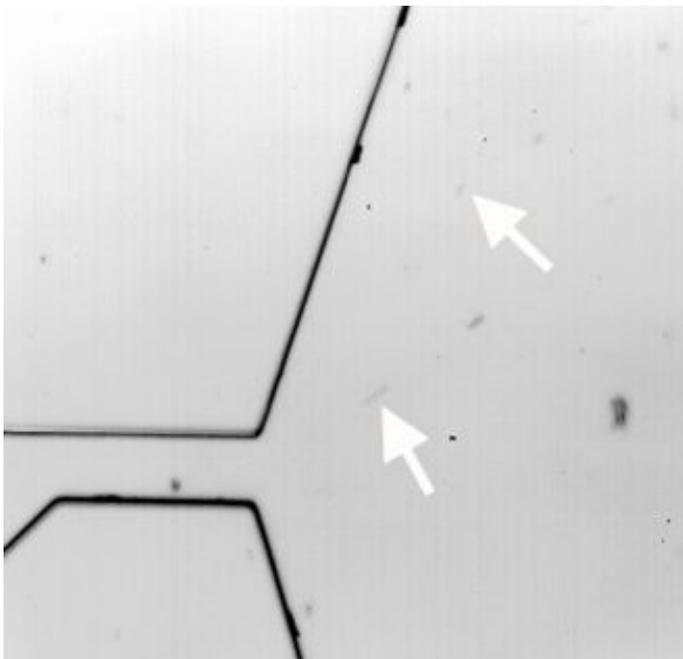
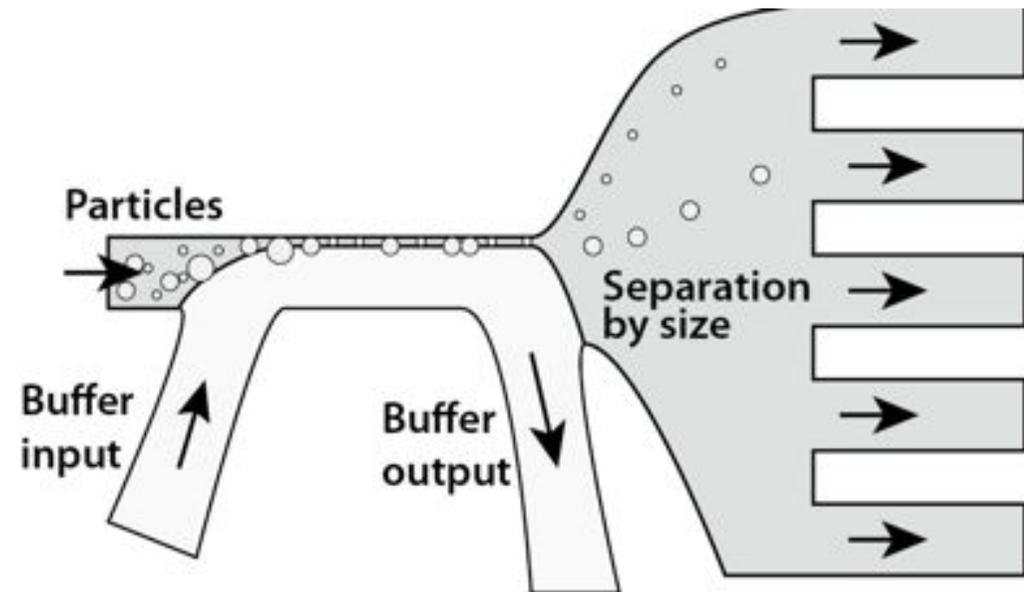
Jetting regime

Different droplet formation dynamic - non newtonian fluids -
Solvent solubility in water is a key parameter

Separation : Pinched Flow Fractionation

Filtering particles by size :

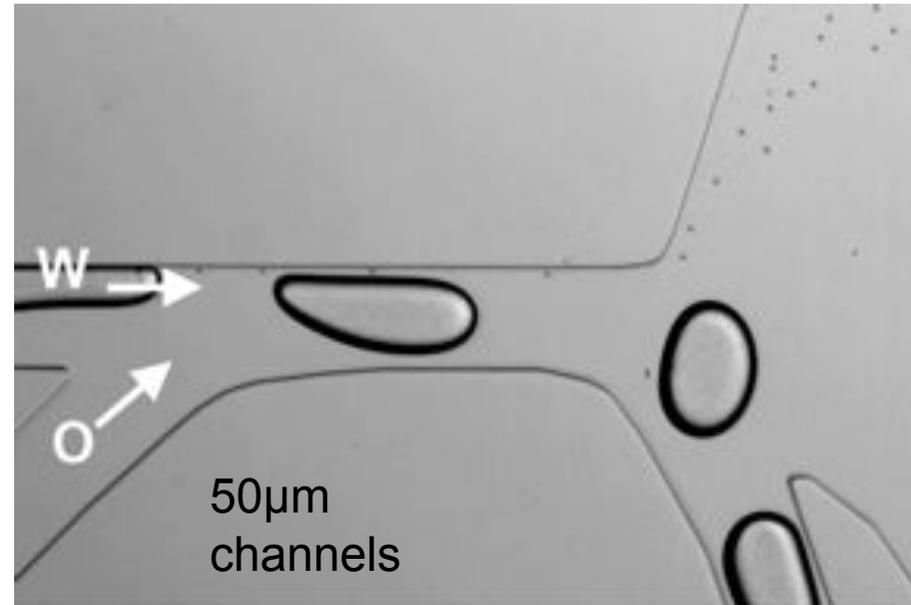
Addition of a particle separation system
Collection of double emulsions by size



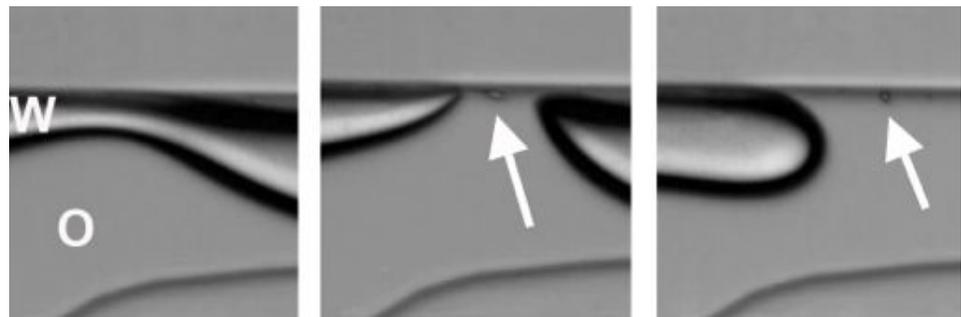
Diphasic stream in a separation structure

Feeding the separation structure with diphasic flow : generation of small sized satellite droplet

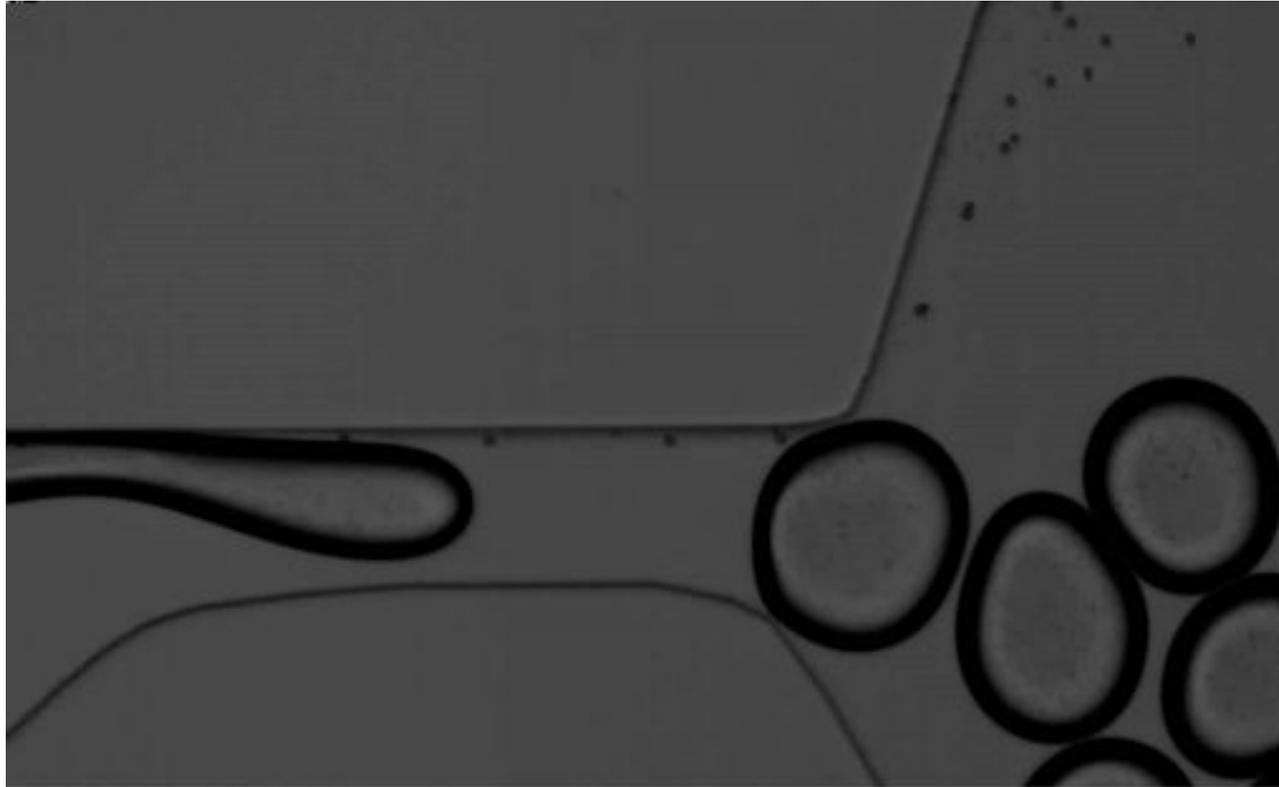
- High stability
- Low size dispersion
- Large channels : less problems with dust



... A second constriction to be added for liposome formation



Diphasic stream in a separation structure



2/14/2014 10:47:46 AM -00:00:03:129.87[HH:MM:SS:mm] 000001243 1040x630 1108fps 9µs

Conclusions

Microfluidic double emulsion generation validated for liposomes and (Pb-Peo) Polymersomes

Issues :

Flow stability (small variation on pressure destroys the dynamic equilibrium)

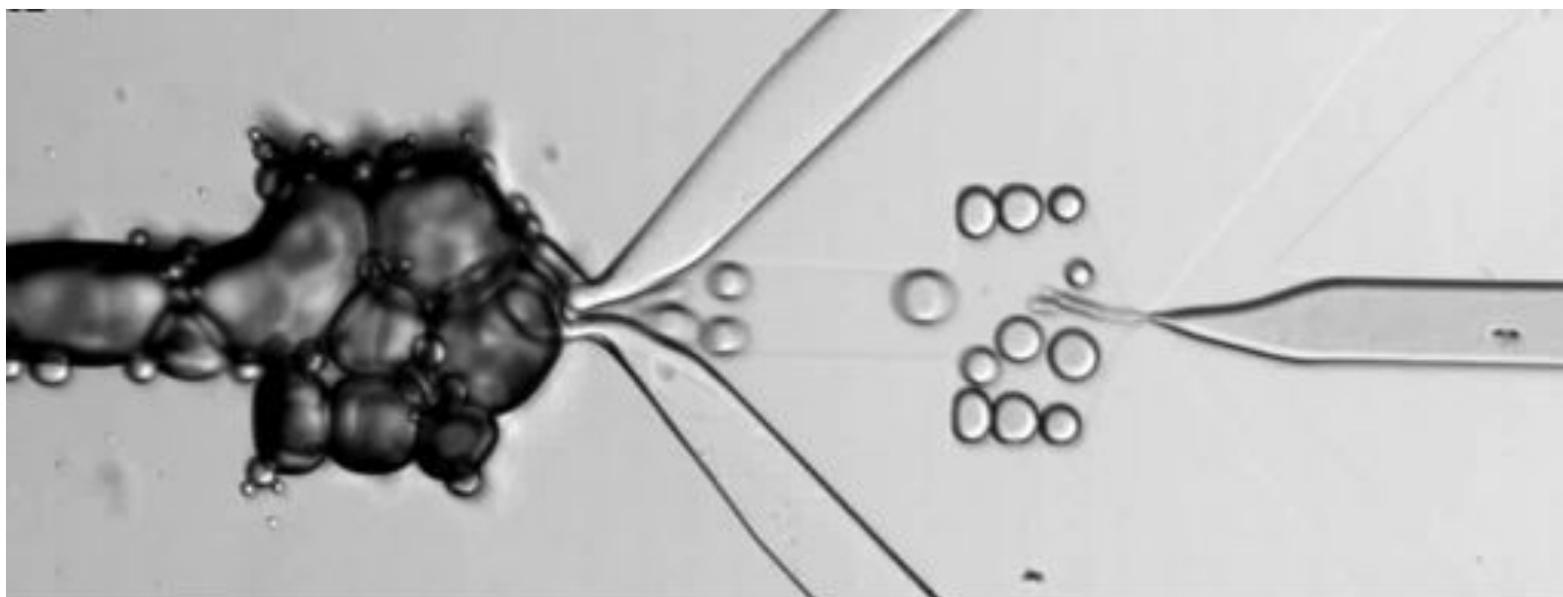
Clogging : Dusts, polymer blocks...

PDMS not really compatible with harsh solvents

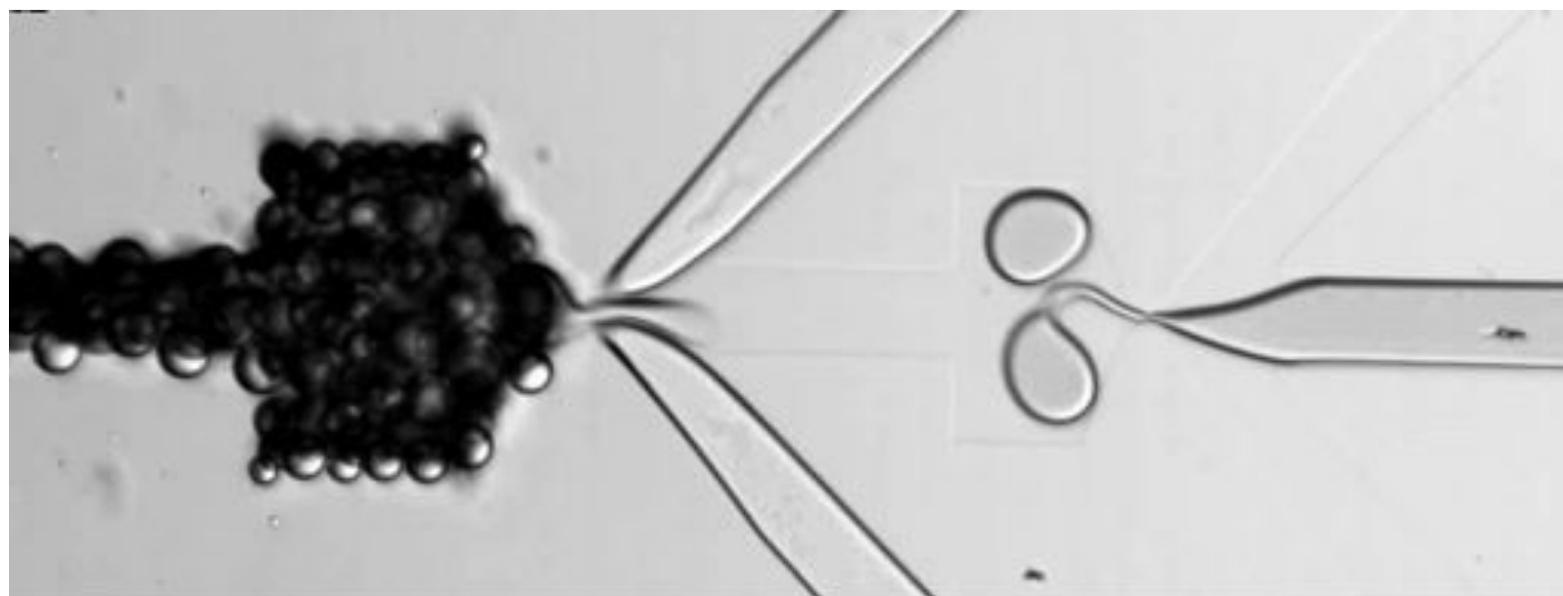
Hydrophilisation of the output not stable over time

Monodispersion (filtering by separation system)

Next : Investigation of the satellite droplet generation for small size double emulsion generation



1/23/2014 12:07:17 PM -00:00:09:117.01[H:M:MM:SS:mm] 000009022 1040x390 1786fps 56µs



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