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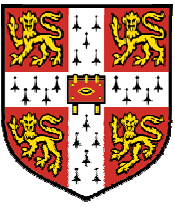
# Fundamentals and applications of an oscillatory flow meso-reactor

Mingzhi Zheng and Malcolm Mackley

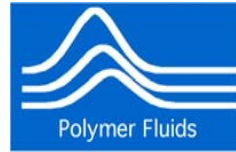
Department of Chemical Engineering

University of Cambridge

16<sup>th</sup> Nov., 2006



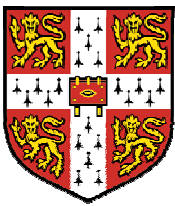
# Concept of meso-reactor



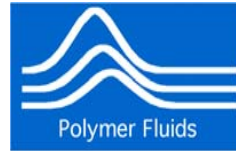
Scale- down  
→



- Glass tube-easier to manufacture in small-scale compared with baffle-tube structure
- Easy to fit into laboratory fume cupboard
- Suitable for doing meso-scale pharmaceutical studies and small manufacturing of a few kilos of material



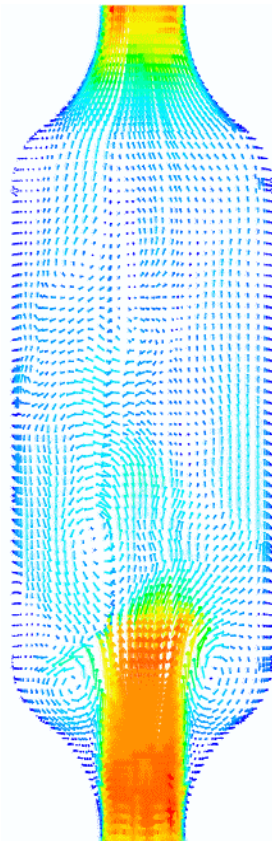
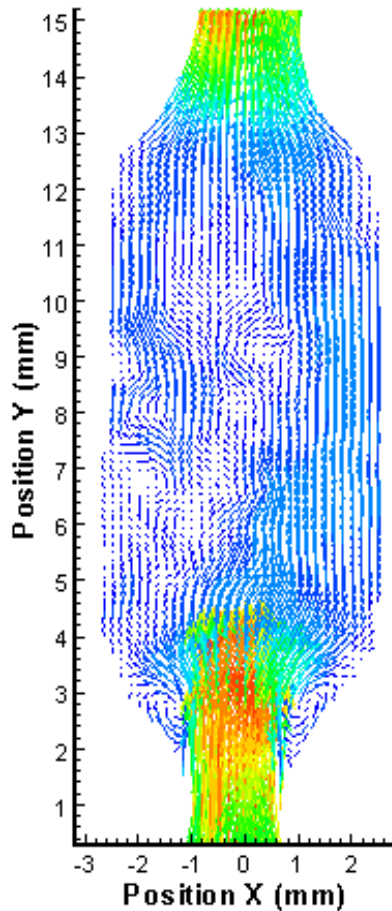
# Experimental PIV and Fluent<sup>®</sup> Simulated flow patterns



## Influence of St

$Re_o=312, St=0.4$

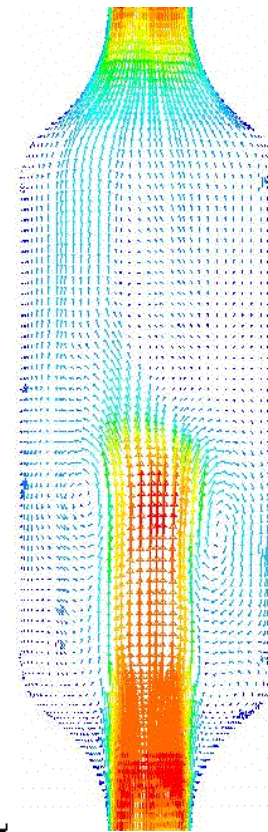
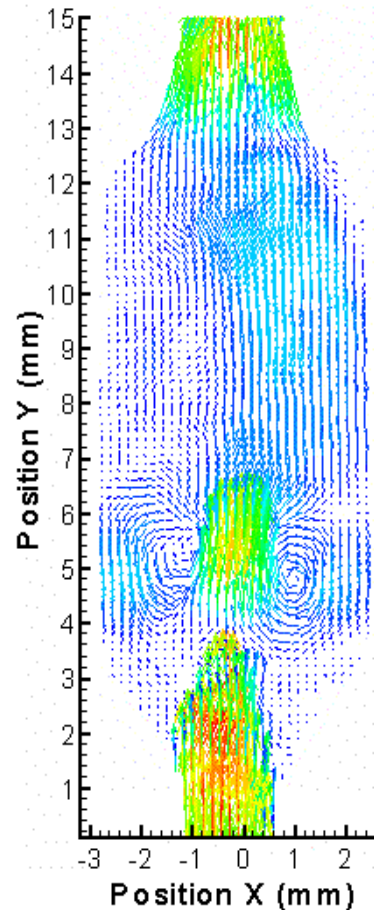
$Re_o=312, St=0.2$



Experiment

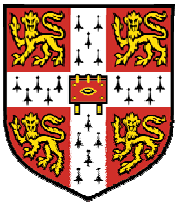
Simulation

3

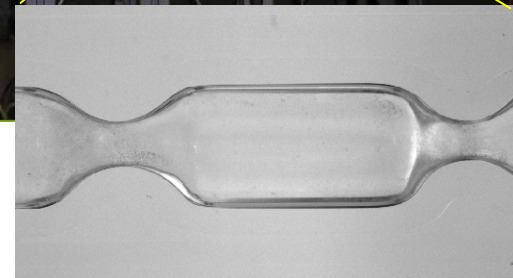
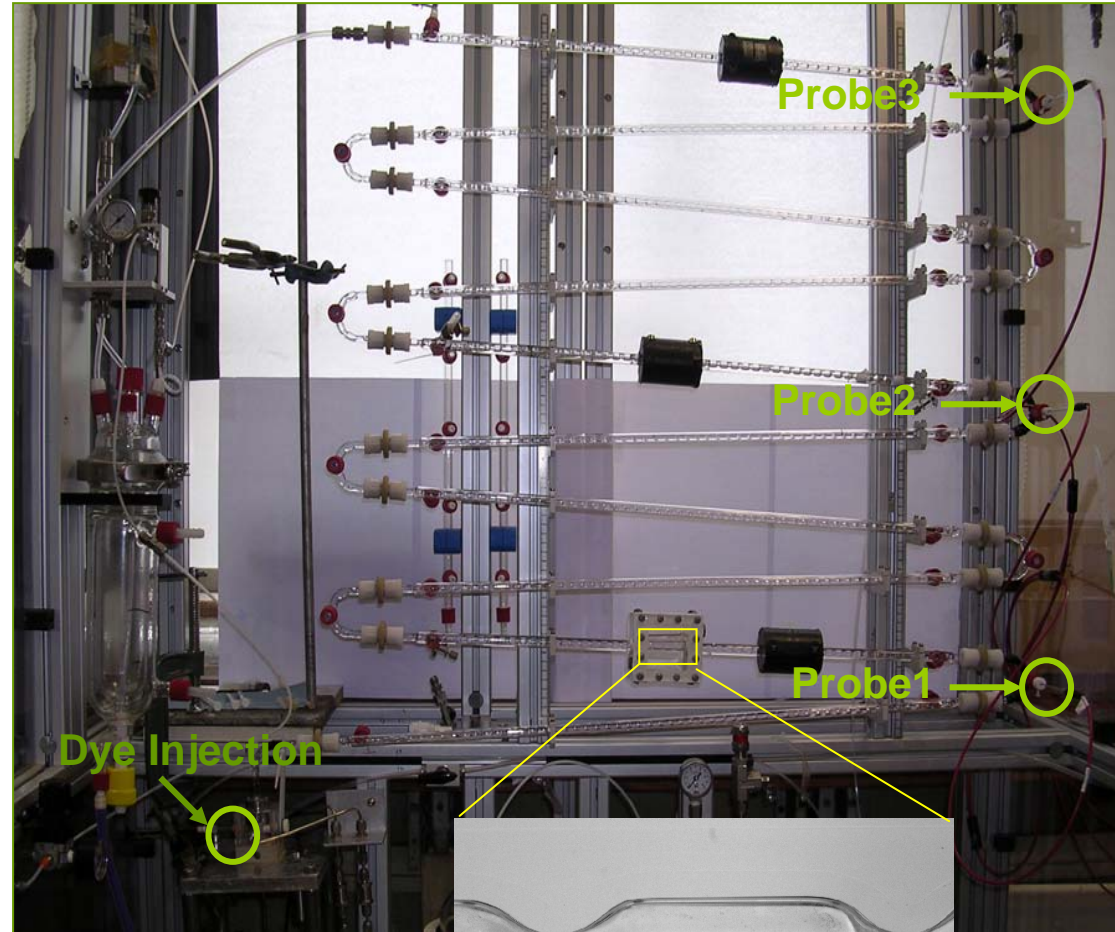
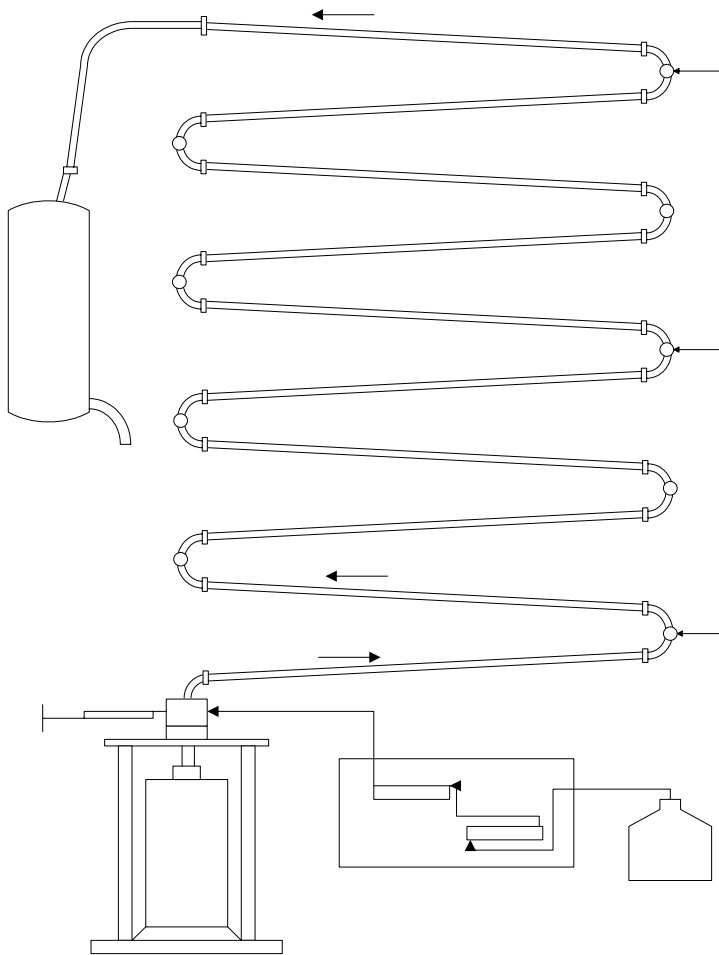


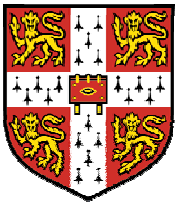
Experiment

Simulation

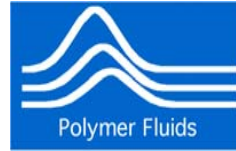


# RTD experiment set-up



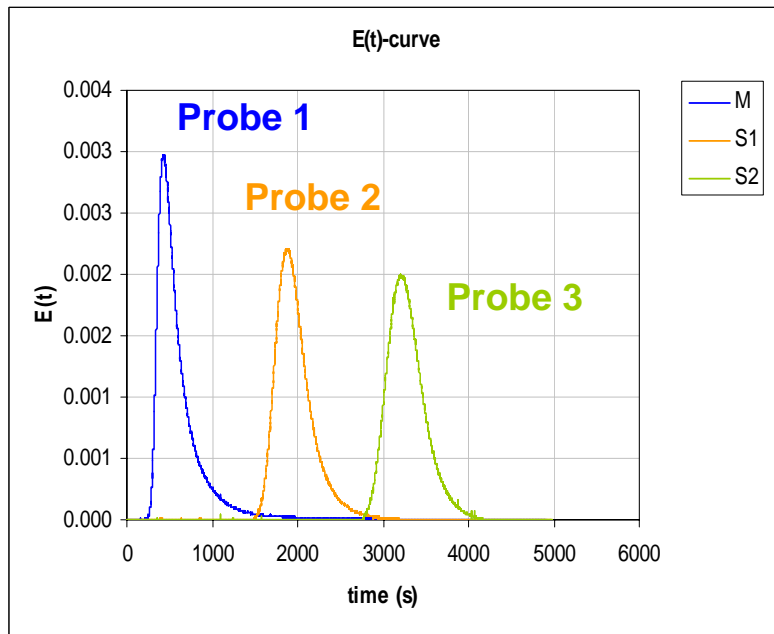


# Experimental E-curves



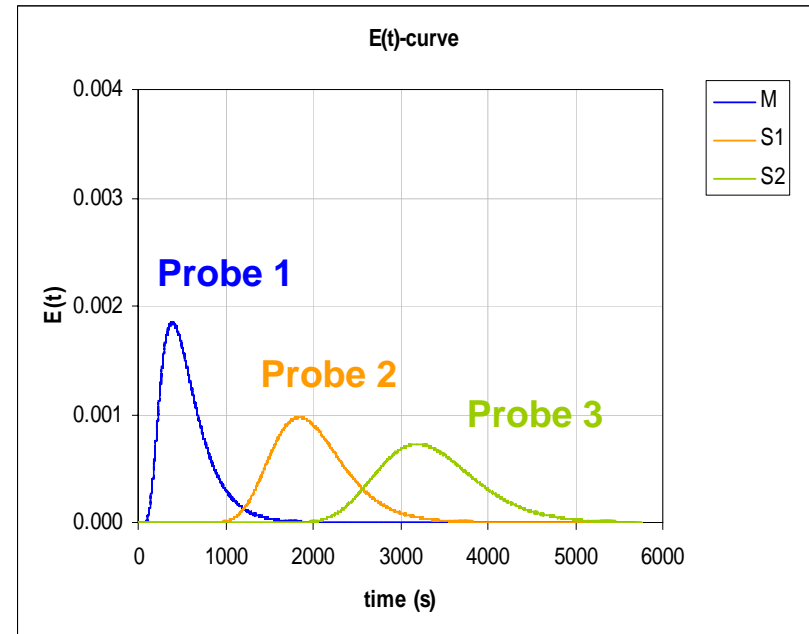
## Small Dispersion

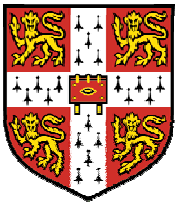
$Ren=9, Reo=156, St=0.8$



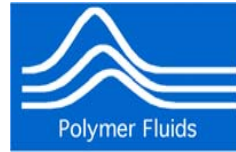
## Large Dispersion

$Ren=9, Reo=438, St=0.11$

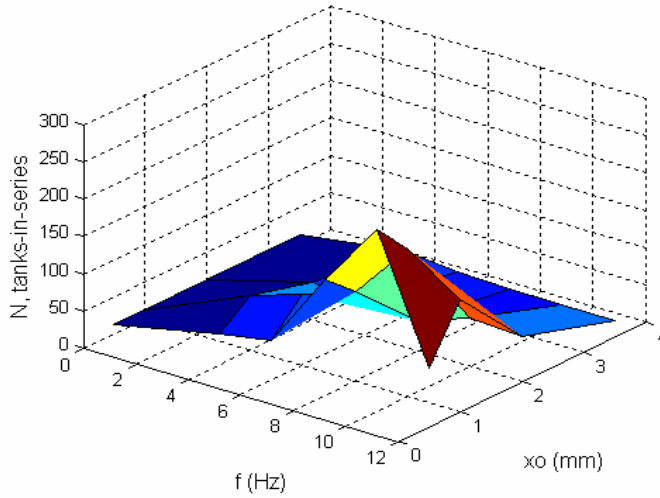




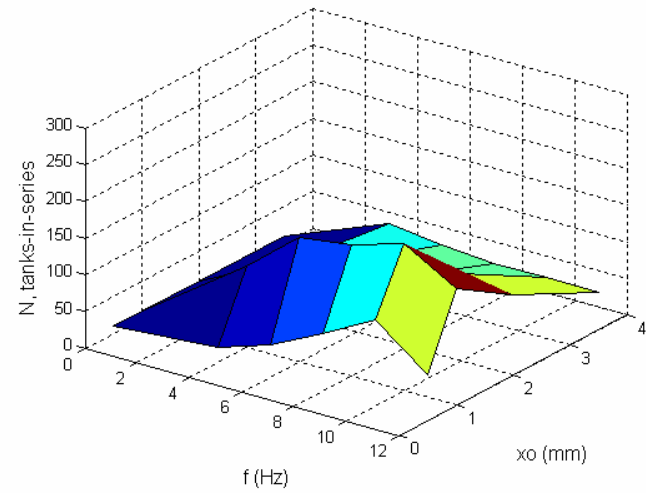
# RTD Model fitting



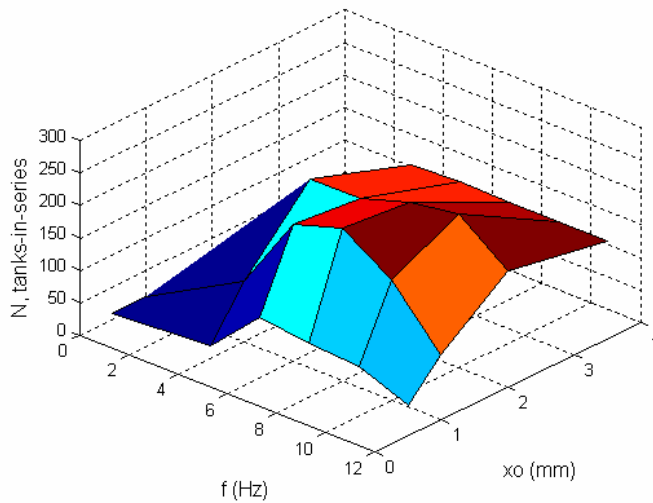
Ren=9



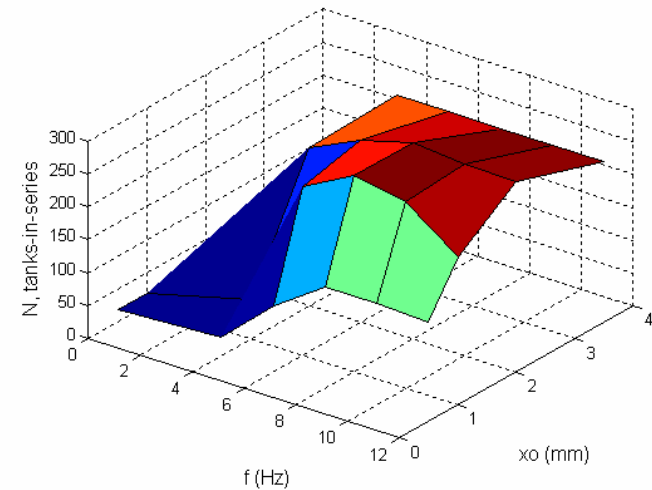
Ren=19



Ren=56



Ren=113



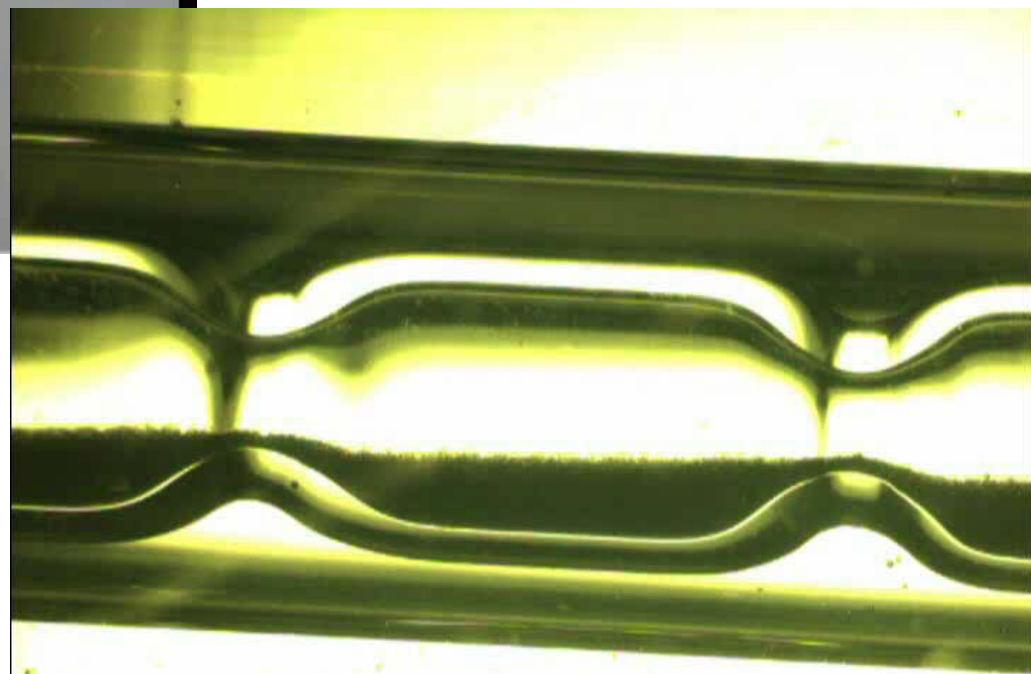
# Ionic Liquid mixing with Diethyl ether



**Start Oscillation**

Liquid-liquid mixing

Particles in suspension



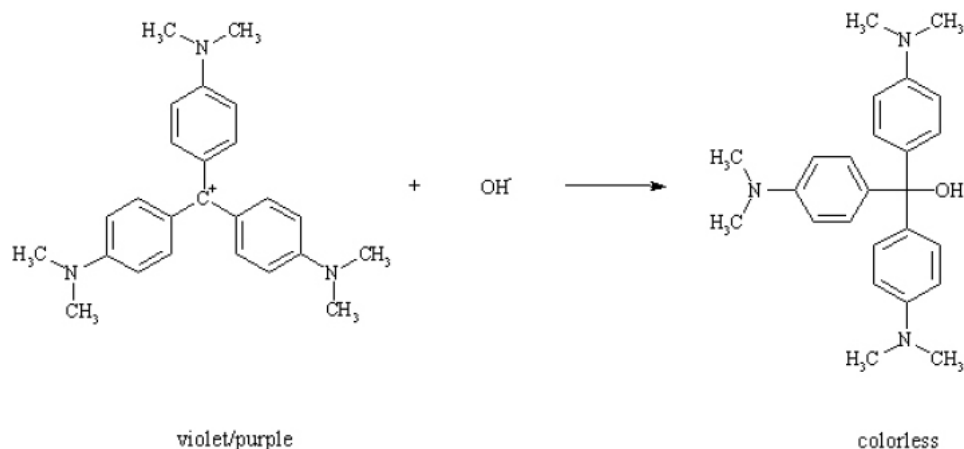
**Start Oscillation**



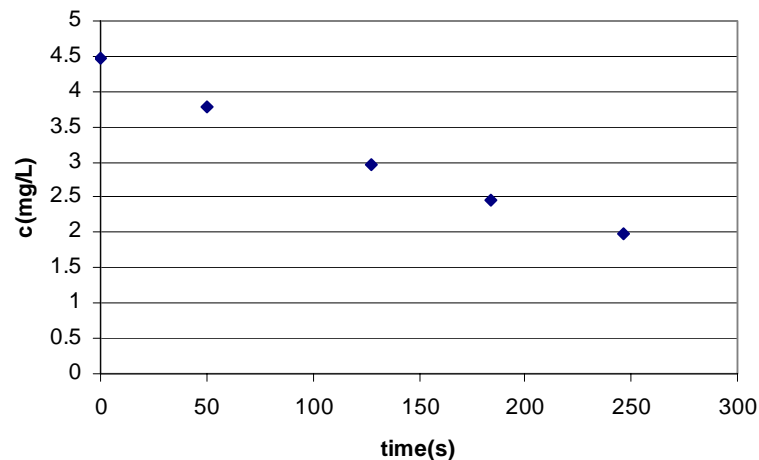
# Case study1: Homogeneous Liquid phase reaction



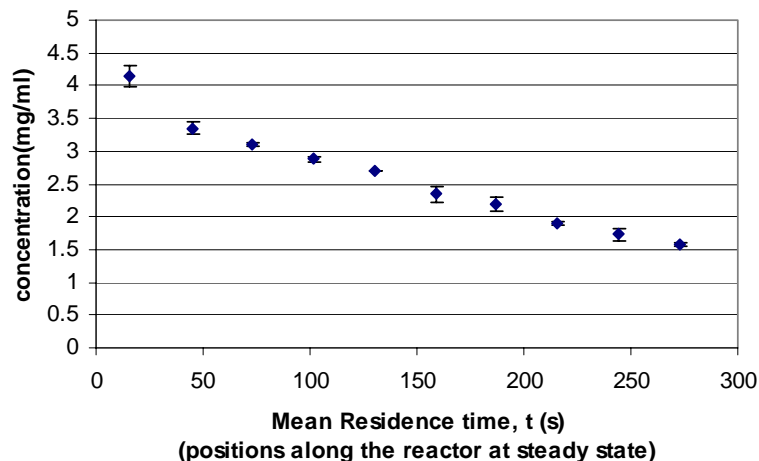
## Crystal violet fading in sodium hydroxide



Crystal violet conc. VS. Time in stirred beaker

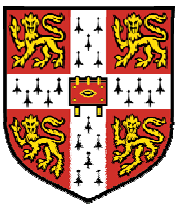


Crystal Violet conc. vs. Time in continuous meso-reactor



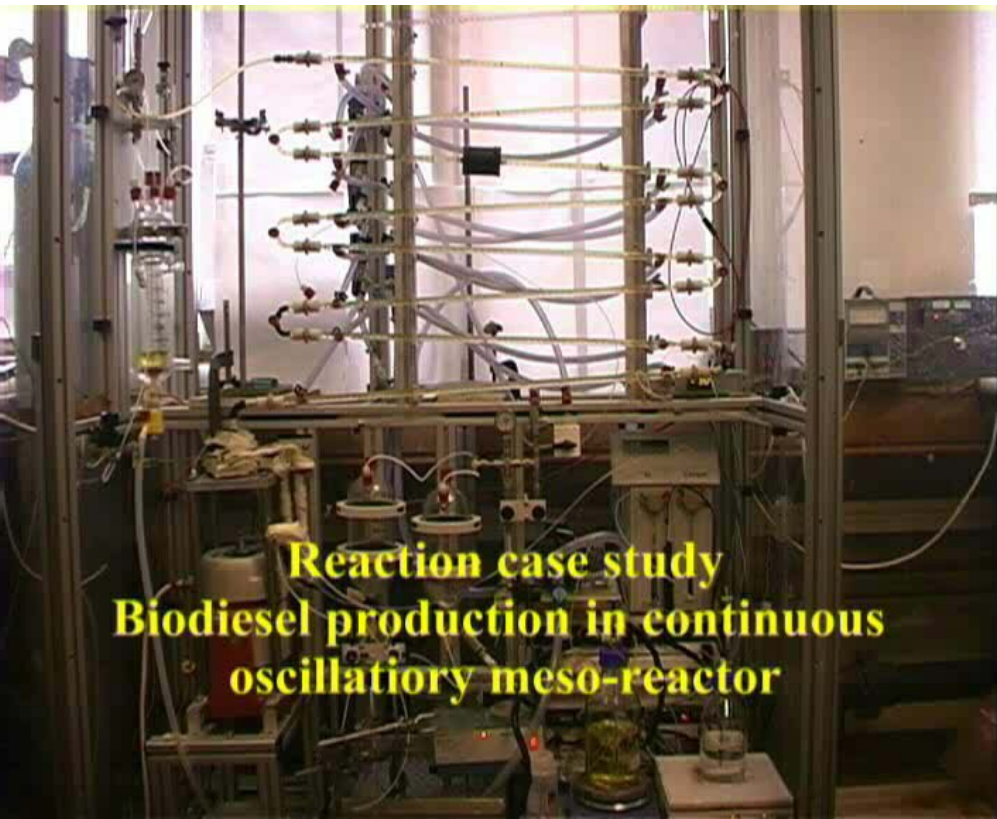
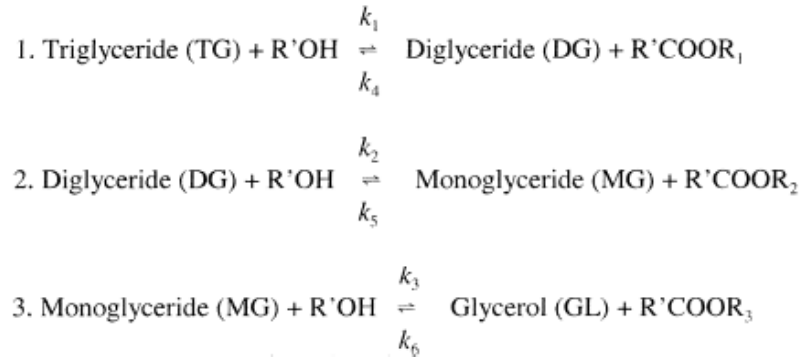
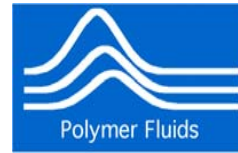
Conversion of crystal violet ( $C_A/C_{A0}$ ) at the end of meso-reactor	
Experiment measurement	Tanks-in-series model + batch reaction kinetics prediction
0.335	0.337



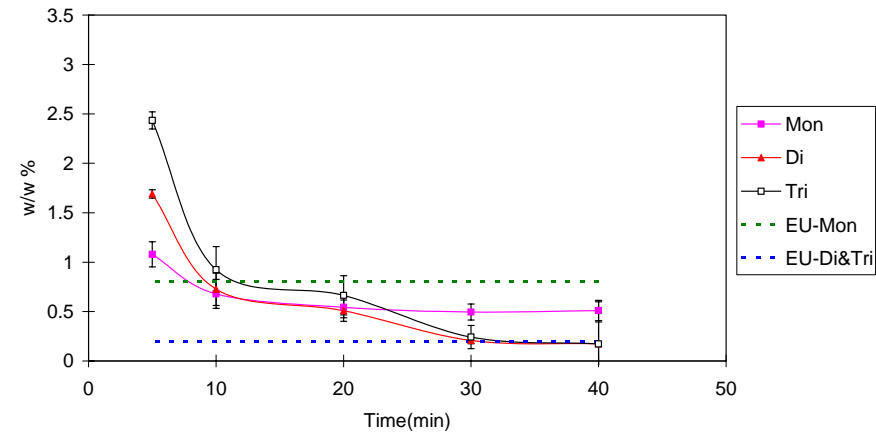


# Case study 2: Liquid-liquid mixing reaction Biodiesel Production

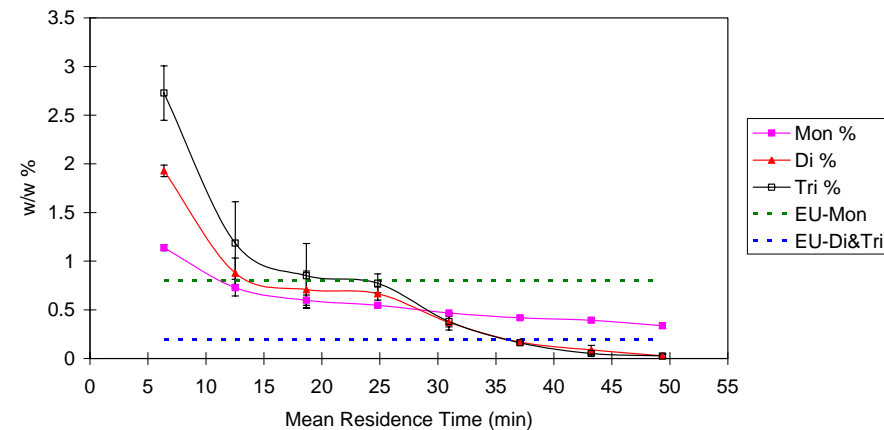
- Transesterification of triglycerides with alcohol



Biodiesel batch operation in meso-reactor  
F=10 Hz, X<sub>o</sub>=2 mm



Biodiesel continuous operation in meso-reactor  
F=10 Hz, X<sub>o</sub>=2.0 mm





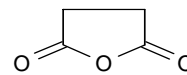
# Case study 3: Precipitation reaction

DIELS-ALDER REACTION MONITORED BY REACTIR



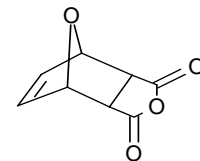
Furan  
(68.03)

+

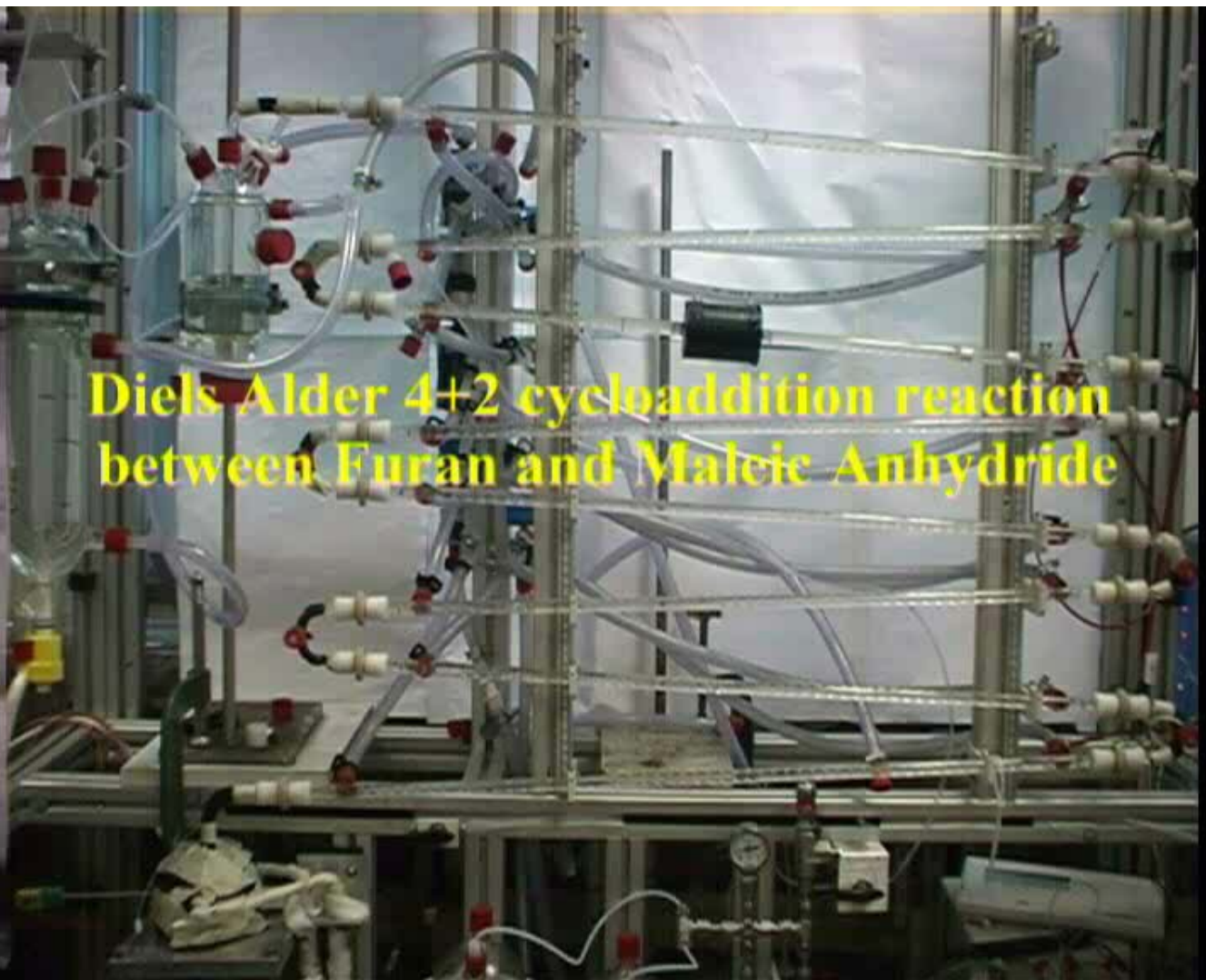


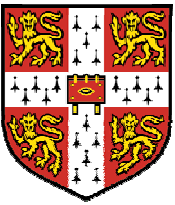
Maleic anhydride  
(98.06)

TBME/50C

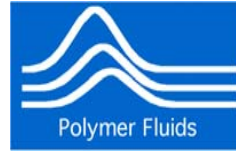


Diels Alder adduct  
(166)

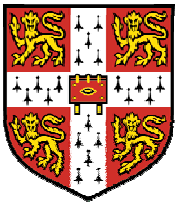




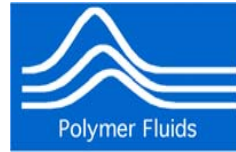
# Conclusion



- Fluid mechanics and Residence Time Distribution (RTD) in meso-reactor has been established.
- Proof of concept reaction has been successfully tested using continuous meso-reactor.
- The oscillatory flow meso-reactor is viable for 'meso-scale' continuous flow multiphase reactor.



# Acknowledgements



- Prof. Malcolm Mackley
- Polymer Fluid Group
- Department of Chemistry in Cambridge
  - Ley Group
- Cambridge Overseas Trust

