

Introduction

Microfluidics offer advantages for studying reaction kinetics due to high spatio-temporal resolution, the use of very low sample volumes and high sensitivity [1,2]. Droplet monodispersity plays a significant role in the reaction kinetic measurements since any variation in droplet size reflects itself as concentration variation. Here, we developed an ultra monodisperse droplet system to study the reaction kinetics involved in Polydopamine (PDA) polymerization and Aggregation Induced Quenching (AIQ) inhibition of PDA. Dopamine is a potential biomarker for neurological diseases such as schizophrenia, Huntington's and Parkinson's diseases. Understanding this reaction is a critical towards a functional assay.

Ultra Monodisperse Microdroplets

We demonstrate enhancement of droplet monodispersity using off-chip compliances to minimize fluctuations due to flow sources. By adding compliant off-chip components (flexible tubings), we were able to significantly damp the flow fluctuations. The electrical droplet detection scheme we have developed gives comparable performance to more commonly used optical detection method [3] and yields real-time droplet length analysis.

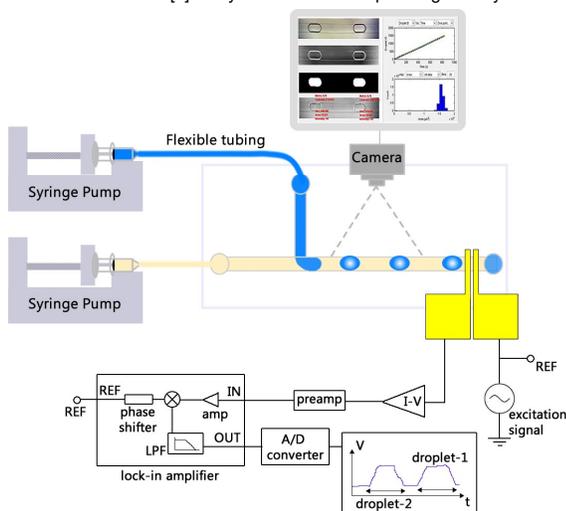


Figure 1. Schematic illustration of T-junction monodisperse droplet generation and characterization setup.

Calculating the coefficient of variation (CV) of the droplet length, droplet monodispersity has been analyzed. CV of the droplet length decreases from 2.12% to 0.19% using compliance damping. The ultra monodisperse droplets provide very precise concentration control for the segmented fluid.

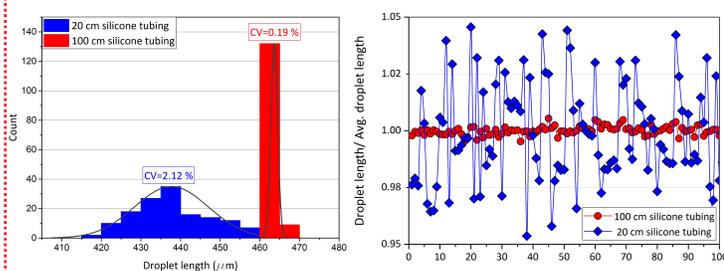


Figure 2. Droplet length obtained using 20 cm and 100 cm – long silicone tubings as compliance unit.

References

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4. Zhang X, Wang S, Xu L, Feng L, Ji Y, Tao L, et al, *Nanoscale*. 2012;4(18):5581-4.
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Microfluidic device

The photoluminescence emission spectra of the polydopamine (PDA) show that the concentration of the reagent and substrate (hydrogen peroxide and dopamine) plays a significant role on reaction kinetics [4,5]. Using our enhanced monodisperse droplet system, we investigate the reaction kinetics of the increased fluorescent emission of PDA.

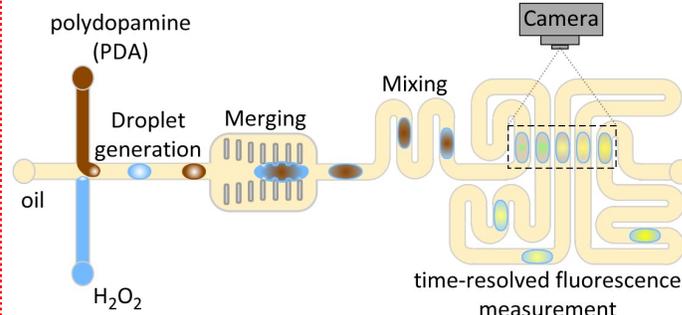


Figure 3. Schematic of ultra monodisperse droplet system used for reaction kinetics investigation. Merging of H_2O_2 and polydopamine droplets were studied.

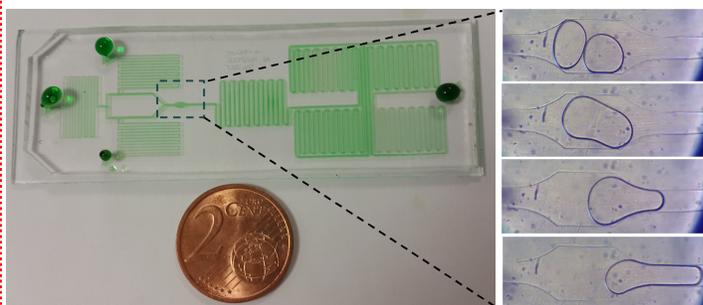


Figure 4. Fabricated microfluidic device containing two T-junction droplet generation module, a passive droplet merging unit and long channel segments for temporal study of the reaction.

Monodisperse droplets of two fluids to be mixed are formed individually and mixed so that the concentration of the final droplet is precisely regulated. After droplet merging, five long channel segments with the same length is used to characterize the reaction in the time scale.

Time dependent reaction kinetics

The change of the fluorescence intensity of PDA due to the change of reaction time is studied. Time-dependent fluorescence spectra of PDA in the presence of 50 mM H_2O_2 was investigated with the droplet system (Fig. 5b) and verified with spectrometer results (Fig. 5a)

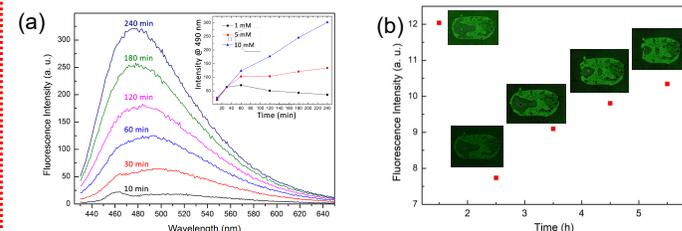


Figure 5. a) Bulk spectrometer fluorescence intensity at 490 nm in the presence of 1 mM, 5 mM and 10 mM H_2O_2 . b) Time-dependent fluorescence spectra of PDA inside droplets for 50 mM H_2O_2 .

Conclusion

The ultra monodisperse droplet-based system provides a sensitive and automated platform to study precision reaction kinetics. Using an automated microfluidic device results reaction kinetics for varying reagent concentrations can be studied to investigate response curves and limit of detection for potential assays.

Supports



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