

Controllable Emulsification and Point-Of-Care Assays Driven by Magnetic Induced Movement of the Fluid

Tech ID: 26032 / UC Case 2016-228-0

SUMMARY

UCLA researchers in the Department of Bioengineering have developed a microfluidic droplet generation technique that only uses magnetic forces to emulsify ferrofluid containing solutions.

BACKGROUND

Digital (or droplet) microfluidics is an emerging liquid-handling technology that can be used in a large range of applications including genome profiling, high throughput digital assays and point-of-care (POC) assays. Traditionally, however, droplets are formed using bulky pressure driven or syringe pump driven flow systems. While this has offered significantly improved control over conventional continuous-flow microfluidics, lack of accurate pumps for particle formation has limited its application in POC formats. There is a need for improved digital microfluidic technology that can adjust flow rates and droplet sizes for use in clinical, POC settings.

INNOVATION

UCLA researchers in the Department of Bioengineering have developed a droplet formation emulsification device that's based on magnetic induced flow of ferrofluid. The emulsification is done in a single step and operates without any pumps. Reagents mixed with ferrofluids can be introduced from two or more inlets and mixed prior to emulsification, allowing efficient mixing of reagents on chip and formation of compartmentalized droplets using only a small external magnet. The enhanced control of droplet formation allows for narrow size distributions. This technology provides a complete solution to combine mixing of reagents, rapid droplet generation, and droplet control that can also be applied to portable devices for POC applications.

APPLICATIONS

- ▶ Digital assays at point-of-care
- ▶ Single-cell whole genome amplification
- ▶ Controlled polymerization of different type of magnetic polymer or hydrogel particles
- ▶ Time-sensitive chemical reactions
- ▶ Cell or particle sorting
- ▶ Particle purity analysis

ADVANTAGES

- ▶ Uniform particle size
- ▶ Tunable particle size and rate of formation
- ▶ Pump-free microfluidic device ·Small sample volume required
- ▶ Adjustable magnetic particles
- ▶ Facile on-chip mixing of different fluids and emulsification
- ▶ Precise control of reagent ratio
- ▶ High operational pressure

STATE OF DEVELOPMENT

Several setups with single and multiple inlets have been fabricated and tested with 2 different aqueous biocompatible ferrofluids. A 10µL solution was emulsified to 125µm droplets in less than 10 minutes with a one-inlet device. The maximum droplet generation rate can be

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INVENTORS

- ▶ Di Carlo, Dino

OTHER INFORMATION

KEYWORDS

emulsification, magnetic nanoparticles, ferrofluid, droplets, microfluidics, digital assays, point-of-care, diagnostics, ferrofluidics, on-chip particles

CATEGORIZED AS

- ▶ **Biotechnology**
 - ▶ Genomics
 - ▶ Industrial/ Energy
- ▶ **Medical**
 - ▶ Devices
 - ▶ Diagnostics
 - ▶ Research Tools
- ▶ **Nanotechnology**
 - ▶ NanoBio
 - ▶ Tools and Devices
- ▶ **Research Tools**
 - ▶ Other

RELATED CASES

2016-228-0

achieved with a permanent magnet of ~0.1 T surface B-field is about 12 droplets/second for each channel. Parallelized designs allow generation of 100s of droplets/sec. The system was used to successfully perform a nucleic acid amplification assay. A handheld device to achieve the combination of mixing of sample with ferrofluid followed by emulsification reactions and downstream detection is in development.

RELATED MATERIALS

- ▶ Kahkeshani S, Di Carlo D. Drop formation using ferrofluids driven magnetically in a step emulsification device[J]. Lab on a Chip, 2016.
- ▶ Kahkeshani S, Kong JE, Wei Q, Tseng D, Garner OB, Ozcan A, Di Carlo D. Ferrodop Dose-Optimized Digital Quantification of Biomolecules in Low-Volume Samples. Analytical Chemistry, 2018.

PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Issued Patent	11,596,909	03/07/2023	2016-228
United States Of America	Issued Patent	10,688,453	06/23/2020	2016-228

ADDITIONAL TECHNOLOGIES BY THESE INVENTORS

- ▶ Integrated Isolation, Emulsification, And Single-Cell Assay
- ▶ Monodisperse Emulsions Templated By 3D-Structured Microparticles
- ▶ Enhanced Fluorescence Readout And Reduced Inhibition For Nucleic Acid Amplification Tests
- ▶ Label-Free Digital Bright Field Analysis of DNA Amplification
- ▶ Robust, Ultra-Flexible, Micro-Encoded Ferromagnetic Tape for Bioseparation and Assembly

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