# Microfluidics

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## Overview

## History of Microfluidics

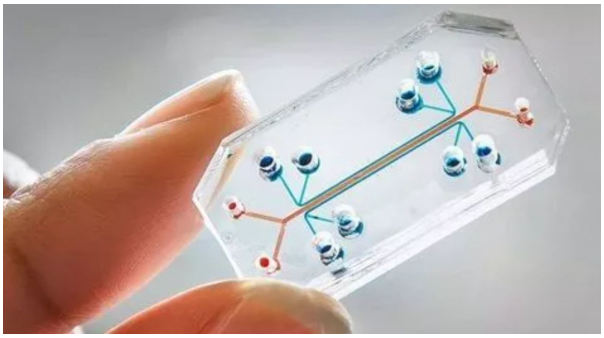
- First microfluidic device developed at Stanford
- Inventors: James B. Angell, John H. Jerman, Stephen C. Terry Ph.D, and Soheil Saadat
- Miniaturized gas chromatography (GC) system
- GC measures and identifies gaseous samples
- Ideal for analyzing industrial environments

Photograph of the prototype gas analysis system

"The first microfluidic device was a miniaturized gas chromatography (GC) system developed by Terry et al. [2] at Stanford University in the 1970s." Terry, et al includes Professor James B. Angell, John H. Jerman, Stephen C. Terry, Ph.D., and, Soheil Sadaat. "A gas chromatograph (GC), which is capable of separating, identifying, and measuring the constituents of a gaseous sample, is an ideal instrument for performing is an ideal instrument for performing the analysis of an industrial environment."

## Microfluidics Technology

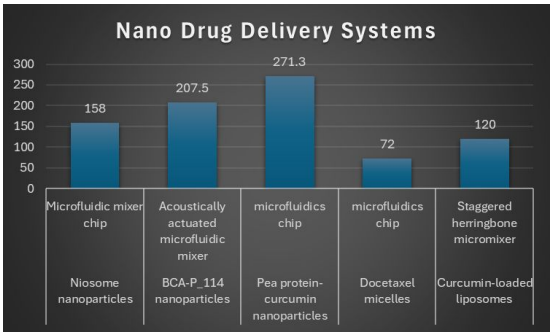
- Combines physics, chemistry, biology, fluid dynamics, microelectronics, and material science
- Various materials processed into miniature chips
- Chips contain microscale channels and chambers
- Used in drug encapsulation, delivery, and targeting
- Utilized in cell analysis, diagnosis, and cell culture



“Microfluidics is a newly emerging field based on the combined fields of physics, chemistry, biology, fluid dynamics, microelectronics, and material science. A variety of materials can be processed into miniature chips with channels and chambers in the microscale range (Nicelscu 1). “They can be used alone or in combination with other devices. Microfluidic chips can be employed in nanoparticle preparation, drug encapsulation, delivery, and targeting, cell analysis, diagnosis, and cell culture.” (Nicelscu 1)

# Microfluidics in Drug Delivery

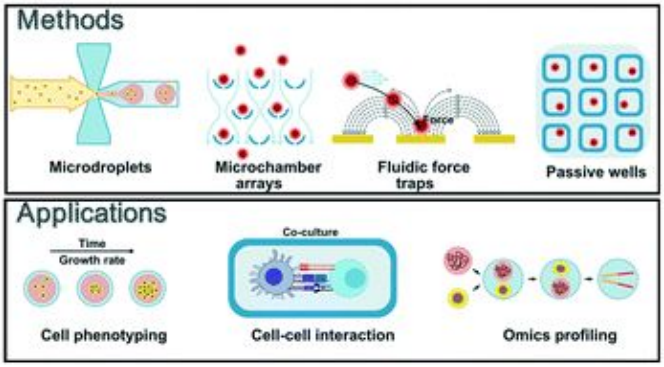
- Lipid-polymer nanoparticles are better in microfluidic devices
- Microfluidic organ-on-a-chip platform
- Organ-on-a-chip synthesizes nanoparticles for drug delivery




| NNDS | Microfluidic device | Size Nanometer (nm) |
|---|---|---|
| Niosome nanoparticles | Microfluidic mixer chip | 158 |
| BCA-P_114 nanoparticles | Acoustically actuated microfluidic mixer | 207.5 |
| Pea protein-curcumin nanoparticles | microfluidics chip | 271.3 |
| Docetaxel micelles | microfluidics chip | 72 |
| Curcumin-loaded liposomes | Staggered herringbone micromixer | 120 |

“Lipid-polymer nanoparticles are problematic to synthesize in a batch approach. However, they have been fabricated with the desired characteristics in microfluidic devices. A newly emerging field, known as organ-on-a-chip introduced a new platform for evaluation and screening for drug delivery. The organ-on-a-chip platforms use microfluidic systems that aim to imitate specific functions of one or more organs. “

# Microfluidics in Cell Analysis




- Real-time cell analysis
- Used for diagnosis of cancer
- Utilized to diagnose immune system diseases

"Lastly, microfluidics applications in single cell sequencing technology for the diagnosis of cancers and immune system diseases are briefly illustrated." (Zhou, et al 1)

"The microfluidic device is a fast-rising system that offers efficient, effective, and sensitive single-cell cultivation and real-time single-cell analysis conducted either on-chip or off-chip." (Aggraini 1)

## Implementation of Microfluidics

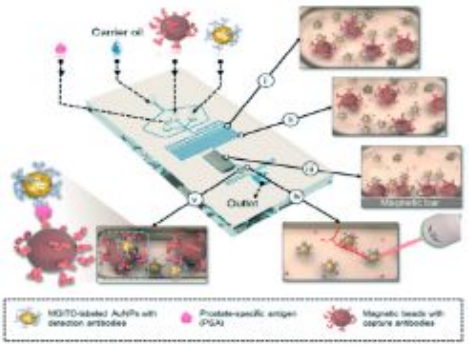
- Microfluidics will impact pharmaceutical companies
- Doctors benefit from better diagnostic tests
- Microfluidics improve speed of cancer diagnosis
- Nano Drug Delivery Systems benefit patients
- Microfluidics help diabetics and asthmatics
- Quicker access to vaccines

“They can deliver drugs to the desired site and realize the drugs' sustained release, thereby reducing drugs' toxicity and improving drugs' bioavailability. Various NDDSs, such as liposomes, nanoparticles, and micelles, have been extensively studied and hold great promise in the treatment of various diseases including tumors, diabetes, and asthma.”

“At present, the marketed microfluidics-mediated NDDSs against COVID-19 include Pfizer/BioNTech's BNT162b2 and Moderna's mRNA-1273, both of which are LNPs-encapsulated mRNA vaccines”

## Benefits of Microfluidics

- Faster reaction time
- Enhanced analytical sensitivity
- Enhanced temperature control
- Better portability
- Relatively cheap



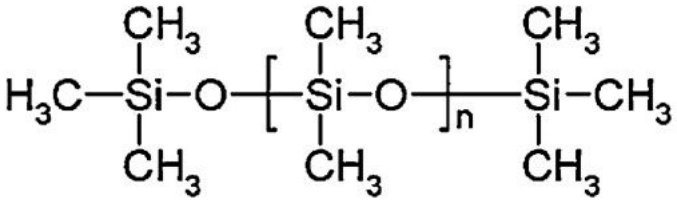

Detection of disease biomarkers

"Microfluidics have diverse assets: faster reaction time, enhanced analytical sensitivity, enhanced temperature control, portability, easier automation and parallelization, integration of lab routines in one device (lab-on-a-chip). It is cheap as it does not involve the use of various costly equipment." (Elveflow)

"Another advantage of microfluidic systems is the increased precision that they offer. Microfluidic systems offer an exceptionally high level of control of experimental conditions because of their custom-designed architectures and atomization. This increased level of control yields itself to more precise experimentation and accurate results. Microfluidic systems allow multiple analytes to be processed at the same time. This simultaneous processing is possible because of the reduced amount of space that each circuit requires. By running multiple circuits at the same time, the amount of time that each experiment takes is greatly reduced, allowing for more efficient processes and increased throughput." (Kelly Pneumatics)

## Drawbacks of Microfluidics

- Chips made of PDMS (Polydimethylsiloxane) too absorbent
- PDMS chips pick up contaminants
- Exposure to certain chemicals dissolves PDMS



Polydimethylsiloxane

"PDMS is known to adsorb hydrophobic molecules onto its surface, which can lead to irreversible binding and potentially alter experimental results."
"PDMS can easily pick up contaminants from the environment."
"Both can lead to inconsistent experimental results."
"PDMS has limited chemical compatibility with some solvents, acids, and bases. Exposure to these chemicals can cause PDMS to swell or even dissolve, compromising the integrity of the microfluidic device and potentially affecting experimental conditions." (Micronit)

## Summary

- I agree with the advancements in microfluidics
- It will greatly revolutionize pharmaceuticals
- Cancer patients will live longer lives
- Asthmatics and diabetics may get a cure
- This will overall benefit the world

## Bibliography 1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- Microfluidics | Definitions | uFluidix
- Advantages of Microfluidic Systems
- Recent advances in microfluidic devices for single-cell cultivation: methods and applications
- Unique strengths of microfluidics: Optofluidic Bioassay LLC
- PDMS for Microfluidics: Limitations and Alternatives

## Bibliography 2


- Microfluidics for nano-drug delivery systems: From fundamentals to industrialization
- Applications of polydimethylsiloxane in analytical chemistry: A review
- Recent progress of microfluidic chips in immunoassay