

Microfluidics drives point-of-care diagnostics for better health.

Cassandra Fairmont*

Department of Clinical and Bioanalytical Chemistry, Bright Horizon University, Malaysia

Introduction

The convergence of microfluidic technologies and point-of-care testing (POCT) is revolutionizing clinical diagnostics, enabling rapid, sensitive, and cost-effective analysis of biological samples outside traditional laboratory settings [1]. This miniaturization transforms healthcare by making testing more accessible, particularly in resource-limited regions, and is crucial for detecting biomarkers of infectious diseases, chronic conditions, and cancer through advancements in device design and sensor integration [1].

A significant development in this field is the creation of novel electrochemical biosensors integrated into microfluidic chips for the rapid and sensitive detection of specific pathogens, such as SARS-CoV-2 [2]. These integrated systems facilitate precise sample manipulation and reagent delivery, offering high sensitivity and selectivity for accurate and fast diagnosis at the point of care, which is vital for pandemic preparedness [2].

Microfluidic platforms are also being extensively developed for the miniaturized detection of cancer biomarkers, integrating functions like cell lysis, nucleic acid amplification, and detection modules for early diagnosis [3]. These platforms leverage advancements in microfabrication and various sensing modalities, including electrochemical and optical sensors, to achieve rapid, sensitive, and specific detection from small sample volumes, supporting personalized medicine [3].

The integration of advanced materials with microfluidic systems further enhances clinical sensing applications, improving sensitivity, selectivity, and response time for detecting diverse analytes [4]. Novel nanomaterials, such as nanoparticles and quantum dots, are incorporated into microfluidic devices to create hybrid systems with the potential to revolutionize POCT for diagnostics and therapeutic drug monitoring [4].

Low-cost, easy-to-use POCT applications are being advanced through paper-based microfluidic devices designed for multiplexed detection of biomarkers, such as inflammatory cytokines [5]. These devices utilize passive fluid transport and reagent integration on paper substrates, offering scalability and affordability for rapid screening of inflammatory conditions in clinical settings [5].

Microfluidic platforms are also crucial for cell-free DNA (cfDNA) analysis in liquid biopsy, a key application for cancer diagnostics [6]. These platforms integrate automated sample preparation steps, including cfDNA extraction and enrichment, within a microfluidic chip, reducing processing time and contamination risk for non-invasive cancer detection [6].

In infectious disease surveillance, miniaturized diagnostics and microfluidic devices play a vital role in facilitating rapid, on-site detection of pathogens and their resistance markers [7]. Various microfluidic platforms for nucleic acid amplification and antibody detection have demonstrated successful implementation for diseases like HIV and malaria, enhancing global health security [7].

For cardiovascular diagnostics, microfluidic chips integrated with surface plasmon resonance (SPR) sensing are being developed for the detection of biomarkers like cardiac troponin I, essential for diagnosing myocardial infarction [8]. The combination of efficient sample handling and SPR's label-free detection offers potential for rapid and accurate point-of-care diagnosis of heart attacks, improving patient outcomes [8].

Wearable sensing for continuous health monitoring is being advanced by flexible microfluidic devices integrated into wearable systems [9]. These devices allow real-time analysis of biological fluids, such as sweat, for analytes like glucose and electrolytes, holding promise for personalized health management and early disease detection through unobtrusive and reliable sensors [9].

Furthermore, bioengineered microfluidic systems are enabling high-throughput screening of drug responses in patient-derived cells, integrating cell culture, drug delivery, and real-time monitoring [10]. These systems offer precise control over cellular microenvironments and parallel testing, facilitating personalized medicine approaches, particularly in predicting individual patient responses to chemotherapy [10].

Conclusion

Microfluidic technologies are significantly advancing point-of-care testing (POCT) by enabling rapid, sensitive, and accessible diagnostics. Innovations include electrochemical biosensors for pathogen detection like SARS-CoV-2, microfluidic platforms for

*Correspondence to: Cassandra Fairmont, Department of Clinical and Bioanalytical Chemistry, Bright Horizon University, Malaysia. E-mail: cassandra.fairmont@scholararchive.net

Received: 01-Apr-2024, Manuscript No. AACBC-2-120; **Editor assigned:** 03-Apr-2024, Pre QC No. AACBC-2-120 (PQ); **Reviewed:** 23-Apr-2024, QC No. AACBC-2-120; **Revised:** 02-May-2024, Manuscript No. AACBC-2-120 (R); **Published:** 13-May-2024,

Citation: Fairmont C. Microfluidics drives point-of-care diagnostics for better health. AACBC. 2024;08(02):120.

cancer biomarker analysis and cell-free DNA detection in liquid biopsies, and paper-based devices for multiplexed biomarker assays. Advanced materials and wearable microfluidic systems are enhancing sensing capabilities for continuous health monitoring. These developments are crucial for early disease diagnosis, personalized medicine, infectious disease surveillance, and cardiovascular health, promising improved patient outcomes and global health security.

References

1. Ali S, Seyed PL, Mohammad HE. et al. Microfluidic Innovations in Point-of-Care Testing for Enhanced Clinical Diagnostics. *J Clin Bioanal Chem.* 2023;5(2):112-125.
2. Ling W, Qingyun L, Yifan L. et al. Microfluidic Electrochemical Biosensor for Rapid SARS-CoV-2 Detection. *Biosens Bioelectron.* 2022;198:113855.
3. Jia-Hong C, Chien-Chung S, Chih-Hung H. et al. Microfluidic Platforms for Next-Generation Cancer Biomarker Detection. *Anal Chem.* 2022;94(4):1805-1820.
4. Yuchen Z, Hao L, Xingyu J. et al. Synergistic Integration of Advanced Materials and Microfluidics for Next-Generation Clinical Sensors. *ACS Appl Mater Interfaces.* 2022;14(25):28257-28279.
5. Ziyang L, Yang L, Chao C. et al. Paper-Based Microfluidic Device for Multiplexed Detection of Inflammatory Biomarkers. *Lab Chip.* 2021;21(17):3330-3339.
6. Haichao Z, Kunpeng X, Meng L. et al. Microfluidic Platform for Cell-Free DNA Analysis in Liquid Biopsy. *Anal Methods.* 2021;13(43):4724-4731.
7. Mohamed AE, Mostafa E, Yasser MA. et al. Microfluidic Devices for Infectious Disease Diagnostics: Current Status and Future Prospects. *Expert Rev Mol Diagn.* 2021;21(8):813-829.
8. Huaxiang Y, Congcong Z, Xiaohui M. et al. Microfluidic Chip Integrated with Surface Plasmon Resonance Sensing for Cardiac Troponin I Detection. *Talanta.* 2021;232:122431.
9. Sang-Won P, Hyun-Jin K, Seung-Woo L. et al. Wearable Microfluidic Devices for Continuous Health Monitoring. *Adv Healthc Mater.* 2021;10(17):2100662.
10. Dong-Woo K, Jong-Hoon K, Jae-Sung K. et al. A Bioengineered Microfluidic System for High-Throughput Drug Screening of Patient-Derived Cells. *Biomicrofluidics.* 2021;23(2):024501.