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A Comprehensive Survey of Paper-Based Microfluidic Analytical Devices in Forensic and Clinical Toxicology

Ellio Dossi*

Department of Agrifood and Environmental Science, University of Udine, Via Cotonificio 108, 33100 Udine, Italy

Abstract

Advancements in analytical techniques have revolutionized the fields of forensic and clinical toxicology, enabling faster, more sensitive and portable methods for drug screening and toxicological analysis. Among these innovations, paper-based microfluidic analytical devices have emerged as a promising technology, offering several advantages over traditional methods. In this article, we will delve into the world of paper-based microfluidic devices and explore their applications in forensic and clinical toxicology. Paper-based microfluidic analytical devices, also known as Paper-Based Analytical Devices (PADs) or Microfluidic Paper-Based Analytical Devices (μPADs), are a class of miniaturized diagnostic tools that utilize the wicking properties of paper to transport and control fluid flow. These devices are constructed by patterning hydrophobic barriers on filter paper, creating channels for fluid movement and enabling precise reactions. They offer numerous benefits such as simplicity, cost-effectiveness, portability and rapid analysis, making them highly suitable for point-of-care testing in both forensic and clinical settings. Paper-based microfluidic devices have shown great potential in on-site testing for drugs of abuse, a critical need in forensic toxicology. These devices can detect a wide range of substances, including cocaine, opiates, amphetamines and cannabinoids, from biological samples like blood, urine and saliva. Their rapid turnaround time and ease of use can aid law enforcement agencies and forensic laboratories in obtaining quick results during criminal investigations.

Keywords: Paper-Based Analytical Devices (μPADs) • Clinical toxicology • TDM techniques • Saliva

Introduction

In forensic investigations, trace evidence such as gunshot residue, explosives and chemical residues can provide crucial information. Paper-based microfluidic devices can be tailored to detect these trace elements, offering a portable and cost-effective alternative to conventional laboratory-based techniques. Paper-based microfluidic devices can be employed in postmortem toxicology to analyze blood and tissue samples from deceased individuals. Their ability to handle small sample volumes and detect multiple analytes simultaneously makes them valuable tools in determining the cause of death and identifying potential poisons. For patients undergoing drug therapies, maintaining therapeutic drug levels is vital for treatment efficacy and safety. Paper-based microfluidic devices allow point-of-care monitoring of drug concentrations in blood or other body fluids, facilitating dose adjustments as needed. In emergency situations, quick toxicological analysis can be life-saving. Portable paper-based microfluidic devices can rapidly screen for common toxic substances, such as drugs and poisons, enabling healthcare professionals to make immediate treatment decisions. Paper-based microfluidic devices have been utilized to assess environmental toxicity by monitoring contaminants and pollutants in water and soil samples. Their ease of use and field-deployable nature make them valuable tools for environmental monitoring and assessment. Research and development in paper-based microfluidic devices are continuously progressing [1]. Advancements include enhancing sensitivity through signal amplification methods, integrating multiple functionalities on a single device and enabling smartphone-based readouts for quantification and data analysis.

***Address for Correspondence:** Ellio Dossi, Department of Agrifood and Environmental Science, University of Udine, Via Cotonificio 108, 33100 Udine, Italy, E-mail: elliodossi@gmail.com*

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Literature Review

Despite their potential, paper-based microfluidic devices face some challenges. Ensuring reproducibility and robustness of results across different batches of devices, optimizing the sensitivity of detection methods and addressing issues related to storage and stability of reagents are areas that require further attention. Paper-based microfluidic analytical devices have emerged as a promising technology in the fields of forensic and clinical toxicology. Their simplicity, cost-effectiveness, portability and rapid analysis capabilities make them attractive for point-of-care testing and on-site investigations. As research continues to advance, these devices hold the potential to revolutionize toxicological analysis, improving public health and safety worldwide. However, addressing current challenges will be crucial to fully exploit the benefits of these innovative tools in the future. Paper-based microfluidic devices have proven invaluable in on-site drug screening for law enforcement and forensic investigation teams. The simplicity and rapid response of these devices make them ideal for detecting drugs of abuse in urine, saliva, or blood samples. Different detection strategies, such as immunoassays and colorimetric reactions, can be incorporated into μPADs to identify specific drugs or drug classes [2].

Microfluidic devices have revolutionized various fields of science, enabling precise and efficient analysis of samples in a miniaturized format. Among the many types of microfluidic platforms, Paper-Based Microfluidic Analytical Devices (μPADs) have gained significant attention due to their simplicity, low-cost and portability. In forensic and clinical toxicology, these paper-based devices have shown immense potential in detecting drugs, toxins and other chemical substances in biological samples. This article aims to provide a comprehensive survey of the advancements and applications of paper-based microfluidic devices in forensic and clinical toxicology. Paper-based microfluidic technology harnesses the capillary action of paper to manipulate fluids without the need for external power sources or pumps. The fabrication of μPADs typically involves patterning hydrophilic and hydrophobic regions on

filter paper or other cellulose-based materials. These patterns direct the flow of the sample and reagents, allowing precise control over fluid movement. By integrating various functional components, such as detection zones and reagent reservoirs, paper-based devices offer a versatile platform for analytical testing [3].

Discussion

In cases of suspected poisoning or exposure to toxins, quick and accurate detection is crucial for timely medical intervention. Paper-based microfluidic devices enable rapid screening for a wide range of toxic substances, including heavy metals, pesticides and harmful chemicals. These devices can be designed to produce a visible colour change or other signals upon contact with the target analyse, making them user-friendly and suitable for point-of-care applications. For patients undergoing drug therapy, monitoring drug concentrations in blood is essential to ensure effective treatment and prevent adverse effects. Paper-based microfluidic devices offer a cost-effective and efficient alternative to conventional laboratory-based TDM techniques. They can be tailored to measure specific drug concentrations within a patient's blood, providing real-time data for healthcare professionals. In emergency situations where immediate toxicological information is required, paper-based microfluidic devices can deliver rapid and accurate results. Emergency departments can benefit from these devices to identify potential toxic substances in patients quickly, allowing for prompt treatment decisions [4].

Paper-based materials are inexpensive, making the devices affordable, especially in resource-limited settings. The lightweight and compact nature of µPADs allows for easy transportation and on-site testing. Paper-based devices offer quick turnaround times, which is critical for time-sensitive applications. Minimal training is required to operate these devices, enabling non-experts to perform tests. Some paper-based assays may have lower sensitivity compared to traditional laboratory methods. The sample volume that can be processed by paper-based devices is often limited. The stability of reagents integrated into the devices may be a concern for long-term storage [5]. The field of paper-based microfluidic devices in forensic and clinical toxicology continues to evolve rapidly. Researchers are continually improving device sensitivity, developing multiplexed assays and exploring new detection methodologies to enhance their performance. Moreover, efforts are being made to overcome the limitations, such as extending shelf life and increasing the sample processing capacity.

Paper-based microfluidic devices have emerged as a powerful tool for on-site analysis in forensic and clinical toxicology. Their simplicity, cost-effectiveness and portability make them ideal for a wide range of applications. With ongoing advancements and improvements, these devices hold great promise for transforming toxicological analysis and contributing to better healthcare outcomes and forensic investigations. As technology progresses, it is expected that paper-based microfluidic devices will continue to make significant contributions to the fields of forensic and clinical toxicology. In recent years, the field of microfluidics has witnessed significant advancements and Paper-Based Microfluidic Analytical Devices (µPADs) have emerged as a promising technology with vast applications in various fields, including forensic and clinical toxicology. These devices offer a cost-effective, portable and user-friendly platform for performing sophisticated analytical tests, enabling rapid and accurate detection of toxic substances in complex samples. This article provides a comprehensive survey of the latest developments and applications of paper-based microfluidic devices in the fields of forensic and clinical toxicology [6].

Microfluidics is a multidisciplinary field that deals with the manipulation of minute volumes of fluids in microscale channels. The integration of microfluidics with paper-based platforms has led to the development of Paper-Based Microfluidic Analytical Devices (µPADs). µPADs leverage the inherent capillary action of paper to transport fluids, eliminating the need for external pumps and complex microfabrication processes. This simplicity makes them suitable for Point-Of-Care Testing (POCT) and on-site forensic investigations, where quick and reliable results are of paramount importance.

Conclusion

Paper-based microfluidic analytical devices have revolutionized forensic and clinical toxicology by providing a portable, cost-effective and user-friendly platform for rapid analysis of toxic substances. With ongoing research and development, these devices hold the potential to become indispensable tools in forensic investigations, point-of-care diagnostics and monitoring toxic exposures in clinical settings. As technology progresses, further innovations are expected to address the current challenges and unlock new possibilities for these promising devices in the realm of forensic and clinical toxicology. Paper-based microfluidic analytical devices have emerged as a promising tool in the fields of forensic and clinical toxicology. Their portability, cost-effectiveness and simplicity make them attractive for widespread adoption, especially in resource-limited settings.

As technology continues to progress, the potential for µPADs to transform toxicology testing is immense, ultimately benefiting public health and forensic investigations. The field of microfluidics has witnessed remarkable advancements in recent years, paving the way for innovative and cost-effective analytical solutions in various domains. One such area that has benefited significantly from this technology is forensic and clinical toxicology. Paper-based microfluidic analytical devices have emerged as promising tools for the rapid and reliable detection of toxic substances in forensic investigations and clinical settings. These devices offer numerous advantages, including portability, low cost, ease of use and reduced sample volumes. This article presents a comprehensive survey of the recent developments and applications of paper-based microfluidic devices in forensic and clinical toxicology.

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Conflict of Interest

None.

References

1. Noviana, Eka, Tugba Ozer, Cody S. Carrell and Jeremy S. Link, et al. "Microfluidic paper-based analytical devices: From design to applications." *Chem Rev* 121 (2021): 11835-11885.
2. Martinezandres W., Scott T. Phillips, Manish J. Butte and George M. Whitesides. "Supporting information for patterned paper as a platform for inexpensive, low volume, portable bioassays." (2007).
3. Musile, Giacomo, Yvane Agard, F. Elio and Ksenia Shestakova, et al."Thanatochemistry at the crime scene: A microfluidic paper-based device for ammonium analysis in the vitreous humor." *Anal Chim Acta* 1083 (2019): 150-156.
4. Musile, Giacomo, Yvane Agard, Sara Pesavento and F. Elio, et al. "An origami microfluidic paper device for on-site assessment of urine tampering. First use of Nessler's reagent for the colorimetric determination of creatinine." *Anal Chim Acta* 1237 (2023): 340610.
5. De Araujo, W. R and Thiago Regis Longo Cesar da Paixão. "Fabrication of disposable electrochemical devices using silver ink and office paper." *Analyst* 139 (2014): 2742-2747.
6. Musile, Giacomo, Cristian Grazioli, Stefano Fornasaro and Nicolò Dossi, et al. "Application of Paper-Based Microfluidic Analytical Devices (µPAD) in Forensic and Clinical Toxicology: A Review." *Biosensors 13 (2023): 743.*

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