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RESEARCH ARTICLE

A NOVEL POINT-OF-CARE DEVICE FOR MONITORING CIRCULATING MIRNA-107 IN PROSTATE CANCER: TOWARDS A USER-FRIENDLY LIQUID BIOPSY

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ABSTRACT: Liquid biopsy represents an advanced non-invasive cancer detection system which analyzes biomarkers found in blood and other body fluids. MicroRNAs (miRNAs) are important biomarkers because they are stable, disease-specific, and have the potential to reflect tumor dynamics. The miRNA-107 plays an important role in the development and progression of prostate cancer (PCa), which makes it a potential target for early diagnosis and monitoring.
A low-cost paper-based electrochemical platform was developed for sensitive miRNA-107 detection, using in-house synthesized gold nanoparticles (AuNPs)-modified screen-printed electrodes (SPEs) to enhance conductivity and surface area. A DNA probe labeled with methylene blue (MB) was immobilized on SPEs via Au-S bonding. It was then rinsed with deionized (DI) water, and blocked with 6-mercapto-1-hexanol (MCH) to lower nonspecific binding. The platform works on "signal-off" square wave voltammetry (SWV) mechanism which decreases current upon addition of target miRNA hybridization. The key parameters AuNPs volume, probe concentration and frequency were optimized. The sensor has achieved detection limits of 1.8 nM in PBS and 1.0 nM in serum, with strong selectivity against non-target miRNAs.
The results show that this approach has a strong potential to be a rapid, reliable and cost-effective tool for PCa detection. It is portable and easy to use, making it suitable for resource-limited settings, and thus a practical solution for early diagnosis and monitoring at the point of care (POC).

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Impact statement: POC devices have the potentiality to revolutionize the access to diagnosis and care. Liquid biopsy on chip means opportunity for all patients to get timely responses and interventions. MiRNAs represent very promising biomarkers in the field of liquid biopsy, and their decentralized monitoring can be performed at portable strips, similarly in simplicity to those utilized by diabetes patients to monitor blood glucose.

Key words: *Liquid biopsy; miRNA-107; prostate cancer; electrochemical biosensor; signal-off detection; point-of-care diagnostics.*

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INTRODUCTION

Prostate cancer (PCa) is the second most frequently diagnosed cancer among men worldwide (1-3). The disease resulted in 397,430 deaths during 2020 and researchers predict 2.9 million new cases will occur each year until 2040 (4, 5). The incidence rate increases dramatically with age. The majority of PCa

cases progress slowly but the disease can transform into an aggressive form that threatens life (6). So premature early detection and precise monitoring become crucial (7).

Current diagnostic practices for PCa include prostate-specific antigen (PSA) testing, digital rectal examination (DRE), and biopsies (8-10) . PSA testing has helped with early detection of PCa. However, it lacks specificity. Elevated PSA levels can also occur due to benign conditions like prostatitis or benign prostatic hyperplasia. This often leads to overdiagnosis and overtreatment of non-aggressive cases (11). DRE serves as a supplementary tool but has limitations in sensitivity and specificity (12). The gold standard for confirming PCa still remains tissue biopsy because it provides detailed histopathological insights. The procedure is invasive and carries risks of bleeding and infection and may miss tumors which results in false negatives (13, 14). Traditional methods have demonstrated such significant drawbacks that alternative methods have become essential to achieve precise results with low /or minimal invasiveness.

The focus of research has moved toward developing more advanced diagnostic tools which combine precision with user-friendly features and minimal invasiveness. Liquid biopsy emerges as a promising alternative among these because it provides non-invasive diagnostic capabilities through the analysis of circulating tumor cells (CTCs) and cell-free DNA (cfDNA) and circulating tumor DNA (ctDNA) and extracellular vehicles (EVs) and non-coding RNAs including microRNAs (miRNAs) and other biomarkers found in bodily fluids (15, 16). The technique provides multiple clinical benefits because it performs minimally invasive procedures while being safer and better suited for repeated testing throughout time which makes it suitable for monitoring diseases longitudinally (17). The technology enables early detection of cancer recurrence as well as immediate identification of treatment resistance which supports personalized patients care. It shows increasing accuracy through molecular analysis advancements which makes it a promising alternative for conventional diagnostic procedures (18-21).

Small non-coding RNAs have emerged as promising biomarkers among the numerous biomarkers. The miRNAs show particular advantages because they are highly stable in bodily fluids, easily detectable, and often exhibit cancer-specific expression patterns. These advantages make them ideal candidates for non-invasive PCa diagnostics (22). PCa shows specific miRNA associations with its disease behavior. The progression of PCa together with its tumor aggressiveness is linked to miRNA-141 (23) and miRNA-21. The metastatic potential of prostate cancer is associated with miRNA-375 (24). Similarly, the miRNA-107 shows promise as a non-invasive biomarker for PCa diagnosis. The diagnostic potential of miRNA-107 is supported by its elevated levels in PCa patient in serum and urine although most studies present relative expression values instead of absolute concentrations (25, 26). Its high levels in castration-resistant prostate cancer (CRPC) and its association with advanced disease stages make it a a promising tool for early-stage diagnosis. Recent studies have demonstrated that circulating miR-107 levels are significantly elevated in patients with CRPC. For instance, Puente-Rivera *et al.* (2024) reported that miR-107 expression in liquid biopsies was significantly higher in CRPC patients compared to non-castration-resistant prostate cancer (NCRPC) patients, with a p-value <0.005, suggesting its potential as a non-invasive diagnostic biomarker for identifying CRPC patients (27). The diagnostic value of miRNA-107 has been expanded through recent research which demonstrates its therapeutic potential to improve PCa treatment results. The radiosensitivity of PCa cells increases when miRNA-107 targets granulin (GRN) because this protein promotes tumor growth and resistance thus improving radiotherapy outcomes (28).

Similarly, other miRNAs such as miRNA-107 have also been identified as potential non-invasive biomarkers. Its high levels in castration-resistant prostate cancer (CRPC) and its association with advanced disease stages make it a potential biomarker for early detection and monitoring (27). The diagnostic value of miRNA-107 has been expanded through recent research which demonstrates its therapeutic potential to improve PCa treatment results. The radiosensitivity of PCa cells increases when miRNA-107 targets granulin (GRN) because this protein promotes tumor growth and resistance thus improving radiotherapy outcomes (28).

The clinical implementation of miRNA-107 shows great promise to revolutionize PCa management through its ability to provide non-invasive blood tests which detect PCa early and predict patient outcomes and tailor treatment plans. This approach improves patient outcomes, reduces the need for invasive biopsies, and provides more targeted and effective care by monitoring treatment responses and refining risk assessments. The clinical application of miRNA-based assays for PCa diagnosis and

prognosis faces challenges because conventional analytical platforms have certain limitations. Northern blotting techniques have limitations for clinical use because they lack sensitivity and require extensive time which prevents their use in routine diagnostics (29). The short sequences and high sequence homology of miRNAs make it difficult to design primers and achieve accurate quantification in real-time quantitative polymerase chain reaction (RT-qPCR) (30, 31). Microarrays and next-generation sequencing (NGS) provide broad profiling capabilities but demand costly infrastructure and extensive sample preparation, limiting their use outside specialized laboratories (32, 33). The NanoString nCounter system provides amplification-free quantification but its high costs and complex normalization procedures limit its use (34). The emerging tool of digital droplet PCR (ddPCR) provides exact miRNA quantification but requires trained personnel and sophisticated equipment (35). Loop-mediated isothermal amplification (LAMP) technique demonstrates potential for field applications yet requires further optimization to detect miRNAs because of sequence constraints (36). While these systems offer strong analytical performance, they often require complex fabrication and instrumentation. So, the focus has shifted to diagnostic formats which offer accessibility and speed and require minimal infrastructure without losing clinical relevance.

The demand has shifted toward decentralized testing through Point-of-Care (POC) innovations which enhance diagnostic access worldwide. The increasing worldwide demand for POC diagnostics demonstrates the critical requirement for quick and affordable testing solutions particularly in resource-limited areas. The latest developments in decentralized testing have demonstrated its worthwhile propelling POC innovations that transform disease diagnosis methods (37, 38). Building on this progress, the mChip represents a practical application of POC technology because it functions as a credit card-sized microfluidic device which performs HIV and syphilis detection from a single drop of blood. The technology proved its effectiveness by reaching 100% accuracy for HIV detection and 94% accuracy for syphilis detection during Rwanda trials while each chip cost approximately $1 which makes it ideal for low-resource settings (39-41). Complementing these advancements, SD Biosensor's dual HIV/syphilis rapid diagnostic test was developed with support from MedAccess. The test has been adopted by more than 100 low- and middle-income countries since 2022. The test uses a finger-prick sample to deliver results within 20 minutes. The test operates at a cost below $1 per unit which makes it suitable for locations with restricted laboratory facilities (42). The widely acceptance of patient-centered care has been further enhanced by basic diagnostic tools including glucose meters, pregnancy tests and COVID-19 kits. These tools provide fast and precise results while enabling testing at the exact location where it is needed (43). These technologies enhance this transformation by both filling critical diagnostic gaps and enabling a decentralized patient-centered care system with better responsiveness. The broad range of applications from infectious diseases to cancer demonstrates how POC tools are increasingly reshaping healthcare delivery systems.

The development of POC devices for miRNA detection has tumor dynamics. transform cancer management in a similar direction. These tools offer timely and cost effective diagnostic solutions, bridging the gap between complex traditional methods and the need for accessible real time testing (44). Extending this potential further, stability and specificity of miRNAs make them valuable biomarkers for cancers including prostate, breast and lung (45). The approach can be further developed by integrating miRNA detection into portable POC platforms that utilize electrochemical sensors and paper-based microfluidic systems to enable early diagnosis and dynamic disease monitoring and tailored therapy outside traditional laboratory settings. This represents a vital advancement in precision oncology that delivers accessible patient-centered care.

Responding to the critical need for rapid and accessible cancer diagnostics, our research group continuously focuses on developing paper-based electrochemical platforms with screen-printed electrodes (SPEs) for cancer detection. The research focuses on converting precise analytical methods into deployable field formats which will enhance point of care biosensing capabilities for resource limited and decentralized clinical settings. Building on this foundation, Cimmino and colleagues developed an electrochemical device for miRNA-224 detection which serves as a biomarker for lung cancer. The system used methylene blue (MB) labeled DNA probes with SPEs on wax patterned paper. The system reached a detection limit of 0.6 nM in spiked human serum which demonstrated both high sensitivity and field deployability (46). Raucci *et al.* developed a biosensor using paper to detect miRNA-652 which serves as a biomarker for triple negative breast cancer. The

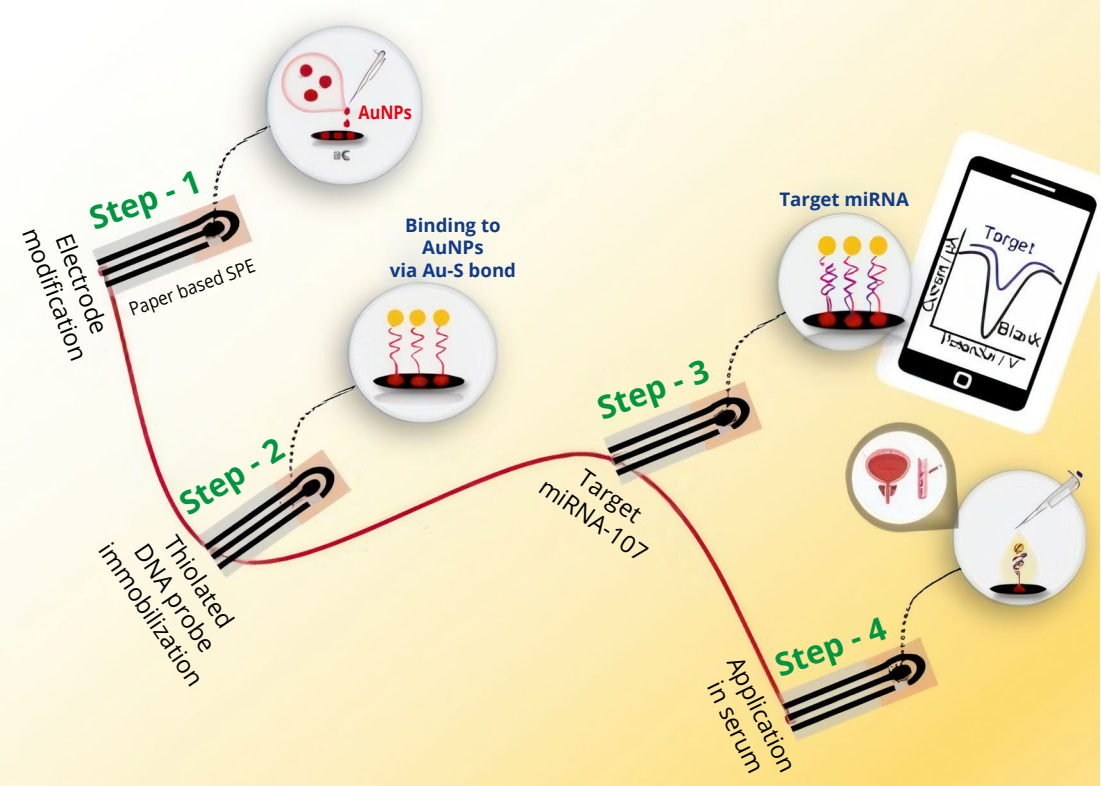
device utilized screen printed electrodes that were modified with gold nanoparticles (AuNPs) on office paper. The system used wax-assisted chromatographic preconcentration as its analytical method. The sensor reached a detection limit of 0.4 nM in human serum while demonstrating good repeatability (47). Martino *et al.* further showed that nanostructured gold composites on microfabricated electrodes enable sub-nanomolar detection of cancer-related miRNAs (48).

The diagnostic application of miRNA detection benefits from AuNPs modified electrodes because they provide both high sensitivity and adjustable surface chemistry. The research presents a portable paper-integrated biosensor, which detects miRNA-107 specifically because this biomarker appears in different cancer types. The sensor combines AuNPs synthesized in-house with SPEs made from standard office paper to create a cost-effective and scalable detection system. The working electrode contains thiolated DNA capture probes which are labeled with MB. The immobilized DNA probe recognizes its target miRNA 107 sequence through hybridization. The molecular interaction between the target and the probe changes the electrochemical properties of the redox label which allows square wave voltammetry (SWV) to obtain electrochemical readout. The platform demonstrates excellent potential for POC applications because it provides high sensitivity and electrochemical readout functionality. Further, it also offers a simple and reliable operation which makes it ideal for decentralized cancer diagnostics particularly in resource limited settings. Our method unites proven sensitivity with home-based manufacturing and inexpensive materials to enhance both accessibility and scalability for clinical and point-of-care applications. The step-by-step fabrication and operation of the paper-based electrochemical biosensor for miRNA-107 detection is illustrated in **Scheme 1** following the detailed description of the platform.

EXPERIMENTAL SECTION

Materials and apparatus

The target sequence for hsa-miR-107 (5'-AGCAGCAUUGUACAGGGCUAUCA-3') and its complementary thiolated DNA probe (5'-TGATAGCCCTGTACAATGCTGCT-3') were obtained from Metabion GmbH



Scheme 1. *The paper-based electrochemical sensor fabrication and working steps for miRNA-107 detection:* ***(1)*** *electrode surface modification using AuNPs;* ***(2)*** *immobilization of a thiolated MB-labeled DNA probe;* ***(3)*** *detection of target miRNA-107 by SWV by signal-off mechanism; and* ***(4)*** *application in serum.*

(Steinkirchen, Germany). Phosphate-buffered saline (PBS) tablets (containing 140 mM NaCl, 10 mM phosphate buffer, and 3 mM KCl), tris(2-carboxyethyl)phosphine (TCEP), MCH, chloroauric acid ($HAuCl_4$), sodium citrate, and sodium borohydride were procured from Sigma-Aldrich (St. Louis, MO, USA). All reagents used were of analytical grade. The fabrication of sensors required AuNPs which were synthesized in our laboratory through a standard method that we use regularly and stored at 4 °C. These AuNPs have been routinely used in our lab across similar biosensor platforms. The synthesized batch was characterized by dynamic light scattering (DLS) and scanning electron microscopy (SEM), confirming a monodisperse distribution with an average diameter of 196.2 ± 20.65 nm and a polydispersity index (PDI) of 0.13 ± 0.07, consistent with previous reports (49). The nanoparticles served as a modification for working electrode surfaces to improve their performance.

All electrochemical measurements were conducted using a PalmSens 4 portable potentiostat (PalmSens, Netherlands) connected to a multi-12 channel reader and operated via PSTrace 5.10 software, ensuring precise control and reproducibility across all experiments.

Fabrication of Paper-Based SPEs: Custom-designed paper-based SPEs were fabricated in-house on Fabriano office paper (80 g/m²) using standard screen-printing techniques. A hydrophobic layout was printed with a Xerox ColorQube 8580 and thermally treated at 100°C for 1 minute to form fluidic barriers. A three-electrode configuration was achieved by first printing silver ink (Loctite, Italy) for the reference, followed by graphite ink (Sun Chemical, USA) for the working (4 mm diameter) and counter electrodes. Each layer was kept at 60°C for 30 minutes. The resulting electrochemical strips measured 2.5 cm × 1 cm, offering a simple, scalable platform for biosensor integration (50).

Optimization of experimental parameters

All the experimental parameters were optimized for the development of highly effective and reliable electrochemical biosensor for detecting miRNA-107. For this, one of the first parameters were amount of AuNPs on the surface of the working electrode, the concentration of the anti-miRNA-107 DNA probe and the frequency of SWV.

Optimization of AuNP volume

Various volumes (2, 4, 8, and 10 µL) of AuNPs were tested to identify the optimal volume for the detection of the electrochemical signal on the electrode surface. This conductive nanostructured layer was formed by depositing AuNPs through drop casting onto the working electrode area of paper-based SPEs, allowing for electron transfer and acting as a high-density binding surface for the immobilization of thiol-functionalized DNA probes.

Concentration of DNA probe

In order to obtain a high-efficiency hybridization interface for miRNA-107 detection, we optimized the concentration of DNA probe. Several probe concentrations (50-200 nM) were tested to obtain the optimal probe density that exhibited maximum signal change.

Optimization of SWV frequency

To determine the optimum condition with the maximum signal intensity as well as a well-defined voltammetric peaks, frequencies ranged from 10 to 100 Hz were optimized. The selection of optimum frequency is a key factor for improving the signal-to-noise ratio and facilitating the electrochemical responses which would generate accurate and reproducible results during target capture.

Electrochemical detection of miRNA-107

Based on the optimized experimental parameters, we carried out the electrochemical detection of miRNA-107 using paper-based SPEs. The working electrode area was modified by drop-casting AuNPs to enhance surface conductivity and probe immobilization. Following AuNP deposition, 20 µL of MB-labeled DNA probe was drop-cast onto the electrode. The modified electrodes were incubated in a humidity chamber for 1 hour to allow probe immobilization via Au-S bonding. After incubation, the electrodes were rinsed with DI water to remove unbound probe. Next, 20 µL of MCH was applied to the electrode surface. MCH acts as a blocking agent to minimize non-specific adsorption and improve probe orientation. The electrodes were again placed in the humidity chamber for 1 hour and 30 minutes. After incubation, the surface was washed thoroughly with DI water. For electrochemical analysis, the modified electrodes were connected to a PalmSens 4 portable potentiostat. Each SPE was exposed to 70 µL of blank PBS, pH 7.4 and allowed to stabilize for 30 minutes to establish a consistent electrochemical baseline. The detection mechanism relies on a “signal-off” electrochemical response. To quantify the analytical response, the percent-

age (%) signal change was calculated using the following equation (1):

$$\text{Signal change (\%)} = 100 \times \frac{(I_0 - I_t)}{I_0} \quad (1)$$

Where I_0 : initial current, and I_t: current recorded after the addition of miRNA-107.

RESULTS AND DISCUSSION

Optimization of experimental parameters

We optimized the experimental biosensor parameters like volume of AuNPs deposited on the electrode surface, the concentration of the MB-labeled DNA probe, and the frequency applied during SWV. The results of this optimization are presented in **Figure 1**.

Effect of AuNPs volume on signal response

As shown in **Figure 1A**, different volumes of AuNPs (2, 4, 8, and 10 µL) were optimized. The highest signal change was observed with 2 µL of AuNPs, suggesting that a low-volume deposition provides a uniform, conductive surface without excessive nanoparticle aggregation. Larger volumes resulted in a gradual decrease in signal response, likely due to the formation of a dense nanoparticle layer that could hinder probe immobilization, increase surface roughness, or impair electron transfer. Thus, 2 µL was selected as the optimal volume, balancing conductivity, probe accessibility, and hybridization efficiency.

Optimization of DNA probe concentration

To determine the optimal probe density on the electrode surface, anti-miRNA-107 DNA probes were immobilized at different concentrations (50, 100, 150, and 200 nM). As depicted in **Figure 1B**, the signal change increased with probe concentration up to 100 nM, beyond which the response declined. This behavior is attributed to the balance between sufficient surface coverage for target recognition and excessive probe crowding, which can induce steric hindrance and reduce hybridization efficiency. Additionally, higher probe densities can affect the orientation and electron transfer of the MB redox tag. Therefore, 100 nM was selected as the optimal probe concentration, offering maximum signal change with efficient target recognition and redox activity.

Influence of SWV frequency on detection sensitivity

The SWV frequency is a critical factor affecting both the resolution and sensitivity of redox-based detection. Frequencies ranging from 10 to 100 Hz were evaluated (**Figure 1C**), with the maximum signal change observed at 50 Hz. At lower frequencies, the system may not efficiently capture the rapid redox events of the MB label, leading to underdeveloped signals. Conversely, higher frequencies may compromise the sensitivity by limiting the time available for redox cycling, thus reducing the current response. Based on this, 50 Hz was determined to be the optimal setting, offering a high signal-to-noise ratio and well-resolved voltammetric peaks.

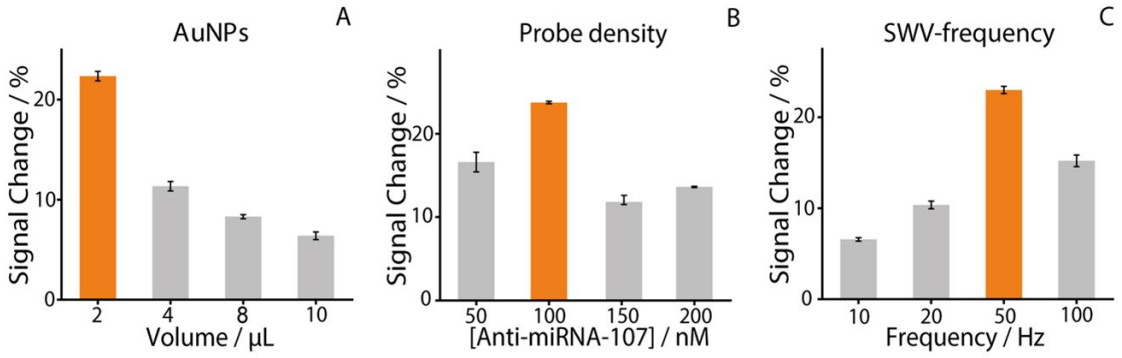


Figure 1. *Optimization of experimental parameters for miRNA-107 detection.*
***(A)** Effect of AuNPs volume (2-10 µL) on signal change. **Experimental conditions:** probe concentration = 100 nM; frequency = 50 Hz; Estart = 0 V, Eend = −0.6 V, Estep = 0.001 V, amplitude = 0.01 V, equilibrium time = 5 s; **(B)** Optimization of anti-miRNA-107 probe concentration (50–200 nM). **Experimental conditions:** AuNPs volume = 2 µL; frequency = 50 Hz; Estart = 0 V, Eend = −0.6 V, Estep = 0.001 V, amplitude = 0.01 V, equilibrium time = 5 s; **(C)** Optimization of SWV frequency (10-00 Hz). **Experimental conditions:** AuNPs volume = 2 µL; probe concentration = 100 nM; Estart = 0 V, Eend = −0.6 V, Estep = 0.001 V, amplitude = 0.01 V, equilibrium time = 5 s. All experiments were conducted in triplicate using 40 nM of miRNA-107 in PBS (pH 7.4), and results are reported as mean ± SD (n = 3).*

Analytical characterization of miRNA-107 detection in PBS and serum

The electrochemical biosensor developed for miRNA-107 detection demonstrated excellent analytical performance across a broad dynamic range in both PBS and serum. As shown in the calibration plots (**Figure 2**), the sensor response increased in a sigmoidal fashion with rising miRNA-107 concentrations, reflecting a characteristic binding curve indicative of efficient and specific hybridization between the surface-bound probe and the target sequence. Following the optimization of experimental parameters, the analytical performance of the developed electrochemical biosensor was systematically evaluated across a wide dynamic range of miRNA-107 concentrations upto 400 nM in both PBS and serum. As shown in **Figure 2**, the biosensor exhibited a characteristic sigmoidal response curve in both matrices, indicating a concentration-dependent decrease in current signal consistent with target-probe hybridization. The calibration data were well-fitted using a four-parameter Hill equation, demonstrating the cooperative nature of binding and supporting its use for quantitative analysis by equation (2).

$$f(x) = y_0 + \frac{a \cdot x^b}{c^b + x^b} \quad (2)$$

A limit of detection (LOD) of 1.8 nM was achieved, with a strong correlation (R^2 = 0.9909), confirming the reliability and linearity of the electrochemical response within the tested range. Notably, the biosensor retained robust performance in serum with LOD of 1.0 nM with an R^2 of 0.9860 and reproducibility in physiologically relevant conditions.

The ability of the biosensor to achieve lower detection limits for miRNA-107 in both buffer and serum matrices represents a substantial advancement in the field of electrochemical diagnostics. This level of sensitivity aligns with the clinical concentration range of circulating miRNAs, affirming the platform's suitability for early-stage disease detection. The sensor shows its robustness, selectivity, and practical translatability in serum. Importantly, this work validates a minimally invasive, cost-effective, and portable diagnostic approach that holds strong potential for deployment in POC cancer screening and longitudinal therapeutic monitoring, particularly in settings where centralized laboratory infrastructure is limited.

Selectivity study

To evaluate the specificity of the developed biosensor, its electrochemical response was measured against miRNA-107 and three non-target miRNAs (miRNA-4676, miRNA-218, and miRNA-21), all at the same concentration (40 nM) as shown in **Figure 3**. As shown in **Figure 3A**, in buffer conditions, miRNA-107 produced a distinct and pronounced signal suppression (~23%), reflecting efficient hybridization with the complementary probe. In contrast, the non-target sequences generated minimal signal changes (≤8%), indicating negligible non-specific binding or cross-reactivity. This selectivity profile was retained in serum (**Figure 3B**), where miRNA-107 still yielded a strong response (~24%), while the off-target miRNAs resulted in significantly lower signal shifts. Despite the increased complexity of the

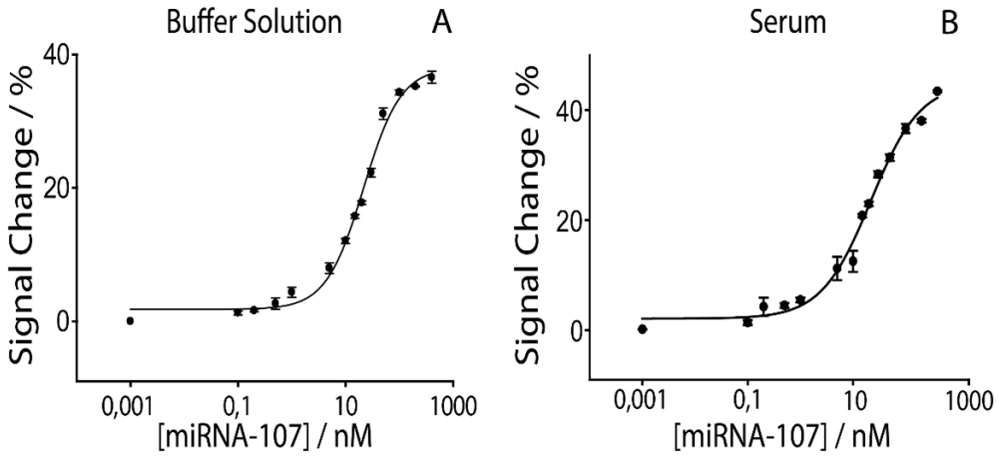


Figure 2. *Analytical characterization of the miRNA-107 biosensor in* ***(A)*** *buffer;* ***(B)*** *serum. Signal change (%) was measured in a concentration upto 400 nM. The data were fitted using a four-parameter Hill equation and sigmoid behavior was observed.* ***Experimental conditions:*** *AuNPs volume = 2 µL; probe concentration= 100 nM; Estart = 0 V, Eend = −0.6 V, Estep = 0.001 V, amplitude = 0.01 V, equilibrium time = 5 s, SWV frequency= 50 Hz. All the experiments were conducted in triplicate and results are expressed as mean ± standard deviation (n = 3).*

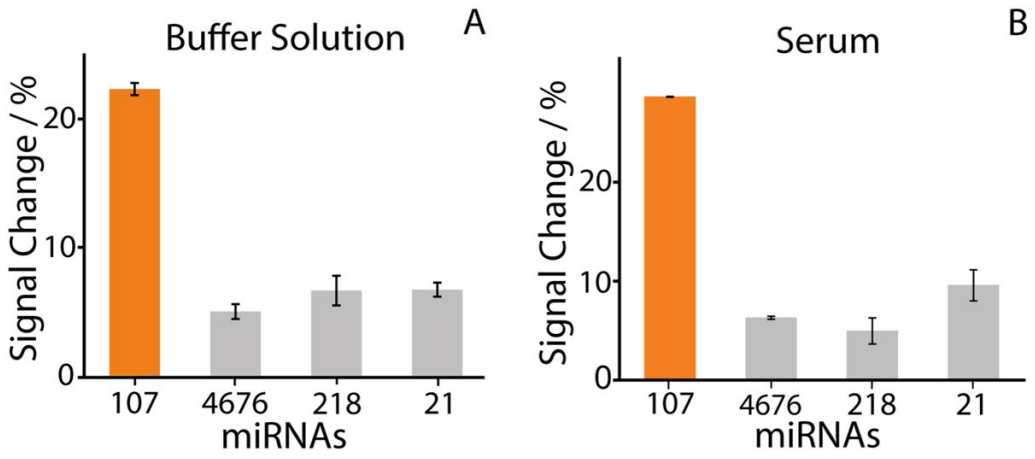


Figure 3. *Selectivity study of the miRNA-107 biosensor in* ***(A)*** *buffer solution;* ***(B)*** *serum using non-target miRNAs (miRNA-4676, miRNA-218, and miRNA-21) at 40 nM concentration.* ***Experimental conditions:*** *AuNPs volume = 2 µL; probe concentration= 100 nM; Estart = 0 V, Eend = −0.6 V, Estep = 0.001 V, amplitude = 0.01 V, equilibrium time = 5 s, SWV frequency= 50 Hz. All the experiments were conducted in triplicate and results are expressed as mean ± standard deviation (n = 3).*

serum matrix-which contains a wide array of electroactive species, proteins, and nucleases-the sensor maintained high target discrimination. The performance in serum validates the robustness of the probe design, surface chemistry, and blocking strategy used during sensor fabrication.

This signifies the ability of the biosensor to differentiate miRNA-107 from closely related sequences underscores the reliability of the probe design and its potential clinical utility. From a translational perspective, such high selectivity ensures diagnostic accuracy by minimizing false positives-an essential requirement for any biosensor intended for use in early cancer screening, treatment monitoring, or recurrence prediction. The fact that this level of performance is maintained in complex biological matrices like serum further reinforces the sensor's suitability for **POC** and **real-world clinical applications,** especially in minimally invasive blood-based diagnostics.

CONCLUSIONS

The research introduces a major advancement in liquid biopsy diagnostics. The diagnostic system consists of a portable electrochemical biosensor. The sensor identifies miRNA 107 which serves as a crucial biomarker for prostate cancer progression and aggressiveness. The biosensor utilized AuNPs modified SPEs. These electrodes were immobilized with an MB labeled DNA probe. The SWV technique served as the detection method. The detection system operated through a signal off mechanism. The design shows both sensitivity and selectivity. It is also easy to use. These features make it appropriate for clinical use and POC applications.

Critical parameters like AuNPs volume, probe concentration, and SWV frequency were systematically optimized to maximize hybridization efficiency and signal resolution. The biosensor exhibited a sigmoidal response curve, achieving detection limit of 1.8 nM in PBS and 1.0 nM in serum. The probe also showed high specificity for miRNA-107, even in complex biological samples, confirming its accuracy.

The biosensor provides practical advantages together with its analytical merits which make it suitable for POC deployment. It works at low-cost while being simple to operate and its production materials can be scaled up for large-scale manufacturing.

Further, the research will evaluate both the shelf-life duration and its resistance to environmental factors to enable wider field applications. The future development of this technology requires multiplexed detection capabilities and clinical specimen validation to achieve routine use in cancer screening and monitoring. Testing with real patient samples will confirm its performance. This study offers a simple, non-invasive tool for cancer diagnosis. The research demonstrates how this accessible non-invasive platform can help with early diagnosis and personalized care in both centralized and resource limited healthcare settings.

COMPLIANCE WITH ETHICAL STANDARDS

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Conflicts of interests

The authors declare no competing interests.

Data availability

All data generated or analyzed during this study are included in this article.

Author's contributions

Conceptualization: SC and SS; writing-original draft: SS and AG; figures: SS and AG; reviewing: SC and MDL; funding acquisition: SC, MDL, AG and SS.
All authors reviewed the manuscript and prepared for submission.

Ethical approval

All solutions were commercially available. Real samples were not used.

Publication ethics

Plagiarism

Authors declare no potentially overlapping publications with the content of this manuscript and all original studies are cited as appropriate.

Data falsification and fabrication

All the data corresponds to the real**.**

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