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Nanostructure-Based Voltammetric Biosensors: Versatile Point-of-Care Electrochemical Platform Development

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INTRODUCTION & AIM

Modern healthcare demands rapid, accurate, and accessible diagnostic technologies. Traditional laboratory-based methods suffer from extended turnaround times, high costs, and centralized infrastructure requirements. Point-of-care diagnostics represent a paradigm shift, enabling immediate clinical decision-making at the patient's bedside. Integration of nanomaterials into electrochemical biosensors has revolutionized analytical capabilities, providing unprecedented sensitivity and selectivity. This research aims to develop nanostructure-enhanced voltammetric biosensing platforms for next-generation medical diagnostics, targeting portable devices suitable for diverse clinical settings [1].

METHOD

Electrochemical sensors were fabricated through layer-by-layer deposition of graphene oxide composites, multi-walled carbon nanotubes, and functionalized gold nanoparticles onto screen-printed electrodes. Nanomaterials were synthesized using modified Hummers method, acid functionalization, and citrate reduction, with comprehensive characterization via cyclic voltammetry, electrochemical impedance spectroscopy, and microscopy techniques. Biorecognition elements including antibodies and aptamers were immobilized through covalent coupling chemistry. Portable point-of-care devices integrated miniaturized potentiostats, microfluidic sample handling, and wireless connectivity with battery operation for field deployment. Clinical samples including blood, serum, and saliva were analyzed for cardiac markers, cancer biomarkers, inflammatory cytokines, and infectious disease indicators, with performance validated against established reference methods.

RESULTS & DISCUSSION

The nanostructure-modified electrodes exhibit superior electrochemical performance through multiple mechanisms: increased electroactive surface area, accelerated electron transfer kinetics, electrocatalytic effects, and enhanced analyte accumulation. The biosensing technology represents significant advancement toward precision medicine and equitable healthcare access. Portable devices enable deployment from specialized medical centers to resource-limited settings. Ongoing developments in regulatory compliance and manufacturing scale-up position this technology for global clinical translation, with potential to transform clinical practice through rapid, accurate, and accessible medical testing.

CONCLUSION

This research successfully demonstrates innovative nanostructure-enhanced voltammetric biosensing platforms for rapid medical diagnostics. Key achievements include 10-100× sensitivity enhancement, ultra-low detection limits (pM-fM range), rapid analysis (5-15 minutes), portable design for diverse healthcare settings, and cost-effective manufacturing. The nanostructure-modified electrodes exhibit superior electrochemical performance through multiple mechanisms: increased electroactive surface area, accelerated electron transfer kinetics, electrocatalytic effects, and enhanced analyte accumulation. The biosensing technology represents significant advancement toward precision medicine and equitable healthcare access. Portable devices enable deployment from specialized medical centers to resource-limited settings. Ongoing developments in regulatory compliance and manufacturing scale-up position this technology for global clinical translation, with potential to transform clinical practice through rapid, accurate, and accessible medical testing.

FUTURE WORK / REFERENCES

[1] Derya Bal Altuntas, Yudum Tepeli and Ulku Anik, Graphene-metallic nanocomposites as modifiers in electrochemical glucose biosensor transducers. 2016 *2D Mater.* **3** 034001