Design and fabrication of nanostructured disposable electrochemical bio-sensing chips for the quick monitoring of Alzheimer's disease biomarkers

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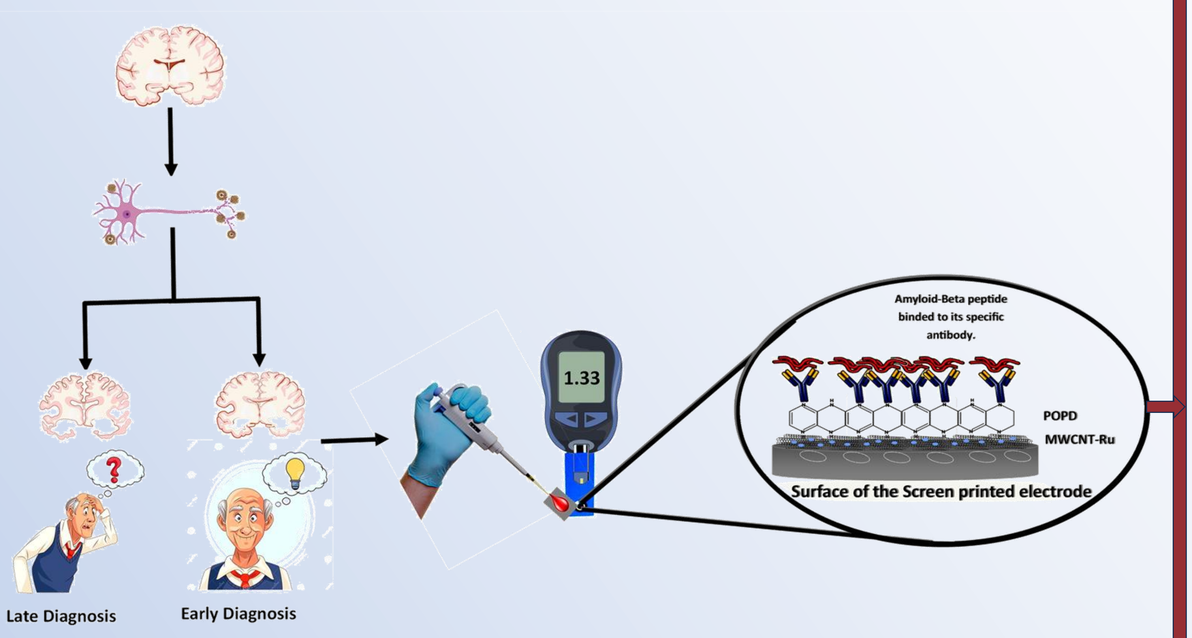
Background

Neurodegenerative diseases (NDs) like Alzheimer's disease (AD), Parkinson's disease, and ALS involve progressive neuronal degeneration, with AD being the most prevalent dementia type, marked by memory loss and affecting ~50 million people globally. Its pathology features amyloid-beta plaques and tau protein tangles, causing neuronal death. Current diagnosis relies on invasive, costly methods like brain imaging and CSF analysis, hindering early detection. Electrochemical nano-biosensors offer a transformative solution, enabling rapid, non-invasive, and sensitive detection of biomarkers such as amyloid-beta oligomers and phosphorylated tau proteins. These biosensors leverage nanocomposites and molecularly imprinted polymers to enhance specificity and portability for point-of-care use. Our study focuses on developing an immunosensor platform using screen-printed electrodes to detect plasma AD biomarkers, aiming to improve early diagnosis and patient outcomes globally.

"Catching Alzheimer's Before It Catches Memories: Early Signals, Lasting Memories with Biosensing."

Methodology



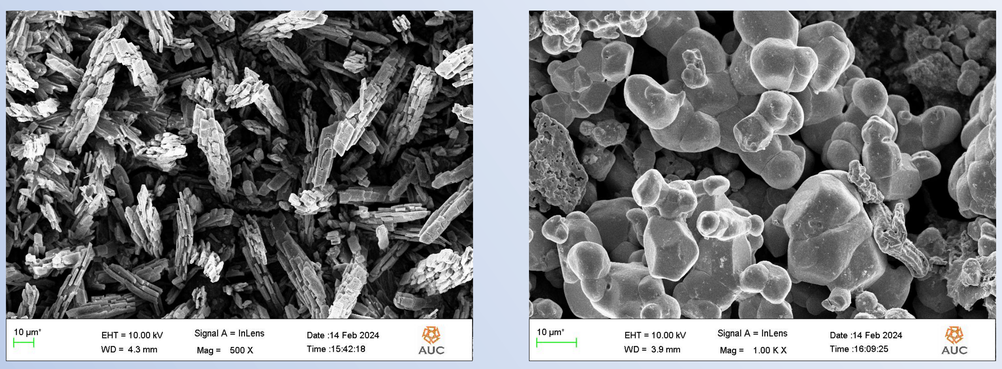


Figure 1: Graphical Abstract of the work. SEM images of (A) Electrodeposited P-OPD on the surface of the modified electrode with MWCNT-Ru composite. (B) Ruthenium (Ru) nanoparticles.

References

1. Abbasi, H. Y., Tehrani, Z., Devadoss, A., Ali, M. M., Moradi-Bachiller, S., Albani, D., & Guy, O. J. (2021). Graphene based electrochemical immunosensor for the ultra-sensitive label free detection of Alzheimer's beta amyloid peptides Aβ (1–42). *Nanoscale Advances*, *3*(8), 2295-2304.
2. Sharma, A., Angnes, L., Sattarahmady, N., Negahdary, M., & Heli, H. (2023). Electrochemical Immunosensors Developed for Amyloid-Beta and Tau Proteins, Leading Biomarkers of Alzheimer's Disease. *Biosensors*, *13*(7), 742.

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Steps of fabrication of the immune-sensing system

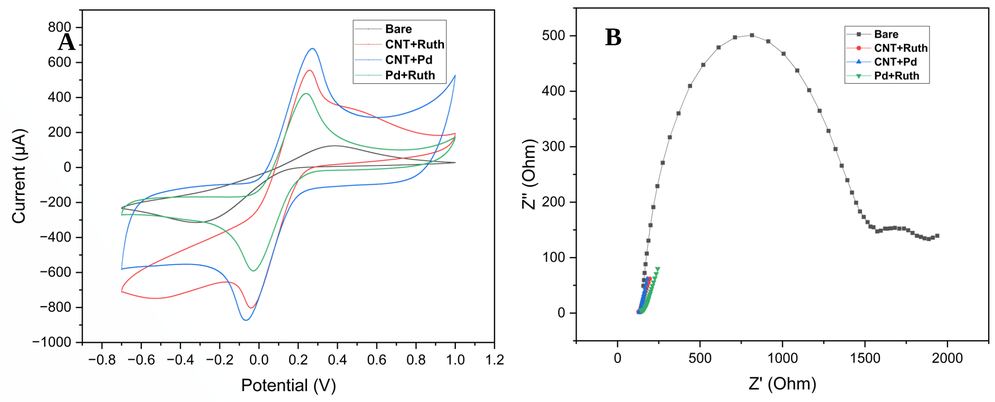

Figure 2: (A-B) Nanomaterial Composite selection. (A) Cyclic voltammetric (CV) characterization of printed electrodes modified with different nanomaterial composites. **(B)** Electrochemical impedance spectroscopic (EIS) characterizations of printed electrodes modified with different nanomaterial composites.

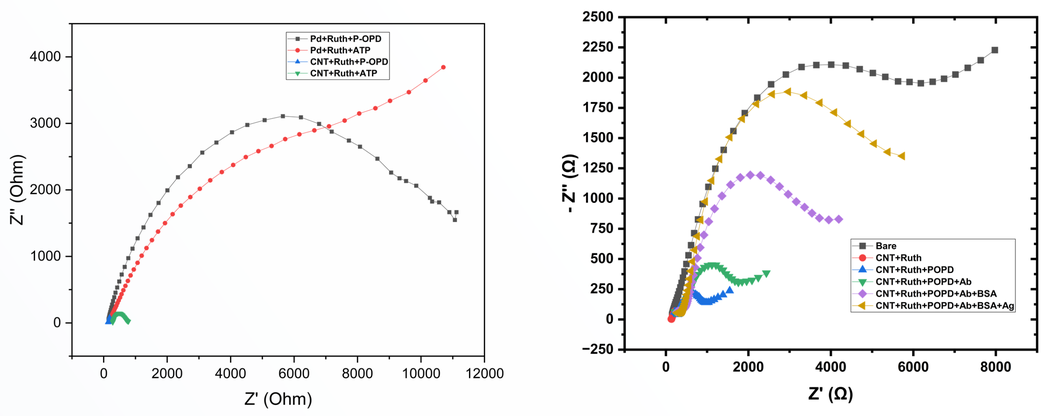

Figure 3: (A) EIS Characterization of printed electrodes with different crosslinkers (electrodeposited POPD vs 4-ATP**, (B)** EIS monitoring of the immunosensor manufacturing steps including the drop-casting of nanocomposites onto the printed electrode surface, formation of a self-assembled monolayer of the P-OPD, conjugation of the antibody, blocking the non-specific binding with the BSA.

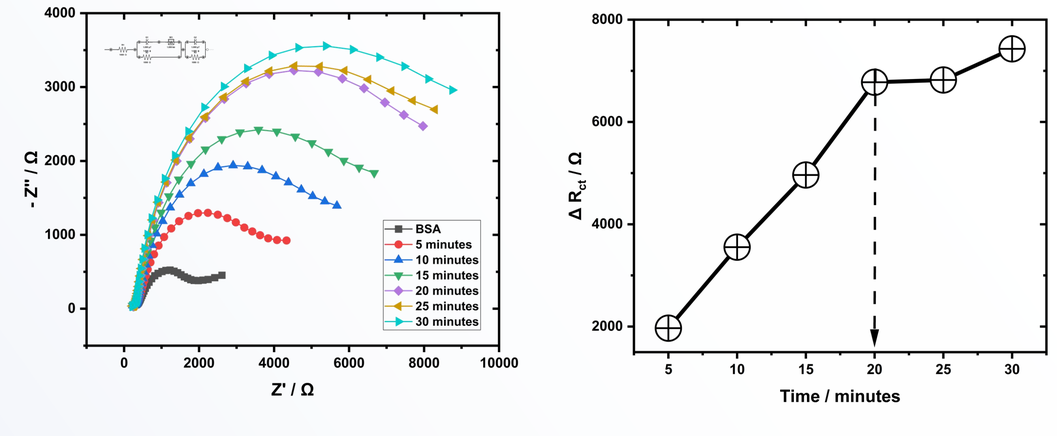

Figure 4: Testing the immune-sensing times effect on the capturing efficiency of the antigen.

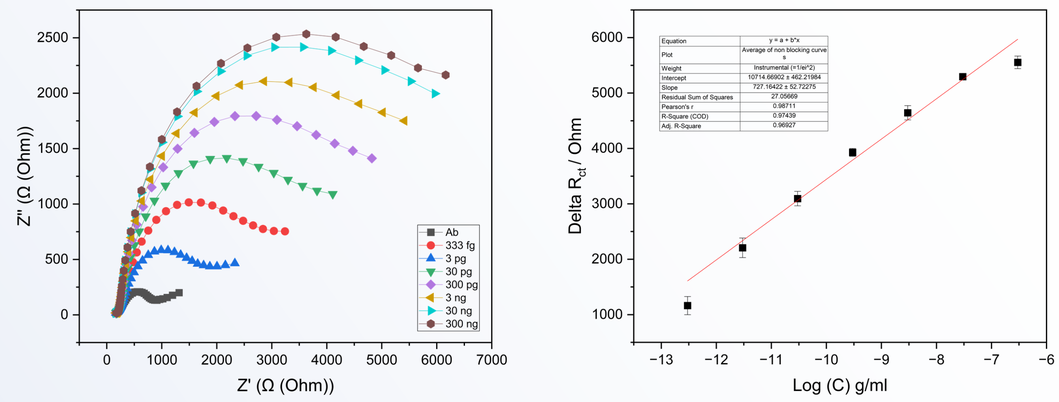

Figure 5: Nyquist plots generated by the Amyloid beta-42-immunosensor against different concentrations of Amyloid beta-42. Calibration curve of the Amyloid beta-42. ΔRct values are extracted from (A) through a modeled equivalent circuit.

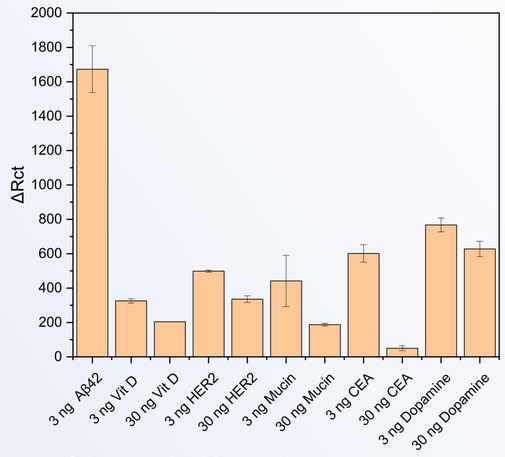

Figure 6: Selectivity testing of the Amyloid beta-42 -immunosensor towards non-targeting common biomarkers. Ten-fold increase in the concentration of each of the non-targeting molecules was used for this experiment.

Conclusion and Future Direction

The MWCNT-Ru nanocomposite significantly enhanced the immunosensor's sensitivity, enabling rapid, low-concentration detection of amyloid-beta-42 (LOD: 0.002 ng/mL) with high selectivity against non-target biomarkers. This cost-effective, portable platform shows promise for early Alzheimer's diagnosis in point-of-care settings.