Team Results Document
G-Pulse



University: Istanbul Technical University

Team members:

İlke Hızal
Sudenaz Köprülü
Feyzanur Eroğlu
İrem Şahin
Elif Nur Göktaş
Karya Özgül
Işıl Uçak
Zeynep Şengün

Supervisor:
Aytekin Uzunoğlu

Coaches:

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SensUs

1. Abstract: Summary for the SensUs website

Managing Parkinson's disease requires precise dosing of levodopa, as fluctuations often cause severe daily side effects for patients. To address this, we have developed an innovative biosensor designed for the continuous and reliable monitoring of levodopa levels, aiming to bridge the gap between complex clinical analysis and patient-friendly care.

At the core of our biosensor is a highly selective molecular recognition system. We utilize Molecularly Imprinted Polymers (MIP), an innovative, cost-effective, and easy-to-produce alternative to traditional biological receptors. Acting as microscopic "locks" specifically shaped for the levodopa "key," these MIPs are seamlessly integrated onto screen-printed carbon electrodes. This combination provides robust and highly accurate physical transduction. For continuous monitoring, we engineered a custom electrochemical flow cell driven by syringe pumps, ensuring stable, real-time measurements.

From our discussions with patients and doctors, it became clear that there is a huge need for an easy, everyday tracking method. Right now, our prototype works perfectly as a continuous-flow system in the lab. However, our main goal for the future is to shrink this durable MIP technology into a wearable sensor. By providing accurate, round-the-clock data, we want to help doctors adjust medications more effectively and make daily life easier for Parkinson's patients.

2. AP award: Biosensor developed for the Eindhoven Testing Event

We developed an electrochemical biosensor for continuous levodopa monitoring in interstitial fluid (ISF). The platform combines a molecularly imprinted polymer (MIP)-based recognition layer with a screen-printed carbon electrode (SPCE) and a microfluidic flow cell.

The key innovation of the system is the integration of a levodopa-selective MIP sensor with a continuous-flow architecture, enabling repeated measurements without manual sample replacement. The current prototype is designed to demonstrate continuous levodopa sensing using a syringe pump-controlled flow system.

2.1. Molecular recognition

The molecular recognition element is based on a molecularly imprinted polymer (MIP). MIPs are synthetic recognition materials that contain selective binding cavities complementary to a target molecule.

During fabrication, levodopa is used as a template molecule and pyrrole is electropolymerized on the SPCE surface. After template removal, cavities complementary to levodopa remain within the polypyrrole matrix. Upon rebinding of levodopa, changes in the electrochemical properties of the sensing interface are generated.

Pyrrole was selected due to its electrical conductivity, simple electropolymerization process, and compatibility with electrochemical sensing platforms. Compared with biological recognition elements, MIPs offer high chemical and thermal stability, low fabrication costs, and long-term storage capability while maintaining selective molecular recognition. These properties make MIPs a promising recognition strategy for continuous biosensing applications where robustness and operational stability are essential.

2.2. Physical transduction

The biosensor uses electrochemical transduction based on a MIP-modified SPCE. Levodopa binding within the imprinted cavities affects electron transfer at the electrode surface, producing a measurable electrochemical response. Cyclic voltammetry (CV) is used for sensor characterization, while differential pulse voltammetry (DPV) is used as the primary method for quantitative levodopa detection due to its higher sensitivity. The combination of selective molecular recognition and electrochemical detection enables miniaturized and low-power sensing suitable for continuous monitoring.

2.3. Cartridge technology

The biosensor cartridge integrates the MIP-modified SPCE within a microfluidic flow cell designed for continuous sample delivery. In the current prototype, a syringe pump is used to provide controlled transport of ISF through the sensing chamber. The continuous flow exposes the MIP sensing surface to fresh sample over time and enables repeated measurements without requiring manual sample exchange.
The cartridge consists of the sensing electrode, microfluidic channel, fluidic inlet and outlet connections, and supporting layers required for stable operation. The integration of a MIP-based sensing surface with a continuous-flow architecture represents the key innovation of the proposed platform, enabling the transition of MIP sensors from conventional single-measurement applications toward continuous biosensing.

2.4. Reader instrument and user interaction

The current prototype consists of a 3D-printed external flow cell integrated with a MIP-modified SPCE, a syringe pump-based flow system, and a potentiostat for electrochemical signal acquisition.

The syringe pump provides controlled transport of ISF through the flow cell, while the potentiostat performs CV measurements for sensor characterization and DPV measurements for quantitative levodopa detection. The obtained electrochemical signals are analyzed through the measurement software to determine levodopa concentration. During operation, the user connects the flow cell to the fluidic system, introduces the sample through the syringe pump, and initiates the electrochemical measurement. The current prototype enables validation of the MIP-based sensing strategy and demonstrates the feasibility of continuous levodopa monitoring under controlled conditions.

Future development will focus on transforming this external measurement setup into a wearable platform by integrating a minimally invasive sampling interface, miniaturized electronics, wireless communication, and a smartphone-based monitoring system.

3. IN award: Biosensor innovation

3.1. Wearable sensor

Our concept addresses the long-term clinical vision of a wearable biosensor that continuously measures levodopa concentration in the skin by introducing an integrated prototype system designed for dermal interstitial fluid (ISF) tracking. Although the current device is structured as a laboratory-stage prototype rather than a fully commercialized wearable product, it incorporates a skin-conformable patch layout designed to interact safely and comfortably with the skin surface in future implementations. It utilizes specialized interfacial structures to access the dermal interstitial fluid without causing major discomfort,and employs a breathable adhesive backing configuration planned to ensure stable contact during daily physical activities and minimize motion-induced signal artifacts.

The functional components incorporate specific recognition elements designed to interact with levodopa within the ISF matrix. Electrochemical transduction techniques, such as Differential Pulse Voltammetry (DPV), are employed to convert biochemical interactions into measurable electrical signals. Signal processing is handled by an integrated miniaturized electronic circuit and low-power wireless communication module integrated into the prototype body, enabling real-time data transmission.

The system achieves continuous monitoring principles by leveraging the natural replenishment and diffusion dynamics of ISF. Short diffusion distances allow the sensor prototype to respond rapidly to concentration changes, tracking both increases and decreases in real time, while advanced surface treatments and calibration strategies are integrated to maintain analytical stability and mitigate bio-fouling over extended wear periods. This concept is supported by recent developments in dermal ISF sampling and electrochemical biosensor technologies (Yuan et al.,2026).

3.1.1. Technological novelty of wearable sensor

The primary technological novelty lies in introducing a continuous wearable biosensing concept specifically tailored for levodopa tracking in interstitial fluid (ISF) at the prototype level, moving away from invasive blood sampling or bulky benchtop setups. The prototype design integrates advanced biomaterials, an optimized electrochemical transduction mechanism, and a miniaturized readout system into a cohesive, skin-conformable platform that maintains stable physiological contact. Furthermore, the prototype architecture is engineered to capture dynamic concentration shifts—both increases and decreases—over extended operational windows by optimizing mass transport and local diffusion pathways within the skin.

To evaluate the system mechanically and fluidically, the flow cell is directly fabricated using a 3D printer, allowing rapid prototyping of customized microfluidic channels. Within this setup, the electrode is carefully integrated into the cell body and sealed using an O-ring, which ensures a leak-proof chamber for a specific volume of the sample. During operation, the test sample is introduced into the chamber, and a controlled pump system applies pressure to direct the fluid. After the levodopa concentration is measured, the sample exits and leaves the system entirely, validating the operational flow dynamics.

3.1.2. Technical feasibility of wearable sensor

Technical feasibility is backed by empirical Differential Pulse Voltammetry (DPV) measurements conducted using PalmSens instrumentation. The optimization of key parameters—such as operating within a potential range of (-0.70 V) - (+1.00 V), a scan rate of 0.05 V/s, and a fine step potential of 0.01 V —proves the reliability of the microampere current responses for the prototype. The feasibility analysis addresses critical technological bottlenecks, including mass transport limitations, background noise reduction, and signal resolution in complex biological fluids. During testing process, it was observed that the selectivity which attempts to react only according to levodopa was provided by the system improved by our team. According to measurements it was confirmed that the sensor reacts different molecules as PBS or gives lower reactions since it doesn’t recognize the molecules

other than levodopa. Grounded in recent literature developments regarding dermal ISF sampling and electrochemical biosensors, the results demonstrate that the transducer-biomaterial interface remains stable under physiological potential sweeps, confirming the solid feasibility of the proposed wearable sensor prototype architecture (Saifullah & Rad, 2023). By merging the sampling interface and the transducer into a single, skin-worn patch controlled via a low-power wireless interface, the design bridges the gap between laboratory-grade electrochemistry and everyday wearable health tracking.

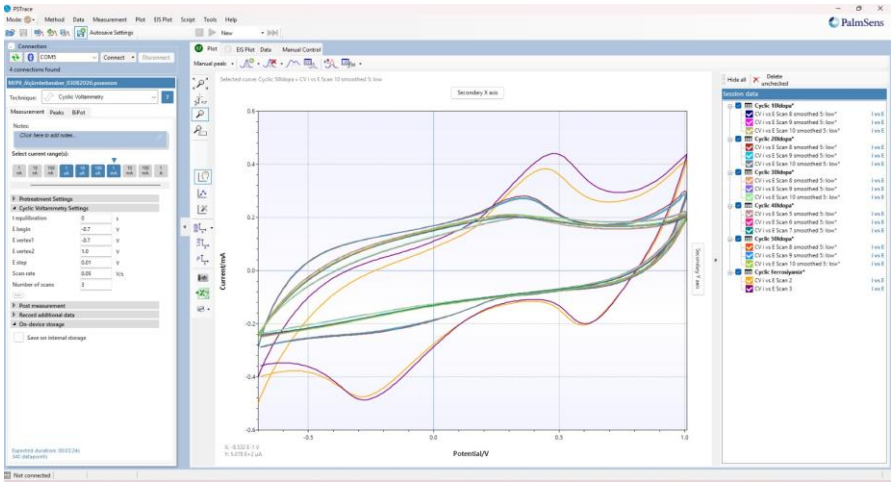


Fig 1. Levodopa Concentration Measurement

3.2. Reliability of sensor output

The primary objective of the developed biosensor is not only to detect levodopa but also to provide analytically reliable and reproducible concentration measurements during long-term continuous operation. Accordingly, reliability has been addressed through the integrated optimization of the molecular recognition mechanism, the microfluidic platform, the electrochemical detection strategy, the data analysis approach, and the supporting electronic readout architecture. The main factors affecting reliability were identified as interference from biological matrix components, accumulation of oxidation products on the electrode surface, variations in flow conditions, signal reproducibility during consecutive measurements, and potential signal instability during prolonged operation. The sensing platform was therefore designed to minimize these effects.

The first key element ensuring reliable sensor performance is the Molecularly Imprinted Polymer (MIP) layer specifically synthesized for levodopa recognition. The selective binding cavities created using levodopa as the template molecule enable selective target rebinding while minimizing interference from other species. Comparison with Non-Imprinted Polymer (NIP) structures confirms that the sensor response originates from levodopa-specific molecular recognition, thereby improving measurement accuracy.

The second key component is the localized microfluidic flow-cell architecture. Unlike conventional electrochemical systems, where oxidation products accumulate on the electrode surface, the proposed design removes reaction by-products following each measurement, preserving the functionality of the MIP layer. In addition, the sensing interface is designed to incorporate surface-treatment strategies that improve long-term analytical stability by reducing surface fouling during prolonged operation. To further improve reliability, the platform operates using a stop-flow protocol. The sample is introduced into the microfluidic channel, the flow is temporarily halted during Differential Pulse Voltammetry (DPV) measurements to eliminate hydrodynamic variability and then resumed to prepare the sensor surface for subsequent analyses. For quantitative analysis, DPV peak currents are correlated with levodopa concentration, while MIP binding behavior is evaluated using the Langmuir adsorption model. Based on this approach, a DPV-derived calibration strategy is proposed to establish the relationship between the electrochemical signal and levodopa concentration, providing an analytical framework for future comparison with established clinical reference methods (gold standards).

Finally, the proposed reliability concept was supported through laboratory validation. MIP synthesis and template removal were verified by Cyclic Voltammetry (CV) and DPV, and the sensor was integrated into a 3D-printed localized microfluidic flow-cell and evaluated in an artificial interstitial fluid (ISF) environment. These results demonstrate the successful integration of selective molecular recognition with controlled microfluidic electrochemical sensing, providing a robust foundation for stable, reproducible, and long-term continuous measurements.

3.2.1. Technological novelty of reliability concept

The key innovation of the proposed reliability concept lies in integrating complementary reliability mechanisms, rather than relying on a single sensing componet. Specifically, it combines MIP-based molecular recognition, a localized microfluidic flow-cell, stop-flow DPV measurements, and Langmuir model-based data analysis to ensure reliable sensor outputs. The MIP layer provides high selectivity toward levodopa, while the flow-cell architecture improves signal stability by reducing the accumulation of reaction by-products on the electrode surface. The stop-flow protocol standardizes measurement conditions, and the proposed DPV-based calibration strategy enables quantitative interpretation of sensor outputs while providing an analytical framework for future validation.

3.2.2. Technical feasibility of reliability concept

The technical feasibility of the proposed reliability concept was demonstrated through laboratory validation. MIP synthesis and template removal were verified by Cyclic

Voltammetry (CV) and Differential Pulse Voltammetry (DPV), and the sensor was integrated into a 3D-printed localized microfluidic flow-cell and evaluated in an artificial interstitial fluid (ISF) environment. The stop-flow DPV protocol and microfluidic flow system maintained controlled measurement conditions, while comparative MIP/NIP analyses confirmed selective molecular recognition. These findings support the laboratory-scale feasibility of the proposed concept. Nevertheless, validation of long-term performance in real biological samples and comparison with gold standards remain important objectives for future studies.

3.3. Original contributions

The overarching concept of developing a continuous biosensing prototype for levodopa tracking using dermal ISF simulation was conceived through an extensive, long-term literature review conducted collectively by the team. While the foundational analytical methods are established in electrochemistry, the specific integration of a 3D-printed flow cell utilizing an O-ring design for precise sample containment, coupled with Molecularly Imprinted Polymer (MIP) recognition layers (pursued upon our supervisor's suggestion), was jointly brainstormed and formulated by the team.

The team recognized and selected the final design pathway. After evaluating multiple configuration options through literature research and consultations with various faculty members, the team chose to combine a 3D-printed microfluidic flow cell with optimized electrochemical detection parameters. This selection was made to bridge the gap between theoretical dermal ISF sampling and a functional, testable laboratory prototype.

The adjustments and iterative refinements were carried out collaboratively between the team and our mentors. Following initial feedback from our supervisor regarding the selection of MIP systems, the team designed the structural layout of the flow cell, incorporating the O-ring sealing mechanism and electrode positioning. Furthermore, Research Assistant Dr. Özüm Özoğlu provided continuous academic guidance, reviewing our progress, offering valuable feedback, and directing us to explore alternative methods and chemical approaches to optimize our system. These designs and methodologies were adjusted iteratively based on these insights and practical fabrication constraints.

The experimental testing and data collection were executed hands-on by the team members. After Research Assistant Dr. Özüm Özoğlu taught us the foundational measurement techniques and operational procedures, the team independently performed the DPV measurements and experimental trials in Prof. Dr. Aytekin Uzunoğlu’s laboratory

using PalmSens instrumentation. The resulting data, calibration outputs, and performance curves were then analyzed by the team and reviewed with our mentors for final validation.

Aytekin Uzunoğlu İlke Hızal Sudenaz Köprülü



(We had contacted you regarding our faculty advisor; however, as they were on vacation, they were unable to sign the document. The assistant professor also declined to sign it because our faculty advisor's name appeared in the competition details. We can email the text to you if you wish.)

3.4. Bonus criteria Innovation

Beyond developing a wearable biosensor, this project broadened our perspective on continuous electrochemical sensing as a future healthcare technology. The increasing prevalence of Parkinson's disease highlighted the need for continuous, personalized, and home-based monitoring, motivating us to view the proposed system as more than a levodopa sensor.

As an additional exploration beyond the core project, we investigated the broader applicability of the proposed sensing strategy. The use of 3D printing enabled rapid fabrication of the localized microfluidic flow-cell prototype. This process led us to recognize that the localized microfluidic flow-cell, combined with MIP-based molecular recognition, can serve as a modular sensing platform rather than a single-analyte device. Since molecular selectivity is determined by the template molecule during MIP fabrication, the same sensing architecture could potentially be adapted to different biomarkers by redesigning only the recognition layer while preserving the underlying platform.

To further explore this concept, preliminary off-target experiments using glucose, alongside previously tested interferents, supported the robustness and specificity of the proposed molecular recognition mechanism.

Overall, these additional investigations demonstrate that the proposed biosensor represents a versatile platform with future potential for personalized medicine, remote patient monitoring, and continuous multi-analyte biosensing.

4. TP award: Translation potential

4.1. Customer interviews

4.1.1. Identification of potential stakeholders

Stakeholders involved in the treatment and monitoring of Parkinson's disease were investigated, including healthcare institutions, physicians, patients, patient relatives, nurses, and caregivers. Physicians provided insight into levodopa monitoring and treatment decisions, while patients highlighted the symptoms, treatment challenges, and individual differences they experience. Healthcare institutions helped identify practical and economic requirements for an objective and accessible monitoring solution. Nurses and caregivers contributed observations on symptom changes, daily care, quality of life, and patient–healthcare interactions. These insights highlighted the need for a rapid, accessible, and objective sensor to support Parkinson's disease management.

4.1.2. Interview approach and execution

For the interview stage, a visit was conducted to Tekirdağ City Hospital, where interviews were held with neurologists, patients, and nurses. Before the interviews, separate sets of questions were prepared for each stakeholder group. The questions were subsequently revised based on the responses obtained from each participant, allowing the interviews to progress systematically.

Face-to-face interviews with physicians and nurses were conducted on 18 March 2026. Five physicians were interviewed to obtain their perspectives and knowledge regarding the treatment process. Questions addressed the importance of levodopa, recommendations for the proposed sensor, the frequency of medication administration during advanced stages of the disease, and the risks associated with the disease. Nurses were also interviewed regarding their key roles in the treatment and monitoring of hospitalized patients with Parkinson's disease.

In a subsequent stage, contact was established with the Deputy Minister of Health, and an online meeting was conducted with the Deputy Minister's advisor. The project was introduced, followed by a discussion regarding the perspective of the Ministry of Health and healthcare institutions on Parkinson's disease and the approaches that should be considered for its treatment. Feedback and recommendations regarding potential improvements to the project were obtained, and points identified as areas requiring further development were documented. Patient interviews were conducted with patients within the team's network. Compared with the other stakeholder groups, these interviews were conducted in a more conversational manner to provide a comfortable environment for patients to share their experiences. The discussions focused on the aspects of the disease

that affected them most.

For all stakeholder groups, questions were prepared in advance according to the characteristics of each group, and the responses were documented throughout the interviews. The collected information was subsequently analyzed and used to improve the project.

4.1.3. Interview results and conclusions

The interviews identified a major unmet need: the lack of continuous levodopa monitoring and the limitations of laboratory-based measurements. Physicians highlighted that treatment decisions largely rely on patient-reported information collected during periodic visits, making it difficult to monitor Off periods and medication response in real time.

Patients reported that fixed medication schedules may not always provide optimal symptom control. As levodopa levels decrease, symptoms such as brain fog, tremor, and reduced mobility may appear before the next scheduled dose, while medication also requires time to take effect. This highlights the need for more personalized treatment management.

Nurses and caregivers emphasized the difficulty of intervening between changes in levodopa levels and the onset of noticeable symptoms. Healthcare institutions also noted that current laboratory measurements are time-consuming and costly.

Overall, the findings highlighted the need for a **continuous, accessible, and objective levodopa monitoring solution**, particularly through a wearable sensor that can be used outside the hospital environment.

4.2. Design of validation study

4.2.1. Selection of the problem

Parkinson's disease (PD) affects approximately 10 million individuals globally (Parkinson's Foundation, 2025). While Levodopa (L-DOPA) remains the gold-standard therapy, its efficacy is constrained by a narrow therapeutic window, a brief 90-minute half-life, and high pharmacokinetic variability (Poewe et al., 2017; Zhou et al., 2025). Consequently, minor serum fluctuations frequently precipitate severe dyskinesia and unpredictable motor complications (Antonini et al., 2018).
To bridge the gap between pharmacology and clinical application, our team interviewed

neurologists, patients, and caregivers. A unified challenge emerged: the systemic absence of continuous monitoring. Physicians rely on transient outpatient evaluations, reducing dosage titrations to estimations. For patients, rapid wearing-off effects exacerbate symptoms, while caregivers endure the psychological burden of managing rigorous schedules where minor delays induce severe motor freezing.

This reactive healthcare paradigm underscores a critical necessity for continuous L-DOPA monitoring. Because conventional methods like HPLC-MS require extensive infrastructure and current electrochemical sensors face selectivity and single-use constraints (Campuzano et al., 2020; Probst et al., 2024), resolving this clinical deficit requires a continuous, wearable-compatible biosensor platform (Gao et al., 2026).

4.2.2. Conceptual design and use case

The proposed prototype is a molecularly imprinted polymer (MIP)-based electrochemical biosensor within a miniaturized flow cell for continuous, real-time levodopa monitoring in interstitial fluid (ISF) (Zhou et al., 2025). The recognition element—an MIP synthesized on a screen-printed electrode (SPE) via pyrrole electropolymerization—features molecule-specific cavities formed by template extraction. This provides a stable, reusable, and cost-effective alternative to biological receptors (Herrera-Chacón et al., 2021).

A 3D-printed flow cell restricts the sample volume to 1.5–2 µL, minimizing dead volume and overcoming delayed signal responses. This architecture enables wash-free, continuous operation via a stop-flow protocol: following rapid sample introduction, flow ceases to record a stable differential pulse voltammetry (DPV) measurement. Reversible MIP binding allows sequential readings without supplementary washing (Campuzano et al., 2020).

Envisioned for future wearable continuous levodopa monitors, this sensor offers significant clinical utility by providing objective data for individualized dosing and improved symptom management (Maddocks et al., 2024). By merging MIP-based selectivity with an ultra-low-dead-volume, wash-free flow cell, this validated concept presents an innovative, cost-effective, and non-implantable analytical solution (Gao et al., 2026).

4.2.3. Validation study design

The validation study is designed to quantitatively test four critical performance aspects of the sensor (selectivity, sensitivity/linearity, response time, and stability/fouling

resistance) using differential pulse voltammetry (DPV) and cyclic voltammetry (CV) as the primary measurement techniques (Probst et al., 2024).

What will be measured and how:

Table 1. Summary of the Validation Study Design

Critical aspect	**What is measured**	**How it is measured**
Calibration/ sensitivity	DPV peak current vs. levodopa concentration	Measure artificial ISF samples (3–50 µmol/L) and obtain the calibration curve, LOD, and LOQ.
Selectivity	Signal change with interferents	Test levodopa with dopamine, ascorbic acid, uric acid, paracetamol, and carbidopa.
Response time	Time to stable current	Record the time from sample injection (~100 µL) to signal stabilization.
Fouling resistance/ stability	Peak current decrease	Perform repeated DPV scans on the same electrode without washing.
Reproducibility	Inter-electrode variability	Repeat measurements on multiple MIP-SPE electrodes and compare with NIP controls.

Methodology

Preparation & Verification: MIP- and NIP-coated SPEs are synthesized via CV electropolymerization, subjected to chronoamperometry (CA) for template removal, and integrated into the flow cell. Coating success is verified using CV and DPV (Herrera-Chacón et al., 2021).

Calibration & Selectivity: Using a stop-flow protocol, DPV peak currents are recorded in artificial ISF (3–50 µmol/L levodopa) to establish calibration curves. Interferent-spiked samples are tested parallelly to assess target specificity (Probst et al., 2024).

Validation: Performance is evaluated in reconstituted human serum to simulate a complex matrix (Campuzano et al., 2020).

Data Analysis: Key quantitative metrics (LOD/LOQ, R^2, selectivity deviation) are analyzed and compared against NIP controls to statistically confirm that the imprinted cavities drive the sensor's sensitivity, speed, and stability (Shah et al., 2022).

4.3. Bonus criteria Translation Potential

Beyond the customer interviews and the validation study, our team explored several aspects that strengthen the real-world translation potential of the G-Pulse biosensor and reflect a proactive approach to moving the device from prototype toward clinical use.

From a manufacturability standpoint, the recognition layer is produced by electropolymerization of pyrrole on commercial SPCEs, which are inexpensive, mass-producible, and widely available. Unlike biological recognition elements, the MIP requires no antibodies, enzymes, or cold-chain storage and can be kept at room temperature, substantially reducing per-unit cost and simplifying large-scale production. The electrode surface can additionally be regenerated through template removal and rebinding, further lowering the effective cost per measurement. Compared with antibody- or nanoMIP-based alternatives that are not suited for field use, this low fabrication cost makes the platform economically viable for widespread deployment.

The economic value also extends to stakeholders. Continuous levodopa monitoring can reduce the frequency of clinical visits, hospital-based blood sampling, and trial-and-error dose adjustment for patients and clinicians, while earlier detection of “wearing-off” fluctuations may lower complications and long-term treatment costs for the healthcare system.

A staged pathway is envisaged for market entry: an initial laboratory and clinical validation phase, followed by a wearable-patch product integrated with a wireless reader and a smartphone application. Although Parkinson’s disease monitoring is the initial target application, the platform can be extended to other electrochemically active drugs and neurotransmitters simply by changing the MIP template, which broadens its potential market. Commercialization is intended through licensing and partnership with medical-device manufacturers rather than in-house mass production.

Finally, because this biosensor measures an analyte from interstitial fluid, it would fall under medical-device regulation and require clinical validation prior to deployment; the relevant regulatory considerations include device classification, biocompatibility of the sampling interface, and clinical performance requirements. As the MIP formulation and the flow-cell integration constitute the core novelty, protection of the imprinting protocol and cartridge design is also regarded as part of the translation strategy.

Together, these considerations indicate that the G-Pulse biosensor is designed not only as a laboratory prototype but as a scalable, low-cost, and clinically deployable platform, with a realistic pathway toward manufacturing, market entry, and real-world use.

5. Team and support

5.1. Contributions of the team members

İlke Hızal: Served as the team leader. Handled material selection and the design of the flow cell.

Feyzanur Eroğlu: Contributed to the material selection processes and the design of the flow cell.

Işıl Uçak: Responsible for signal processing, specifically converting sensor currents into meaningful signals and interpreting the data.

Elif Nur Göktaş: Analyzed biological reactions and ensured their compatibility with the sensor system.

Sudenaz Köprülü: Conducted the analysis of chemical reactions occurring within the biosensor.

İrem Şahin: Managed sensor characterization and the analysis of measurement data.

Karya Özgül: Coordinated field tests and managed communications with external stakeholders.

Zeynep Şengün: Handled biosensor surface modifications, managed biological reactions.

5.2. People who have given support

Prof. Dr. Aytekin Uzunoğlu: He provided our team with full access to the ITU Metallurgical and Materials Engineering laboratory, including the use of essential materials and testing equipment. He also offered foundational guidance that was crucial for the development of our biosensor.

Res. Asst. Dr. Özüm Özoğlu: She actively supervised our experimental processes and provided direct, hands-on assistance in the laboratory. Her continuous presence and practical guidance helped us navigate and execute complex laboratory procedures effectively.

Asst. Prof. Gizem Kaleli Can: She helped us interpret and analyze the electrochemical signals obtained from our biosensor. Her expertise was highly valuable in making sense of the complex measurement data we gathered.

Asst. Prof. Dr. Çiğdem Yılmaz Çolak: As our team supervisor, she provided essential guidance and mentorship from the very beginning of the project. Her continuous support kept the team motivated and on track during both the design and execution phases.

5.3. Sponsors and partners

ITU Foundation (İTÜ Vakfı): They provided financial support to cover our team's travel and accommodation expenses. This funding made it possible for us to travel to Eindhoven and participate in the competition.

6. Final remarks

As team G-Pulse, developing this biosensor has shown us the real-world importance of continuous levodopa monitoring for Parkinson's disease management. Building this prototype was a complex challenge,but having a highly multidisciplinary team -with students from metallurgy, molecular biology, electronics, and chemistry- allowed us to approach the problem from different engineering angles and successfully create a working MIP-based system.

We would like to sincerely thank Prof. Dr. Aytekin Uzunoğlu for opening his laboratory to us, and Res. Asst. Dr. Özüm Özoğlu for her help and guidance during our experiments in the lab. We are also very grateful to the ITU Foundation for their financial support, which made our team's trip to Eindhoven possible.

Looking ahead, our goals do not end with the SensUs competition. While our current work has focused on proving the concept in a continuous-flow setup, our next major step is miniaturization. We plan to refine and adapt our MIP-based sensor technology so it can be integrated into a user-friendly wearable device. We believe that making this technology wearable is the key to truly improving daily life for patients who rely on continuous levodopa tracking.

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