Team Results Document

SenseNC

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SensUs 2024
Acute Kidney Injury

SensUs

Abstract

In the continuous biosensor developed by SenseNC, creatinine is measured in interstitial fluid (ISF) by exploiting its binding with copper (Cu) ions. Copper is selectively and precisely incorporated into patient samples via solid-state anodic dissolution of electrodeposited copper. The copper ions that do not form complexes with creatinine are reduced and oxidized via cyclic voltammetry (CV), resulting in a measurable current that correlates to the concentration of creatinine in patient samples. Our sensor is able to transduce a range of detection of 30-300 µmol/L with a coefficient of determination of $R^2 = 0.9707$, corresponding to the clinically relevant concentrations of creatinine in patient samples. The use of a non-biological agent for creatinine detection increases the shelf life of the sensor and vastly reduces the cost of sensor fabrication in comparison to biosensors that utilize biological recognition elements. In order to ensure that the biosensor system can perform several longitudinal creatinine measurements, separate electrodes are used for the injection of copper ions into applied samples and the electrochemical transduction of voltammetric signals. This eliminates sensor drift between measurements and ensures consistency in the quantities of copper added to each sample.

Biosensor

2.1 Device Overview

The device developed by SenseNC eliminates the need for biological recognition elements in creatinine determination, resulting in unprecedented cost efficiency and shelf stability. It utilizes copper ions, a non-biological recognition element, which results in a cost 75 times less than the use of a biological method such as an antibody or enzyme. [1-3] Creatinine is measured within complex media using a custom potentiostat which further reduces the cost of device production by eliminating unnecessary, and often costly, electrical components.

2.2 Molecular Recognition

In the presence of copper ions, creatinine will form a copper-creatinine complex that becomes more strongly oxidized than free-hydrated copper ions [4] and behaves peroxidase-like, catalysing the oxidation o [5]. It has been demonstrated that the formation of these complexes on a bare glassy carbon electrode [4] is not only possible but selective and sensitive. With copper present in our system, the formation of copper-creatinine complexes will be evident when cyclic voltammetry is run. Indicative peaks in the resulting current-voltage waveform demonstrate the reduction and oxidation of Cu^{+} to Cu^{2+} and then neutral Cu. Then, the peak-to-peak distance between redox potentials can be used to create a calibration curve at different concentrations of creatinine.

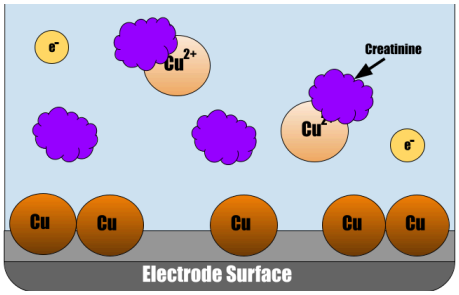


Figure 1

2.3 Physical Transduction

The sensor uses electrochemical transduction. A commercialized electrode with copper deposited on it has a flow cell chamber made of PDMS placed across its surface. Copper ions are then ejected into solution in response to applied voltages, forming the aforementioned copper-creatinine complexes and creating an electrochemical current when a varying voltage is applied to the electrochemical cell.

2.4 Cartridge Technology

Because the copper reagent is plated onto the electrode, no sample pretreatment is required for the sensor system. However, there is no certainty that the copper-creatinine complex will split apart, so we plan to look into the sequestration of these complexes as well as utilization of excess copper in the future. For example, the use of acrylamide-maleic acid hydrogels to remove copper (II) ions from a solution could be one method to investigate. [6] While copper is involved in many physiological pathways, there are risks to altering the homeostasis that exists in the body. Copper overload or deficiency from over-sequestration cause undesirable symptoms. [7] This would require the additional investigation of the behavior of such hydrogels in a physiological environment.

2.5 Reader instrument

Our sensor uses a commercial off-the-shelf connector that allows the electrode to be connected to the hardware. To use the sensor system, the user first inserts a new sensor into the connector and then interacts with the software.

2.5.1 Hardware

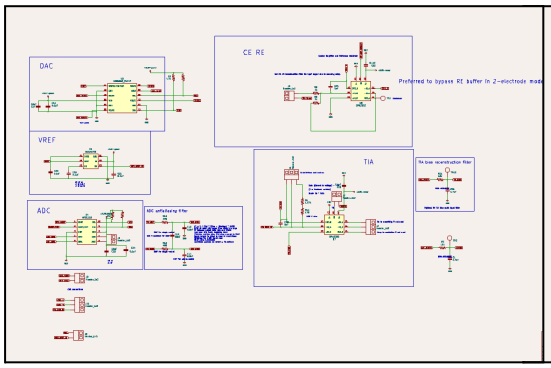


Figure 2

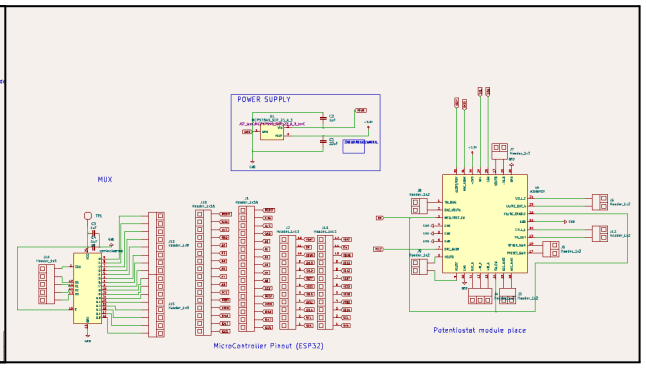


Figure 3

A circuit schematic of the castellated system-on-module is displayed in Figure 2. The system consists of a potentiostat (using a summing amplifier setup), a trans-impedance amplifier (for measurement of current), onboard DAC and ADC as well as a VREF circuit. Voltage is supplied by the DAC generating the desired signal to be fed into the inverting input of the counter electrode. The other side of the op amp acts as the reference electrode with the cell input going into the noninverting input and the output going into the other resistor to be summed with the ADC signal. The channel current is fed into a trans-impedance amplifier (TIA) which amplifies the current to a voltage proportional to the feedback resistance. This signal is then sent to the ADC to be digitized and recorded using the main board.

In Figure 3, a circuit schematic for the main board in which the potentiostat module is placed is present. The board contains connectors designed for a microcontroller to be plugged into the board (designed for the Adafruit ESP32 Huzzah!) while also leaving headers for potential future connections to the same pins. With use of an ESP32, the board receives power from the micro-USB connection and is routed to a 3.3V linear voltage regulator to provide a clean voltage to the module. The module connects to the board through a connector called FlexyPins, this allows for easy insertion and removal of the module without the need for soldering. Some pins have header connections to allow for many configurations of the board to be used, allowing for measurements or alternative inputs for the module. The board also contains a 1 x 16:1 multiplexer with all pins connected to headers to be as reconfigurable as possible.

2.6 User Interface

Given the widespread use of mobile devices in everyday life, we plan to integrate our technology with a mobile app that is user-friendly and allows the patient to see their creatinine levels, as well as understand what they mean. Green and red signals will be displayed when the concentration of creatinine are in range and high respectively. They can also see a graph with a trend, as well as their daily average on their screen. Buttons will allow users to easily update their settings, get notifications, and share their health data with their physicians. Figure 4 includes an example of what the interface for the user may look like. The complete system will include a sensor with a microneedle patch to draw ISF into the device, a sensor with our electrodes, and then a connection to our electronic system which includes our original, modular potentiostat as well as a bluetooth transmission to the mobile device or a separate receiver.

Figure 4

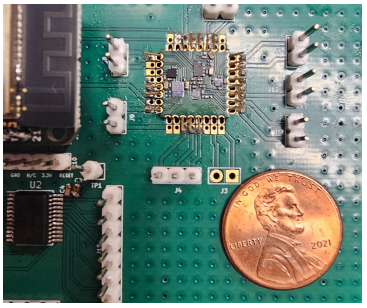


Figure 5

Technological feasibility

3.1 Sensor Fabrication and Functionality

3.1.1 Sensing Results

The aim of our team was to create a sensor that did not require the use of a biological recognition element. Not only would this drastically reduce production costs, but improve the shelf stability of the sensor, making it more accessible to our intended users. Using the copper gave us the following results. The graph of CV shown in Figure 6 is representative of the results we obtained from running CV on different electrodes in a solution with copper (II) sulfate and creatinine. The higher levels of creatinine showed higher peak to peak separation, allowing more current to flow at a particular voltage due to incapacitation of the copper ions caused by the formation of the copper-creatinine complex.

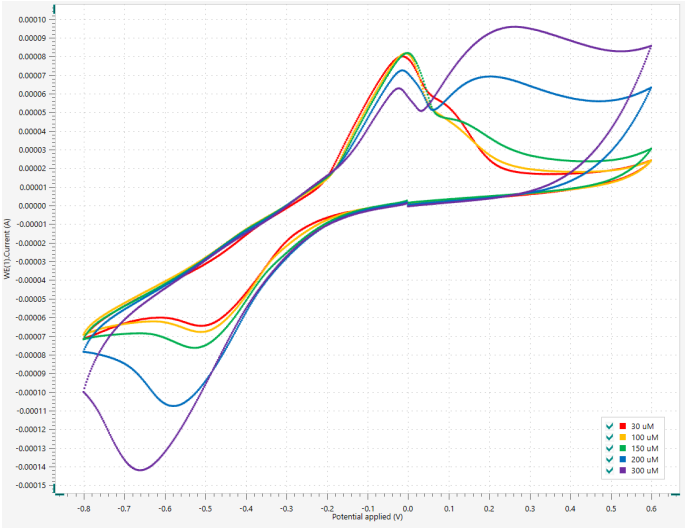


Figure 6

3.1.2 Creation of Calibration Curve

Using the measurements from CV's like the one shown above, a calibration curve was created using the peak-to-peak separation. The results above show a linear trend with a coefficient of determination of $R^2 = 0.9707$.

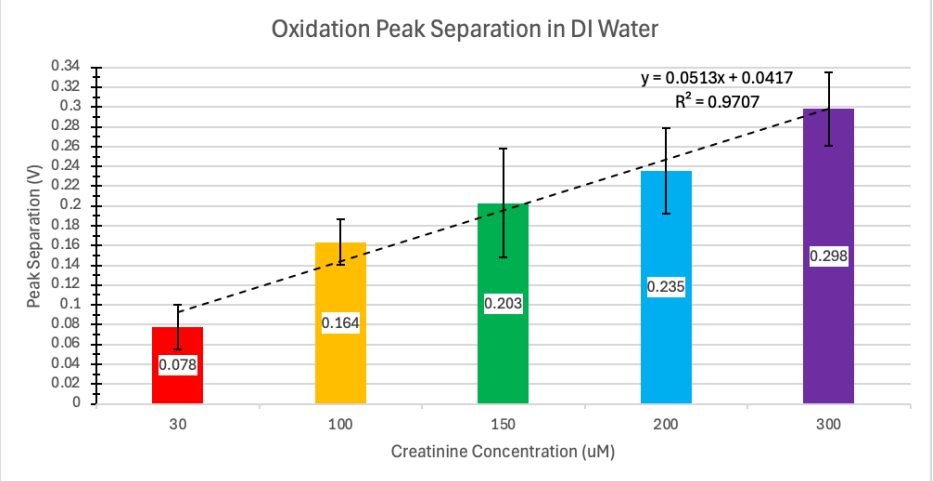


Figure 7

3.1.3 Continuity

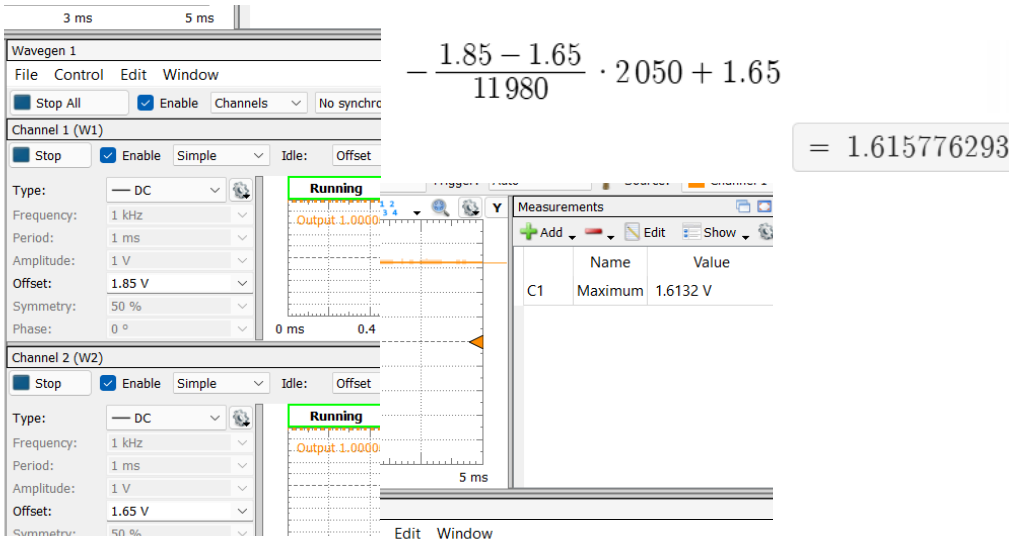
While considering the continuous aspect of our sensor, we had to take into account the challenge of using a single electrode for multiple scans. To make our electrode capable of withstanding multiple scans, we plated an excess amount of copper onto it. Because we are unable to accurately predict the amount of copper plated onto one electrode, it is necessary to first perform a calibration step, in which an excessive amount of creatinine is placed through the flow cell to measure the peak-to-peak current that flows when a voltage is swept. We had to take into account the full potential of the reactions occurring, or the reduction and oxidation of copper. The process of binding copper and creatinine appears to be

irreversible, leading to some difficulties with the proper sensitivity of the sensor. To compensate for this, the sensor has a new baseline calibration after each round of CV is run. This allows each reading to be compared to the one before, preserving the same electrode.

3.2 Reader Instrument:

3.2.1 Circuit Design Verification

Simulation software (LTSpice, Analog Devices) was used to simulate the potentiostat circuit before fabricating it as a PCB. We verified that the theoretical models of our circuit would behave as intended and would amplify the relevant current range with little voltage offset and high reproducibility.



$$-\frac{1.85-1.65}{11980}\cdot 2050+1.65$$

$$=1.615776293$$

Figure 8

3.2.2 Analog Circuit Verification

Verification of the potentiostat with an injected signal was done through isolated testing of the potentiostat and TIA. The TIA was first verified by itself by producing a current (~.02 mA) through a 12k Ohm resistor before being converted to a voltage and amplified (~1.613 V), matching our equations (1.616 V). The potentiostat as a whole was tested using a Randles circuit, an equivalent circuit to an electrochemical cell. Our measured results have shown that the potentiostat circuit works with the change in the voltage across the working and reference electrodes being seen in the TIA measured voltage.

3.2.3 Software Testing

Software was coded using the Arduino IDE to autonomously sweep and measure the electrodes for the concentration. In the future this is then ported into Matlab to provide a user-friendly interface, and down the line a user interface with . Black box testing (BBT) was used to verify the functionality of our desktop application. BBT is a form of testing in which the user has no knowledge of the internals of the software, and they instead observe the output they receive from the input they give to the final user interface.

Originality

The SenseNC biosensor was developed by experimenting with the novel concept of nonbiological detection methods for creatinine through interstitial fluid. Through trials with commercially available electrodes, our chemistry team was able to develop a system with multiple electrodes that selectively and accurately introduces copper into a sample and measures the target molecule. Using the potentiostat designed by our electrical team, we are able to sweep a voltage across the electrode to identify the concentration. The novelty of the potentiostat is that it was built in house, and is a module based design with multiple ways to implement and use it. Designed as a proof of concept for a modular electrochemical platform, the module was designed to be as small as possible, while not restricting its capabilities to perform different electrochemical techniques. Combining the innovation of our chemistry and electrical teams, we have created a unique biosensor and established a foundation for further experiments.

Ashley Dehn

Jacob Linnabary

The creatinine sensor presented utilizes a novel catalytic/electrochemical measurement technique. Interactions of copper ions with creatinine for electrochemical sensing have been previously demonstrated in solution; however, this presents the first attempt to realize a “solid-state” electrochemical approach for measuring copper-creatinine complexes. This method is particularly original as it uses copper ions, incorporated via solid-state anodic dissolution, to form a measurable complex with creatinine. The design of an “enzyme-free” or “biologics-free” sensor was conceived by the Team after a thorough literature search and review. All biochemical assays, electrochemical testing, hardware design, fabrication, and testing were carried out by the Team. The Faculty Supervisors and Team Guides provided guidance and access to laboratory instrumentation and protocols, along with funds for material procurement. The team worked with their Faculty Supervisors for improvement of experimental methods, and the Team independently carried out the research and development objectives. Testing of the electrochemical sensors, complete development of the electronic hardware, investigation of the translation potential, and completion of all SensUs requirements were completed nearly 100% independently by the members of the Team.

Michael Daniele (Supervisor)

Translation potential

5.1 - Business Model Canvas

The business model described here aims to profitably address the need for continuous AKI monitoring in various settings. The stakeholders and target customers are identified and described. A comprehensive description of the business plan's feasibility and financial viability is provided.

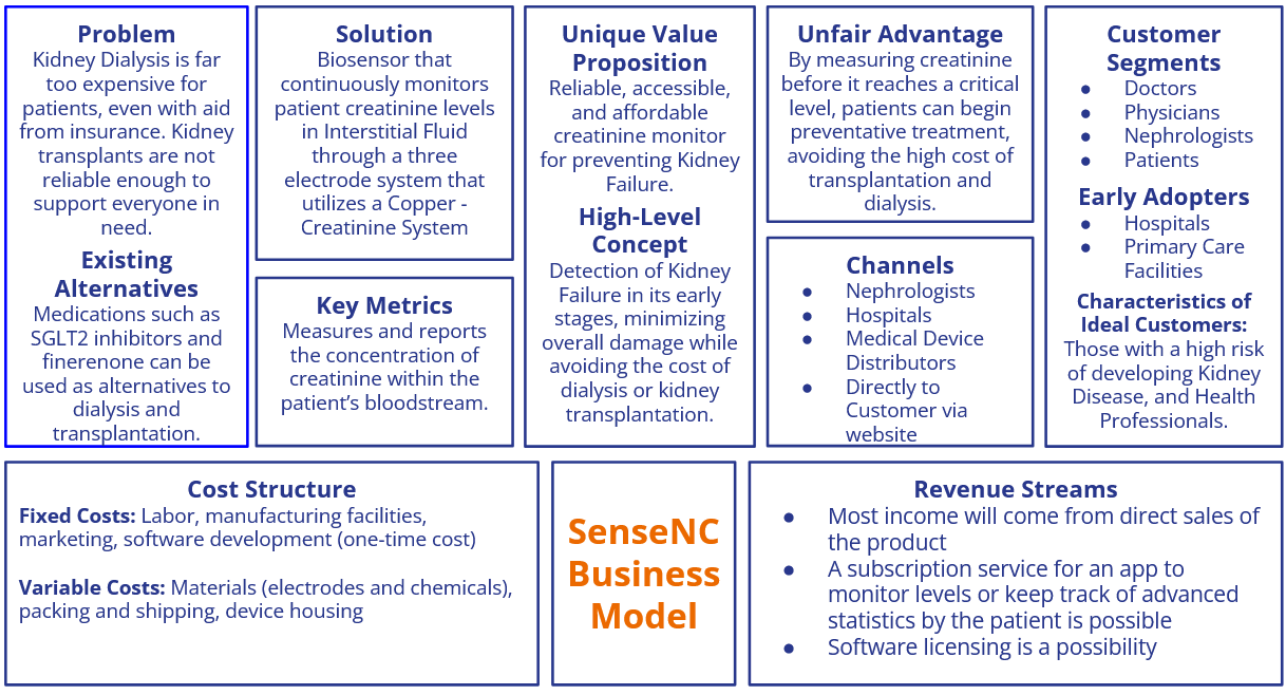


Figure 9

5.2 - Stakeholder Desirability

5.2.1 - Customers and Stakeholders

Worldwide, it is estimated that over 850 million people are suffering from AKI [7], with the number of people who are being diagnosed with AKI increasing each year. In the USA alone, annual hospitalizations increased from 953,926 in 2000 to 3,959,360 in 2014 [8]. Alongside AKI, the risk factors for AKI (obesity, diabetes, hypertension) are increasing as well [9]. It is also estimated AKI has a mortality rate of 15-20% in the first year and 50% after 5 [10]. Diagnosing AKI is straightforward with a blood test and optional urine test usually being enough. Annually, patients and families affected by AKI spend upwards of $120 billion a year on treatments [11]. The most expensive part of treating AKI comes from dialysis. Dialysis is the process of using machines to filter and excrete waste from blood, as kidneys usually do. In America, dialysis can cost up to $72,000 per person per year without insurance [12]. If kidney damage is severe enough, doctors may recommend a kidney transplant. After a transplant dialysis is no longer needed [13]. However, this is a very costly procedure as the average cost is $442,500 with no insurance [14].

For a patient experiencing AKI, the costs are high. Without insurance, a single visit to a Nephrologist averages about $300-$600 USD [15]. They then must add in the average cost for a kidney function blood test panel at $250 USD [16], and the cost of treatment which can cost up to $1000 USD a month. [17] While the use of our sensor would not eliminate all of these costs, it may alleviate some of the financial burden, requiring less money and time spent at the clinic because of a mobile point of care system.

SenseNC's proposed sensor can detect creatinine levels in a sample of interstitial skin fluid, with the results of the sensor viewable on a smartphone device. After analyzing the market, we have identified four main, sizable market segments: patients at risk for kidney disease, patients with kidney disease (and their families), patients who have received kidney transplants, and medical professionals (nephrologists, physicians, nurses, technicians, etc.).

The first group, those at risk for kidney failure, are arguably the biggest customers for our sensor. According to the National Kidney Foundation it is believed that 1 in 3 Americans are at risk for kidney disease, with other groups (African Americans, Latinos, and Asian Americans, just to name a few) being at greater risk than others [18]. Further, 9 in 10 Americans with kidney disease have no

idea they have it and 1 in 3 Americans have severe kidney failure without their knowledge [19]. Our sensor for this market sensor shall be used as a preventative measure. Those at risk will be able to see their kidney function in real time and can make informed decisions about lifestyle changes, diet changes, or possible medications. The doctors' of the at-risk population will also benefit from our sensor as they will have more time to design effective treatment plans and can see how kidney function trends in the short and long term.

The second group that would benefit from our sensor are those diagnosed with AKI/kidney disease and actively managing the condition. Worldwide, it is estimated that roughly 850 million people are living with kidney disease [7]. Being able to check kidney function at home in realt-time without any sophisticated tests would allow for patients to manage their condition effectively, resulting in a greater quality of life. Real-time updates would allow for patients to make adjustments in their lifestyle or medication without having to see a doctor, resulting in more time and greater freedom. Another benefit would be psychological and morale boosts. The sensor would allow for patients to see the positive effects their lifestyle changes and medications are having on kidney function, which will make adhering to treatment plans easier. For patients who are in the early stages of kidney disease, this sensor could help them slow progression and delay the need for dialysis and transplantation, saving time and money in the long term.

Similar to those who have kidney disease, this sensor would also be of benefit to those who have received kidney transplants. In the US alone there are 786,000 people living with kidney transplants [20]. In 2022, 25,000 kidney transplants were performed and kidneys are the most transplanted organ [20, 21]. In this context, the sensor shall help manage any complications that may come up after the transplant. The sensor can track the function of the kidney and can alert the patient if kidney functionality dips below a certain level, allowing for the patient to seek prompt care to take care of any issues and prevent further ones. The sensor could also be useful to the donor (if the donor was live). The donor and doctors can track the activity of the lone kidney and monitor how it is adapting to the new, increased workload and can prevent complications before they arise.

Another group that could benefit from our sensor are doctors: nephrologists, urologists, nurses, and technicians, just to name a few. The sensors give patients greater independence, enabling them to manage minor issues on their own without the immediate need for a doctor's intervention. This leaves the doctor with more time to take care of more urgent or severe cases. On a similar note, the sensor would allow for remote monitoring of the patient. The doctor can remotely view kidney health via the sensor without needing the patient to come in, saving time for both parties. Lastly, the sensor can save time and money for both parties by preventing hospitalizations and ambulance rides. Along the same lines, the sensor can aid EMTs who are taking the patient to the hospital in an emergency situation. The sensor can provide vital information about the patient and his/her condition, allowing for more effective care in the ambulance.

5.2.2 - Value Proposition

Currently on the market there is a single FDA-approved sensor made by Nova Biomedical, is a sensor that tests for creatine in a blood sample. Nova Biomedical claims to generate results in 30 seconds. An independent study funded by the NIH showed the sensors to have a concordance coefficient of about .997 [22]. However, this sensor is not continuous and requires a finger prick. This sensor is also designed for medical professionals only, unlike our sensor which is designed for professionals and patients alike. The specific technology behind the sensor is unknown; however, the website states that it uses electrochemistry. The sensor comes with a hefty price tag at about $1100.

5.3 - Business Feasibility

5.3.1 - Key Resources

The most vital resources for this business are raw materials, skilled personnel, and facilities for research, development and manufacturing. The raw materials necessary for sensor fabrication are electrodes and chemical reagents. Additional raw materials are necessary for enclosure materials, PCB fabrication and packaging. PCB fabrication will be outsourced to large-scale manufacturers until revenue is sufficient to bring this process in-house.

In its current form, the biosensor is functional as a diagnostic instrument. Further optimization and standardization can be accomplished in order to improve sensitivity and batch-to-batch variation.

This will require skilled scientists and engineers to enhance the product's technical quality and improve our competitive advantage. However, due to the functional state of the biosensor, the vast majority of necessary personnel are operators for manufacturing, supply chain management, distribution, and customer support.

Another key aspect of this business's success is regulatory approval and compliance. We intend to target the United States market and will have to seek FDA approval. The process of obtaining FDA approval demands extensive product testing, clinical trials, and regulatory affairs specialists, among other things. However, because a biosensor for GFAP is commercially available and has obtained FDA approval, we will seek premarket approval (also known as the 510(k)) by demonstrating the technological equivalence of our biosensor with commercially available devices [23]. This has the potential to significantly reduce the amount of resources necessary for regulatory approval. Nonetheless, resources will be necessary for quality assurance, postmarket surveillance and compliance with all regulatory standards.

5.3.2 - Key Activities

Because there are existing commercially available diagnostic devices for creatinine detection, we must use a competitive pricing model. While our device has some key benefits over our competitors (faster time for results, continuous biosensing, selling directly to the consumer), the only feasible way of initially capturing market share is pricing our device below those that currently exist while offering the equivalent or improved accuracy.

Early company efforts will be devoted to acquiring FDA approval via the 510(k) pathway. This mechanism will significantly reduce the financial burden of seeking full FDA approval. Since we are a brand new company in the diagnostics industry, it is of the utmost importance that we establish our legitimacy by obtaining FDA approval. This will serve as a means of informing all potential customers and users that our products are safe and effective.

Further, we will also pursue a provisional patent with the US Patent Office to protect our novel method of detecting creatinine and kidney function. A provisional patent will allow us to better and perfect our sensor before applying for a complete patent. Although currently there are patents to detect creatinine (US5733787A & US4215197A), none have achieved it through our Copper-Creatinine system.

5.3.3 - Partnerships

For partnerships, there are 3 groups that we plan to partner with: the American Kidney Fund (AKF), the American Society of Nephrology (ASN), and insurance companies. The first group will have two main functions: helping acquire additional funding to improve our sensor and connecting us with patients who could benefit from our sensor (kidney transplant recipients, patients diagnosed with kidney failure, and at-risk groups). According to statistics from the AKF, roughly 37 million Americans are suffering from kidney disease and 808,000 are suffering from kidney failure [24]. 250,000 Americans are living with transplanted kidneys and in 2023, approximately 27,000 transplants were performed and 6,000 of those transplanted kidneys came from living donors [24]. Partnering with these foundations would allow us to effectively reach more patients and help them manage their condition with our sensor.

The ASN is a group of doctors that are committed to eradicating all forms of kidney disease. Teaming up with the ASN will have a plethora of benefits: credibility, wider market, and education. Having our sensor approved by the ASN will increase our credibility as we will have the approval of many doctors on our sensor. The ASN has doctors from all over the USA, allowing our sensor to be bought by many patients and prescribed by many doctors. Educating doctors will benefit us as doctors are more likely to prescribe and recommend our sensor to patients if they are educated about it.

The last group is arguably the most important. Insurance companies will offer our greatest advantage yet: subsidization of our sensor. Insurance companies will allow for our sensor to be sold at a lower cost to consumers, allowing for our sensor to reach a greater population. Direct consumer feedback is another benefit insurance companies can give us. Consumers can relay any feedback about the sensor to the insurance company which they can forward to us, allowing us to better our sensor.

5.3.4 - Sustainability

SenseNC is committed to sustainable business practices. We use environmentally friendly

materials for enclosure fabrication and constantly seek new ways to improve manufacturing efficiency and techniques in order to reduce waste.

5.4 - Financial Viability

5.4.1 - Costs Projection

Below is the cost breakdown for the material production of the biosensor. We predict a cost of about $8 USD (€7.50 EUR) per sensor, however, the use of large scale manufacturing techniques and production optimization is believed to be able to reduce this price by an estimated 25%, resulting in a new predicted cost of about $6 USD (€5.50 EUR). With optimized production techniques, it is possible to fabricate an estimated 108 sensors in 3 hours. With the cost of labor averaging at a competitive $20 per hour in the United States, the estimated cost increases to $6.65 USD (€6.12 EUR) per sensor. The creation of a sensor without biological agents such as antibodies and enzymes is cheaper and more shelf stable than alternatives. Our system's electronics, added with cost of manufacturing, currently suggest a cost of $438 (€403 EUR) USD per device. Our current prototype utilizes a generalized USB potentiostat (Analog Discovery 2) and a custom amplification board. Shifting electronics development away from general potentiostats and towards specialized hardware will likely reduce cost on a per-device basis. We believe that using our own custom electronics for all of our system's hardware will significantly reduce the cost of our electronics from $438 USD (€403 EUR) per device to approximately $200 USD (€184 EUR) per device. Many of the features available on our current electronics, such as an excess of electrodes that we intended to use, are unnecessary, and thus can be eliminated to reduce cost. All electronics fabrication will be outsourced to reputable suppliers and the projected costs provided incorporate the costs associated with outsourcing electronics fabrication.

Further costs are incurred with the corporation of FDA guidelines, requiring the testing, submission, and FDA user compliance, resulting in an estimated one-time cost of $400000 USD (€368000 EUR). [25] This is necessary for the distribution of our medical device in the United States. Additionally, the up front costs of starting production such as a clean room, operating facilities, production equipment, warehouses, and more would increase the anticipated cost of purchase to an estimated $900000 USD (€829000 EUR), with monthly operating expenses of $80000 USD (€74000 EUR). This includes the cost per sensor and electronics system.

Sensor Materials	Per Sensor (USD)	Electronics Materials	Per Device (USD)
Electrodes	7.87	Potentiostat	47.0
PDMS	.10	Main Board	35.0
Copper (II) Sulfate	.03	Enclosure Materials	10
HEPES Buffer	.12		
Buffers	0.1		
Total	8	Total	92

Table 1: Projected Costs

5.4.2 - Sales Price

Current sensors on the market include the Nova at $740.99, also have to pay for strips.The Nova Biomedical StatSensor Creatinine costs a total of $740.99 for a set of 50 test strips, not including the cost

of the electronic device itself. Additionally, it is not continuous and is sold to medical providers, not individuals [26].

Therefore we intend to sell each biosensor at a price of $100 USD (€91 EUR), and our electronics will retail for $400 USD (€365 EUR). While this profit margin on the electronics is smaller, the consumable margins drive the business model. With each sensor lasting an estimated 8 days, requiring 3.5 sensors a month. With American Medicare covering up to 80% of out of pocket costs after deductibles are met, American consumers may pay as little as $90 USD a month.

5.4.3 - Market Analysis

At the moment, there are no continuous biosensors on the American market that can be used at home and without the need of a medical professional.

Our goal is to target patients that are suffering or recovering from kidney failure or are at risk for kidney disease. According to the American Kidney Fund, there are over 250,000 kidney transplant receivers in the United States alone that could benefit from the continuous monitoring our sensor provides.

Targeting this group would be most ideal because even if half of this population bought a sensor, that would be 125,000 sensors sold in the first 2 years or so. Furthermore, 90% of people with kidney disease have no idea that they have it [21], leaving a large untapped market. Kidney disease diagnoses are increasing each year, from 53,926 in 2000 to 3,959,360 in 2014 [8], meaning that demand for our sensor will continue to grow.

5.4.4 - Revenue Streams and Strategies

Revenues will be generated by one-time sale of electronics and repeated sales of biosensors. Using the market analysis above, the first couple years can expect a total revenue of at least $250 million USD from electronics alone. We can expect about $180 million per year from recurring sensor sales, assuming 8 sensors are bought per month per user. As more kidney transplants are performed (about 25,000 per year, assuming half purchase our sensor) that is an additional $25 million from the one-time electronics purchase and $1.8 million/year in recurring sensor sales per year (8 per month per person). Furthermore, even if 1% of patients suffering from kidney disease bought our sensor (370,000), that is an additional $740 million that can be expected over the first couple years as people learn about our sensor. Along with this, $532 million can be expected per year from sensor sales (8 per month per person). After the initial boom of our sensor hitting the market, expected yearly revenue will be around $760 million ($26.2 million from transplant patients and $21 million from 10,000 newly diagnosed kidney disease patients along with the combined $713 million in recurring sensor sales).

The net profit of this business plan would be approximately $710 million USD annually. Assuming that virtually all profits would initially be used to cover wages (approximate $400000 USD), debts accrued from FDA approval ($500000 USD, €460000 EUR), and facility and equipment purchases ($1 million USD, €921000 EUR), the company would reach its breakeven point within the first year.

Team and support

6.1 Team Members

Dr. Michael Daniele and Dr. Stefano Menagatti were crucial in the development of our biosensor. Their support in the process of creating and testing our designs as well as their guidance through the technical decisions were necessary for our ability to compete.

Kirstie Queener and Gabby Rusch were our coaches for this competition, providing invaluable advice and keeping us on track to meet our goals.

Jacob Linnabary acted as a captain and member of the electrical team, heading the efforts of creating our potentiostat and leading weekly meetings.

Ashley Dehn acted as a captain and member of the chemistry team, putting in countless hours of testing our binding agents as well as leading team meetings.

Chris Sharkey served as a member of the chemistry team, providing invaluable experience with the SensUs competition as well as knowledge of biosensing and lab techniques.

Rohan Parashar served as a member of the electrical team, working on coding the microcontroller we used for testing our sensor.

Munish Nidadavolu served as a member of the electrical team as well as heading up the business side of the competition. He is heavily responsible for the transportation that allowed us to attend the competition in Eindhoven.

Casey Chason served as a member of the chemistry team, spending time in the lab and researching the relationship between biological molecules and copper reduction.

Bella Agusta served as a member of the chemistry team and social team, leading the instagram as well as helping out with the development of the chemistry side of the sensor.

Mikey Spaulding served as a member of the chemistry and social teams, posting on social media and contributing to the work done on the chemistry side.

Sarah Asher served on the chemistry team, aiding in the investigation of creatinine and copper's electrochemical behavior.

6.2 Those who have given support

Jack Twiddy provided insight into potentiostat configurations, PCB design, and electrical development.

Dr. Victor Agusta Sr. provided useful insight as a urologist on the typical procedures for sensing creatinine and assessing the health of kidney patients.

Travis McKay shared helpful feedback about the entrepreneurship side of our project.

Tracy Lavorini provided help in the graphic design of our product.

6.3 Sponsors and Partners

PalmSens was our partner for Partner Sessions. PalmSens provided us with feedback about our chemical and electrical components, as well as answering specific electrochemical questions we had.

Final Remarks

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We look forward to seeing the continuation of research in sensing using non-biological methods and its effects on shelf stability and accessibility of biosensors.

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