Scent-Sationals

SNIFFDRONE

International Product Development Project

2023

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Ipdp		Abstract
Team	Scent-Sationals	Year 2023
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Company SNIFFDRONE in collaboration with ATTRACT challenged our team Scent-Sationals to find an alternative application for the ongoing project SNIFFIRDRONE. The final product revolves around the application of cutting-edge technology aiming to create an innovative product capable of identifying airborne viruses. Providing healthcare professionals with an invaluable resource to effectively combat the transmission of infectious diseases. The primary challenge is the difficulty hospitals encounter in identifying COVID-19, especially in high-risk areas. Transmission is reduced and aids hospitals in maintaining a safe environment. Equipping with proper tools, we empower to proactively safeguard themselves and others. This device holds the promise of saving lives, preventing outbreaks, and relieving the burden on healthcare systems.

Keywords ATTRACT, SNIFFDRONE, COVID-19, healthcare

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1 Executive Summary

Our project revolves around the application of cutting-edge technology based on the PNNL research using minuscule structures known as Micelles, with the ultimate aim of creating an innovative product capable of identifying airborne viruses. Customized specifically for hospital use, this device intends to provide healthcare professionals with an invaluable resource to effectively combat the transmission of infectious diseases. The primary challenge we address is the difficulty hospitals encounter in identifying airborne viruses, especially in high-risk areas like healthcare facilities. Traditional detection methods often involve time-consuming laboratory analysis or direct contact with potentially infected individuals. These approaches not only pose risks to healthcare workers but also hinder the prompt detection and containment of contagious diseases. By harnessing the remarkable capabilities of Micelle detection technology, our device presents a non-intrusive and highly efficient solution. It empowers healthcare workers to swiftly and accurately detect airborne viruses, including the current threat of coronavirus. As a result, it significantly reduces the risk of transmission and aids hospitals in maintaining a safe environment for their staff and patients. Our project is guided by two primary objectives. Firstly, we aspire to develop an exquisitely sensitive and reliable device capable of detecting airborne viruses. This advancement will greatly enhance the ability of healthcare workers to promptly identify infected individuals and implement appropriate measures. Secondly, we endeavor to develop a user-friendly and easily accessible device that requires minimal training for healthcare professionals to operate effectively. The significance of our project lies in its potential to revolutionize the detection and mitigation of airborne viruses spread within hospitals. By equipping healthcare workers with state-of-the-art tools, we empower them to proactively safeguard themselves and others from contagious diseases. This device holds the promise of saving lives, preventing outbreaks, and relieving the burden on healthcare systems. It represents a substantial leap forward in ensuring the safety and well-being of healthcare workers and patients in hospital settings.

2 Introduction

Our undertaking revolves around a particular application of cutting-edge technology called micelles, developed by the PNNL, with the primary objective of developing an inventive resolution to address a crucial concern. We set out to confront a common obstacle faced by diverse establishments, especially in the healthcare domain, by providing a valuable tool that effectively mitigates its impact. The core issue pertains to identifying specific occurrences within a defined framework. Existing methods have proven inadequate, time-consuming, or potentially risky for those involved. Consequently, there is a clear necessity for a fresh and improved approach to effectively tackle this challenge. Our project encompasses multiple aims. Firstly, we sought to devise a solution that surpasses the limitations of current methodologies, offering enhanced precision and dependability. This advancement would significantly bolster the capacity to detect and analyze the targeted phenomena. Secondly, our goal was to play with an idea of an intuitive and easily accessible tool that professionals can utilize with minimal specialized training. The significance of our project lies in its potential to revolutionize existing practices and yield substantial benefits across various sectors. By addressing this longstanding challenge, we empower establishments to optimize their operations, bolster safety measures, and potentially save lives. This endeavor represents a significant stride forward in the field, with wide-ranging implications that extend beyond the initial problem it endeavors to solve.

2.1 Ipdp program

IPdP (International Product Development Project) 2023 brought together HAMK Design Factory and inno.space Design Factory Mannheim. The program was started with a MOOC course - Massive Open Online Course, which prepared and supplied tools for effective design thinking and methodology. During a few months, the work has been divided into two remote weeks and online work.

Alongside the work of the project, there were weekly scheduled meetings that offered teachers insight, reflection, and support in design thinking.

IPdP provided an opportunity to work on real-life company projects. ". The project's aim is to recognize the product or service development possibilities and to find innovative insights for development." - stated by HAMK Design Factory in an article.

Overall, with the iPdP program, we have accomplished each step in the design thinking methodology that led us to the final prototype.

2.2 Team Scent-Sationals

Our project team consists of six exceptionally talented students, each bringing their unique expertise and perspective to the table. The team comprises a computer science student (Arash), two chemical engineering students (Luca and Paul), an international business student (Nisansala), and two automation and electrical engineering students (Dominik, Katarzyna). Throughout the project, our team fostered a dynamic and collaborative environment, where active participation in various assignments and tasks was encouraged. We deeply acknowledged the value of harnessing the strengths and skills of each team member to effectively achieve our project goals. While all team members contributed to the overall project progress, during the final stages, specific tasks were assigned to optimize efficiency. Paul took charge of the technological aspects and the creation of the team poster. Extensive research on the viability of the technology was conducted by Paul, while Luca skillfully crafted the final presentation slides. Arash, in collaboration with Dominik and Katarzyna, wrote the role-play script, edited the video, and also prepared the project report. Nisansala was responsible for designing the product poster and the signage poster. This strategic allocation of responsibilities allowed us to concentrate on our respective areas of expertise and deliver exceptional outcomes in a streamlined manner. The success of the project was greatly influenced by our collaborative efforts and effective communication. Regular team meetings, brainstorming sessions, and open discussions played a pivotal role in our ability to share ideas, overcome challenges, and make well-informed decisions as a collective unit. By harnessing the diverse talents and perspectives of our team members, we were able to achieve a remarkable level of synergy, thereby maximizing the project's potential. The strong collaboration and unwavering support among our team members were instrumental in propelling the project forward and ensuring its overall success.

3 The challenge

3.1 Sponsors

Although the team was faced with many HMW questions, there were two main questions given:

- How might we find a new alternative solution to the existing odor sensing technology?
- How can this alternative solution improve the lives of people without harming our planet?

These challenges were given by a company developing ‘‘SNIFFDRONE’’. SNIFFDRONE is an R&D project funded by the European Union through the ATTRACT initiative in 2019-2020. The main purpose of the project is the development of a drone with olfaction capabilities to provide spatially dense odor measurements and autonomously localize the source of odor nuisances in wastewater treatment plants (WWTPs).

ATTRACT, on the other hand, is six of Europe’s leading scientific laboratories that have joined forces with industry and experts in business and entrepreneurship to develop next-generation scientific tools and co-create new products, companies and jobs.

The six labs – CERN, the European Southern Observatory (ESO), the European Synchrotron Radiation Facility (ESRF), the European Molecular Biology Laboratory (EMBL), European X-Ray Free-Electron Laser (European XFEL) and Institut Laue-Langevin (ILL) – will partner with Aalto University, European Industrial Research Management Association (EIRMA) and Esade Business and Law Schools.

For the first time, this consortium of big research infrastructure projects — including telescopes, particle accelerators and other capital-intensive scientific instruments — and leveraging in the know-how of industry and business and entrepreneurship experts will be explicitly used to generate and capture value, create jobs, and promote growth.

During a meeting with a sponsor our team got informed that the Institute for Bioengineering of Catalonia (IBEC) focuses on the development of different sensor technology. We have focused on developing technology, mainly focusing on sensor and detection.

3.2 Project Background

So far, the company has come up with different and innovative use cases for their technology. The applications included volcanic research, landfill emission monitoring, chemical monitoring in industrial sites, early fire detection, residential emissions monitoring, ship emission monitoring, precision agriculture and urban air quality.

Based on previous HMW questions stated in the previous chapter, our team got thinking during boot camp and came up with various HMW questions in different fields, such as the ones set by SNIFFDRONE and some additional ones. The main idea taken from the boot camp was to use a SNIFFDRONE as an oil and gas leak detector. We interviewed some people working in these areas, and created personas, but later our sponsor said that the SNIFFDRONE is not able to find these threats in a large area, due to technical limitations. So, the whole idea had to be scratched, and worked on from the beginning. For the halfway gala, our team prepared three visualizations of different prototypes:

- Snifferoni - Detecting viruses in hospitals and keeping people safe

The initial idea consisted of a box located in the waiting room to detect viruses and alarm about the hazardous health of the patient.

- SmelliVision - Fire, gas and mold detector

The prototype was meant to boost a regular fire detector. Connected with smart houses improve the well-being of tenants and keeps control of the state of the house.

- SniffBox - Detecting illnesses through breath

The prototype was designed to monitor the health of patients in hospitals, elderly houses or households etc…. The main disease tracer was narrowed down to diabetes.

After the feedback we received during the halfway gala (unfortunately the sponsor was at this point unavailable), we decided to combine the Snifferoni and Sniffbox into one prototype called Smellivision. More about the prototype can be found in the chapter Solution.

4 Problem Background

4.1 COVID-19 pandemic

Since the first outbreak in 2019, there have been around 690 387 006 coronavirus cases from which around 6 891 772 resulted in death. The most affected regions were Europe, Western Pacific and both South and North America.

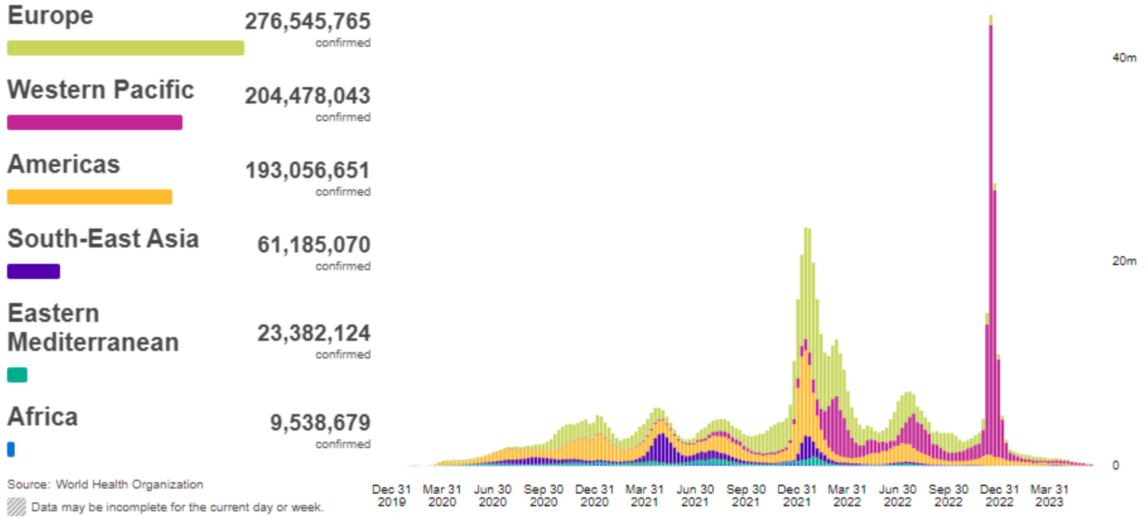

Figure 1. The situation of COVID-19 cases (*Coronavirus Disease (COVID-19) – World Health Organization*, n.d.)

To limit the spread of COVID-19 each country, territory and area has taken steps called PHSM - Public Health and Social Measures. Repetitive policy responses to diseases around the world were: workplace and school closures, stay-at-home restrictions, face coverings, testing and cancelling international and domestic travels. Many lives have also been affected by those changes.

However, the most challenges were faced by the healthcare providers. They were the ones directly exposed. It became a critical mission to trace the COVID-19 outbreak and gathering data became an important task. COVID-19 is attacked off guard, therefore data insight gives advance to healthcare providers. The first contact people with covid ill patients were medical professionals, therefore it was crucial to keep them safe. The pandemic put a lot of pressure and work overload on nurses and doctors. Hospitals and other medical facilities became severely capacitated, alongside the distribution of supplies, equipment and medicine were caught shorthanded. With a large number of people passing through hospitals there is a greater risk of infecting vulnerable patients and medical staff. (*Maintaining Essential Health Services*, n.d.)

Therefore, experiencing the huge impact and damage caused by COVID-19 we have decided to explore this topic more and base the product on this issue.

Given all in mind, how might we question resolved around how might we create a device that helps to detect airborne spread viruses at hospitals automatically?

4.2 Persona

In the past, we would develop various personas for our product. These personas represented potential customers who could benefit from our offerings. Specifically, in the case of Smellivision, our target customers or users would include nurses, hospital workers, and healthcare professionals. They would utilize Smellivision as a tool to detect various scents, such as the presence of COVID-19, enabling them to identify potential cases quickly and effectively.

5 User Journey

Step 1: Discovery

A healthcare worker becomes aware of Smellivision through a colleague, online research, or a professional event.

They learn that Smellivision is a cutting-edge technology designed to detect specific scents, including the presence of COVID-19, aiding in early identification and prevention.

Step 2: Research

Intrigued by the potential benefits, the healthcare worker conducts further research on Smellivision.

They explore the product's website, read testimonials from other healthcare workers, and seek information about its accuracy, ease of use, and integration with existing protocols. They may also compare Smellivision to other similar scent-detection technologies in the market.

Step 3: Decision-making and Purchase

Convinced of Smellivision's potential, the healthcare worker decides to incorporate it into their workplace. They discuss the product with their colleagues, supervisor, or procurement department to gather additional insights and gain support for the purchase. They review the pricing options, warranty, and customer support offered by the Smellivision provider. Finally, they make the decision to purchase Smellivision and proceed with the order.

5.1 User testing

Gathering feedback and insights directly from individuals who utilize our product is an invaluable process known as user testing. By engaging with users, particularly those within the healthcare industry, we gain a profound understanding of their requirements, preferences, and how we can optimize our product to surpass their expectations. In the user testing phase, we initiated the process by approaching individuals and seeking their opinions on our product. This approach enabled us to obtain valuable insights into the specific needs of healthcare professionals regarding a product like ours. We aimed to comprehend their requirements, evaluate the user-friendliness of our product, and identify potential areas for improvement. To ensure a comprehensive understanding, we concluded our user testing with an interview involving an Emergency doctor from the UK. During this interview, we exchanged ideas and discussed his experiences during the COVID-19 pandemic at the hospital. We sought his expert opinion on whether our product could assist in managing the infection and reducing its transmission. The doctor confirmed that the pandemic situation was indeed severe, and healthcare workers had to exercise utmost caution to avoid contracting COVID-19. He expressed confidence that our product would be immensely beneficial, as it would facilitate early detection of the virus and prompt action, leading to effective containment. Overall, the process of user testing proved to be highly valuable. It provided us with firsthand insights from end-users, ensuring that our product aligns perfectly with their needs and expectations. The feedback from healthcare professionals, especially the Emergency doctor, reinforced the significance of our product in tackling the challenges posed by the pandemic. Equipped with this knowledge, we can continue to refine and improve our product, making it even more impactful and indispensable for healthcare professionals who tirelessly strive to safeguard public health.

5.2 Existing solutions

Up to this day, medical facilities and pharmacies utilize COVID-19 PCR tests to diagnose patients, visitors, or staff. The test is required to be done with a healthcare provider when entering any healthcare facility. The procedure requires a sample from the throat or nose. The test is then approved by them, and the diagnosis is set. Another system was to measure each person's temperature at the entrance of the medical facility.

This process takes a lot of time and patients go through uncomfortable procedures. During a pandemic, it was essential to cancel any unimportant visits to the hospitals and stay at home. It was not possible to check on every person if he or she is free from the COVID-19 virus.

6 Our solution

6.1 The Smellivision

We have developed Smellivison. A device to detect COVID-19 from breath. It is made to be placed on the wall in medical facilities to quickly and efficiently check on people well being. Smellivison is meant to provide valuable information on possible pre-diagnosis of COVID-19.

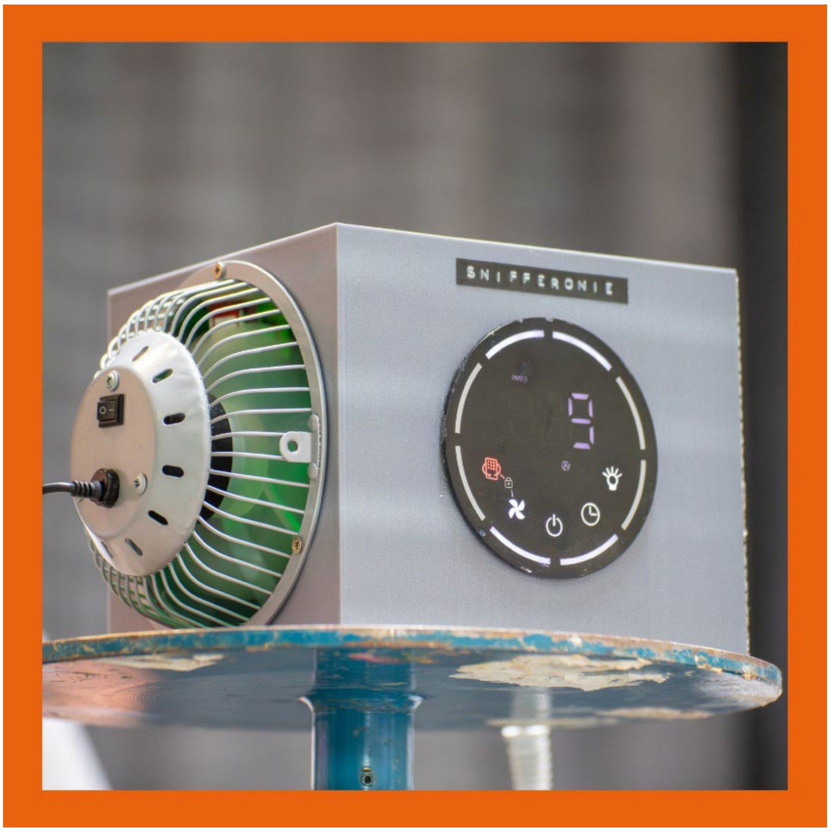

Figure 2. Smellivison (inno.space - Design Factory Mannheim, n.d.)

Smellivison is automated in a way that it does not need a person to use it or maintain it after every use. This provides a safe space for nurses or other medical staff to safely run a health check. This is because the patient can interact with the device independently and the results can be controlled and monitored from a safe distance.

Smellivison was designed for facilities providing healthcare therefore it is made to be accessible to different users. During the design process, we solved the height. As the device should be on a head level for the user to be comfortable breathing into the device, we implemented theoretical automated height adjustment.

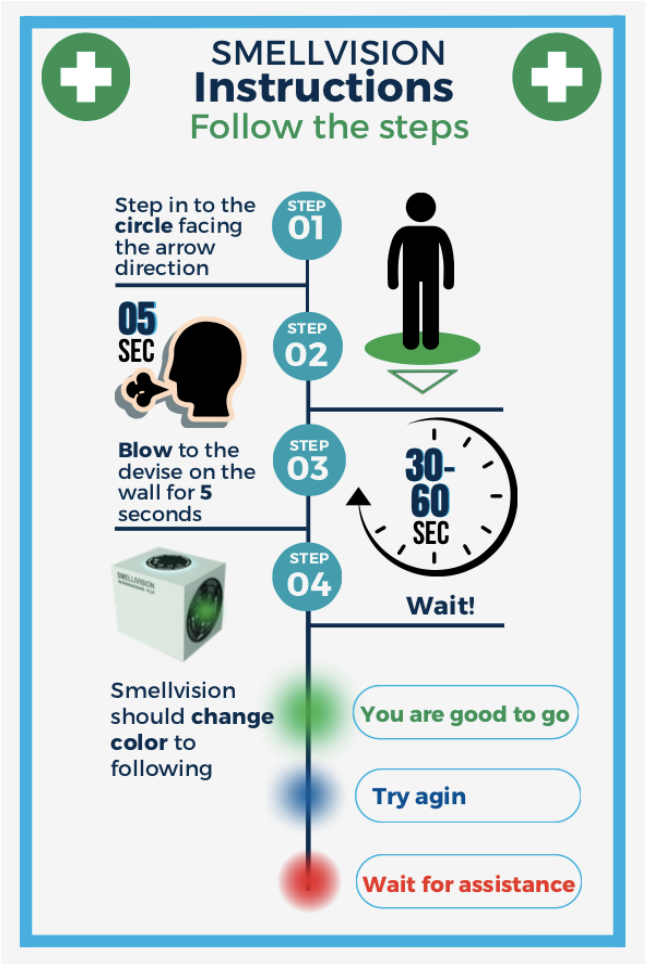

Figure 3. Smellivision instruction board

Smellivision has additional instructions for the user to follow. There are 4 quick steps for patients to go through, they are designed in a clear and direct way. First, the user is required to stand in a designated place facing the Smellivision. Then the patient needs to breathe into the device for around 5 seconds. Results appear in 30 to 60 seconds. With the changed color of the indicator light, the patient follows the assigned rule. There is intended to be a medical staff around so if any issue or red colour appears, the patient is immediately escorted to further tests.

6.2 Technology

The technology we use in our idea is based on the research results of a scientist group from the Pacific Northwest National Laboratory. “The SARS-CoV-2 virus is detected using a complex of nanotechnology-packed micelles, which splash the chemicals they contain as they encounter the viruses.” (*COVID-Causing Virus in Air Detected with High-Tech Bubbles | PNNL*, n.d.)

Our device, the “SMELLIVISION”, is designed to be used at the entrance of health care facilities like hospitals. The patients and the staff who want to enter the hospital use it instead of the common methods to test on a SARS-CoV-2 infection. The client must blow into the device, so the viruses can be collected by the mechanism. After that, they are transported to the sensor technology which consists of the micellar complex. Although this idea is a bit different than the technology used in a Sniffdrone, the goal to “smell” is the same. This decision was done based on a consultation with sponsor, where it was revealed that most of the common uses of the sniffdrone have been explored. Where the sniffdrone uses sensible electrochemical sensors, our prototype would be using micelles because they are more suitable for this use.

According to research adapted from the PNNL micelle is a structure consisting of one micelle inside the other. They are coated with a polymer and have a width of about 5 microns. The outer surface has several imprinted areas made of silica, where the viruses can bind to the micelle. Also, the micelles are placed in a water bath, whose electric conductivity is constantly measured. If a virus touches the surface of the micelle, it pops open and releases salt molecules. As the salt is spilled out with very high speed, the electric conductivity of the water changes instantly. (*COVID-Causing Virus in Air Detected with High-Tech Bubbles | PNNL*, n.d.)

Figure 4. Scientist handling the micelles (*COVID-Causing Virus in Air Detected with High-Tech Bubbles | PNNL*, n.d.)

“Combining micelles with a technology to imprint or stamp them is not something many people have done before,” said Lance Hubbard, an expert in nanosynthesis. “Imprinting a molecule with our molecule of interest inserts a vulnerability into the micelle—which is what we want in this case.” (*COVID-Causing Virus in Air Detected with High-Tech Bubbles | PNNL*, n.d.)

Our idea is that this effect is measured by the sensors and the signal gets amplified so the LED lights, that indicate whether viruses are detected (red light) or not (green light). If there was only a small number of viruses detected and the electric conductivity hasn't changed much, the LED can also change its color to blue, which implies that the test must be done again by the client.

To avoid incorrect measurements after each patient, the device has to be cleaned after every use. To solve this problem, several UV-C radiation emitters are implemented into the areas inside the device, where viruses can come in contact with. After the patient has finished the test, they light up and thus clean the SMELLIVISION from viruses and other contaminants, guaranteeing a perfect test result for the next patient.

This technology, according to the developers, is a much faster option than the commonly used SARS-CoV-2 tests and requires a smaller number of viruses to give the client a result with fewer errors.

Another big advantage the technology provides is that it can detect one viral particle out of billions of other particles. The detector is so sensitive that the team was challenged by identifying the lower limit of the micelle technology.

6.3 The Prototype

The solution includes basic structure and components of the Smellivision is shown in Figure 5. The case of the Smellivision is made of plastic with a copper coating inside. The copper ions help to reduce the viral load inside the device. The copper ions located on the surface of the copper coating can penetrate the outer shell of viruses and attack the viral RNA or DNA. This leads to damage of the genetic material of the virus and finally to its killing. This special surface ensures that no viruses set in the device and lead to false alarms.

Breathing air is blown in through a funnel-shaped opening on the side of the device. Directly behind the opening is an air flow sensor, which is used to quantify the amount of breathing air flowing in. To ensure that the test conditions are always the same for each individual test, a sound and light signal is emitted when a certain amount of air has flowed through. This signal tells the test person to stop blowing into the device (after approx. 5 seconds). You can imagine the whole thing like a breath alcohol test.

The breath air then enters the measuring cell via a pipe connection. The envelope of the measuring cell is a tube and is also made of plastic with a copper coating. Inside the tube, a TLC plate (Thin Layer Chromatography Plate) is rolled up with a coating of the polymer polypyrrole (PPy). Such a TLC plate is also used in a normal nasal corona test as a running surface on the test strip. The advantage is the absorbent and at the same time inert property of the TLC plate. The polymer coating also allows current to be conducted through the plate. The eluent (water-micelle mixture) is contained in a reservoir inside the instrument. The reservoir is connected to the measuring cell via a capillary rod. Due to the capillary effect, sufficient liquid always reaches the TLC plate and is thus always saturated with the eluent. Inside the reservoir there is also an agitator to keep the eluent dispersed. At the end of the measuring cell is the air outlet, from which the breathable air leaves the device again.

The solution includes the detector unit including a signal amplifier that is connected directly to the TLC plate. The detector unit measures the electrical signal generated in the measuring cell, amplifies it and passes it on to the recording unit. The detector provides a signal faster, requires a smaller amount of viral particles, and generates fewer errors compared to liquid-based testing methods.

The desinged technology can detect the virus within a millisecond, but requires an additional minute for quality control to confirm the signal and avoid false alarms (faster in the future).

The recording unit represents the brain of the complete setup, so to speak, and is responsible for classifying and saving each signal received. Depending on the previously set limit value, a light signal can then be emitted via a signal lamp.

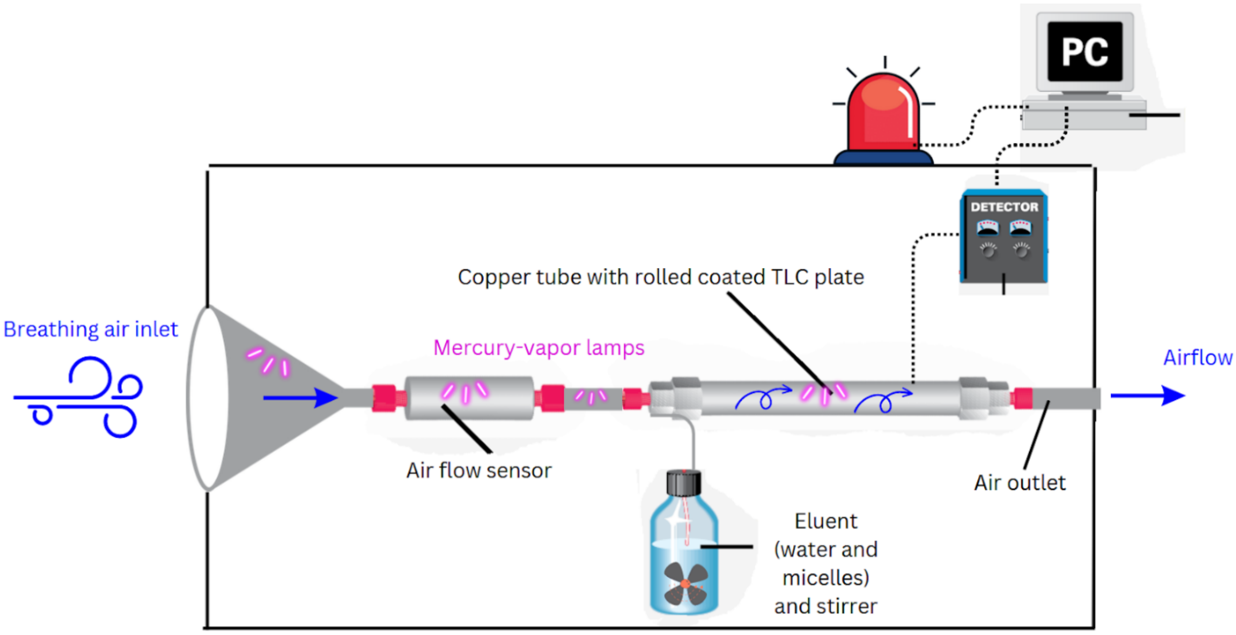

Figure 5. Basic structure and components of the Smellivision

The included schematics has been developed by the team Scent-Sationals. However, the main part of the device, micelles, is research conducted by PNNL. This type of sensing technology turned out to be the most reasonable solution for this case.

To prevent the viruses from settling in the device and the detector outside the test plate, the complete pipe, sensor and detector are illuminated with several very small mercury vapor lamps for 30 seconds after each test procedure. The lamps are located directly in the piping and are automatically activated after each test. The special feature of this type of lamp is that they produce high UV-C radiation. In this case, 3.7 mJ/cm^2 is sufficient to reduce the virus on a surface by more than 99.9%. (Hubbard et al., 2022) This eliminates the need for continuous cleaning of the interior of the instrument and ensures that it is always sterile prior to each test run. A total test run takes about 1-1.5 minutes. The number of Smellivisions at the reception has to be adjusted according to the size of the hospital or the number of visitors.

For maintenance and to ensure operation, the TLC plates must be replaced after a certain number of tests have been performed. With every test procedure, saliva and all kinds of other particles get onto the detector in addition to the respiratory air. To ensure consistent test conditions, it is therefore essential to change the plate regularly. This procedure can be performed by previously trained hospital personnel. Furthermore, the reservoir containers must be regularly filled with new eluent. This can either be mixed directly in the hospital from the micelles and distilled water or purchased ready-mixed. Overall, maintenance of the Smellivision is not a major challenge. In the event of a malfunction, as with any other medical device, there are technicians on hand to ensure smooth operation.

Since the only validated Corona test is a PCR test, after a positive signal such a test will be performed by the hospital staff. The normally used nasal rapid tests can be completely replaced by the Smellivision in the hospital.

6.4 Value of the idea

Our primary goal from the very beginning was to develop Smellivision, a revolutionary technology designed to enhance working conditions and ensure the safety of healthcare professionals. Upon receiving feedback and recognizing the challenges posed by the Corona pandemic, we resolved to bring joy back into their lives. Our mission was to develop a solution that not only alleviates their fears of contracting the virus but also enhances their overall well-being, enabling them to perform their duties more effectively. This innovative device could be equipped with the ability to detect

Corona and promptly alert the hospital staff whenever an individual carrying the virus attempts to enter the premises.

Overall, the product is easy to use and what's more importantly quick. The device has been designed having in mind multiple use and efficiency in quality results for each patient. Additionally, we have taken into account the second HMW: How can this alternative solution improve the lives of people without harming our planet?, the device has the potential to replace single-use COVID-19 PCR tests, which during the pandemic became low in numbers. (Lim, 2022)

7 Conclusion

Overall, the journey to the final solution was long and came with many obstacles but overall we have prepared a solid idea. Smellivision has shown to work as intended and is expected to be applied in real-life situations. The intended environment for this product is ideally a hospital as it was the main area. However, the device can be applied to other highly populated areas like concerts, stadium games or events. The device will be used instead of the nasal swap COVID-19 tests in future.

The future development of the product is seen to be easily adjustable for different viruses or even illnesses, focusing on airborne based diseases. This is highly achievable with the right technology and research about the virus. Smellivison can be extended to detect already existing diseases or can be a part of the outbreak control for new viruses. Smellivison works with electronics which gives a huge step into the automatization of healthcare pre diagnosis.

As already mentioned, our idea focuses more on alternative way of using the air sniffing technology rather than finding a new purpose for the SniffDrone. Because of this, many regulations were not taken into account and may result in challenging implementation if considered to be mounted on a drone.

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