PRESS RELEASE

Sensor bracelet measures a range of environmental forces to improve the treatment of lung diseases

Tiny particulates or noxious gases: From the day they are born, all people are exposed to a range of environmental forces. These forces constitute the exposome and affect the health and wellbeing of people around the world. A European research project has been set up to explore how the exposome affects the course of lung diseases. The microelectronics specialists at Fraunhofer IZM are on board and have developed a unique sensor bracelet that can pick up even tiniest concentrations of more than 40 individual harmful substances. The collected clinical data will show how these affect the lives of patients and may feed into more targeted and customized treatments.

Pulmonary diseases kill around seven million people per year and reduce the quality of life for countless others[1]. They can be caused by many factors. Whether genetic in origin or caused by our lifestyle, one thing that always plays a part is the exposome, that combination of internal and external forces, like air quality, sunlight, exposure to harmful substances, or nutrition. Our understanding of the complex interplay of these factors is far from complete. All that is certain is that its effect on the course of pulmonary diseases cannot be overestimated. With this in mind, the multidisciplinary consortium formed for the REMEDIA project has taken on the challenge to explore the vast pool of environmental parameters and biomarkers to learn more about their relevance for pulmonary health.

Two diseases are the focus of the project: Cystic fibrosis or CF, a genetic metabolic disease that can affect the correct functioning of human organs, and chronic obstructive pulmonary disease or COPD, which is in most cases due to smoking. Both can be treated, but not cured, and both can dramatically lower the life expectancy of patients. Although CF and COPD develop in similar ways, they differ in their causes, which makes them an interesting and important target for medical research. What is clear is that both diseases cannot be blamed solely on genetic factors or unhealthy habits like smoking – other, as yet unknown factors must be at play. To be able to

[1] https://h2020-remedia.eu/

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identify these and get reliable insights about the correlations at work, a lot of data has to be collected and analysed by pathologists.

The consortium decides to develop two innovative devices for the monitoring system: A sensor that measures several of the body's internal biomarkers in the patients' breath and a sensor covering a whole range of environmental factors affecting patients. The Fraunhofer Institute for Reliability and Microintegration IZM took over the job of developing and constructing the environmental toolkit. The vision of the team assembled around group leader Christine Kallmayer was a highly miniaturized and wearable device that can provide extremely precise measurements: "The relevant gases are present in extremely tiny concentrations, which means that our sensors had to be particularly sensitive. At the same time, the device had to be small enough for people to wear it on a regular basis. This balancing act led us to an electronic bracelet carrying the miniature sensor toolbox." The precision aimed for by the team was stunning: the device is meant to measure the exposome not in "parts per million", but in ppb – that is, individual molecules present in a billion molecules of the surrounding air ("parts per billion").

Before work on the actual construction could start, the researchers had one important job: testing. They had to find exactly the right sensors from the vast range of components available in the market to match their high standards in terms of miniaturization and precision. When a good candidate had been found, they developed an energy-efficient circuit to transmit the data from the sensors, which were integrated in a flexible and stretchable bracelet. Other sensors, a controller, GPS module, a tiny antenna, an SD card, and the necessary battery were all fitted into a case the size of a mobile phone. To keep the device to this compact scale, the researchers miniaturized all components, including a system-in-package design for the circuits, which stacks several ICs on top of each other in one encapsulated package.

Over the first year of the project, the consortium produced a catalogue of around 40 relevant parameters to include in the system's specifications. Their goal was to measure the concentration of gases like CO, O_3, NO_2, CO_2, SO_2, and volatile organic compounds or VOC, as well as humidity, air pressure, dust particles and air quality indicators or even the light, temperature, and noise around the system. This comprehensive selection of parameters represented a considerable challenge on the technical side, as the different particle sizes at play typically mean that different technologies are used to measure them. In the end, a decision was taken in favour of electrochemical and MOS (metaloxidation semiconductor) sensors, combined with dynamic laser scattering. This choice and the use of special algorithms for processing the data meant that the researchers could also overcome the problem of cross-sensitivity, that is, sensors responding incorrectly when exposed to multiple substances at the same time.

The next phase of the project will put the sensor processes to the test under real-life conditions: Patients will be wearing the bracelets in their everyday lives and their local environment. The environmental data collected by the patients will be collected on

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built-in SD cards and displayed on the device through the software developed at Fraunhofer IZM. Once the data has been captured, it can be used by the project partners to replicate the exposomes encountered by the patients in special atmospheric simulation chambers and compare the experimental data with real data from the field. AI and machine learning will help create prognostic models that can be used to mix and match preventative treatments for each patient. Quantifying the factors at work not only represents a major asset for medicine – the sensor bracelet is in itself a technical milestone with its small size, mobility and performance even with minute exposome concentrations.

The European Human Exposome research network is the largest of its kind in the world, dedicated to exploring the impact of environmental factors on human health. It covers nine separate research projects that are supported with more than €100 million in funding as part of the EU's Horizon 2020 programme for research and innovation. Its insights will feed into improved prevention measures and contribute to the overall goals of the European "Green Deal": Protecting the health and wellbeing of Europe's population from the harmful effects of pollution and environmental damage.

For more information about the contents and contributors of the project, visit https://h2020-remedia.eu/

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The sensor bracelet tracks forty exposome parameters that can affect pulmonary health. I Technical University of Berlin/Basel Adams

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