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Abstract

A Novel Modular System for Breath Analysis Using Temperature Modulated MOX Sensors †

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Abstract: In this work, a new generation of gas sensing systems specially designed for breath analysis is presented. The developed system comprises a compact modular, low volume, temperature-controlled sensing chamber with three compartments that can host different sensor types. In the presented system, one compartment contains an array of 8 analog MOX sensors and the other two 10 digital MOX sensors each. Here, we test the system for the detection of low concentrations of several compounds.

Keywords: gas sensor array; MOX sensors; VOCs; breath analysis

1. Introduction

Breath analysis is becoming an important field of research, since it has been proved that some volatile organic compounds (VOCs) present in the human breath can be potential biomarkers for several diseases [1]. The analysis of breath can therefore be used as a diagnosis or a therapy progress monitoring method, being very convenient for the patient because breath sampling is not invasive and thus not painful [1]. Currently, the experimental techniques for detection of VOCs in exhaled breath is gas chromatography coupled to mass spectrometry (GC-MS) and proton-transfer reaction-mass spectrometry (PTR-MS). These techniques are very powerful, but they need highly skilled operating personnel, are time consuming and have high costs. As an alternative, breath analysis based on gas sensors would be fast, low cost, portable and easier to operate [2].

In this work, we present a novel sensor-based system for breath analysis—the Modular Breath Analyzer (MBA) and show results of initial tests aiming to detect low concentrations of several VOCs of interest.

2. Materials and Methods

The MBA contains a breath sampling unit for direct collection of the exhaled breath, and a compact modular, low volume, temperature-controlled sensing chamber with three exchangeable compartments capable of hosting up to 30 sensors. This versatile modular sensor system allows the combination of different sensor types within one device. The sensors can be commercial or experimental, only the circuitry of one compartment must be updated to incorporate a new sensor array to the MBA. Therefore, the MBA is an excellent platform for testing new sensor technologies

applied to breath analysis. Figure 1 shows an external (a) and an internal view of the MBA with its components (b), as well as a list of the series of MOX sensors used; an array of 8 analog MOX sensors, and two arrays with 10 digital MOX sensors each, 4 of which are modulated in temperature. Thus, a total of 36 sensors (real and virtual).
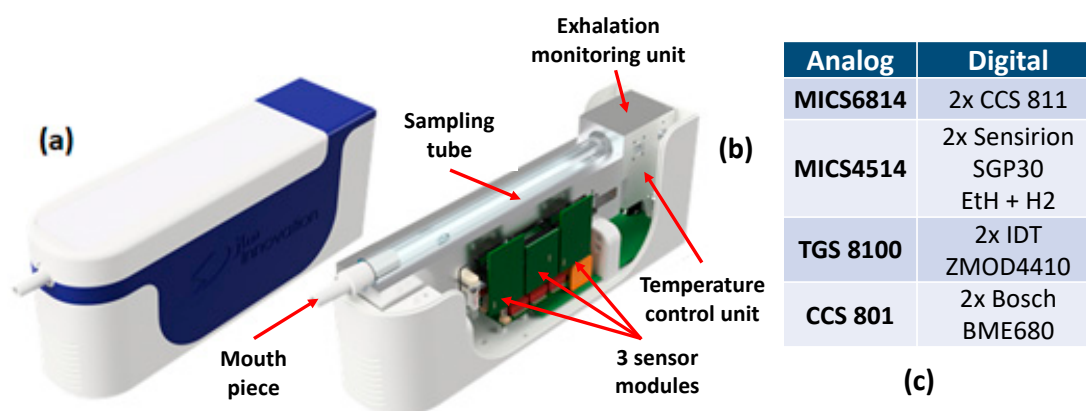

Analog	Digital
MICS6814	2x CCS 811
MICS4514	2x Sensirion SGP30 EtH + H2
TGS 8100	2x IDT ZMOD4410
CCS 801	2x Bosch BME680

Figure 1. External (**a**) and internal view of the MBA system (**b**), and list of MOX sensors (**c**).

The breath sampling unit is designed to capture the deep portion of the exhaled breath (alveolar breath) which contains the VOCs biomarkers related to the disease of interest. In the two experiments shown here the breath sampling unit was excluded, thus the air sample is directly driven to the sensing chamber.

The aim is to test the MBA with samples similar to human breath: VOCs of interest at body temperature and high humidity. At this moment, two preliminary experiments have been performed; a first experiment to detect several VOCs at different low concentrations (isopropanol, isoprene, n-pentane from 5 to 10 ppm, and acetone from 80 to 500 ppb) under dry conditions, and a second experiment to detect acetone and ethanol (3 to 18 ppm) under moderate humidity conditions (22% RH). Before and after exposing the sensors to the analytes during 10 min, the sensors were cleaned with synthetic air during 10 min.

3. Results and Conclusions

Figure 2a shows some of the raw sensors signals and Figure 2b a scores plot of a Principal Component Analysis with first results, showing that the VOCs can be easily differentiated with the MBA. More experiments will be performed to test the MBA in real human breath conditions.
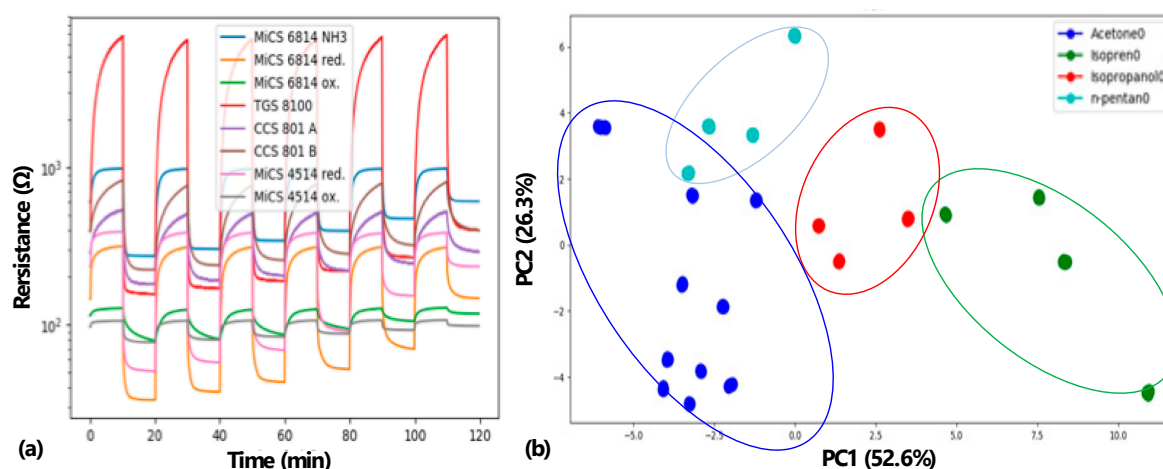

Figure 2. Raw signals from analog MOX sensors in one of the three compartments responding to several concentrations (3–18 ppm) of ethanol at 22% of RH and 45 °C (**a**), and PCA scores plot of 25 measurements from first experiment (**b**).

References

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