Reproducibility study of metal-oxide gas-sensors using two different temperature setup

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OUTLINE

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INTRODUCTION

The olfactory sense is very important for the quality of life. The electronic nose device have been used for different type of applicative scope. The system must guarantee good performance in order to sensitivity and specificity and the sensors should be interchangeable with nominally identical ones in case of failure. For these reasons, in this work the reproducibility of nominally identical sensors was tested comparing the features extrapolated with sensors working in the two modes: isothermal and temperature modulation.

MAMMALIAN NOSE

| Olfactory epithelium (Receptor cells) | Olfactory bulb | Brain (Olfactory cortex) |

ELECTRONIC NOSE

| Sensor array | Readout electronics | Software |
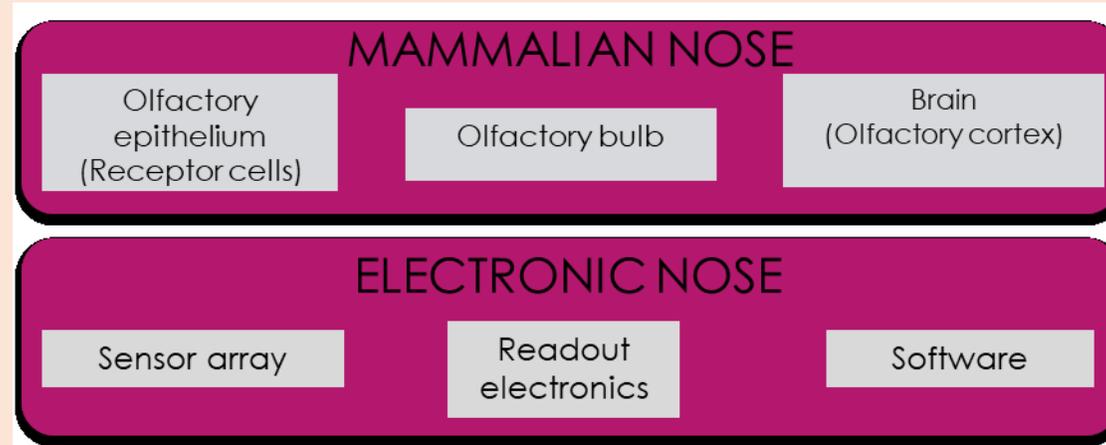
MATERIALS AND METHODS

In this work, we used a JLM MOX STICK (JLMInnovation Gmbh) device to perform experiments. That instrument include the sensors control software and the electronic part. The experiments were made using 4 commercial sensors (TGS 2620 - Figaro Sensor) exposed to vapours from pure solution of water and lactic acid.
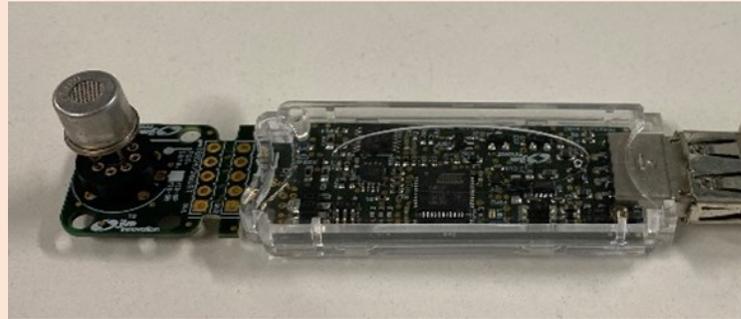
Each sensor was turned on and exposed to ambient air (environmental temperature 21°C) for one hour in order to it stabilized before performing the planned series of measurements.

Two vials were prepared using 10 ml of water and 10 ml of lactic acid.

Measurement times were as follows:
- 10 minutes in contact with the compound vapors
- 10 minutes recovery in air.
- Each substance was replicated 3 times.

MATERIALS AND METHODS

Custom temperature profile protocol:

Isotermal profile protocol:
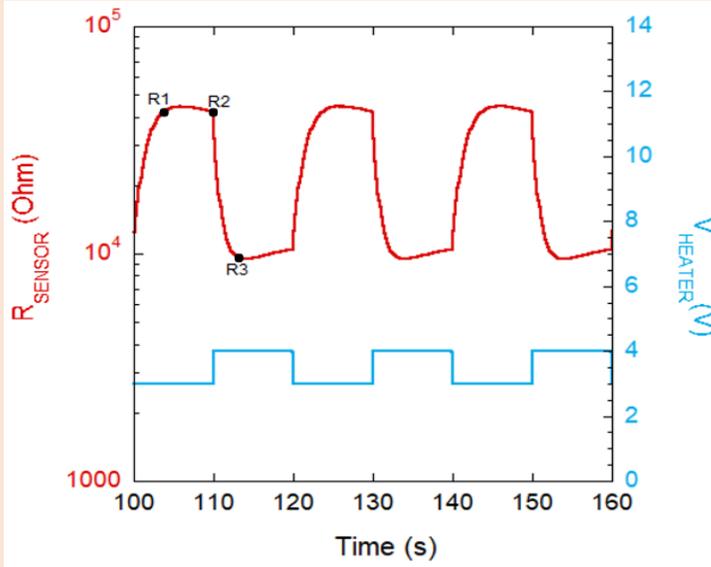
Two different working methods were used for the sensors
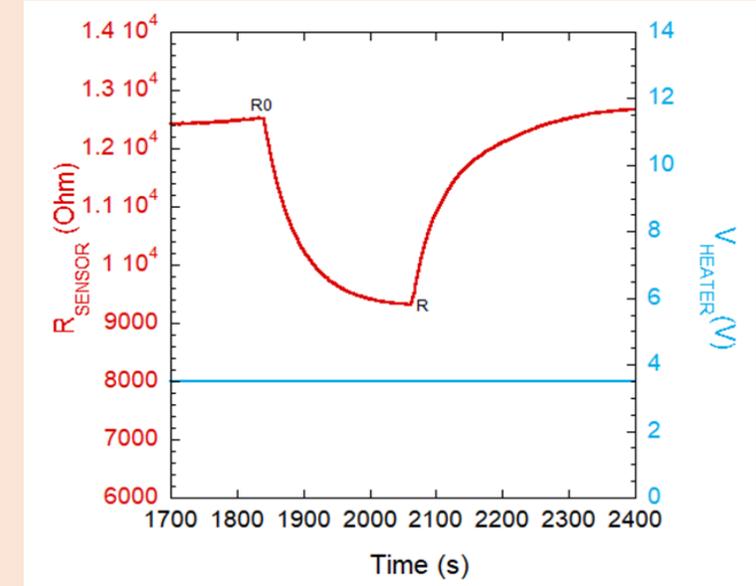
- Curve form R=R(t) depending on gas
- Features: it describes the trand of curve R(t)
- Time of response/recovering = modulation period 3/4 Volt
- Ratio-CH = ratio among the sensor resistance i.e. Ratio-CH = R2/R3.
- Delta-C = change of sensor resistance i.e. Delta-C = R1-R2

- Curve form R=R(t) depending on gas
- Time of response/recovering = Isotermal period 3.5 Volt
- Response calculated as R/R0

RESULTS AND DISCUSSION

Water
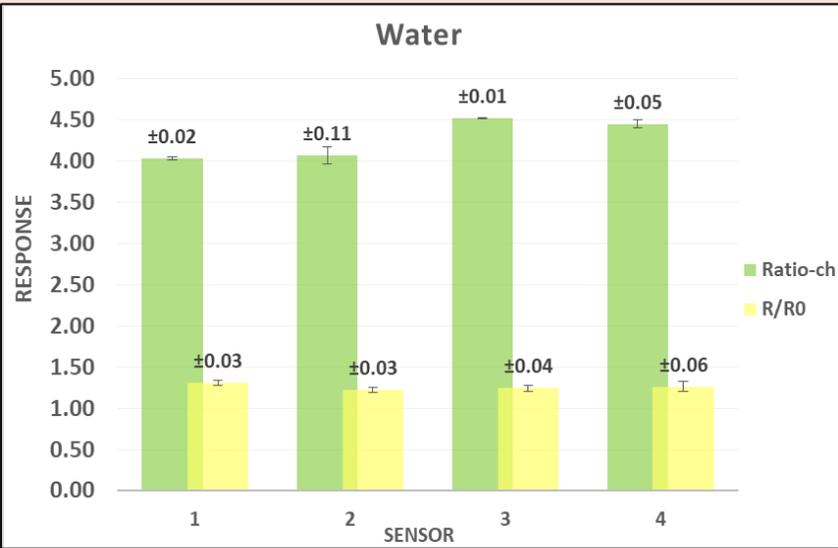
❑ The value of each single response is the average of the single values obtained.

❑ **The first thing to note is that for both compounds analyzed and for both methods used, the sensors give a reproducible response**.

❑ The standard deviation (absolute value) for temperature modulation is always lower than that obtained using the isothermal method.

Lattic acid
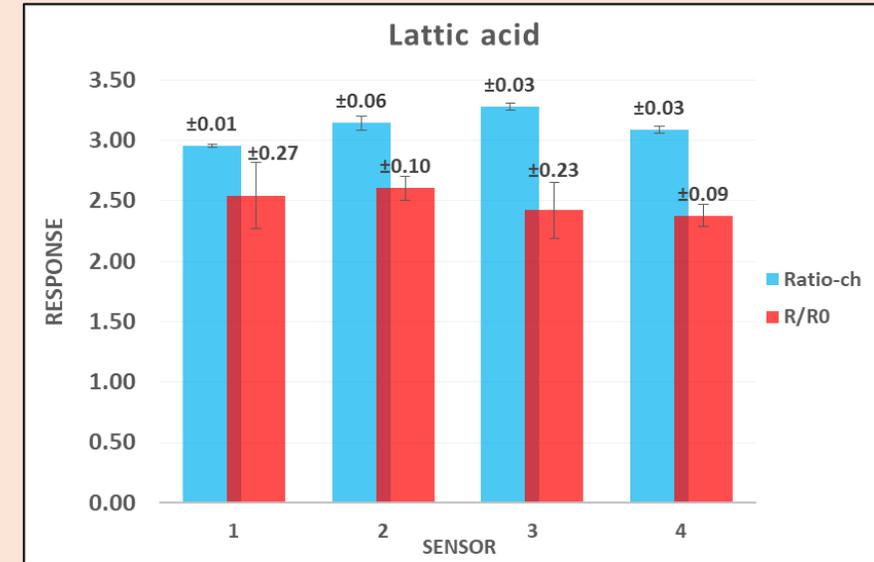
STANDARD DEVIATION

❑ Ratio – CH water = the value change from 0.5% to 2.6%.

❑ R/R0 Water = the value from 2.25% to 4.65%.

❑ Ratio-CH Lactic Acid = the value change from 0.5% to 3.9%.

❑ R/R0 Lactic Acid = the value change from 3.80% to 10.74%).

DeltaR-C
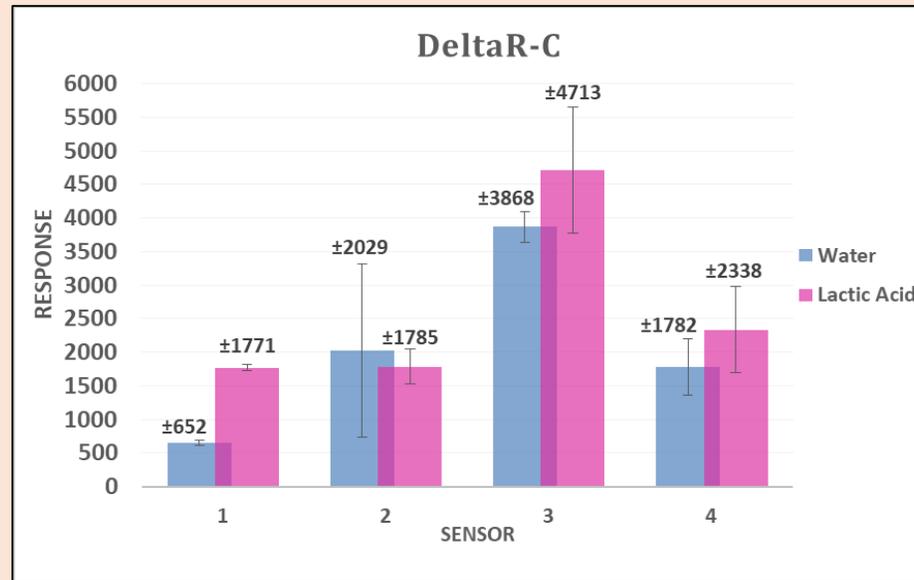
DeltaR-C

❑ **One of the features that bring a lot of information in the construction of the PCA [1,2].**

❑ The reproducibility of the sensors is relatively poor.

❑ We find a standard deviation that ranges from 5.3% to 63% (water) and from 2.5% to 27.6% (Lactic acid).

1. Zambotti, G.; Soprani, M.; Gobbi, E.; Capuano, R.; Pasqualetti, V.; Di Natale, C.; Ponzoni, A. Early detection of fish degradation by electronic nose(2019)

2. Soprani, M.; Zambotti, G.; Gobbi, E.; Ponzoni, A. Application of a Micro-Machined Electronic Nose to Detect Escherichia Coli in Human Urine Samples.(2019)

CONCLUSION

❑The experiments carried out with temperature modulation show that some extracted features are more stable than others, even if from the PCA it is possible to deduce that also the latter ones provide important information.

❑For the constant temperature the normalized feature may be more or less repeatable than those extrapolated from the other mode depending on individual features, though the response extrapolated from this working mode benefit from the normalization to the reference air while this not occurs for the temperature modulation mode.