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Innovative IAQ organic sensor

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Abstract

An innovative organic sensor for the monitoring of indoor air quality is described. For office buildings and schools the main requirements are: temperature, RH %, O2 and CO2 concentrations. Moreover low O2 and high CO2 concentrations can be hazardous. There are a lot of sensors based on different principal transducers that are able to detect very low concentrations of CO2 , O2 , and RH%.
The system is based on a resistive interdigital sensor based on an organic sensing material, anthocyanin. Anthocyanins are natural pigments widely distributed in nature: they are produced by plants as secondary metabolites responsible for the pigmentation of many flowers, fruits and vegetables. In this work authors show the possibility to use this innovative organic sensor to monitor indoor air quality by measuring O2 concentration shifts with respect to a standard of 20% (20.000 ppm) and the critical CO2 concentration value of about 5% (5000 ppm) which is comparable with OSHA (Occupational Safety & Health Administration) standard in an eight-hour time-weighted average (TWA).

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Keywords: Indoor Air Quality (IAQ); Gas Sensors; Anthocyanins; Oxygen; Carbon Dioxide

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1. Introduction

Indoor air pollution can be considered among the main environmental risks for health: people spend about 90 percent of their time indoors where pollution could be higher than the outdoor one [2]. A number of approaches exists to evaluate building ventilation and indoor air quality: the measurements and analysis of oxygen and carbon dioxide concentrations can be useful for understanding indoor air quality. Moreover exposure to high CO2 concentration can be hazardous: OSHA (Occupational Safety & Health Administration) standard is an eight-hour time-weighted average (TWA) of 5,000 ppm with a short-term 15-minute average limit of 30,000 ppm (3%). So in this work the authors investigate the performance of the sensor to measure the lower toxic level of CO2 in indoor air (5,000 ppm – 0.5%). There are a lot of sensors based on different principal trasducers that are able to detect very low concentrations of CO2 , O2 , and RH%. Considering the main issues of each sensors then others they can be synthetized in : drift, high operating temperature and the influence of other compounds.

In this work the authors have explored the properties of a biological material used as a chemical interactive sensing layer on interdigital fingers. The aim of this work is to study the interactions of these materials with CO2, O2, RH%. The novel aspect is relative to the development of new sensors based on biological material easy to producing and cheap. The widely varieties of these compounds could allow to develop a novel kind of sensors based on an array of interdigital fingers each of them covered with different sensing materials able to work at room temperature and easily integrated.

2. Materials and Methods

The resistance variation of the sensor was measured using a calibration set up by a microcontroller with an embedded ADC resolution of 0,0049 V. The resistive interdigital sensor was functionalized with anthocyanins extracted from a blue hortensia flower (Hydrangea macrophylla). For extraction, fresh plant tissues (10 g) were harvested and immediately incubated for 2 h at room temperature in an acidic methanolic solution (0.1% HCl v/v). Crude extracts were clarified by centrifugation at 10.000 rcf and 4 °C for 15 min to remove any traces of particulates. The recovered supernatant was then stored at −20 °C until use.

The sensors have been calibrated using a system composed of four mass flow controllers. Each mass flow can operate in a range of 0-400 sccm. The relative concentrations of CO2 and O2 were obtained mixing nitrogen with different ratios of single gases. The temperature has been performed at room temperature. The interdigital fingers were placed in a steel chamber to avoid adsorptions and emissions of material during the measurement phase. Figure 1 report the experimental set-up.

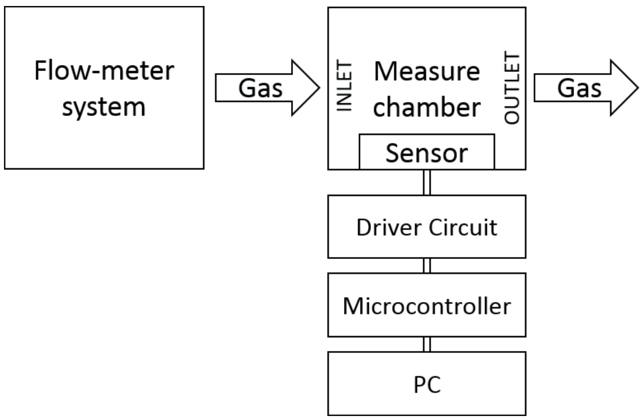

Fig. 1. Experimental set-up.

3. Results

All sensor figures were experimentally estimated, being the theoretical modelling of the anthocyanins adsorbing dynamic beyond the scope of this work. The RH% values here tested are: 40%, 50%, 60% and 70%. The calibration results are reported in Fig. 2. Sensitivity to RH% goes from a minimum value of about 3.2 MΩ/% to a maximum value of about 12 MΩ/%. The measured concentration levels of O2 are: 15%, 20% and 25%. Calibration results are shown in Fig.3. The sensitivity range goes from a minimum of about 350 KΩ/% to a maximum of about 400 KΩ/%. The LOD experimentally measured is of 0,0048%. The measured concentration levels of CO2 are: 1%, 4% and 8%. Calibration results are shown in Fig.4. The sensitivity range goes from a minimum of about 820 KΩ/% to a maximum of about 1.1 MΩ/%. The LOD experimentally measured is of 0,0017%.

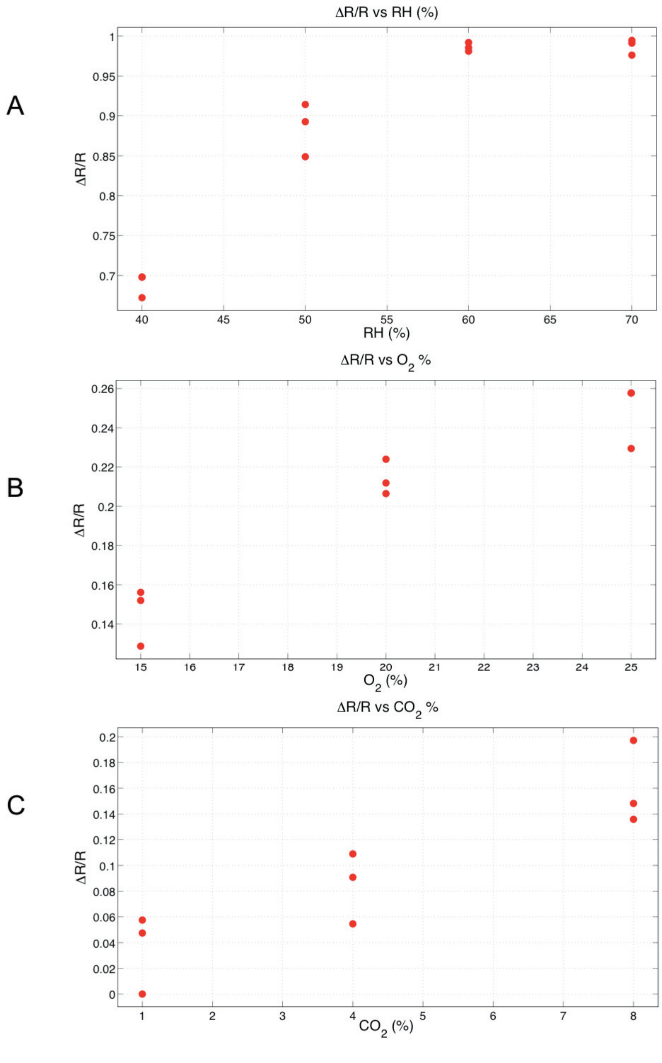

Fig. 2. Calibration curves relative to RH% (A), O_2% (B), CO_2% (C).

A crucial verification of sensors effectiveness in IAQ contexts consists of the calibration to a binary mixture of CO_2 and O_2. As can be observed from figure 3, the decreasing of O_2 concentration corresponding to a complementary increasing of CO_2 % is revealed by the sensors with a promising performance.

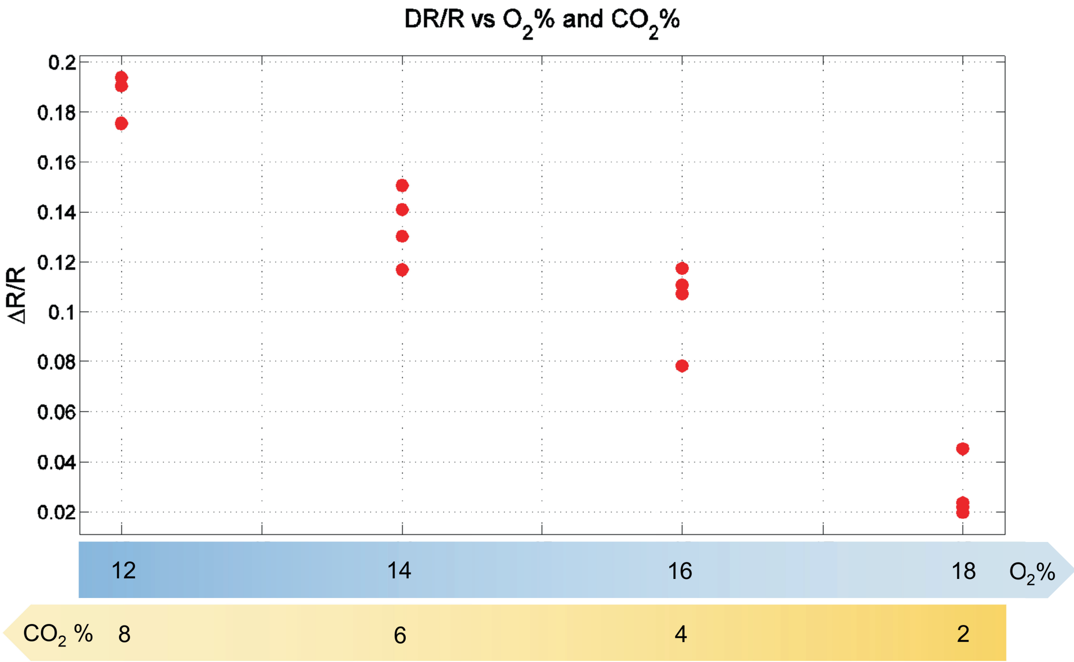

Fig. 3. Calibration curve relative to the binary mixture of CO_2 and O_2.

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