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ScienceDirect

Procedia Chemistry 1 (2009) 991–994

Procedia Chemistry

www.elsevier.com/locate/procedia

Proceedings of the Eurosensors XXIII conference

# Portable e-Mucosa System: Mimicking the biological olfactory

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**Abstract**

Here we report on the implementation of a new portable electronic nose instrument, inspired by the human olfactory system. Our 'Portable e-Mucosa' (PeM) utilizes three large sensor arrays consisting of 200 chemoresistive sensors per array, combined with two columns coated with differently retentive layers. This combination provides spatio-temporal information, mimicking the biological 'nasal chromatograph' effect[1]. These have been integrated with control electronics, a pre-concentrator, temperature control and a sample delivery system to produce a fully functional electronic nose (e-nose) instrument. Data from this device, when used with a pattern recognition method that utilizes temporal information and the large data set, we believe improves the discrimination power of this instrument over conventional e-noses.

Keywords: electronic nose, electronic mucosa, portable instrument, portable e-nose, spatio-temporal

## 1. Introduction

Almost all e-nose instruments operate by exposing a small number of sensors simultaneously to a sample composed of a large number of vapour phase chemicals. In comparison, the biological system uses a large number of sensors with a diverse number of binding proteins, combined with a 'nasal chromatograph' effect – similar to a GC column. This additional functionality allows the biological system to significantly outperform present e-nose instruments. Previously, we have reported on our work to create an artificial system that mimics this biology[2, 3]. Here we report on further progress and the resultant implementation of a portable e-nose instrument based on this principle (Figure 1).

## 2. Design and Fabrication

In our design, a sample first passes over a pre-concentrator employing a carbon black layer as the absorbent coating. This is connected to an initial sensor array of 200 chemoresistive sensors that gives a traditional e-nose output. The sample flow is then divided and passes along two plastic channels coated with Carbowax 20M and OV-1 (polar and non-polar compounds) with channel dimensions of 0.25 mm × 0.38 mm × 1 m, formed from a direct

1876-6196/09/$– See front matter 
doi:10.1016/j.proche.2009.07.247

manufacturing process. As the odours are emitted from the channels they pass over additional sensor arrays, (also with 200 sensors), producing spatio-temporal data.

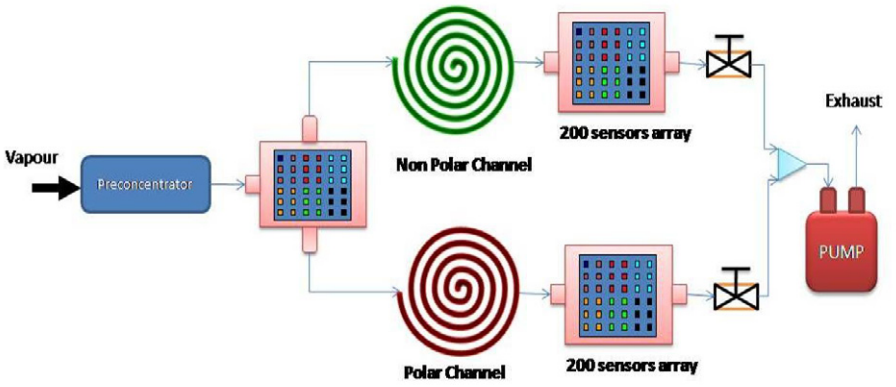



*Figure 1: Concept Diagram of Portable e-Mucosa*

The instrument is fully contained with integrated electronics and fluidic components. Figure 2 shows the composition of these two systems (Figure 2(a)) including the flow diagram of the odour through the system (Figure 2(b)). An air filter was used to filter large particles from going into the system and temperature and humidity sensor is placed on the inlet to measure the incoming odour condition. The instrument has been designed with separate control and acquisition systems offering simple re-configuration. Furthermore, a dedicated processor used for the data acquisition is important with this large number of sensor to improve speed of acquisition.

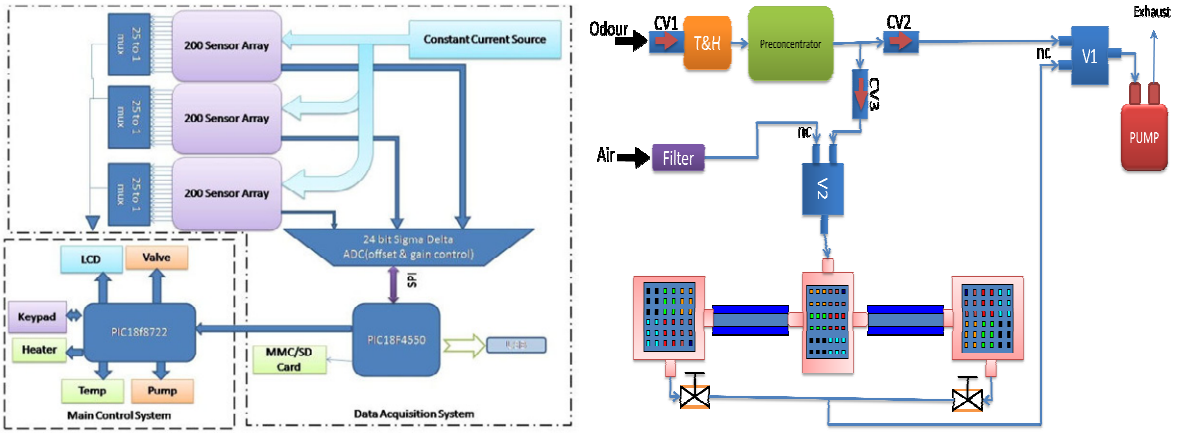



*Figure 2: a)Block Diagram for Vapour Delivery System and Data Acquisition System b) Flow Diagram of Odour throughout the system*

Figure 3 (a) illustrates the PeM, comprising of three PCBs with all the components and sensors integrated. Figure 3 (b) is a CAD design of the casing with Figure (c) showing a fully fabricated casing compared with a commercial e-nose, Cyranose 320. Although the PeM is slightly larger than the cyranose, it contains more sensors (600 compared to 32 in Cyranose) with two retentive columns. The casing was built using a Fused Deposition Modeller(FDM) called Dimension from Stratasys.

On this first instrument, the sensor arrays were coated with 24 different carbon black polymer composite films (8 replicas of each type), with the substrate fabricated using a standard in-house silicon process. The sensing

films were deposited using an airbrush with the baseline resistances continuously measured throughout the process to improve repeatability.

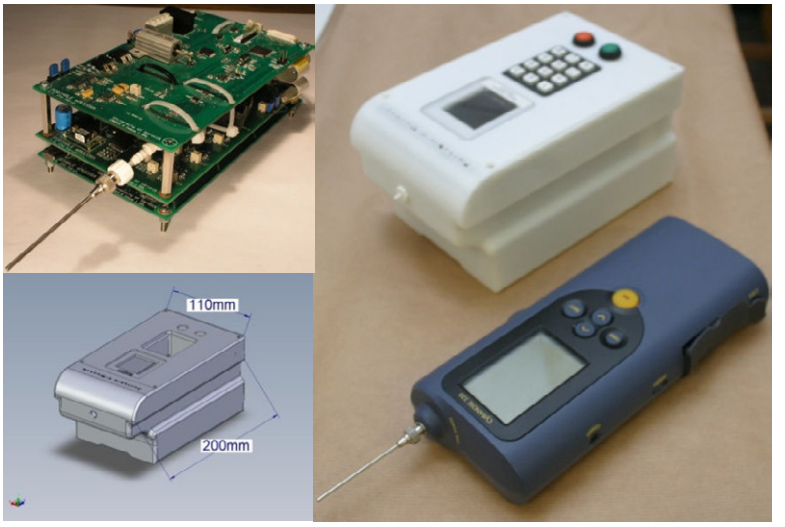
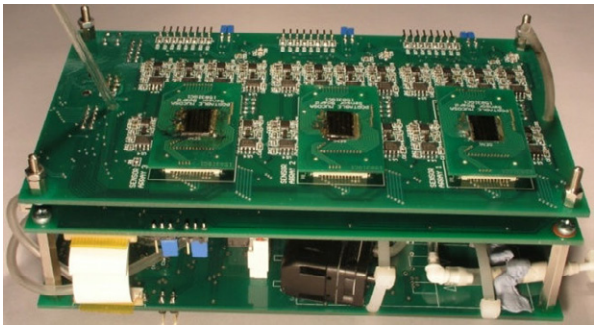



*Figure 3: a) Portable eMucosa PCB b) CAD Design of Casing c) Comparison of PeM with Cyranose 320*

Figure 4(a) shows the underside of the unit with three large sensor arrays and integrated heaters underneath the arrays to control the temperature during operation. The integrated heater was used to control the temperature of the sensor during sampling. Figure 4(b) shows the response of the sensor at various temperature to show the ability of the portable nose to operate at a controlled temperature..



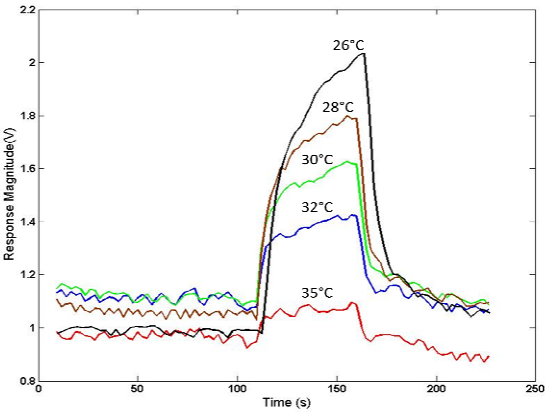



Figure 4 a) Three Large sensor array at the bottom of the instrument b) Temperature controlled response of the large sensor array.

## 3. Experimental Results

Figure 5 shows a coloured plot of spatial information, obtained with the instrument sniffing four essential oils. These plots, taken with preconcentrator on for 100 s shows good separation between the odour. In the portable instrument, continuous data is stored in the MMC/SD Card using SPI communication. Advantages of using MMC

card for storage includes the ability to have a truly portable system without the need of a PC, Laptop or PDA during data acquisition. FAT16 format was implemented to enable the file created with this device compatible with a Windows or Mac environment. The file created can be read directly using a card reader with a MAC or PC for further data post processing. The system is capable of using MMC Card up to 4GB of storage. Data is stored using standard comma separated values .txt format and can be converted into Nose II XML data format for further processing using Matlab 2008 or Multisens Analyzer.

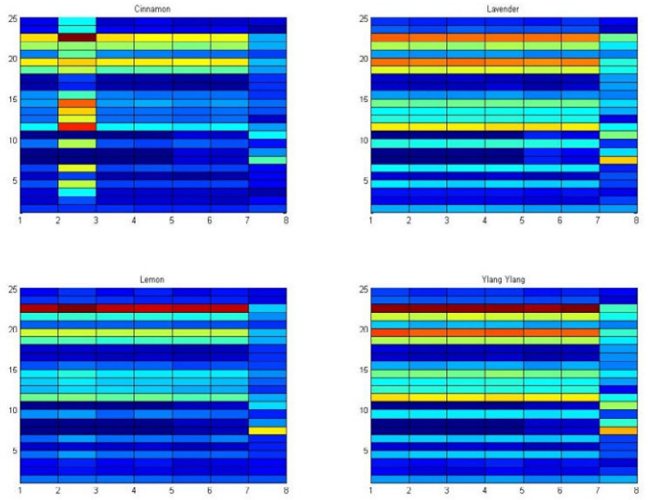



Figure 5: *Colour Plot of Sensor Array 1 Response to four essential Oils*

## 4. Conclusion

We have successfully designed and fabricated a Portable e-Mucosa device to produce a large number spatio temporal signal using 6oo sensors in three arrays. The instrument is fully contained with integrated electronics and micro fluidic components. A result shows the ability of on board preconcentrator to concentrate essential oil odour to produce good classification between the four odours. Spatio temporal signal analyses are discuss in more details in a separate paper[2].Further works in progress will includes live monitoring of sensor response using USB connection and integrated pattern recognition module on board the instrument.

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