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Procedia Engineering 87 (2014) 1051 – 1054

Procedia Engineering

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EUROSENSORS 2014, the XXVIII edition of the conference series

Acetone and ethanol selective detection by a single MOX-sensor

A. Shaposhnik[a]*, A. Zviagin[a], E. Sizask[a], S. Ryabtsev[b], A. Vasiliev[c], D. Shaposhnik[d]

[a]*Voronezh State Agriculture University, Michurina, 1, Voronezh, 394087, Russia*
[b]*Voronezh State University, Universitetskaya, 1, Voronezh, 394006, Russia*
[c]*Center of Physical and Chemical Technology, NRC Kurchatov institute, Kurchatov sq., 1, Moscow, 123182, Russia*
[d]*University Roviry i Virgili, 43007 Paisos Catalans, 26, DEEEA, Tarragona, Spain*

Abstract

Non-stationarity temperature regime allows us to increase sensitivity and selectivity of acetone and ethanol determination. It is possible not only detect 0.1 ppm concentration, but also distinguish ethanol from acetone using single MOX-sensor. The multidimensional data were processed with principal components analysis.

Peer-review under responsibility of the scientific committee of Eurosensors 2014

Keywords: Ketosis diagnostics; individual MOX-sensor; acetone; ethanole; selective detection; non-stationary temperature; tin dioxide.

1. Introduction

Determination of acetone concentration in air exhaled by persons suffering from diabetes is an actual problem of medical diagnostics. Ketosis is an diabetes complication demanding special treatment methods.

Ketosis diagnostics, based on chemical interaction of patient's urine with test papers, can not be called neither precise, nor comfortable for the patient, and in many cases this method can not be applied.

Analysis of expired air can give information about acetone and other "ketone bodies" content in organism and thereby realize express noninvasive ketosis diagnostics. However, up to now this problem is not solved in view of insufficient detection limits of acetone with chemical sensors. Another important challenge, which is not answered yet, is selective detection of ethanol vapors. Semiconductor sensors are widely used for the breath analyzers,

* A.V. Shaposhnik. Tel.: +7-473-253-7678; fax: +7-473-253-8651.
*E-mail address:*a.v.shaposhnik@gmail.com

Peer-review under responsibility of the scientific committee of Eurosensors 2014
doi:10.1016/j.proeng.2014.11.343

however these devices can not easily distinguish ethanol from acetone. Thus, ketosis status could be falsely taken for alcoholic intoxication.

The solution of these problems is related with the search for new sensitive materials [1]. In present work, we suggest another solution – the substitution of stationary temperature operating mode of semiconductor sensors with non-stationary one. Sensor pulse heating and abrupt cooling allows the combination of high catalytic activity with significant analyte adsorption value and thus to increase the sensor response. On the other hand, nonstationary temperature conditions enable the discovery of individual peculiarities of analytes. Therefore, we have a possibility for not only quantitative, but also for qualitative determination of analyte concentration.

2. Experimental

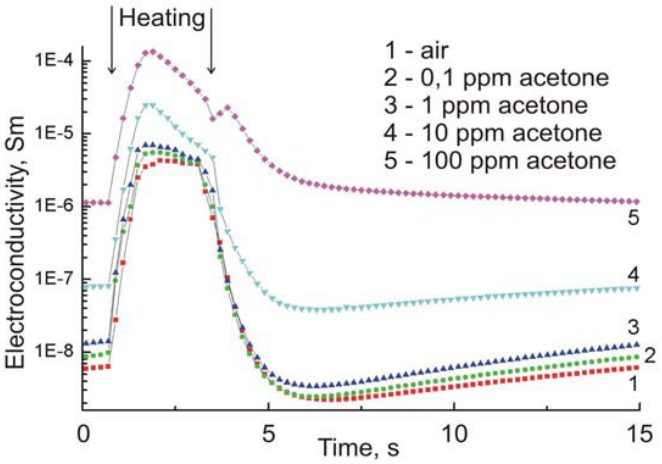

Fig. 1. Electrical conductivity of SnO_2(Pd)-sensor in acetone vapour.

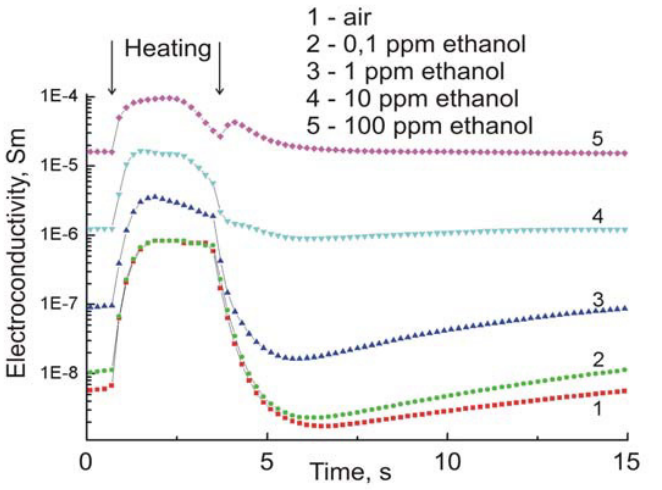

Fig. 2. Electrical conductivity of SnO_2(Pd)-sensor in ethanol vapour.

We used SnO_2 based sensors with additions of 3 % palladium (1), 2,5 % palladium and 0,5 % platinum (2), 2 % antimony and 2 % lanthanum (3). Sensitive material was prepared by sol-gel method.

Surplus of hydrogen peroxide was added to the solution of tin acetate in the glacial acetic acid. Sol of α-tin acid was formed when small amount of ammonia add. Sol was precipitate by centrifuge. Tin dioxide nanopowder was formed as a result of tin acid calcination. Average size of SnO_2 granules was 4-6 nm.

Glycol was added to nanopowder. Paste was placed onto special dielectric substrate with platinum electrodes. After calcination sensor was formed.

Temperature mode of sensor consists in periodically repeated "steps", sensor was heated up to 450 ^oC (3 seconds) and was cooled to 100 ^oC (12 seconds). Fig. 1 shows electrical conductivity of sensor SnO_2(Pd) as a function of time in air with different acetone concentrations. Fig. 2 demonstrates corresponding dependences obtained in ethanol containing athmosphere.

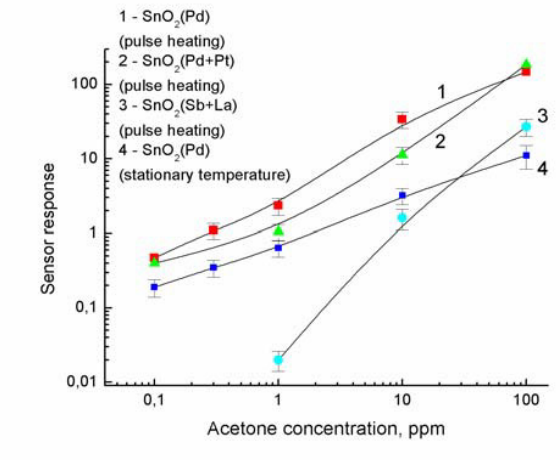

Fig. 3. Sensor response for acetone.

Sensor response is the normalized difference between the sensor electrical conductivity in atmosphere under investigation and in standard one. Electrical conductivity was registered before the heating pulse. Applying of non-stationary temperature conditions increases sensor response to acetone and ethanol by approximately one order of magnitude (Fig. 3, 4). Sensor, based on SnO_2 with palladium addition (3 %) shows the the highest response to

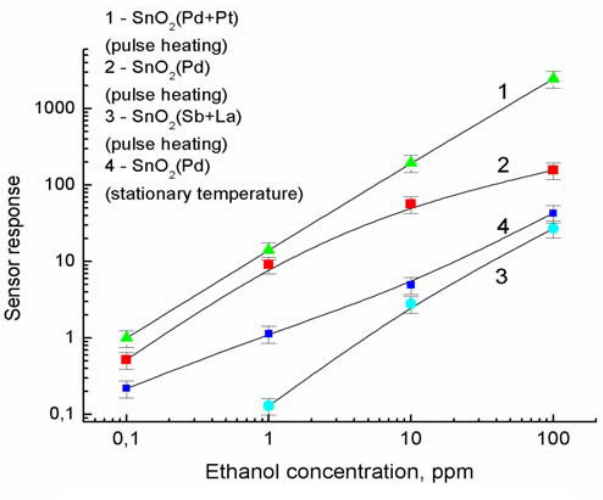

Fig. 4. Sensor response for ethanol.

acetone (Fig. 3), however the best response to ethanol was shown by the sensor based on SnO_2 with palladium (2,5 %) and platinum (0,5 %) addition (Fig. 4).

Combination of quantitative and qualitative determination of gases and vapors may be realized using a set of several sensors ("sensor array"). The use of non-stationary temperature mode gives novel possibility for selective detection of gases and vapors with a single sensor. In this case, sensor's electrical conductivity as a function of time are considered as multidimensional data array. We selected 25 electroconductivity values from each curve (Fig. 1). Thus, we characterized each investigated gas system as a point of 25-dimesional space, and processed these values by principal component analysis.

It's possible to single out non-overlapping areas corresponding to ethanol and acetone with different concentrations. Therefore, we found a principle possibility for quantitative and qualitative determination of acetone and ethanol with a single sensor (Fig. 5).

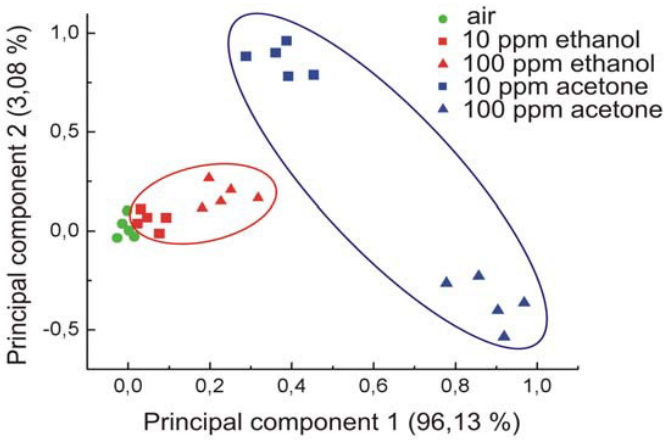

Fig. 3: Principal component analysis of acetone and ethanol

3. Conclusions

The present results show that the use of impulse mode allows us not only to reduce power consumption, but also to increase sensitivity and selectivity of analysis.

Acknowledgements

Authors are thankful to the European Comission for financial supporting this activity in the framework of the joint EU-Russia cooperation (project "S3", no 247768), to the RSCF (Russia), project no. 14-13-01470, and to the RFBR (Russia), project no. 13-04-97542.

References

[1] Ryabtsev S.V., Shaposhnik A.V., Lukin A.N., Domashevskaya E.P., Application of semiconductor gas sensors for medical diagnostics, Sensors & Actuators B, V. 59 (1999), 26-29.