

Determination of the Concentration of Gaseous Impurities in Air Using a System of Uncalibrated Sensors of Amperometric Type

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The methods for determining the concentration of gaseous impurities in air by means of electrochemical sensors (ES) are relative ones, and ES's need periodic calibration. The calibration procedure complicates the operation of analytical instruments with ES's.

The known methods of an analysis by means of uncalibrated ES's are based on the coulometric pumping of the gas to be determined into a closed air space or on its removal from this space followed by the determination of the initial gas concentration by calculation. The additional operations of pumping or removing the gas to be determined lengthen the duration of analysis, and its results for closed air space can be distorted by the adsorption of this gas on structural elements of the system. The proposed method for determining the concentration of gaseous impurities in an air stream by means of a system of uncalibrated ES's of amperometric type is free from these disadvantages.

The system is shown schematically in the figure. It consists of two amperometric ES's 1 and 2 and a distributor 6. On the position a), the distributor 6 directs the air stream with the concentration C of the gas to be determined to the ES 1 and then to the ES 2. In the position b) the same air stream flows to the ES 2 and then to the ES 1. The figure shows two-electrode ES's containing indicator electrodes 3 and auxiliary electrodes 5, which are separated by separators 4. The structural elements of the system are made of teflon. Three-electrode ES's can also be used in the system.

In the position a), the following relations are valid for the regions of the linear plot of output current signals for the ES's 1 and 2 (I_1^a and I_2^a respectively) against the concentration of the gas to be determined

$$I_1^a = k_1 \cdot C, \quad (1)$$

$$I_2^a = k_2 \cdot C_1, \quad (2)$$

where k_1 and k_2 are the transformation coefficients for the ES's 1 and 2, and C_1 is the gas concentration in the air stream that flows from the ES 1 to the ES 2. From the material balance for the system it follows that

$$(C - C_1) \cdot V = \frac{I_1^a \cdot M}{zF}, \quad (3)$$

where z is the number of electrons in the electrochemical reaction of the gas to be determined on the ES's indicator electrodes, M the molecular mass of the gas to be determined, F the Faraday constant, and V the air flow rate.

In the position b), it may be written like equations (1) – (3):

$$I_2^b = k_2 \cdot C, \quad (4)$$

$$I_1^b = k_1 \cdot C_2, \quad (5)$$

$$(C - C_2) \cdot V = \frac{I_2^b \cdot M}{zF}, \quad (6)$$

where C_2 is the gas concentration in the air stream that flow from ES 2 to the ES 1.

From equations (2), (3) and (4) and equations (1), (5) and (6) follow, respectively, the equations:

$$C = \frac{I_1^a \cdot I_2^b \cdot M}{z \cdot F \cdot V \cdot (I_2^b - I_2^a)}, \quad (7)$$

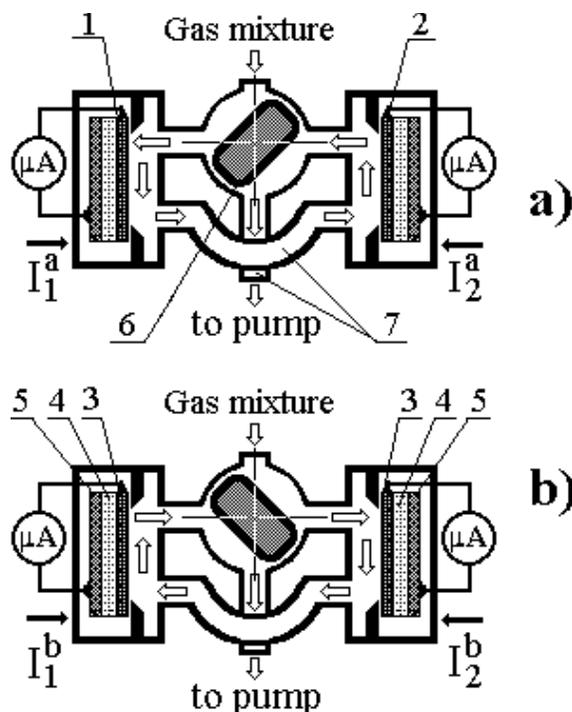
$$C = \frac{I_1^a \cdot I_2^b \cdot M}{z \cdot F \cdot V \cdot (I_1^a - I_1^b)}. \quad (8)$$

As is evident from equations (7) and (8), four current signals from the ES's measured in the positions a) and b) at a constant airflow rate make it possible to perform two independent determinations of the gas concentration. The true value of the gas concentration in air may be assumed to be the average of the values calculated from equations (7) and (8).

The duration of measurement of current signals from the ES's in each of the positions is comparable to the response time for each ES. The range of use of the method is determined by the linearity range of the relation such as (1) and the measurement error by the accuracy of the material balance according to equation (3) or (6).

In the experimental part of the work, low-temperature solid state ES's for chlorine and ozone were used, which had been developed at the National Technical University of Ukraine [1, 2]. The diameter of the free surface of the ES indicator electrodes was 15 mm at a thickness of the gas layer over the indicator electrodes of 2 mm and a gas channel 7 diameter of 3 mm. The (1) – type relation for chlorine ES's held up to $I_l \leq 180 \mu\text{A}$ and for ozone ES's up to $I_l \leq 15 \mu\text{A}$. This allowed us to determine experimentally a chlorine concentration of down to ≤ 12 ppm and an ozone concentration of down to ≤ 2 ppm at $1 \leq V \leq 10 \text{ cm}^3 \text{ s}^{-1}$ at a sensitivity of this system to these gases of 0.01 ppm.

From the experimental data presented in the paper it follows that the uncalibrated sensor system can determine the concentration of gases in air with a relative error less $\pm 15\%$.



References:

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- [2] V. Chviruk, O. Linyucheva, O. Buket. Electrochimica Acta, 42, p. 3155 – 3165 (1997).