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STUDY OF REPEATABILITY OF RESULTS IN THE LINEAR REGION IN THE MEASUREMENT OF PECTIN WITH A HYBRID BIOSENSOR

This paper is an attempt to apply the statistical method for processing the results of repeated measurements with the hybrid biosensor. Fivefold measurement is held in the same point of the linear scale of the hybrid biosensor for pectin. For each group of measurements evaluation of the dispersion is calculated. The F-criterion is calculated too and compared with table value Ft. As results a repeatability of results is observed.

Keywords: Repeatability, hybrid biosensor.

1. Repeatability

Classical amperometric hybrid biosensors are divided into tissue enzyme, enzyme-microbial and microbial-tissue [1]. Their principle of operation is based on sequential or parallel operation of several biochemical reactions in the active membrane.

Mathematical modeling is an essential part of the implementation and testing of hybrid biosensors. Modeling is complicated greatly by increasing the number of measured substrates and reaction volumes [2].

Repeatability is the variation in measurements taken by a single person or instrument on the same item and under the same conditions. A less-than-perfect test-retest reliability causes test-retest variability. Such variability can be caused by, for example, intra-individual variability and intra-observer variability. A measurement may be said to be repeatable when this variation is smaller than some agreed limit.

The purpose of this paper is to verify the repeatability of the results of measuring the concentration of pectin with a hybrid biosensor. To accomplish this purpose were conducted fivefold measurements of pectin in two points on the linear scale of the function of transformation of hybrid biosensor under the same initial conditions.

2. Instrumentation

The Clark oxygen electrode and analyzer of dissolved oxygen "BIOGALIK" are used. Constant and even saturation of the solution with atmosphere oxygen is secured with a magnetic stirrer. Digital pipette type PL01-200 is used for making injection with certain volume in the measuring cell.

The construction of the hybrid biosensor (HB) includes: oxygen electrode, which consists of a polyethylene membrane, platinum cathode and anode; active membrane, which is composed of the orange tissue and brewers' yeast. The active membrane is laid over the polyethylene membrane of the oxygen electrode and is covered with dialysis membrane and is

secured with a rubber O-ring. This hybrid biosensor is research in [3].

3. Experiments

The experiments are held at a constant temperature of 20°C. The hybrid biosensor is dipped into a vessel containing 10 ml buffer solution with pH 6.38 and a magnetic stirrer. The magnetic stirrer at a speed of 900 rev/min insures the saturation of the buffer with oxygen.

To demonstrate the repeatability of the results experiments were conducted under the same initial conditions. For this reason fivefold measurements at two points on the linear scale of function of transformation is performed – 0.02 mg/ml and 0.06 mg/ml. After the stabilization of the output signal's value of the biosensor an injection of pectin (20 µl or 60 µl) is added. When the output signal of the hybrid biosensor reach steady-state reading of the analyzer display is recorded. After the first measurement the hybrid biosensor is placed in a new buffer solution with the same value of pH. When the output signal of the hybrid biosensor is establish new measurement of the same amount of pectin is performed. Thus made five measurements for 0.02 mg/ml pectin and 0.06 mg/ml pectin.

4. Results

The results from the previous section are shown in Fig. 1 and are given in Table 1.

For performed measurements null hypothesis H_0 is verified for repeatability of results. The testing of hypothesis is done by juxtaposing of calculated statistical criterion with theoretical critical (table) values. Probability of hypothesis to be true is introduced to the concept of "significance level" α . Usually α can be 0.1, 0.05, 0.01. In this case significance level $\alpha = 0.05$ is accepted.

For every point from the scale n measurements y_j ($j = 1, \dots, n$) are held. For each group of measurements evaluation of the dispersion is calculated using the next formulae:

$$s_j^2 = \frac{1}{n-1} \sum_{j=1}^n (y_j - \bar{Y})^2 \quad (1)$$

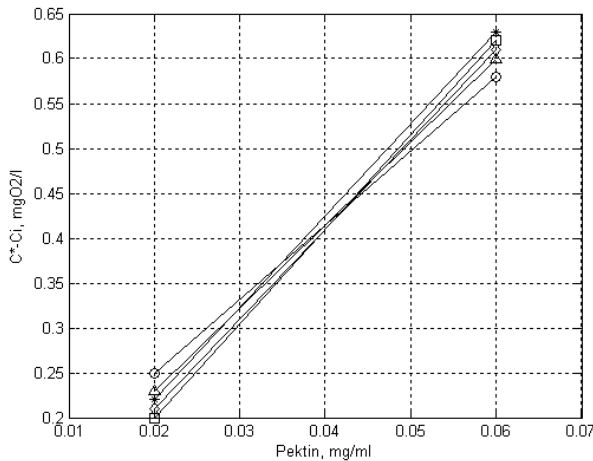


Fig.1. Repeatability study of hybrid biosensor

Table 1

Experimental results

pectin,mg/ml	ΔC_1	ΔC_2	ΔC_3	ΔC_4	ΔC_5
0.02	0.20	0.23	0.21	0.25	0.22
0.06	0.62	0.60	0.61	0.58	0.63

Where ΔC_i – measured relative concentrations of oxygen.

Where \bar{Y} is average value of repeated measurement. As a criterion to verify of null hypothesis the magnitude F is used:

$$F = \frac{s_{jmax}^2}{s_{jmin}^2} \quad (2)$$

Which has F-distribution of Fisher with $v_1 = n - 1$ degrees of freedom for numerator and $v_2 = n-1$ for portentous. Calculated value of the F-criterion is compared with critical (table) value $F_t = F(\alpha, v_1, v_2)$. If $F \leq F(\alpha, v_1, v_2)$ the null hypothesis H_0 is accepted.

In Table 2 calculated dispersions and criterion F are given. Degrees of freedom are $v_1 = 4$ for numerator and

$v_2 = 4$ for portentous. From the table we have $F_t(0.05, 4, 4) = 9.60$. Calculated value is $F = 1.44$. As $1.44 < 9.60$ therefore a repeatability of results is observed.

Table 2

Calculated dispersions and criterion F

	n_i	1	2	F
HB	s_i^2	0.000225	0.000324	1.44

5. Conclusion

This work is an attempt to apply the statistical method for processing the results of repeated measurements with the hybrid biosensor obtained from previous work. The evaluation of the dispersion for two groups of measurements is calculated. The F-criterion is calculated too and compared with table value F_t . Based on obtained results the applicability of the statistical method for processing the results of measuring concentration of substances with hybrid biosensor is proved.

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ДОСЛІДЖЕННЯ ВІДТВОРЮВАНОСТІ РЕЗУЛЬТАТІВ У ЛІНІЙНОЇ ОБЛАСТІ ПРИ ВІМІРЮВАННІ ПЕКТИНУ ГІБРИДНИМ БІОСЕНСОРОМ

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Дана стаття є спробою застосування статистичного методу обробки результатів багаторазових вимірювань до гібридних біосенсорів. Проводилися п'ятикратні вимірювання в одній і тій же точці лінійної шкали гібридного біосенсора для пектину. Для кожної групи вимірювань обчислювалася оцінка дисперсії. Для перевірки повторюваності застосовувався критерій Фішера. Перевіркою було встановлено відсутність повторюваності результатів вимірювань.

Ключові слова: повторюваність, гібридні біосенсори.

ИССЛЕДОВАНИЕ ВОСПРОИЗВОДИМОСТЬ РЕЗУЛЬТАТОВ В ЛИНЕЙНОЙ ОБЛАСТИ ПРИ ИЗМЕРЕНИИ ПЕКТИНА ГИБРИДНЫМ БИОСЕНСОРОМ

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Данная статья является попыткой применения статистического метода обработки результатов многократных измерений к гибридным биосенсорам. Проводились пятикратные измерения в одной и той же точке линейной шкалы гибридного биосенсора для пектина. Для каждой группы измерений вычислялась оценка дисперсии. Для проверки повторяемости применялся критерий Фишера. Проверкой было установлено отсутствие повторяемости результатов измерений.

Ключевые слова: повторяемость, гибридные биосенсоры.