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## **MS EXCEL AND STANDARDIZATION OF MEASUREMENT RESULT EVALUATION OF BIOSENSOR INPUT CONTROL**

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**Abstract** – Nearly in every practical part of some scientific project solution we meet demand to discover or verify a function of a developed device (instrument, sensor, etc.) This process (a measurement) is usually executed repeatedly and usually by various people. A practice shows that if we don't unify the evaluation result, especially if we have greater number of measurements (hundreds or more), it can cause its ambiguity and thereby to its depreciation. To prevent this depreciation, it is necessary jointly to interpret and to evaluate attained results – to standardize. Analysis and practical solution exploiting Microsoft Excel is presented in this paper.

**Keywords** : Biosensor, standardization, result evaluation

### 1. INTRODUCTION

This paper describes standardization problems of measurement result evaluation and demonstrates solution of this problem in ANTOPE project [1], in particular it is shown the standardization of measurement result evaluation input biosensor control exploiting of Microsoft Excel. It is a demonstration how simply, effectively and relatively cheap it is possible to establish standardization of measurement result evaluation.

### 2. APPROPRIATE SOFTWARE CHOICE

This time is typical for computer processing as the most common way to data processing. A little bit more complex problem is appropriate software choice.

#### *2.1. State of art*

If we take a look at situation in math data processing software sector, we find out that these programs may be divided in two categories:

- single-purpose application software,
- universal programs for data processing.

Application programs are single-purpose programs especially suitable for real problem solving. There is no need to enumerate the advantage against universal programs, but they have also one essential disadvantage – time and professional difficulty of such software development.

Universal programs are actually collection of tools and functions for data processing usually differing only by amount of this functions, optionally their orientation - for

example MatLab, EfLAB, etc. but it certainly includes a modern spreadsheets. The best software in this branch is probably Matlab program from MathWorks [2], however its cost and demand to hardware is really high, this product is rather directed to sophisticated application and simulations.

#### *2.2. Microsoft Excel*

On the other hand, spreadsheets are relatively cheap, hardware unassuming and they contain sufficient set of mathematic functions for processing simple as well as sophisticated measurements. The most common spreadsheet is probably Microsoft Excel from Microsoft Office package.

Next important matter is, that MS Excel contains not only tools and functions needed for data processing, but also a programming interface for access to them, in the concrete a Visual Basic for Application programming language. When comparing this programming language to common programming languages (C/C++, Pascal, etc.), it is relatively "simple" and it can be very quickly mastered by one with basic knowledge of programming language. And in connection with MS Excel functions it is a very powerful tool for automation of all required tasks in a spreadsheet environment.

For above mentioned advantages, the MS Excel was chosen as the optimal software tool for the standardization of measurement results evaluation.

### 3. FORM FOR MEASUREMENT RESULT EVALUATION

In this chapter there is shown one practical solution of standardization of result evaluation problem – the form for measurement result evaluation of biosensor input control, which has been used in ANTOPE project [1].

#### *3.1. Form description*

First of all, let us see how such form looks like (Fig.1). The background colour of the cells is distinguished for better lucidity. Cells for editing are marked in green (brighter) colour, cells with formulas are marked in blue and orange (darker) colour. Upper half part of the form is used for constants entries which are applied in all computation (voltage, current, area of electrodes, basic volume of buffer, addition of measured analyte, concentration of analyte, temperature, background current, polarization voltage, filter, noise current). There are also written all basic details

concerning measurement like date, type of sensor, material of working electrode, etc.

In lower half part there are printed measured values themselves. Two magnitudes are recorded in this type of measurement – an addition of analyte concentration and an increase of current. Visual Basic macros are executed after addition every pair of values and all resulted values are calculated:

- concentration of analyte,
- current,
- total volume of peroxide,
- slope of calibration curve,
- correlation,
- exponent of calibration curve,
- limit of detection.

Experiment record				Date:	4.12.2001	
Type of sensor:	AC9.W2.RS č.1			Material of working eld.:	W2	
Identification of sensor:	AC9.W2.RS č.1			Area of work. eld.[mm <sup>2</sup> ]:	1	
Parameters of Microflow arrangement						
Voltage [V]:	1			Current [A]:	0,15	
Parameters of experiment						
Buffer:	0,05 M KH <sub>2</sub> PO <sub>4</sub>					
Measured analyte:	H <sub>2</sub> O <sub>2</sub>					
Basic volume of buffer [ml]:		10		Polarization volt [mV]:	650	
Addition of measured analyte [ml]:		0,05		Time const. filtr [s]:	1	
Conc. of analyte stock solution [mM]:		4,38				
Temperature [°C]:		25				
Background current [nA]:		12		Noise current [nA]:	0,48	
Remarks:						
Addition of concentration of analyte [mM]	Increase of current [nA]	Total concentration of analyte [mM]	Current density [nA/mm <sup>2</sup> ]	Total capacity [ml]		
Noise current:		1,818E-02	4,800E-01			
Limit of detection:		5,455E-02	1,404E+00			
1,265E+01	1,100E+00	6,294E-02	1,100E+00	10,05		
1,265E+01	2,000E+00	1,252E-01	3,100E+00	10,1		
2,530E+01	4,300E+00	2,493E-01	7,400E+00	10,15		
2,530E+01	4,500E+00	3,721E-01	1,190E+01	10,2		
2,530E+02	4,180E+01	1,604E+00	5,370E+01	10,25		
2,530E+02	2,240E+01	2,825E+00	7,610E+01	10,3		
2,530E+02	1,450E+01	4,033E+00	9,060E+01	10,35		
2,530E+02	1,130E+01	5,230E+00	1,019E+02	10,4		
2,530E+02	7,500E+00	6,416E+00	1,094E+02	10,45		
Slope of calibration curve [nA/mM/m <sup>2</sup> ]:				24,07154041	Exponent of cal. Curve:	0,9769878
Correlation:				0,989265694	Limit of detection [mM]	5,46E-02

Fig. 1. Form for measurement result evaluation of biosensor input control

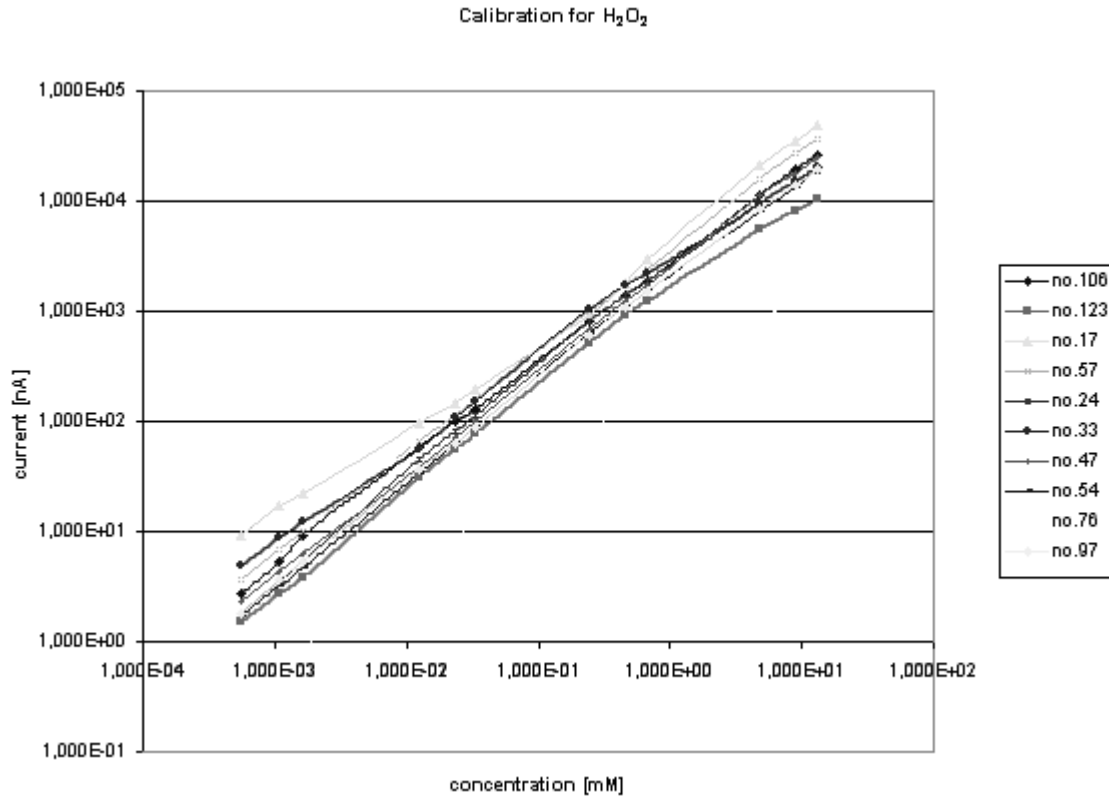


Fig. 2. Resulting charts for 10 comparative measurements

It is possible in one sheet to have unlimited number of forms, starting with one and by means of macros it is possible to add other forms.

The form is, of course, also capable to draw graphic curves using measured values. Curves are drawn in one chart in separate sheet, so it is possible to compare attained result one another with ease (Fig. 2).

### 3.2. Formulas used in the form

Current  $I_n$  in  $n$ -th measurement

$$I_n = I_{n-1} + \Delta I$$

where  $\Delta I$  is increase of current.

Concentration of analyte  $C_n$  for  $n$ -th measurement

$$C_n = \frac{C_{n-1}V_{n-1} + V_0C_0}{V_{n-1} + V_0}$$

where  $V_n$  is volume of analyte in  $n$ -th measurement,  $C_0$  is initial concentration of analyte,  $V_0$  is initial volume of analyte.

Slope of calibration curve  $k_{kk}$

$$k_{kk} = \exp \left( \frac{\sum_{i=1}^n (\ln C_i)^2 \cdot \sum_{i=1}^n \ln I_i - \sum_{i=1}^n \ln C_i \cdot \sum_{i=1}^n (\ln I_i \cdot \ln C_i)}{\sum_{i=1}^n (\ln C_i)^2 \cdot \sum_{i=1}^n \Delta C_i - \left( \sum_{i=1}^n \ln C_i \right)^2} \right)$$

where  $C_i$  is concentration of analyte in  $i$ -th measurement,  $I_i$  is current in  $i$ -th measurement,  $\Delta C_i$  is addition of analyte concentration in  $i$ -th measurement.

Exponent of calibration curve  $E$

$$E = \frac{\sum_{i=1}^n \Delta C_i \cdot \sum_{i=1}^n (\ln I_i \cdot \ln C_i) - \sum_{i=1}^n \ln C_i \cdot \sum_{i=1}^n \ln I_i}{\sum_{i=1}^n (\ln C_i)^2 \cdot \sum_{i=1}^n \Delta C_i - \left( \sum_{i=1}^n \ln C_i \right)^2}$$

Correlation  $K$

$$K = \frac{\sum_{i=1}^n \Delta C_i \cdot \sum_{i=1}^n (\ln I_i \cdot \ln C_i) - \sum_{i=1}^n \ln C_i \cdot \sum_{i=1}^n \ln I_i}{\sqrt{\left( \sum_{i=1}^n (\ln C_i)^2 \cdot \sum_{i=1}^n \Delta C_i - \left( \sum_{i=1}^n \ln C_i \right)^2 \right) \cdot \left( \sum_{i=1}^n \Delta C_i \cdot \sum_{i=1}^n (\ln I_i)^2 - \left( \sum_{i=1}^n \ln I_i \right)^2 \right)}}$$

Noise current  $N$

$$N = \left( \frac{I_B}{S_E \cdot k_{kk}} \right)^E$$

where  $I_B$  is background current,  $S_E$  is initial noise current.

Limit of detection  $M_D$

$$M_D = 3 \cdot N$$

## 4. CONCLUSION

It is evident from the solution mentioned above, that standardization of relatively complex measurement exploiting Microsoft Excel and Visual Basic for Application programming language is very easy and effective. Similar technique can be applied to any other measurement.

## REFERENCES

- [1] ANTOPE Project FD-K2/53, Research Report Draft, Czech Ministry of Industry and Trade, FEEC BUT, Brno 2003.
- [2] <http://www.mathworks.com/products/matlab/>

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