

BVT Technologies



SPRING 2016



Starter KIT for electrochemistry

Dear customers,

In this edition of our newsletter we introduce our **Starter kit for electrochemistry (SK4E)** and will also demonstrate a series of applications for the kit.



Some test of SK4E was made by Leonardo Spinelli during his stay in BVT.

Leonardo Spinelli participated in WorkSpace Europe—International student and graduate work placement programme



“New product—Starter kit for electrochemistry— is an example of effective collaboration with PalmSens (NL). It succeeded in competition of Innovation of year 2015 in Czech Republic.”

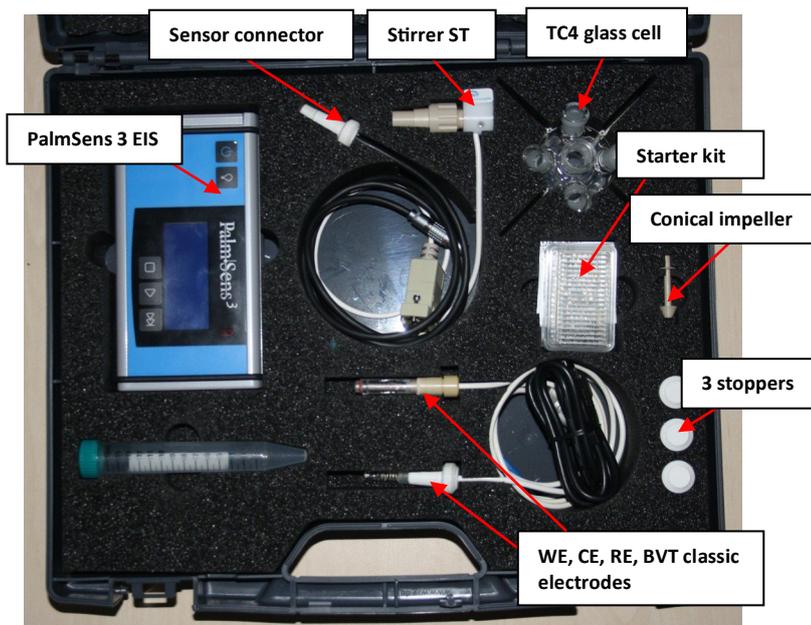
Dr. Jan Krejci, CEO



The Electrochemistry Kit was awarded by Innovation of year 2015 in Czech Republic.

Starter Kit for Electrochemistry (SK4E)

SK4E enables you to start basic electrochemical measurements. You only need the chemicals and solutions. SK4E involves BVT electrodes (Classical, screen printed or sputtered), reaction vessel, stirrer, connectors, etc. with the functional, convenient and high quality equipment of BVT and the portable, economical and easy to use research grade potentiostats of PalmSens. Some examples of measurement are presented in next text.



Basic set

- Potentiostat
- Stirrer ST
- Glass cell

Two options of electrodes:

1. With classical electrodes (counter, reference, working)
2. with SPE (screen printed electrodes) with connectors

Note: It is possible to order both options of electrodes in one set.

Optional

Accessories

- pH electrode
- Redox electrode
- USB pH meter
- Oxygen electrode
- Minithermostat (-10°C – 60°C)
- External thermometer
- Rotating disc electrode
- Classical glassy carbon electrode

Examples of measurement with Starter Kit for Electrochemistry

Basic set consists of:

- Potentiostat + SW (PalmSens)
- Stirrer ST (BVT)
- Glass cell (BVT)
- Connector (BVT)
- Sensors or classical electrodes (BVT)

Use of set:

- Basic education experiments in electrochemistry
- Detection of heavy metals by polarography
- Detection of organic pollutants by polarography
- Application of main electrochemical methods

(Cyclic voltammetry, Amperometric detection, Differential pulse voltammetry, Stripping methods, Electrochemical impedance spectroscopy, ...)

Work with Starter Kit for Electrochemistry in laboratory of BVT Technologies (BVT), Czech Republic.



Photo is made by Jana Pospíchalová, BVT Technologies, a.s., Czech Republic.

1) Impedimetric lectin biosensor for detection in the glycan structure

Prepared: Dr. Jan Tkáč (Institute of Chemistry, Slovak Academy of Sciences, Slovakia)

BVT delivered the kit. The first measurement were done with technical support of BVT. Full publication is in print: BERTOK, T.; DOSEKOVA, E.; et al., *Mixed zwitterionic-based self assembled monolayer interface for impedimetric glycomic analyses of human IgG samples in a array format*; 2016^[1]

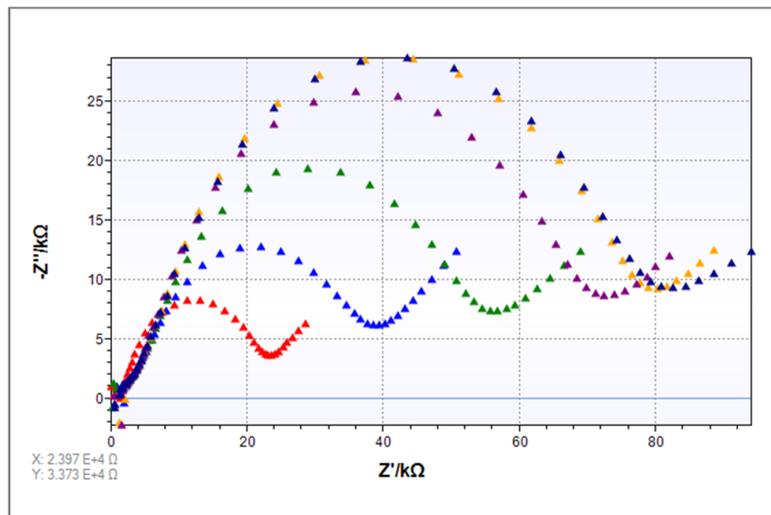
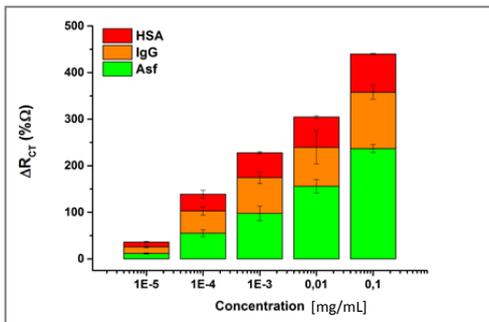


Fig.1: Impedance spectra obtained with SK4E with PalmSens 3 EIS. Red curve is SAM + receptor-modified electrode (blank).

Other curves are the increasing concentrations of analyte from $1 \cdot 10^{-5}$ to 0,1 mg/mL.

2) Double layer capacity characterization [2]

Prepared: Iva Ventrubová

The double layer capacity is main limiting factor of low concentration measurement. Stable double layer capacity enables compensation of its influence.

Polished glassy carbon classical electrode BVT was characterized by cyclic voltammetry in 1M KCl.

Diameter of electrode is 1 mm. The area of electrode is 0,785 mm².

The specific double layer capacity is 56 μF/cm². Double layer capacity behaves as ideal capacitor in potential window from -1 V to 0,8 V. (Oxygen removed by N₂ bubbling.)

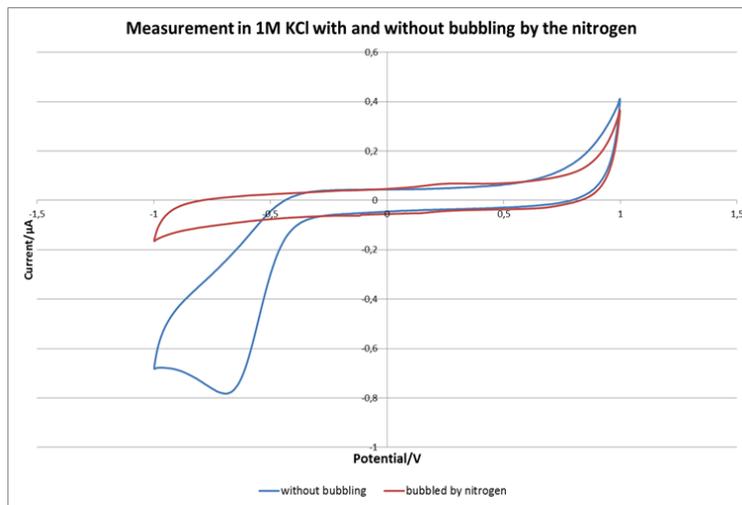


Fig. 2: The effect of oxygen on the measurement is visible on the blue curve (without bubbling by nitrogen).

3) Influence of electrode activation on electrode signal^[2]

Prepared: Iva Ventrubová

The cyclic voltammetry in 0,01 mol/L ferri—ferro cyanide $K_3[Fe(CN)_6]/K_4[Fe(CN)_6]$ is a classical tool to characterize the electrode electrochemical properties.

BVT classical glassy carbon electrode before and after activation. Activation was made by ten cycles in 1 mol/L of potassium chloride from $-1V$ to $1V$, scan rate 100 mV/s . The separation voltage is decreased but it still does not have theoretical value.

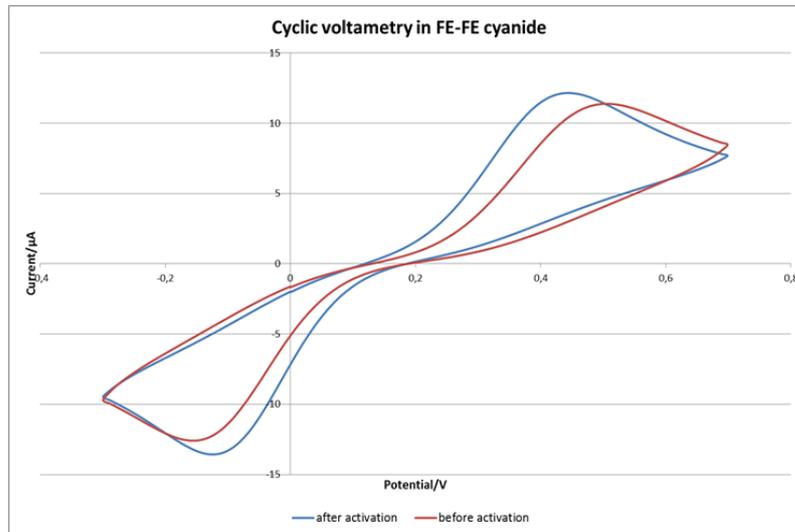


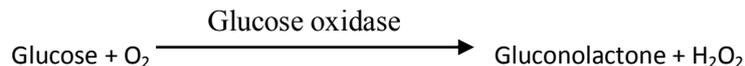
Fig. 3: Measurement of cyclic voltammetry in 0,01 mol/L of ferri—ferro cyanide on polished glassy carbon classical electrode.

4) Measurement of enzymatic activity of glucose oxidase

Prepared: Iva Ventrubová

The kit needn't to be used for pure electrochemistry. Next example demonstrate the measurement of enzymatic activity.

The analysis of enzyme kinetics is used as a tool to find out the enzyme activity and enzyme-substrate interaction and affinity. The example shows the measurement of **glucose oxidase activity**.



Glucoseoxidase catalyzes the reaction between the glucose and oxygen. The product of reaction is gluconolactone and hydrogen peroxide. **We can measure the increase of hydrogen peroxide** by BVT sensor AC1.W2.RS for amperometric measurement. Working electrode is platinum, reference electrode is silver and auxiliary electrode is from platinum too. ^[3]

The measurement was done in 5 mL of phosphate buffer solution.

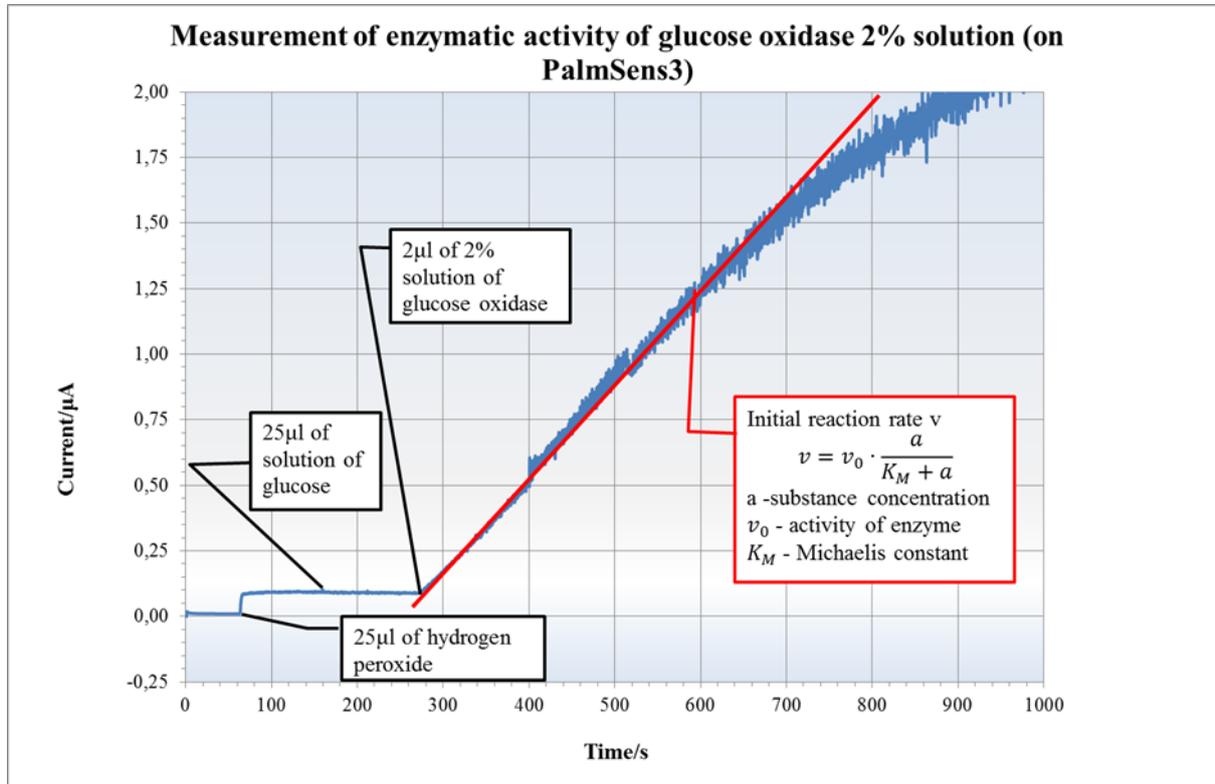


Fig. 4: Schematic description of measurement principle

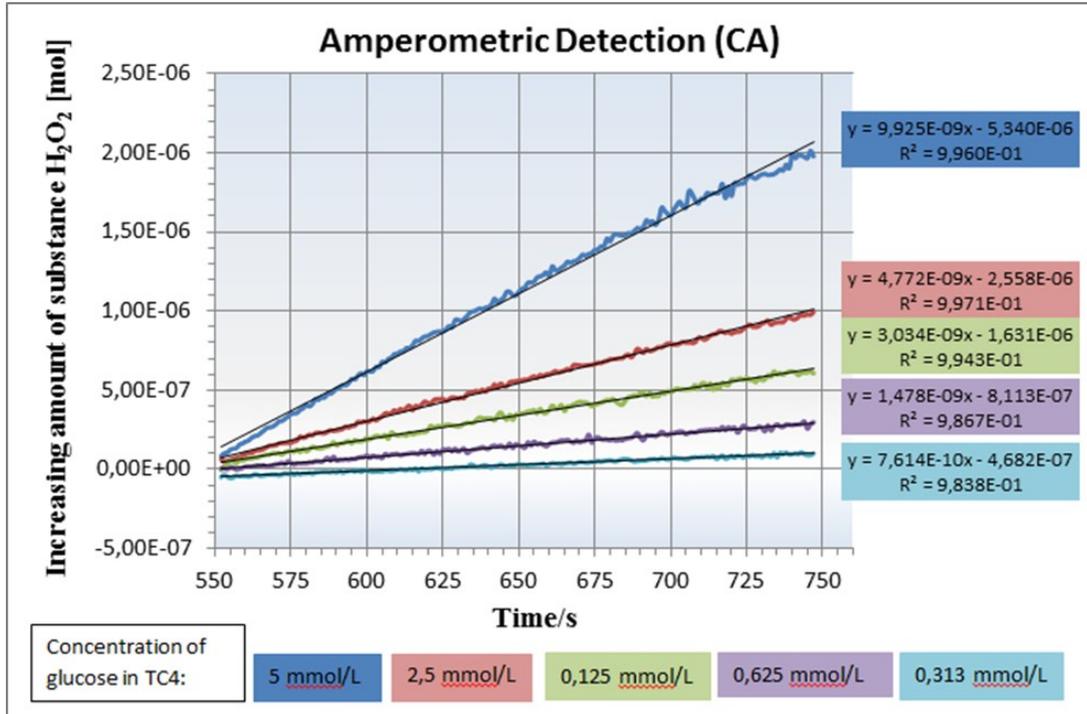


Fig. 5: Different reaction rates at different glucose concentrations (See fig. 4 where a=glucose concentration).

5) Characterization of double layer capacity at Pt electrodes

Prepared: Leonardo Spinelli and Iva Ventrubová

The **Pt electrode** in form of small ball (Hanging platinum drop electrode, HPDE) is very similar to a classic HMDE (hanging mercury drop electrode). The second electrode is a Pt wire melted in glass and polished. The active area is $3,5 \text{ mm}^2$.

An HPDE electrode was created by local heating of a platinum tip to $2500 \text{ }^\circ\text{C}$. The drop of Pt hangs on tip of glass tube. Due to surface tension quite regular spherical surface was formed. Careful cooling results in high quality electrode surface. The electro active species diffuse to surface in radial direction.

A **PalmSens 3** (with PStTrace software) was used in a TC4 glass cell containing 5 mL of potassium chloride (KCl). The cyclic voltammetry was carried out with the scan rates 1 V/s ; $0,1 \text{ V/s}$ and $0,01\text{V/s}$.

As the capacity depends linear on scan rate the responses were scaled by 1, 10, 100.

In range of $-0,2$ to $0,2 \text{ V}$ both electrodes behave as an ideal capacitor. The HPDE is more sensitive to adsorption and its reaction is faster.

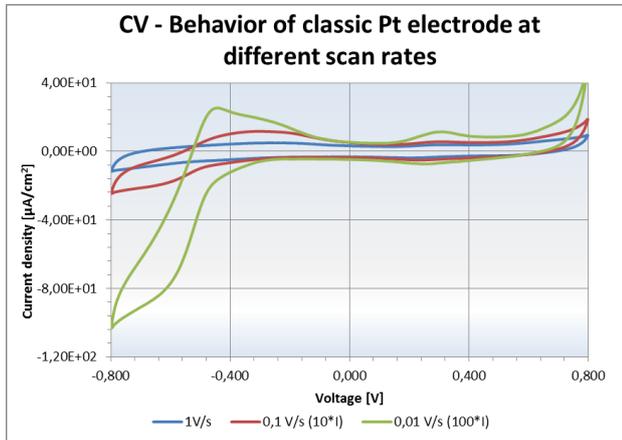


Fig. 6: Polarization curves at different scan rates. Classic polished platinum electrode. Differential capacity 43 $\mu\text{F}/\text{cm}^2$.

As explained in section 5 platinum creates after cooling nearly an ideal spherical surface with homogenous macro and micro structure. The difference between classical and HPDE is seen in fig. 6 and fig. 7.

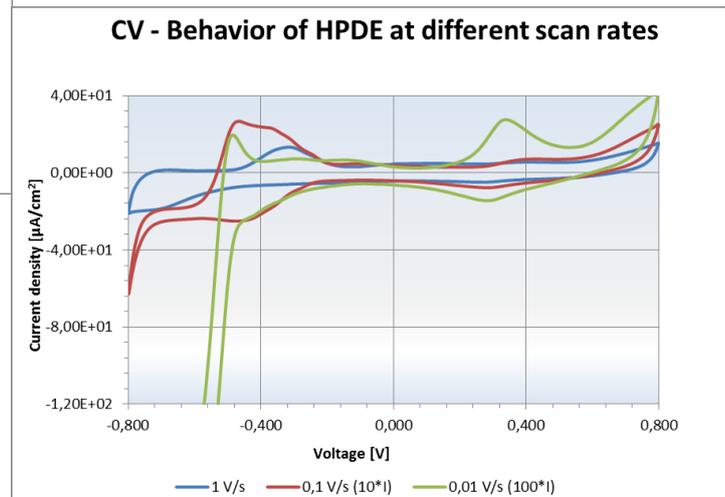


Fig. 7: Polarization curves at different scan rates. Hanging platinum drop electrode. Differential capacity 50 $\mu\text{F}/\text{cm}^2$.

6) Comparison of polished Pt electrode with HPDE using CV in $K_3[Fe(CN)_6]/K_4[Fe(CN)_6]$ at different scan rates

Prepared: Leonardo Spinelli and Iva Ventrubová

The response of electrode depends on its macro and micro dimensions. The KIT is used to compare properties of flat polished platinum electrode and HPDE. Platinum after cooling creates nearly ideal spherical surface with homogenous macro and micro structure.

The results were scaled with respect of : $\sqrt{1}$; $\sqrt{10}$; $\sqrt{100}$

The current depends on scan rate (v) as square root of v . HPDE has higher current density and better experimental and theoretical results agreement.

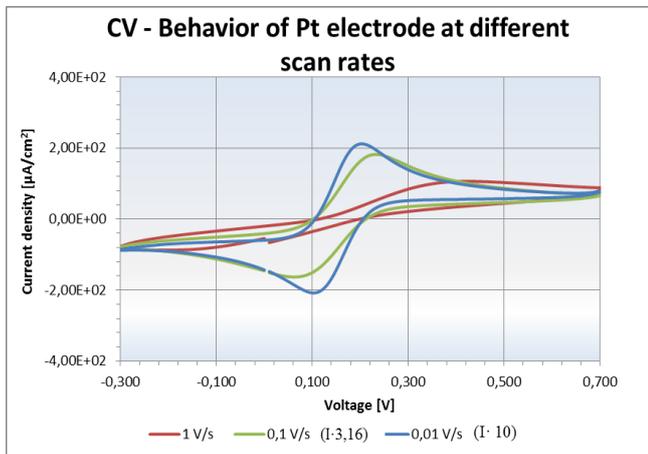


Fig. 8: Current density at flat, polished Pt electrode in 0,01mol/L solution of $K_3[Fe(CN)_6]/K_4[Fe(CN)_6]$. The separation voltage increases with decreasing scan rate.

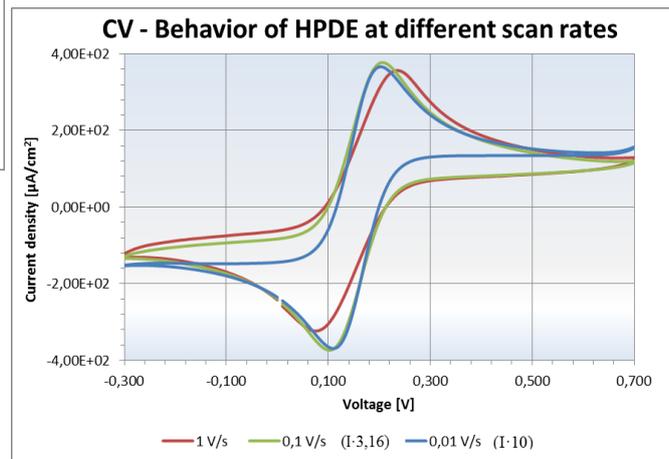


Fig. 9: Current density at HPDE in 0,01mol/L solution of $K_3[Fe(CN)_6]/K_4[Fe(CN)_6]$. Agreement with theory.

7) The dependence of current on stirring rate

Prepared: Iva Ventrubová

Stirring is one of the important factors for most measurements.^[4] It dramatically influences mass transport from bulk of solution to electrode's surface. Different stirring rates can generate different responses on the electrode. The example demonstrates this with amperometric detection in 0,01mol/L ferri-ferro cyanide $K_3[Fe(CN)_6]/K_4[Fe(CN)_6]$.

The most suitable stirring speed should be chosen on the basis of the ratio of the signal to noise.

The dependency of the current on the stirrer speed is very sensitive to the exact positioning of stirrer in the axis. However the small imprecision of stirrer position modulates the measured signal with sinusoidal signal the frequency of which agrees with stirrer revolution. This modulation enables to measure the stirrer rotation speed and subtract harmonic (sinusoid) part of the noise. It also enables to make experiments very similar to rotated disk electrode.

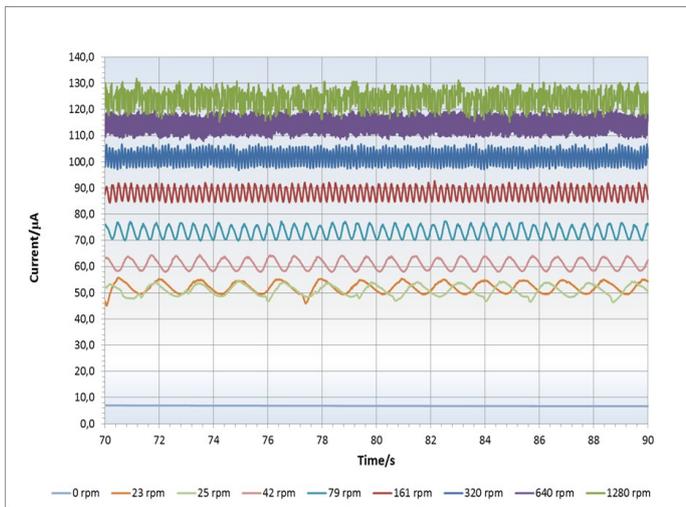


Fig. 10: Current at different stirring rates from 23 rpm to 1280 rpm.

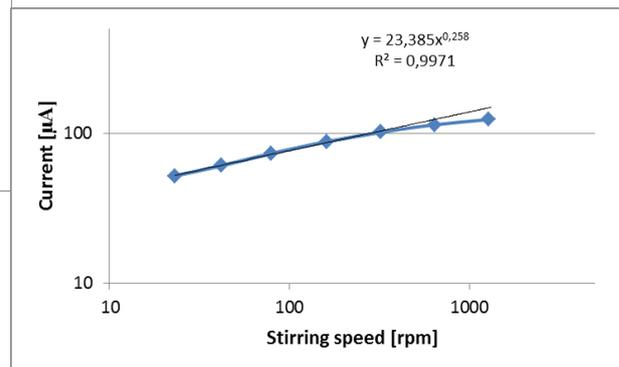


Fig. 11: The dependence of response [µA] on the stirring rate. Approximated by power function. Scales on axes are logarithmic.

References

- [1] BERTOK, T.; DOSEKOVA, E.; et al., *Mixed zwitterionic-based self assembled monolayer interface for impedimetric glycomic analyses of human IgG samples in a array format*; “submitted to Langmuir”
- [2] A. Dekanski, J. Stevanović, R. Stevanović, B. Ž. Nikolić, V. M. Jovanović, *Glassy carbon electrodes I. Characterization and electrochemical activation*, Carbon 39 (2001), 1195-1205 s.
- [3] MACHOLÁN, Lumír. *Enzymologie*. 2. upr. vyd. Brno: Vydavatelství Masarykovy univerzity, 1994. 152 s. ISBN 80-210-1039-8.
- [4] LEVICH, V. *Physicochemical hydrodynamics*. Englewood Cliffs, N.J.: Prentice-Hall, 1962.

The device **Starter Kit for Electrochemistry** was developed in cooperation with the company **PalmSens BV** from The Netherlands.



The **Starter Kit for Electrochemistry** was tested by our customer **Dr. Jan Tkáč** from Institute of Chemistry, Slovak Academy of Sciences (SAV), Bratislava, Slovakia.



Where we can meet in future:

July 2016

- follow www.bvt.cz for details
- Roadshow Dresden, Sensortechnik Mains, Liberec, Czech Republic
- 17th European Congress on Biotechnology (ECB 2016), 3rd – 6th July 2016, Krakow, Polsko

July - August 2016

- follow www.bvt.cz for details

September 2016

- 18th Heiligenstädter Kolloquium, 19th - 21st September 2016, Germany

October 2016

- 16th International Nutrition & Diagnostics Conference, INDC 2016, 3rd - 6th October 2016, Prague, Czech Republic

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