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Understanding the Role of Physical Properties in the Design and Construction of an efficient Screen Printed Electrodes Sensor Kit

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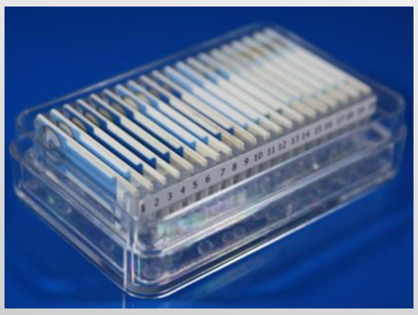
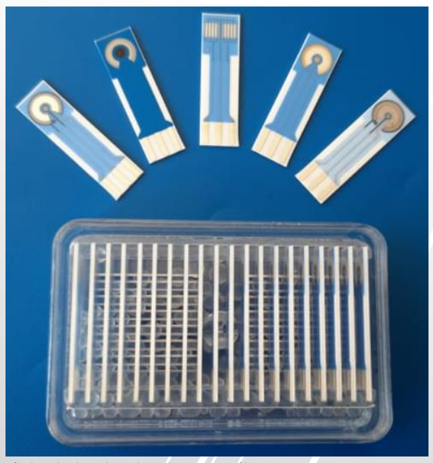
Abstract

Electrochemical Screen-Printed Sensors (SPEs) are important tools for routine analysis in various fields of electro-analytical chemistry. However, they are not recognized as universal tools by various researchers in the scientific community. Knowledge of specific features enables optimum choice a sensor for the required application. The Poster demonstrates **Screen Printed Electrodes Sensor Kit** (Kit) which enables to test the main different types of SPEs.

The Kit contains **samples of 20 electrochemical sensors with different topology and surface structure**.

The use of different topologies of working electrode, which can be optimized for amperometry, conductometry or differential conductometry applications are demonstrated. The different sensors from the kit are also used to demonstrate the role of properties such as Material Purity, Range of Materials, The role of Surface Structure and Electrode topology.





BVT Technologies Screen Printed Electrodes Sensor Kit

BVT created some **standard description of (SPEs) sensors**. It enables easy navigation on the sensors and the possibilities they offer. **The formula** is composed of a two letters code followed by a numeral, followed by specification of working and reference electrodes and possibly some accessories.

AC*. W*. R* (*)
CC*. W* (*)

The asterisk ***** is replaced by the appropriate number or letter

The **first letter characterizes the electrochemical method** which is **suitable for this sensor**. (A,C,... amperometry, conductometry...). The **second letter describes a substrate on which a sensor is printed** (C, P, G,.. ceramics (typically alumina ceramics), plastic or glass). It is also possible to use some special material such as boron nitride ceramic or beryllium ceramics. **Numbers characterize the topology of the sensor** (for example sensors AC1, AC2, CC1, CC2 ...). By this it is defined the basic materials of sensors and their topology.

The **next letter describes the material of the active surface**. The letter **W*** specifies the **working electrode**. **The number following the letter specifies the working electrode material**. (**WS** – standard material, W**1** - pure gold, W**2** - pure platinum, **W3** - pure silver, **W4** and W**5** – printed or coated graphite). Then follows the **description of the reference electrode R*** and the **number specifying its material**. (R**S** - silver, R1 - a mixture of silver and silver chloride in a polymeric binder, R**2** - silver covered by AgCl.

<u>For example AC1.W1.RS electrode</u> is an electrode that is used for **A**mperometric measurements, built on a **C**eramic substrate (96% Al_2O_3) and topology is the number **1**. As a working electrode **W1** is an Au layer and reference electrode **RS** is an Ag layer.

Each material of working (W) and reference electrode (R) has different mechanical and chemical properties

WS – Au+Pt alloy
- **good adhesion and chemical resistance**

W1 – Au
- pure Au

W2 – Pt
- pure Pt
- can be destroyed by sonification, current over 10 mA, mechanical cleaning

W3 – Ag
- pure Ag

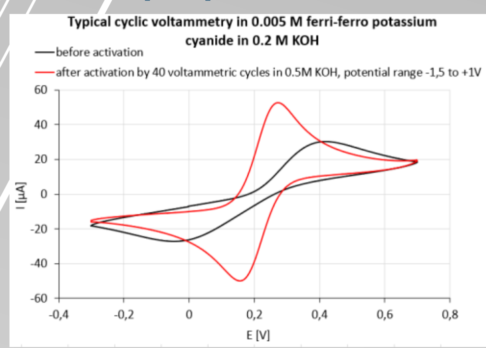
W4 – printed graphite
- **working and auxiliary electrode made of graphite**
- the dielectric layer is made of polymer
- limited resistance to organic solvents and sonification

W5 – coated graphite
- made by **manual microdispersing**
- **only a working electrode made of graphite**
- the **auxiliary electrode from another material (Au+Pt alloy)**, the dielectric is usually ceramic
- limited resistance to organic solvents and sonification

<u>**Main difference between W4 and W5:**</u>
- the **resistance** of W4 and W5 surface and output contact lies in range (0,1-10 kΩ) and (1-10 Ω) respectively

BVT offers unactivated version of sensors. Both, W4 and W5 graphite layer must be activated before measurements

Demonstration of graphite sensor activation
- Sensors: **AC1.W4.RS, DW = 2mm**



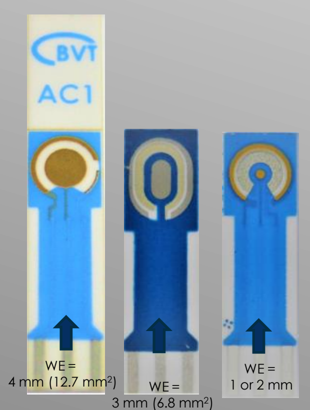
RS – robust Ag reference electrode with additives for better adhesion
- **excellent resistance against temperature up to 600 °C and organic solvents**
- lover resistance against acids and bases

R1 – 65% Ag/35% AgCl (powder mixture in polymeric binder)
- **resistant against bases and acids**
- fragile, must not be used organic solvents and sonification
- temperature resistance up to 120 °C

R2 – Ag covered by AgCl electrolytically
- the color from light to dark brown
- degrades under the influence of light
- temperature resistance up to 300°C

BVT Electrochemical sensors in Sensor Kit - overview:

Starting kit is the **set of twenty electrochemical sensors which cover all common application of sensors.** Starting kit contains 10 types of electrochemical sensors (2 sensors of each type), simple sensors connector and sensors box with numbered positions and silica gel.



AC1.W*.R* (*)

The most used **amperometric 3-electrode sensor** with working, reference and auxiliary electrodes. This sensor is **used as a substrate for** glucose oxidase or acetylcholine esterase **biosensor** preparation (AC1.GOD, AC1.AChE).

<u>**WE material**</u>: WS, W1, W2, W3, W4 and W5
<u>**RE material**</u>: RS, R1, R2
<u>**(*) Additional Technical specification**</u>:
(H) – Heating of the sensor,
(T) – Temperature sensing element
<u>**WE diameter**</u>: 1, 2, 3 (6.8 mm²) and 4 (12.7 mm²) mm

AC2.W1.R* (*)

Amperometric sensor with **two working** electrodes and **one reference electrode** allowing differential measurement of two signals at once. Different **bio-chemically active substance** can be immobilised on the working electrode to create a biosensor. Measurement in presence of interfering compound.

<u>**WE material**</u>: WS, W1, W2, W3, W4 and W5
<u>**RE material**</u>: RS, R1, R2
<u>**(*) Additional Technical specification**</u>:
(H) – Heating of the sensor,
(T) – Temperature sensing element
<u>**WE diameter**</u>: 1 mm

AC1P.W1.R* (*)

Amperometric three-electrode sensor with patented structure type AC1 with **polished working electrode** made by thick film technology. The influence of surface structure can be demonstrated.

WE material: W1 - polished Au
<u>**RE material**</u>: (RS, R1, R2
<u>**(*) Additional Technical specification**</u>:
(H) – Heating of the sensor,
(T) – Temperature sensing element
<u>**WE diameter**</u>: 1, 2 mm

CC1.W* (*)

A **conductivity sensor** made by thick film technology with interdigitated structure of electrodes. Measurement of conductivity, bacterial contaminations, urea using biosensor.

<u>**WE material**</u>: WS, W1, W2, W3, W4
<u>**(*) Additional Technical specification**</u>:
(H) – Heating of the sensor,
(T) – Temperature sensing element
<u>**WE dimension**</u>: 2.00 x 2.00 (+-0.05) mm

CC2.W* (*)

A **conductivity sensor** with **two active parts** made by thick film technology with interdigitated structure of electrodes. Designed **for differential measurements of conductivity** on the background of another effect. Differencial conductometry, bacterial contamination, urea in presence of backround conductivity of sample.

<u>**WE material**</u>: W1, W2, W3, W4
<u>**(*) Additional Technical specification**</u>:
(H) – Heating of the sensor,
(T) – Temperature sensing element
<u>**WE dimension**</u>: 3.00 x 3.00 (+-0.05) mm

AC4.W* (*)

A single working electrode sensor with a high metal surface area, for example external auxiliary It may serve for metal coating.

<u>**WE material**</u>: W1, W2, W3, W4
<u>**WE dimension**</u>: 4.60 x 7.30 (+-0.05) mm

Reference:
KUCEROVA, Radka, Lucie JEZOVA, Stepanka BENDOVA, Anna BELUSOVA, Yuvraj BHARDWAJ a Jan KREJCI. Perspective—Thick Film Technology. *Journal of The Electrochemical Society* [online]. 2022, 169(2). ISSN 0013-4651.