K_{cell} DETERMINATION IN INTERDIGITATED ELECTRODES THROUGH IMPEDANCE MEASUREMENTS

Summary:

Planar microelectrodes for impedimetric measurements are very interesting for developing new types of (bio)sensors. A basic parameter of characterization, especially in conductivity sensors, is the so called "cell constant" K_{cell}. This constant depends on the geometry of the sensor and the current paths (often affected by the overall geometry and volume of the sample). Among different configurations, interdigitated electrodes present low cell constant that permit the measurement of low conductivity solutions, as well as the measurement of dielectric properties.

The cell constant value is related to electrode geometrical parameters (such as digit length, number of digit pairs, gap between digits…) however, this constant can be determined experimentally[1]. The cell constant is defined as:

$$K_{cell} = \frac{R_{sol}}{\rho_{sol}}$$

Where R_{sol} is the resistance of the medium and ρ_{sol} is electrolyte resistivity. Impedance measurements allow to determine R_{sol} at frequencies where phase angle is 0 or close to 0 (Bode plots).

Apparatus and accessories:

- Impedance measurements are carried out with an Autolab PGSTAT 204 controlled by NOVA 1.10 software. Impedance spectra were taken in the range from 100 Hz to $1x10^6$ Hz, RMS 10mV (peak-to-peak amplitude). There is an equilibration time before each measurement of 5 s. Measurements were performed with IDEs of each geometry and material (Au and Pt).
- K_{cell} is calculated as the slope from the plot Impedance (|Z|) vs Solution resistance (ρ)

Reagents:

- KCl solutions are made from dilutions of a conductivity standard 1.0M (111,8 mS/cm). The conductivity from KCl solutions is calculated by Kohlrausch equation ($EC = \Sigma(c_i \times f_i)$; c_i=mg/L and f_i is the conductivity factor).

Method:

The impedance spectra of each sensor immersed in the different KCl solutions were registered. All measurements were done at 25-26ºC. |Z| (or solution resistance) is plotted versus the inverse of the conductivity (or resistivity) at a frequency where ϕ or angle phase is close to 0 or has minimum value. The slope of these curves is the electrodes cell constant.

Results

IDE	Frequency	Conductivity range	N	K_{cell} (cm^{-1})	Intercept	r^2
G-IDECONPT-10	23KHz (23300Hz)	7,39-1478 µS/cm 135,3 to 0,68 KΩ×cm	10	0,0089±0,0002	0,3917	0,994
G-IDECONAU-10	40KHz (40949Hz)	7,39-1478 µS/cm 135,3 to 0,68 KΩ×cm	10	0,0091±0,0001	0,1489	0,998
G-IDEAU5	10KHz (10985Hz)	7,39-1478 µS/cm 135,3 to 0,68 KΩ×cm	10	0,0001±0,0042cm^{-1}	0,1765	0,995
G-IDEAU10	40KHz (40949Hz)	7,39-1478 µS/cm 135,3 to 0,68 KΩ×cm	10	0,0083±0,0002cm^{-1}	0,0832	0,994
G-IDEPT5	28 KHz (28118Hz)	7,39-1478 µS/cm 135,3 to 0,68 KΩ×cm	10	0,0043±0,0001cm^{-1}	0,1598	0,992
G-IDEPT10	28 KHz (28118Hz)	7,39-1478 µS/cm 135,3 to 0,68 KΩ×cm	10	0,0090±0,0001 cm^{-1}	0,1611	0,998
P-IDEAU100	5 KHz (5179Hz)	7,39-1478 µS/cm 135,3 to 0,68 KΩ×cm	10	0,092±0,0001	0,6474	0,999
PW-IDEPD100	9 KHz (9103 Hz)	7,39-1478 µS/cm 135,3 to 0,68 KΩ×cm	10	0,0713±0,0001	0,8147	0,997
IDEAU200	16 KHz (15999 Hz)	7,39-1478 µS/cm 135,3 to 0,68 KΩ×cm	10	0,0166±0,0003	0,0331	0,999

[1] De la Rica, R.; Fernández-Sánchez, C.; Baldi, A. *Electrochem. Commun*. **2006**, *8*, 1239