Floating Minipotentiostat for In-Situ Analysis

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Electrochemical measurement techniques are intrinsically well suited for on-line water monitoring, being both cost-effective and easily miniaturized. The continuous monitoring of drinking water through the detection and quantitative measurement of chlorine is a prime example of an industrial application of this electro-analytical technique.

For such on-line and industrial applications — where the medium to be measured is electrically at ground potential — it is mandatory to transform the previously developed minipotentiostat into a floating minipotentiostat. This instrument can now be used to carry out measurements inside metallic pipes, i.e. in a typical industrial or household situation, as well as in flowing water for environmental monitoring with the following brief specifications: V = +/– 2.5 V, current 2 pA to 1 μA, f_{max} = 10 kHz.

This floating minipotentiostat is not limited to concentration measurements by amperometry, but represents a versatile and programmable platform able to perform a wide variety of electrochemical measurement techniques under computer control, via its Labview™ interface. A user-friendly software interface is currently under development; it will facilitate the exploitation of this miniaturized potentiostat for a wide range of field and laboratory applications.

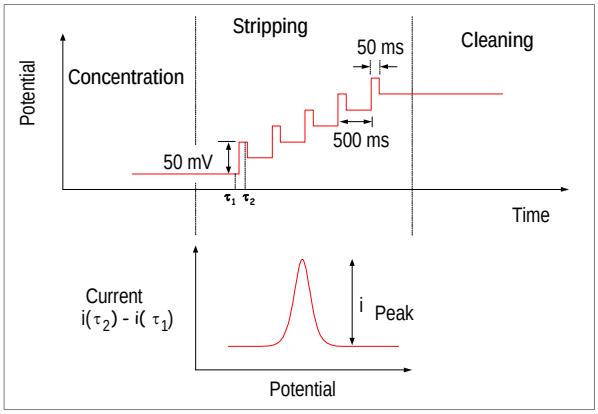

Figure 1
Differential pulse stripping voltammetry (DPASV). The metal is first concentrated on the electrode by electrochemical deposition at a potential typically 0.3 to 0.5 V more cathodic than the peak potential for a given time period. The metal is stripped from the electrode by sweeping the potential anodically while applying constant height pulses. The current is measured at τ_1, shortly before the pulse is applied and at the end of the pulse at τ_2. The difference between these two values is plotted as a function of the base potential.

One example is the anodic stripping voltametry (ASV) method for the electrochemical detection of trace metals (Fig. 1). In this case, the metal is concentrated by electrodeposition on the electrode surface. The concentration is done by cathodic deposition at controlled time and potential. The duration of the deposition step is selected according to the concentration level of the metal ions. The metal is then stripped from the electrode by scanning the potential anodically (at a given potential according to the metal being analyzed). Traditionally one uses mercury on the electrode, so that a mercury-metal amalgam is formed, leading to a significant increase in the sensitivity of the method. For on-line and environmental applications, where the use of mercury should be avoided, a similar increase in sensitivity is obtained by reducing parasitic effects, such as capacitive currents. This can be achieved by superimposing short potential pulses (typically 50 ms and 50 mV) on the potential ramp. Differential pulse anodic stripping voltammetry (DPASV) allows the mercury-free detection of metal ions in water in the ppb concentration range.

The measurements made with this instrument are practically flow independent when micron-sized planar microelectrodes are employed. This interesting feature has a price: a consequent reduction in the measured current, which can, however, easily be compensated through the use of microdisk arrays.

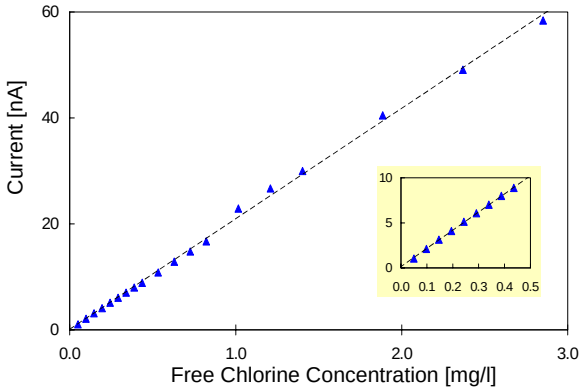

Figure 2
Calibration curve for free chlorine in water, as measured with an array of 130 microdisks

Figure 2 shows an example of results obtained for the already mentioned chlorine concentration measurements in water, with an accuracy of 0.3% of the measurement range.

To the best of our knowledge, the developed floating minipotentiostat is the only miniaturized instrument of this type available. It can now be used to carry out field measurements for environmental monitoring.