Automatic Electrochemical System for Titration Analysis in Biochemistry Using DAQ and LabVIEW™

by

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Products Used:
* LabVIEW™ 5.0
* DAQ

The challenge
To combine the complexes of electrochemical system with rotating electrodes in micro system technique, of telemetry and of LabVIEW in a small portable PC for automatic runs with the aims to improving the analytical sensitiveness, reducing the time of analytical runs and increasing the efficiency of the whole analytical system.

The Solution
Realisation of a measuring and controlling system for automatic analytical estimation of nitrogen till very low concentrations in Biochemistry by using micro system technique and PC-measuring technique with LabVIEW. New system using in chemical analysis and as model for testing this technology to apply in Biomedical Technique of Medical Research.

Introduction
Rotating electrodes are very important in liquid electrochemical analytical processes based on good flow conditions and small diffusion layers. However, much problems occur in technical realisation:
* In the context of electrotechnics and electronics: Establishing connections; different transmissions between stator and rotating system; absolute galvanic separation between different electrical current circuits relating to the electrochemical electrodes in the analytical cell.
* In the context of miniaturisation of electrochemical analytical measuring technique: Reduction of the cuvette volume for small millilitres; impairment of flow through and mixing in the analytical cell due to the effect of surface tension.

All these problems were coped with the technical realisation of a new automotive measuring system, which we integrated into the PC-measuring technique for detection and controlling the automatic coulometric titration analysis. That system should estimate low concentrations of ammonium ions in mineralised samples directly after thermal wet digestions [1] for applications in protein-nitrogen-analytic in Biochemistry.

Material and Methods
Starting point and comparison to this new electrochemical analytical system was an own laboratory device in conventional analogous technique for such coulometric titration analysis [2]. A new rotating electrochemical system [3], Fig. 1, was constructed in micro system technique and carries out coulometric titration analysis in a minimal cuvette volume of 3 ml. An amplifier unit with telemetric system [4] realised the signal connections by telemetry with infrared light between rotating system and stator. Its frequency modulated signal is the input for the data acquisition (DAQ) by the real time connected PC-measuring technique, which controls the electrochemical processes in a closed loop, like it is demonstrated in Fig. 2 as complete device configuration in a global flow diagram and especially as LabVIEW diagram in Fig. 3.
The Hardware and Software of portable measuring PC (Notebook)

**Hardware:** Pentium, 120 MHz; measuring- and controlling card DAQ 1200;
input 1: Counter; output: DAC  input 2: ADC

*Special input unit:* Amplifier unit with telemetric system: inductive electrical power supply, input measuring amplifier for the sensor signal; supply for the electrode voltage; voltage-frequency-converter; transmission to the stator by telemetry with infrared light.

*Special Output unit:* Voltage-current-supply for generator-current Ug: 0-10 V; Ig: 0-10 mA.

**Software:** Windows 95/NT; Graphical Program LabVIEW 4.0.1 / 5.0 with toolkits for DAQ and analysis;

**Fig. 1: Rotating Complex**
Fig. 2: Electrochemical System

Fig. 3: LabVIEW Diagram with Data acquisition and process control
Virtual Instruments for automatic coulometric titration analysis

The running titration analysis is indicated biamperometrically by rotating pair of electrodes, which are polarised by 200 mV DC. The indicator current $I_i$ of depolarisation runs from 0 till 3 $\mu$A, is measured and translated to frequency from 5 till 15 kHz as input 1-signal. The chemical titrator is generated by electrolysis on the rotating working electrode in the microcuvette, directly. Its current $I_g$ is controlled by the analogue output signal and integrated by input 2 for the analysis time. This forward titration analysis is finished by dead-stop-principle as endpoint, exactly.

**Fig. 5**: Monitor picture of a typical titration curve in concentration range of 10 $\mu$g nitrogen per sample.
Results

* Realization of the rotating complex with absolutely galvanic separation of both current circuits (indicator, generator) by telemetry results in reproducible titration curves, Fig. 5.
* Optimal controlling of titration processes by direct adjustment of control parameters using virtual instruments.
* Microsystem technical construction of the rotating complex with an electrochemical system allows a miniaturization of the measuring cell to minimal volume of 3 ml.
* The lower limit of the estimation method for ammonium ion concentration was reduced to 0.1 µg nitrogen in the sample volume.
* Analytical procedure and technique are demonstrated to be an Absolute Chemical Method, which spares calibration curves and application of chemical standard samples.
* Translation of analytical values to EXCEL files in measuring PC for data storage and processing.
* The complete device configuration or the rotating complex for itself can be used for analysis of trace elements and drugs.
* This system with electrochemical sensor, with telemetry for absolutely separation between input and output and with PC based measuring and controlling technique could apply by biomedical objects in Biomedical Technique with its safety recommendations.

Reference

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