



Application Note AN-T-076

自来水中的电导率、pH 值、碱度、硬度和氯化物

Fully automated determination including sample preparation

The analysis of tap water plays an important role to assess the water quality or to identify possible contaminants. Parameters such as conductivity, pH value, alkalinity, water hardness, and chloride content are routinely analyzed.

In this application note, a fully automated system is presented which allows the determination of several parameters according to various standards within one analysis. These include conductivity (ISO 7888, EN 27888, ASTM D1125, EPA 120.1), pH value (EN ISO 10523, ASTM D1293, EPA 150.1), alkalinity (EN ISO

9963, ASTM D1067, EPA 310.1), Ca/Mg (ISO 6059, ASTM D1126, EPA 130.2), and chloride (ISO 9297, ASTM D512, EPA 325.3). Additionally the system transfers the required volume of sample into external titration vessels for the different analyses, reducing manual sample preparation. Furthermore, all sensors can be automatically calibrated and the titer of each titrant can also be determined.

This high degree of automation minimizes errors and guarantees outstanding reproducibility by freeing up valuable time for operators.

SAMPLE AND SAMPLE PREPARATION

The method is demonstrated for a tap water sample. No sample preparation is required as the system automatically transfers the defined

sample volume to external titration vessels after conductivity measurement.

EXPERIMENTAL

This analysis is carried out automatically on an 815 Robotic USB Sample Processor XL equipped with two external titration vessels. One is set up with an iAquatrode plus and a combined Ca-ISE, and the second vessel is set up with an iAg-Titrode.

The samples are poured into beakers and then placed onto the rack. First, the conductivity measurement is directly performed in the beaker with a 5-ring conductivity measuring cell with integrated temperature sensor. Afterwards, a sample aliquot is transferred into the first external titration vessel to perform the pH measurement and then the alkalinity titration (using standardized HCl solution). Next, the pH value is adjusted by the addition of TRIS buffer, and the sample is titrated with standardized EDTA titrant until after the second equivalence point is reached. A second portion of the sample is transferred into the second titration vessel for the chloride determination with standardized silver nitrate titrant (after an acidification step). Finally, cleaning of both titration vessels and sensors is carried out automatically.

The pH electrode and the conductivity measuring cell are calibrated prior to the analysis.

RESULTS

The system enables reproducible results for all analyzed parameters. The overall analysis time for one sample is less than 15 minutes. All results

are summarized in **Table 1** and exemplary titration curves are given in **Figures 2, 3, and 4**.



Figure 1. Example setup of a 815 Robotic USB Sample Processor XL with one external titration vessel, a 905 Titrand and 856 Conductivity Module equipped with iAquatrode plus, combined Ca-ISE, iAg-Titrode, and 5-ring conductivity measuring cell for the analysis of tap water.

Table 1. Analyzed parameters for tap water (n = 10).

Parameter	Mean	SD(rel) in %
Conductivity	567.4 $\mu\text{S}/\text{cm}$	0.84
pH value	7.83	0.32
p-value	N/A	N/A
m-value	5.44 mmol/L	0.09
Calcium	84.57 mg/L	0.50
Magnesium	19.66 mg/L	1.74
Total hardness	2.92 mmol/L	0.62
Chloride	10.87 mg/L	1.51

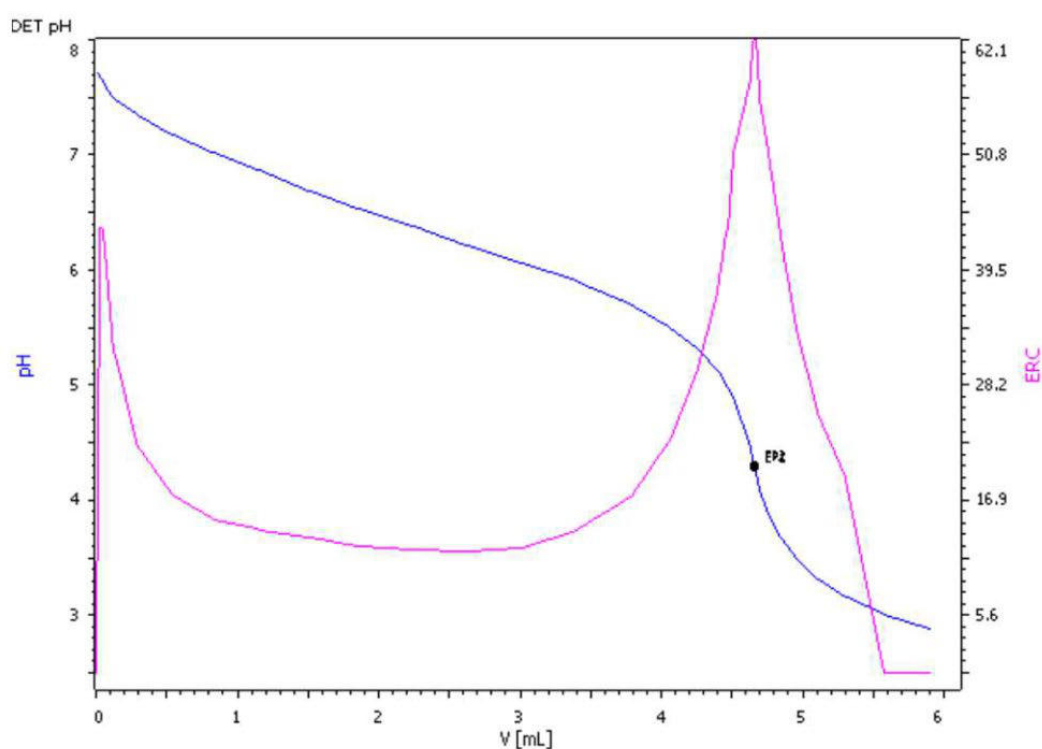


Figure 2. Example of a titration curve for alkalinity measurement in tap water.

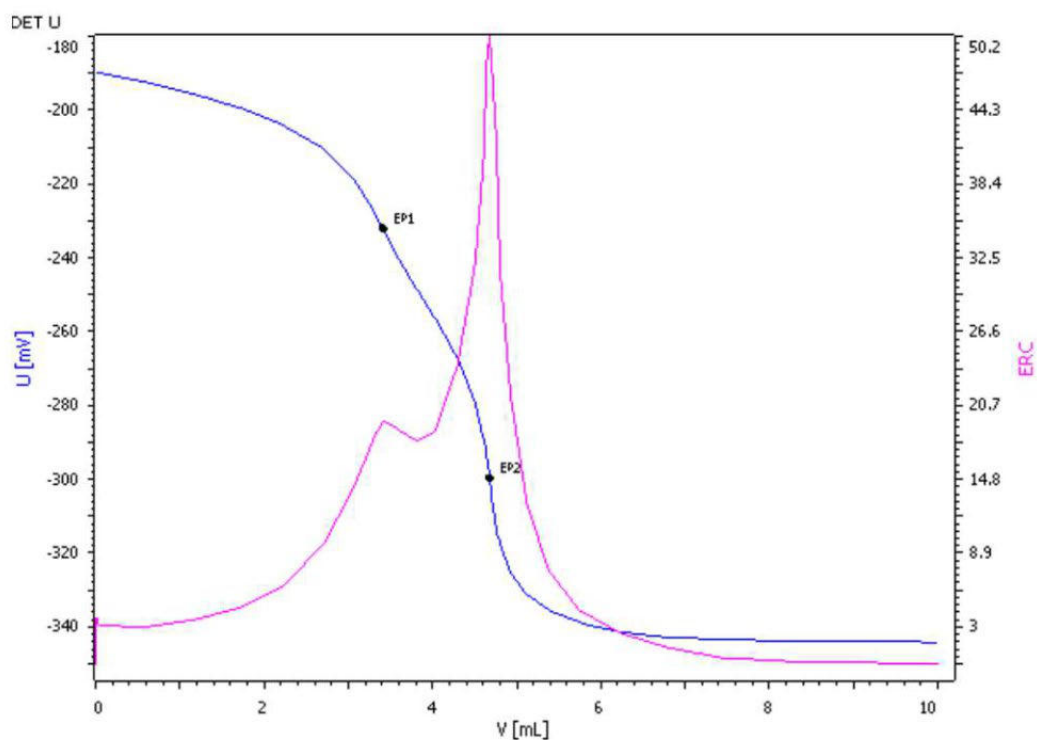


Figure 3. Titration curve for the determination of water hardness, the first EP corresponds to the Ca content and the difference obtained by EP2-EP1 corresponds to the Mg content.

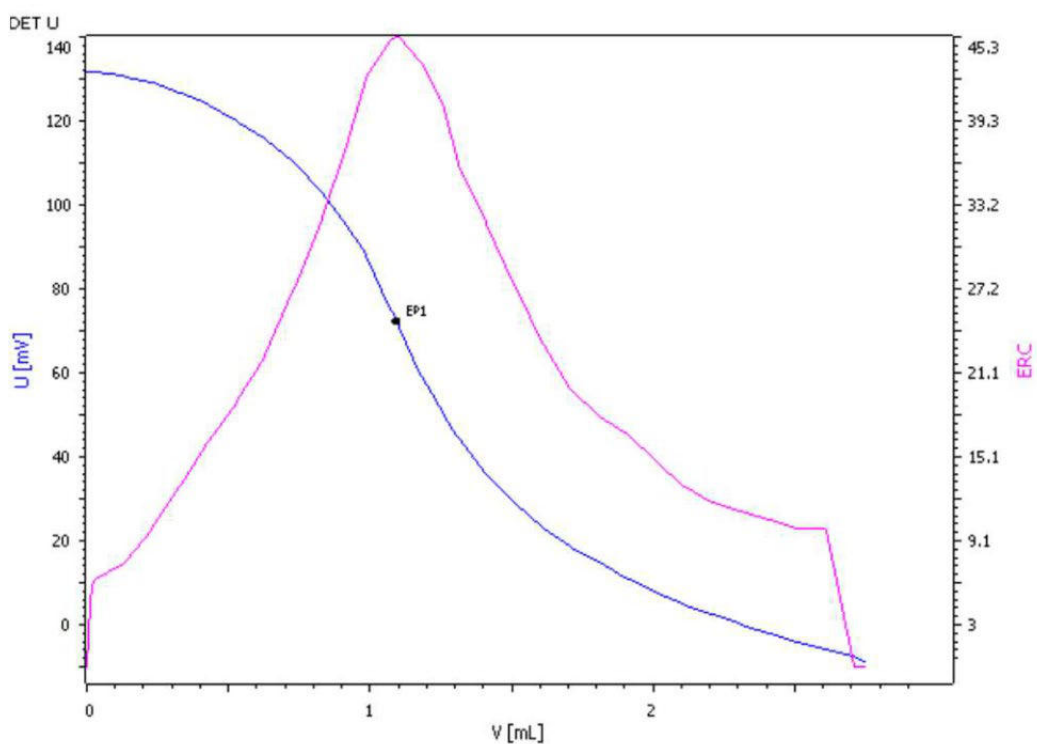


Figure 4. Titration curve for the determination of chloride in a tap water sample.

CONCLUSION

The high degree of automation for water analysis allows an increase in sample throughput, minimizes errors, and guarantees outstanding reproducibility. As the presented system includes sample preparation, the sample only needs to be placed in a beaker onto the rack and the system runs all analyses

(conductivity, pH value, alkalinity, water hardness, and chloride) autonomously in one run. The automatic and accurate addition of the solutions combined with the automated system frees up valuable time of the operator and therefore increases the productivity in the lab.

Internal reference: AW TI CH1-1215-082011

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CONFIGURATION



815 Robotic USB Sample Processor XL (1T/2P)

Robotic USB Sample Processor XL 包括一个工作站和两台内置的隔膜泵,可用于自动处理大量常规样品系列以及完成复杂样品前处理或并列处理流程。还可再连接多达三台加液器用来进行 LQH 加液处理。

由于其应用范围很广,因此必须根据具体应用来选择合适的样品盘、搅拌器、滴定头、机械臂和 Swing Head 以及样品容器并单独订购。

通过 Touch Control 实现单机控制。有以下 PC 控制用软件产品可供选择: 滴定软件 tiamo™、色谱分析软件 MagIC Net、伏安法软件 viva 或 OMNIS。



843 ()

843 泵模块 (蠕动泵式) 含有两个内置式的蠕动泵。它们可用 远程信号接口直接控制或通过手动按钮控制。



856 Conductivity Module

电导率测量模块作为现有 Titrand 系统的扩展设备或作为«独立设备»与 900 Touch Control 一起使用。通过 856 Conductivity Module 模块即可测定电导和温度也可测定总溶解固体值和盐度。它也支持五环电导电极。

该 Conductivity Module 有 2 个 USB 接口,用于连接打印机、条形码读取器或自动进样器,以及 4 个 MSB 接口用于连接搅拌器或 Dosino。

使用 OMNIS-Software、tiamo-软件或 Touch Control。如果需要,满足 GMP/GLP 和 FDA 要求,比如 21 CFR 第 11 部分。



905 Titrand

用于使用两个测量接口和内部滴定管驱动滴定分析的电位滴定仪。

- 多达四套 800 Dosino 加液系统
- 动态等当点滴定(DET)、等量等当点滴定 (MET)和终点设定滴定(SET)
- 使用离子选择性电极测量(MEAS CONC)
- 带监控的加液功能,LQH
- 用于额外搅拌器或加液器系统的四个 MSB 接口
- 智能电极“iTrode”
- USB 接口
- 使用 OMNIS-Software、tiamo-软件或 Touch Control
- 如果需要,满足 GMP/GLP 和 FDA 要求,比如 21 CFR 第 11 部分



5 c= 0.7 cm⁻¹ Pt1000

带池常数的 5 环电导电极 $c = 0.7 \text{ cm}^{-1}$ (指导数值),集成有温度探针 Pt1000 和固定电缆 (1.2 m),用于连接到 856 电导率模块上。

该传感器适用于测量中等的电导率(5 $\mu\text{S}/\text{cm}$ 至 20 mS/cm),例如:

- 饮用水
- 地表水
- 废水



iAquatrode Plus Pt1000

集成了传感器数据存储芯片和 Pt1000 温度传感器的用于在离子含量低的含水介质(例如,饮用水、工艺用水)中进行 pH 测量/滴定的数字组合 pH 电极。这种电极在这些样品中显示出非常快的反应时间。

固定磨口隔膜对污染不敏感。

当使用 $c(\text{KCl}) = 3 \text{ mol} / \text{L}$ 作为中间电解质时,建议在储存溶液中储存。

中间电解质可以用不含氯离子的电解质(例如,硝酸钾 $c(\text{KNO}_3) = 1 \text{ mol}/\text{L}$ (6.2310.010))代替。存储在用过的电解质中。

iTrodes 可用于 Titrande, Ti-Touch 或 913/914 米。



Ca

带聚合物膜的组合式钙选择性电极。

该 ISE 电极适用于:

- 水性溶液中 Ca^{2+} 的离子滴定(5×10^{-7} 至 1 mol/L)
- 络合滴定(复)滴定(例如:测定水硬度)

得益于坚固/为易碎的聚丙烯塑料杆和高分子膜片衬垫,传感器可以承受较高的机械载荷。

使用的参考电解液为 $c(\text{NH}_4\text{NO}_3) = 1 \text{ mol}/\text{L}$ 。



iAg-Titrode

带 pH 玻璃膜且集成了传感器数据存储芯片的智能组合式银环形电极,用作参比电极。

该免维护电极适用于 pH 值恒定的沉积滴定(硝酸银滴定剂),例如:

- 氯化物、溴化物、碘化物
- 硫化物
- 硫化氢
- 硫醇
- 氰化物

该电极存放在蒸馏水中。

据具体应用,建议使用带 Ag_2S 涂层的 Ag Titrode,其可以相应订购。

iTrodes 可在 Titrando、Ti-Touch 或 913/914 Metern 上使用。