

Determination of arsenic in water with the gold electrode (scTRACE GOLD)

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Introduction

Arsenic is ubiquitous in the earth's crust in low concentrations. However, elevated levels can be found in mineral deposits and ores that were formed due to specific geological conditions (volcanic rock, phosphate and sulfide mineral deposits). Arsenic from such deposits leaches into the groundwater in the form of arsenite (AsO_3^{3-}) and arsenate (AsO_4^{3-}), causing its contamination.

In addition to the arsenic originating from natural sources, industry and agriculture contribute to the contamination to a lower extent. The World Health Organization (WHO) recommends a maximum arsenic content in drinking water of 10 $\mu\text{g/L}$.



Total arsenic determination

Analysis basics

As(V) is electrochemically inactive. Therefore, to be measured, it must be reduced in situ to As(III) by nascent hydrogen. Together with the As(III) present in the sample, As(V) is electrochemically reduced to As(0) and simultaneously deposited on a gold electrode in the deposition step. In the determination step, the accumulated As(0) is reoxidized to As(III) producing the analytical signal.

Sample preparation

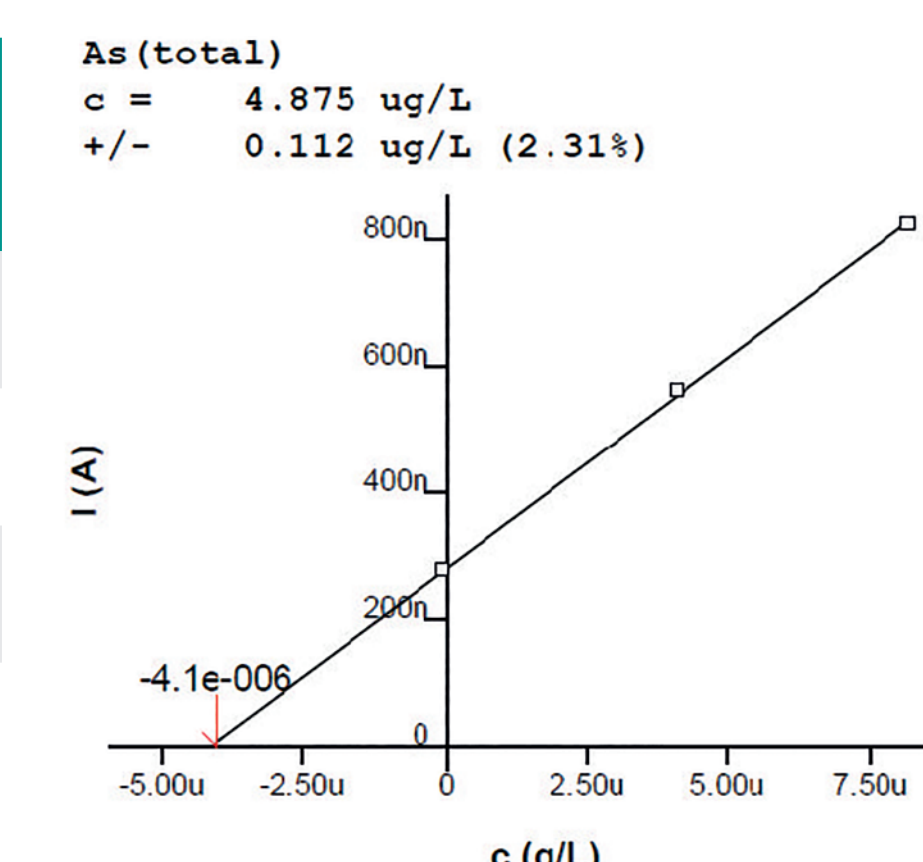
Usually, groundwater, drinking water, and mineral water can be analyzed directly. Water that contains low-to-medium levels of organic contamination is treated with the 909 UV Digester. 10 mL of acidified water sample ($\text{pH} = 2$) is mixed with 10 μL of 65% HNO_3 and 50 μL of 30% H_2O_2 , then irradiated with UV for 90 min at 90 °C.



Voltammetric analysis

10 mL of the sample is pipetted into a measuring cell and 2 mL of the supporting electrolyte (1 mol/L sulfamic acid, 0.5 mol/L citric acid, and 0.45 mol/L KCl) is added. The concentration of total As is quantitatively determined using the standard addition method with two additions of As(V) standard solution.

Deposition time	Detection limit	Linear range
30 s	2.1 $\mu\text{g/L}$	40 $\mu\text{g/L}$
60 s	0.9 $\mu\text{g/L}$	20 $\mu\text{g/L}$
90 s	0.7 $\mu\text{g/L}$	7 $\mu\text{g/L}$



Determination of arsenic(III)

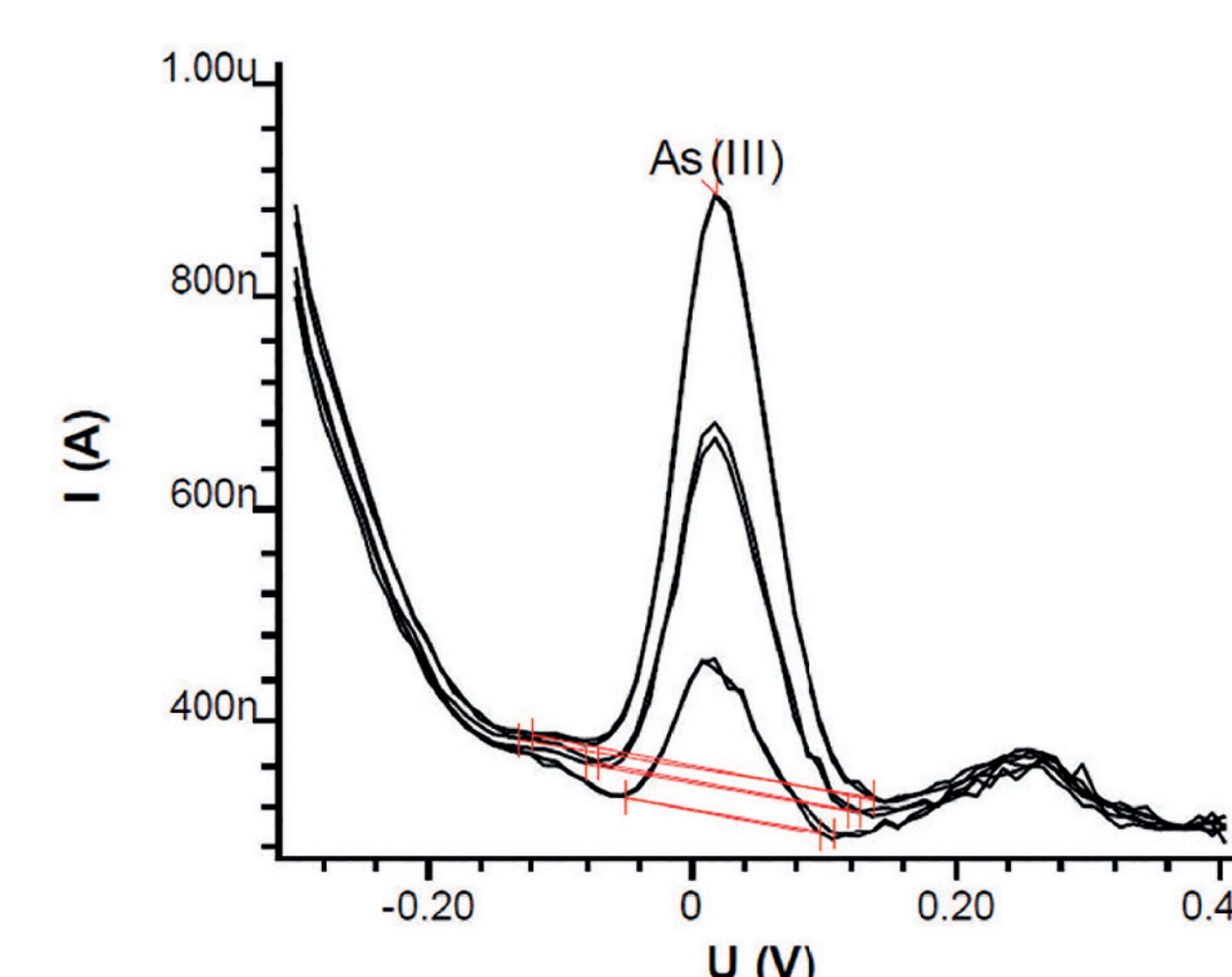
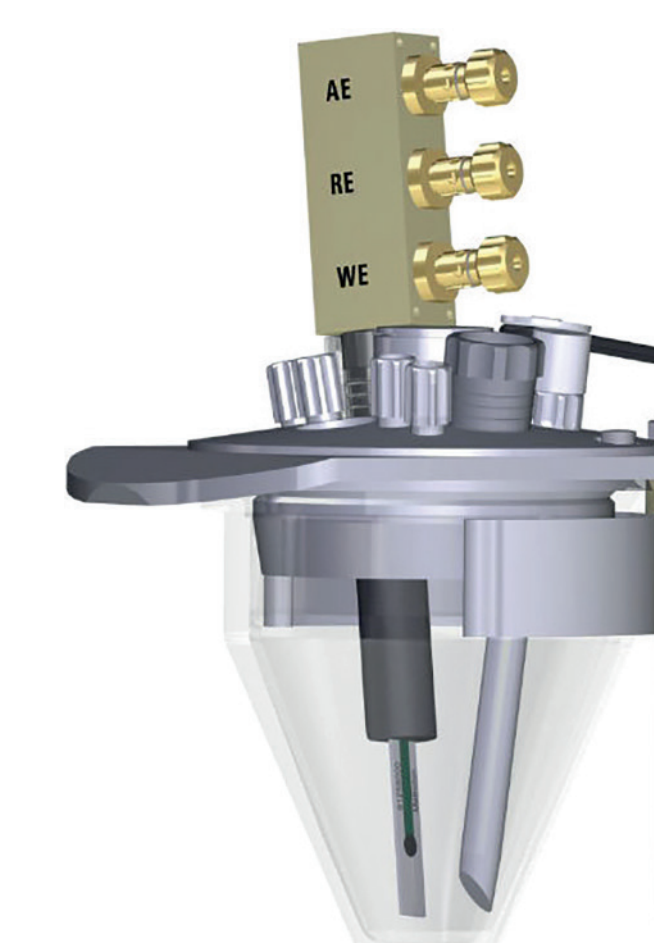
Analysis basics

The negative potential used to accumulate As(III) on the electrode is lower than the one used for total arsenic determination. At the given potential value, only As(III) ions are reduced to elemental arsenic and deposited on the gold working electrode.

As(V) is not reduced or deposited under these conditions. In the stripping step, the deposited As(0) is reoxidized to As(III), producing the analytical signal.

Sample preparation

Usually, groundwater, drinking water, and mineral water can be analyzed directly. Determination of As(III) is not possible if the sample has to be mineralized. In such case, only total arsenic can be measured.



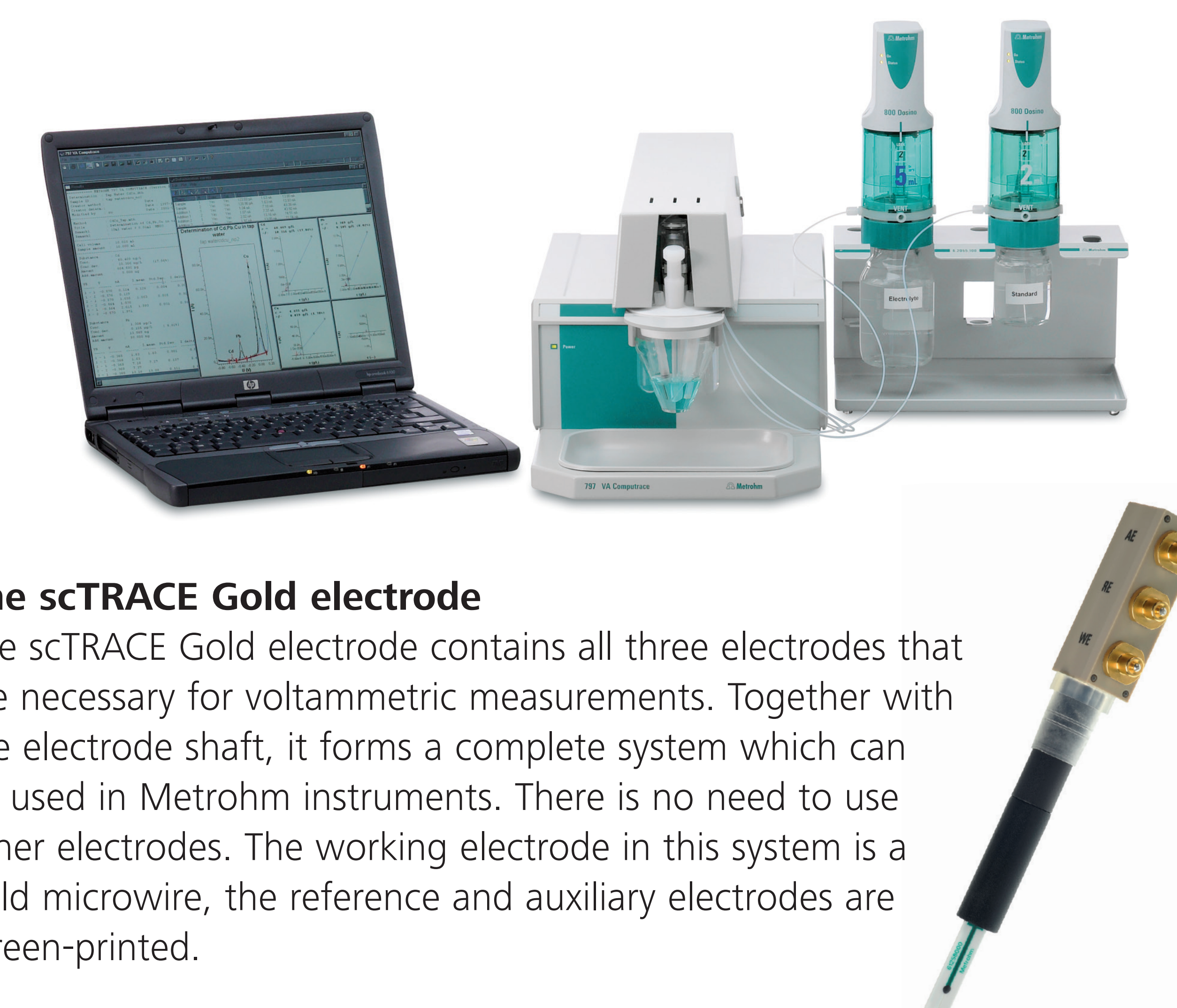
Voltammetric analysis

10 mL of the sample is pipetted into the measuring vessel and 2 mL of the supporting electrolyte is added. The concentration of As(III) is quantitatively determined using the standard addition method, with two additions of As(III) standard solution.

Deposition time	Detection limit	Linear range
30 s	0.5 $\mu\text{g/L}$	30 $\mu\text{g/L}$
60 s	0.3 $\mu\text{g/L}$	21 $\mu\text{g/L}$
90 s	0.2 $\mu\text{g/L}$	11 $\mu\text{g/L}$

Analytical system

The determination of arsenic in surface water and groundwater samples was carried out using anodic stripping voltammetry with the scTRACE Gold electrode as the working electrode.



The scTRACE Gold electrode

The scTRACE Gold electrode contains all three electrodes that are necessary for voltammetric measurements. Together with the electrode shaft, it forms a complete system which can be used in Metrohm instruments. There is no need to use other electrodes. The working electrode in this system is a gold microwire, the reference and auxiliary electrodes are screen-printed.

Unlike other solid-state electrodes, the scTRACE Gold does not require any time-consuming conditioning before use. The only action required before the first measurement is its initial activation, which takes approximately 10 minutes.

Summary

The application allows the determination of both total arsenic and As(III).

Setting the deposition time to 60 s, the limit of detection (LOD) obtained was 0.9 $\mu\text{g/L}$ for total As and 0.3 $\mu\text{g/L}$ for As(III).

References

- (1) Metrohm Application Bulletin AB-416, Determination of arsenic in water with scTRACE Gold.
<http://www.metrohm.com/applications/#query=AB-416>
- (2) The multipurpose poison, Metrohm Information 1/2014, pp. 16–19.
<http://www.metrohm.com/applications/#query=multipurpose%20poison>