

Aluminum in Soils

Photometric determination with Chrome azurole S subsequent to acid extraction

Introduction

The assessment of mobile aluminum in soil is essential for evaluating soil quality and its suitability for plant growth, particularly in acidic environments where Al^{3+} toxicity can limit nutrient uptake and impair crop productivity.¹ Elevated aluminum levels can interfere with the availability of key nutrients such as phosphorus, calcium, and magnesium, making its routine monitoring important for agricultural and environmental analyses.¹

Photometric techniques are commonly used for the routine determination of aluminum in soil extracts due to their simplicity and suitability for laboratory workflows. As Al^{3+} ions do not exhibit intrinsic absorbance in the visible region, these methods rely on the formation of colored complexes between aluminum ions and suitable chromogenic reagents, enabling quantification in the visible range.¹

This protocol provides a practical and efficient approach for the determination of mobile aluminum in soil extracts, supporting routine soil assessment across a range of sample types.

Experimental

This application note details the photometric determination of aluminium in soils, using the Chrome azurole S method, after its extraction with acid solution.

Method

In weakly acidic, acetate-buffered solution aluminium ions react with Chrome azurole S to form a blue-violet compound that is determined photometrically. Due to the intrinsic orange coloration of the reagent blank, the measurement solution is orange-red to red in color.

The method is analogous to APHA 3500-Al B and DIN ISO 10566.

Measuring Range

Spectroquant® Aluminium Cell Test (1.00594)	Test kit: 0.020–1.20 mg/L Al Method: 0.40–24.0 mg/kg Al
Spectroquant® Aluminium Test (1.14825)	Test kit: 0.02–0.50 mg/L Al Method: 0.40–10.0 mg/kg Al

Applicable Sample

Soil samples

Reagents, Instruments and Materials

Test/Reagent Kit(s)

For the measurement one of the following Spectroquant® test kits is necessary:

- Spectroquant® Aluminium Cell Test (1.00594)
- Spectroquant® Aluminium Test (1.14825)

Instrument(s) & Devices

For the measurement one of the following Spectroquant® photometers is necessary:

- Spectroquant® VIS Spectrophotometer Prove 100 plus (1.73026)
- Spectroquant® UV/VIS Spectrophotometer Prove 300 plus (1.73027)
- Spectroquant® UV/VIS Spectrophotometer Prove 600 plus (1.73028)
- Spectroquant® Colorimeter Move 100 (1.73632)

Note: Also, legacy Spectroquant® instruments are suitable.

Software for Data transfer

- Optional Spectroquant® Prove Connect to LIMS software package (Y.11086) to transfer your data into an existing LIMS system.

Instrument Accessories

If the Spectroquant® Aluminium Test (1.14825) choose one of the following cells depending on the measuring range:

- Rectangular cells 10 mm (1.14946)
- Rectangular cells 20 mm (1.14947)
- Rectangular cells 50 mm (1.14944)

Other Reagents and Accessories

- Hydrochloric acid 25% for analysis (**1.00316**)
- Hydrochloric acid 1 mol/L for analysis (**1.09970**)
- Sodium hydroxide solution 10% for analysis (**1.05588**)
- MQuant® Universal Indicator strips pH 0–14 (**1.09535**)
- MQuant® Indicator strips pH 0–6 (**1.09531**)
- Water for analysis (**1.16754**)
- Charcoal activated for soil tests
- Analytical balance
- pH meter
- Standard laboratory glassware (e.g., glass beakers) and pipettes
- Spatula
- Stirring plate or shaker
- Folded filter

Analytical Procedure

Sample Preparation

- In a glass beaker place 10 g of air – dried and sieved (mesh 2 mm) sample with 100 mL hydrochloric acid 1 mol/L and a spatula – tipfull of charcoal activated for soil tests and mix well for 1 hour. The pH - value should be 1–2 (check with MQuant® Indicator strips). If necessary, adjust with hydrochloric acid 25%.
- Afterwards adjust the pH value of the suspension to 3.0 with sodium hydroxide solution 10%, using the pH meter.
- Then remove the undissolved matter by filtration through a folded filter and wash the filter residues 3 times with water for analysis.
- Collect the filtrate and the washings in a 200-mL volumetric flask, finally fill up to volume with water for analysis and mix well.

Using Cat. No. 1.00594: Procedure and measurement

For more information on the measurement see the packaging insert of the test

Procedure

- Pipette 6.0 mL pretreated sample into a reaction cell and mix.
- Add 1 level blue microspoon (in the cap of the Al-1K bottle), close the cell tightly, and shake vigorously until the reagent is completely dissolved.
- Add 0.25 mL Reagent Al-2K with a pipette and mix.
- Leave to stand for 5 min (reaction time), then measure the sample in the photometer.

Measurement

- For photometric measurement the cells must be clean. Wipe, if necessary, with a clean dry cloth.

- Measurement of turbid solutions yields false-high readings.
- Aluminium-free samples turn orange on addition of reagents Al-1K and Al-2K.
- The pH of the measurement solution must be within the range 5.5–6.0.
- The color of the measurement solution remains stable for 15 min after the end of the reaction time stated above.

Hints for Measurement

- It is recommended to zero the method each new working day. To do this, open the method, either by manually selecting the method or by inserting a barcoded cell. Tap the <Settings> button and select the <ZERO ADJUSTMENT> menu item. After prompting, insert the 16 mm zero cell through the corresponding opening. The zero adjustment is performed automatically. Confirm the performance of the zero-adjustment procedure by clicking on <OK>.
- After the zero has been performed, insert the barcoded Spectroquant® round cell through the corresponding opening, ensuring that the white position mark on the cell is aligned with the positioning mark on the spectrophotometer. The measurement starts automatically.
- Read off the result in mg/L from the display.

Hint: The above written measurement description is only valid for the Spectroquant® Prove (plus) series photometer. If a different instrument is used, please consult the corresponding instrument manual for more details on how to perform the measurement.

Using Cat. No. 1.14825: Procedure and measurement

For more information on the measurement see the packaging insert of the test

Procedure

- Pipette 5.0 mL pretreated sample into a test tube.
- Add 1 level blue microspoon (in the cap of the Al-1 bottle) Reagent Al-1 and shake vigorously until the reagent is completely dissolved.
- Add 1.2 mL reagent Al-2 with pipette and mix.
- Add 0.25 mL reagent Al-3 with pipette and mix.
- Leave to stand for 2 min (reaction time), then fill the sample into the cell, and measure in the photometer.

Notes:

- For measurement in the 50 mm cell both the sample volume as well as the quantities of reagents Al-1, Al-2, and Al-3 must be doubled. Alternatively, the semi-microcell (**1.73502**) can be used.

- When using the 50 mm cell, perform the measurement against a separately prepared blank (preparation as per measurement sample, but with distilled water instead of sample). Configure the photometer for blank measurement.

Measurement

- Certain photometers may require a blank (preparation as per measurement sample, but with distilled water instead of sample).
- For photometric measurement the cells must be clean. Wipe, if necessary, with a clean dry cloth.
- Measurement of turbid solutions yields false-high readings.
- Aluminum-free samples turn orange on addition of reagents Al-1, Al-2, and Al-3.
- The pH of the measurement solution must be within the range 5.5–6.0.
- The color of the measurement solution remains stable for 15 min after the end of the reaction time stated above.

Hints for Measurement

- It is recommended to zero the method for each new working day. To do this, open the method by inserting the barcode, tap the <Settings> button and select the <ZERO ADJUSTMENT> menu item. Fill the same cell which will be used for the sample measurement with distilled water. After prompting, insert the filled rectangular cell into the cell compartment. The zero adjustment is performed automatically. Confirm the performance of the zero-adjustment procedure by clicking on <OK>.
- After the zero adjustment, fill the measurement sample into the same or a matched rectangular cell and insert

the cell into the cell compartment. The measurement starts automatically.

- Read off the result in mg/L from the display.

Hint: The above written measurement description is only valid for the Spectroquant® Prove (plus) series photometer. If a different instrument is used, please consult the corresponding instrument manual for more details on how to perform the measurement.

Analytical quality assurance

Analytical quality assurance (AQA) is recommended before each measurement series.

To check the photometric measurement system (test reagent, measurement device, handling) and the mode of working, the aluminium standard solution (see section 5 of the respective instruction leaflet) or Spectroquant® CombiCheck 100 can be used. Besides a standard solution with 0.40 mg/L Al, CombiCheck 100 also contains an additional solution for determining sample dependent interferences (matrix effects).

Sample-dependent interferences (matrix effects) can be determined by means of standard addition or dilution.

To view additional notes, visit

[SigmaAldrich.com/qa-test-kits](https://sigmaaldrich.com/qa-test-kits).

Calculation

Aluminium content in mg/kg Al = analysis value in mg/L Al x 20

References

- Lokhanina, S.; Trubacheva, L.; Ivanova, M.; Trubachev, A. Spectrophotometric Determination of Exchangeable (Mobile) Aluminum in Soil Using Arsenazo I. *Fine Chem. Eng.* 2025, 6 (1), 46–52. DOI: 10.37256/fce.6120255406.

Featured Products

Description	Cat. No.
Test Kits	
Spectroquant® Aluminium Cell Test	1.00594
Spectroquant® Aluminium Test	1.14825
Instruments & Accessories	
Spectroquant® VIS Spectrophotometer Prove 100 plus	1.73026
Rectangular cells 10 mm	1.14946
Rectangular cells 20 mm	1.14947
Rectangular cells 50 mm	1.14944
Semi micro cells	1.73502
Reagents & Test Strips	
Hydrochloric acid 25% for analysis	1.00316
Hydrochloric acid 1 mol/L for analysis	1.09970
Sodium hydroxide solution 10% for analysis	1.05588
MQuant® Universal Indicator strips pH 0–14	1.09535
MQuant® Indicator strips pH 0–6	1.09531
Water for analysis	1.16754

Related Products

Description	Cat. No.
Instruments & Software	
Spectroquant® UV/VIS Spectrophotometer Prove 300 plus	1.73027
Spectroquant® UV/VIS Spectrophotometer Prove 600 plus	1.73028
Spectroquant® Colorimeter Move 100	1.73632
Spectroquant® Prove Connect to LIMS software package	Y.11086
Reference Materials	
Spectroquant® CombiCheck 100	1.18701
Spectroquant® Aluminium standard solution, 0.200 mg/L Al	1.32225
Reagents, Test Strips, & Accessories	
Semi-microcells 50 mm (2 pcs)	1.73502
Sulfuric acid 95–97% for analysis EMSURE®	1.00731
Spectroquant® Crack Set 10	1.14687
Spectroquant® Crack Set 10C	1.14688
MQuant® pH-indicator strips pH 5.0–10.0	1.09533
Sodium hydroxide solution 1 mol/L Titripur®	1.09137
Sulfuric acid 0.5 mol/L Titripur®	1.09072
2-Propanol for analysis EMSURE®	1.09634

For more information visit us at SigmaAldrich.com/photometry



To place an order or receive technical assistance:
SigmaAldrich.com/support



For local contact information:
SigmaAldrich.com/offices

MilliporeSigma
400 Summit Drive
Burlington, MA 01803
SigmaAldrich.com

We have built a unique collection of life science brands with unrivalled experience in supporting your scientific advancements.

Millipore® Sigma-Aldrich® Supelco® Milli-Q® SAFC® BioReliance®

© 2026 Merck KGaA, Darmstadt, Germany and/or its affiliates. All Rights Reserved. MilliporeSigma, the vibrant M, BioReliance, Millipore, Milli-Q, SAFC, Sigma-Aldrich, Supelco, Spectroquant, MQuant, EMSURE and Titripur are trademarks of Merck KGaA, Darmstadt, Germany or its affiliates. All other trademarks are the property of their respective owners. Detailed information on trademarks is available via publicly accessible resources.

MS_AN14524EN Ver. 1.0 71276 08/2026

