

Boron in Soils

Photometric determination with Azomethine H or Curcumin subsequent to extraction

Introduction

The determination of boron in soil is important for assessing soil fertility and plant-available micronutrient levels, particularly in agricultural systems where both deficiency and excess can impact crop performance. Boron is typically present in soils at concentrations ranging from approximately 5 to 150 mg/kg, with plant-available levels required to be maintained within a narrow range to avoid deficiency or toxicity.¹

In soil systems, boron predominantly exists as boric acid or borate species, with its availability influenced by factors such as soil pH, texture, and organic matter content. Plants take up soil boron in the form of boric acid (H_3BO_3) under acidic conditions or as tetrahydroxyborate $[B(OH)_4]^-$ at neutral to alkaline pH. Accurate quantification of this fraction is therefore necessary to evaluate boron availability across different soil matrices.²

A variety of analytical methods are available for boron determination, including ICP, AAS, and mass spectrometry techniques. However, these often require expensive instrumentation and complex sample preparation. In contrast, spectrophotometric methods are widely used for routine analysis due to their simplicity, low cost, and availability. These methods are based on the formation of colored complexes between boron species and specific reagents, with azomethine H and curcumin among the most commonly applied.³

Experimental

This application note details the photometric determination of boron in soils, using the curcumin method, after its extraction.

Method

Azomethine H method (used in Boron Cell Test 1.00826): In a weakly acidic solution borate reacts with azomethine H to form a yellow compound that is determined photometrically.

The method is analogous to DIN 38405-17.

Curcumin method (used in Boron Test 1.14839): In acidic solution borate ions react with a diol to form chelates that are selectively extracted. In the extract the chelates react with curcumin to form a red complex that is determined photometrically.

The method is analogous to EPA 212.3, APHA 4500-B B, and ASTM D3082-15.

Measuring Range

Spectroquant® Boron Cell Test (1.00826)	Test kit: 0.05–2.00 mg/L B
	Method: 0.10–4.00 mg/kg B
Spectroquant® Boron Test (1.14839)	Test kit: 0.050–0.800 mg/L B
	Method: 0.100–1.600 mg/kg B

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® Boron Cell Test (1.00826)
- Spectroquant® Boron Test* (1.14839)

* Not compatible with Move 100

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

- Rectangular cells 10 mm (**1.14946**)
- Rectangular cells 20 mm (**1.14947**)

Other Reagents and Accessories

- Water for analysis (**1.16754**)
- Acetic acid 100% for analysis (**1.00063**)
- Ammonium nitrate for analysis (**1.01188**)
- Ammonium fluoride for analysis (**1.01164**)
- Titriplex® III for analysis (**1.08418**)
- Nitric acid 0.1 mol/L (**1.09964**)
- Analytical balance
- Standard laboratory glassware (e.g., glass beakers) and pipettes
- Sieve
- Polyethylene bag
- Water bath
- Folded filter

Analytical Procedure

Extraction solution

- Dissolve 6 g acetic acid 100% for analysis, 10 g ammonium nitrate for analysis, 0.28 g ammonium fluoride for analysis, 0.19 g Titriplex® III for analysis and 65 mL 0.1 M nitric acid with water for analysis in a 500-mL volumetric flask, mix and fill up to volume with water for analysis.

Sample Preparation

- Place 20 g of dried and sieved sample of soil in a polyethylene bag (alternative to glass due to the B - content) with 40 mL extraction solution in a boiling water bath for 5 minutes.
- After cooling, filter through a folded filter. If the filtrate is not clear, it should be re-filtered.

Using Cat. No. 1.00826: Procedure and Measurement

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

Procedure

- Pipette 1.0 mL Reagent B-1K into a reaction cell and mix.
- Add 4.0 mL Pretreated sample with pipette, close the cell, and shake (15–40 °C) until the reagent is completely dissolved.
- Leave to stand for 60 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.
- The pH of the measurement solution must be within the range 5.2–6.0.
- The color of the measurement solution remains stable for at least 60 min after the end of the reaction time stated above.
- The reaction cell contains a lyophilized reagent whose appearance and shape may change during storage. This has no effect on the functionality of the boron cell test and does not represent a reduction in quality.

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. 1.14839: 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 with screw cap.

- Add 1.0 ml Reagent B-1 with a pipette and mix. The pH must be below 1. Check with MQuant® pH-indicator strips. Adjust the pH, if necessary, by adding reagent B-1 dropwise.
 - Add 1.5 mL Reagent B-2 carefully with a pipette (Attention! The reagent contains chloroform!), close the test tube tightly, and shake vigorously for 1 min → lower (organic) phase = extract
 - Withdraw 0.50 mL Extract with pipette and transfer to the second test tube.
 - Add 0.80 mL Reagent B-3 (Hold the bottle vertically while adding the reagent!) to the second tube with pipette, close tightly, and mix.
 - Add 4 drops Reagent B-4 (Hold the bottle vertically while adding the reagent!) to the second tube, close tightly, and mix.
 - Carefully (Attention! The reagent contains concentrated sulfuric acid! Wear eye protection!) add 18 drops Reagent B-5 (Hold the bottle vertically while adding the reagent! The bottle containing the reagent B-5 may become discolored. Any discoloration has no negative impact on the functionality of the test.) to the second tube, close tightly, and mix.
 - Leave to stand for 12 min (reaction time A).
 - Add 6.0 mL Reagent B-6 to the second test tube with pipette, close tightly, and mix.
 - Leave to stand for 2 min (reaction time B), then fill the sample into a 10 mm cell, and measure in the photometer.
- Notes:** Due to the temperature dependence of the color reaction, both the sample and the reagents should have a temperature of at least 20 °C.

Measurement

- Certain photometers may require a blank (preparation as per measurement sample, but with distilled water instead of sample).
- The blank is yellow in color. 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.
- The color of the measurement solution remains stable for at least 60 min after the end of the reaction time B 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 reagents, measurement device, handling) and the mode of working, a diluted boron standard solution containing 1.00 mg/l B or 0.400 mg/L B, respectively can be used.

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

Boron content in mg/kg B = analysis value in mg/L B x 2

References

1. Pawong, K. *Development for Boron Analysis Method in Soil Using a Fluorescence Sensor*; Doctoral Dissertation, Mae Fah Luang University, Learning Resources and Educational Media Centre. <https://mfuir.mfu.ac.th/jspui/bitstream/123456789/1450/1/140516-Fulltext.pdf> (accessed 2026-07-13).
2. Vera-Maldonado, P.; Aquea, F.; Reyes-Díaz, M.; Cárcamo-Fincheira, P.; Soto-Cerda, B.; Nunes-Nesi, A.; Inostroza-Blancheteau, C. Role of Boron and Its Interaction with Other Elements in Plants. *Front. Plant Sci.* **2024**, *15*, 1332459. DOI: 10.3389/fpls.2024.1332459.
3. Carrero, P.; Malavé, A.; Rojas, E.; Rondón, C.; de Peña, Y. P.; Burguera, J. L.; Burguera, M. On-Line Generation and Hydrolysis of Methyl Borate for the Spectrophotometric Determination of Boron in Soil and Plants with Azomethine-H. *Talanta* **2005**, *68* (2), 374–381. DOI: 10.1016/j.talanta.2005.08.058.

Featured Products

Description	Cat. No.
Test Kits	
Spectroquant® Boron Cell Test	1.00826
Spectroquant® Boron Cell Test	1.14839
Instruments & Accessories	
Spectroquant® VIS Spectrophotometer Prove 100 plus	1.73026
Rectangular cells 10 mm	1.14946
Rectangular cells 20 mm	1.14947
Reagents	
Water for analysis	1.16754
Acetic acid 100% for analysis	1.00063
Ammonium nitrate for analysis	1.01188
Ammonium fluoride for analysis	1.01164
Titriplex® III for analysis	1.08418
Nitric acid 0.1 mol/L	1.09964

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	
Boron standard solution Certipur®, 1000 mg/L B	1.19500
Reagents & Test Strips	
MQuant® pH-indicator strips pH 0–6.0	1.09531
MQuant® Universal indicator strips pH 0–14	1.09535
Sodium hydroxide solution 1 mol/L Certipur®	1.09137
Nitric acid Titrisol® for 1 mol/L	1.09966

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, Titriplex, Titrisol, and Certipur 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_AN14525EN Ver. 1.0 71275 07/2026

