Supelco®
Analytical Products

Manual
Methods for color measurements

Spectroquant®
Prove

MilliporeSigma

Contents

Methods

* not for Spectroquant® Prove 100

Introduction

I Colorimetry

The perception of color and its interpretation play an essential role in everyday life. In nature, for example, red and yellow count as warning colors. With their bright yellow or vivid red appearance, poison-dart frogs scare off their potential enemies, thus securing their survival and at the same time signalling their toxicity. The effect of these colors is used to communicate messages in many areas of everyday life, for instance in the form of signalling systems, mandatory instructions, and warning signs. In the food area, the colors can provide valuable information on the maturity of the product. Whenever products like paper or drinking water are affected, discolorations are an andesirable effect and are taken as an indication of contamination or impurity. In other applications, however, a comparison of colors plays a major role. These include, for instance, the assessment of the quality of beer, surfaces, printing inks, paints, and oils, the analysis of printed materials – or using color scales to assess detection reactions, e.g. in the determination of the pH of products using pH test strips.
In the easiest cases, the human eye is the ideal tool for the assessment of a color. The differences in perception of colors between one person and the next, however, can result in considerable variances in the final interpretation. This is why color scales or color charts, colored solutions, or color glasses are used in many cases to facilitate an objective color comparison or color match. The most important color scales used in this regard are the Ph Eur and the US Pharmacopoeia color scales, the Hazen or Pt/Co color scale, and the iodine color value. Beyond these, colors can be compared visually using color systems such as the RAL® or Pantone® systems, for which there are a broad variety of sample books and charts as well as catalogues depicting innumerable color nuances covering the entire visual color spectrum.
One weakness of the visual method for comparing colors – besides the influence of the individual observer – is the impact of other factors, with the ambient light, for instance, or the angle of observation, or the distance between the observer and the object – all potentially affecting the way in which the color is perceived. As a measure to prevent these – in some cases subjective – factors from distorting the objective results, many scientists resort to spectral methods using state-of-the-art measurement instruments. These devices run a wavelength scan over the entire visual spectrum (approx. 360 nm to 800 nm) or measure at specific wavelengths, determining the reflection or transmission or else the absorption of the sample ander investigation. The results can then be used to calculate the most varied color spaces (e.g. LAB, LUV), color values (e.g. Gardner, Saybolt), or fine color gradations (e.g. EBC, ICUMSA).
The precise conditions for measurement and the principle by which results are calculated are described in the individual method descriptions of this manual or in the cited technical Literature.

Note
The measurement conditions and the calculation formulae of the colorimetric methods are pre-programmed in the Prove spectrophotometers. After selecting the method, the device menu guides the user through the procedure. The measurement results are automatically calculated and shown in the spectrophotometer display.

II Overview of methods

Parameter	Standard	Sample material	Measuring range	Method principle	Method No.	Photometer Prove
ADMI color measurement	APHA 2120 F	Liquid samples	2.0 - 100.0 ADMI 10 - 600 ADMI 10 - 1000 ADMI	Transmittances from 400 - 700 nm	2518 2517 2516	100, 300, 600
Anisidine value	ISO 6885, DGF C-VI 6e	Animal and vegetable fats and oils	0.0 - 200.0 AV	Color comparison at 350 nm	2584	100, 300, 600
ASTM color measurement	ASTM D6045	Liquid samples, petroleum products	0.5 - 8.0 ASTM	Transmittances from 380 - 780 nm	2562	100, 300, 600
CIE color distance	DIN EN 11664-4, DIN 5033-3	Liquid samples	ΔE*ab 0.00 - 200.00 ΔL* -200.00 - 200.00 Δa*-200.00 - 200.00 Δb*-200.00 - 200.00 ΔC*ab -200.00 - 200.00	Comparative measurement of transmittances from 360 - 780 nm	2584	100, 300, 600
CIELAB color space (brightness, chroma)	DIN EN 11664-4, DIN 5033-3	Liquid samples	ΔE*ab 0.00 - 200.00 ΔL* -200.00 - 200.00 Δa*-200.00 - 200.00 Δb*-200.00 - 200.00 ΔC*ab -200.00 - 200.00	Comparative measurement of transmittances from 360 - 780 nm	2584	100, 300, 600
CIELUV color space	DIN 5033-3, ISO CIE 11664-5	Liquid samples	L* 0.00 - 105.00 u* -180.0 - 180.0 v* -180.0 - 180.0 C*uv 0.00 - 300.00 S*uv 0.000 - 200.000	Transmittances from 360 - 780 nm	2581	100, 300, 600
CIExyY color space	CIE 15:2004, Technical Report - Colorimetry	Liquid samples	x 0.0000 - 0.8000 y 0.0000 - 0.8000 Y 0.000 - 200.000	Transmittances from 360 - 780 nm	2582	100, 300, 600
Color (ASBC method)	ASBC Method Beer-10, ASBC Method Wort-9	Beers, worts, liquid malt substitutes	0.0 - 50.0 °SRM 0.0 - 100.0 EBC Units	Absorption at 430 nm	2633	100, 300, 600
Color (EBC method)	MEBAK Method 2.13.2, EBC Method 8.5 and 9.6	Beers, worts, liquid malt substitutes	0.0 - 60.0 °SRM	Absorption at 430 nm	2602	100, 300, 600
Color Hazen						
340 nm	-	Yellow to yellow-brownish liquid samples	0.2 - 500 CU	Absorption at 340 nm	32	100, 300, 600
445 nm	DIN EN ISO 6271, ASTM D 1209-05	Yellow to yellow-brownish liquid samples	1 - 1000 CU	Absorption at 445 nm	179	100, 300, 600
455 nm	DIN EN ISO 6271, APHA 2120C, ASTM D 1209-05	Yellow to yellow-brownish liquid samples	1 - 1000 CU	Absorption at 455 nm	180	100, 300, 600
465 nm	DIN EN ISO 6271, APHA 2120C, ASTM D 1209-05	Yellow to yellow-brownish liquid samples	1 - 1000 CU	Absorption at 465 nm	181	100, 300, 600
Color 410 acc. to EN 7887	DIN EN ISO 7887:2011 Verfahren C	Water from water-treatment plants	2 - 2500 CU	Absorption at 410 nm	303	100, 300, 600

Parameter	Standard	Sample material	Measuring range	Method principle	Method No.	Photometer Prove
Color – Spectral absorption coefficient acc. to DIN EN ISO 7887						
436 nm	DIN EN ISO 7887:2011 - Verfahren B, deutsche Trinkwasserverordnung Anlage 3, No. 7	Water from water-treatment plants	0.1 - 250.0 m^{-1}	Absorption at 436 nm	15	100, 300, 600
SAK α(436)	DIN EN ISO 7887:2011 - Verfahren B, deutsche Trinkwasserverordnung Anlage 3, No. 7	Water from water-treatment plants	0.1 - 250.0 m^{-1}	Absorption at 436 nm	302	100, 300, 600
525 nm	DIN EN ISO 7887:2011 - Verfahren B	Water from water-treatment plants	0.1 - 250.0 m^{-1}	Absorption at 525 nm	61	100, 300, 600
620 nm	DIN EN ISO 7887:2011 - Verfahren B	Water from water-treatment plants	0.1 - 250.0 m^{-1}	Absorption at 620 nm	78	100, 300, 600
436, 525 and 620 nm	DIN EN ISO 7887:2011 - Verfahren B	Water from water-treatment plants	0.0 - 250.0 m^{-1}	Absorption at 436, 525 and 620 nm	2588	100, 300, 600
Gardner color measurement	DIN EN ISO 4630-2, ASTM D6166	Clear, yellow to yellow-brownish liquid samples, products made of natural resins	1.0 - 18.0 Gardner	Transmittances from 360 - 780 nm	2561	100, 300, 600
Hess-Ives color scale	DGK Prüfmethode F 050.2	Fat derivatives, surfactants	0.0 - 400 H-I	Absorption at 460, 470, 560 and 640 nm	2586	100, 300, 600
Hunter color distance	HunterLab Application Note Vol. 8, No. 9, 06/08	Liquid samples	ΔE^*_H 0.00 - 200.00 ΔL* -200.00 - 200.00 Δa*-200.00 - 200.00 Δb*-200.00 - 200.00	Transmittances from 360 - 780 nm	2585	100, 300, 600
HunterLab color space	HunterLab Application Note Vol. 8, No. 9, 06/08	Liquid samples	L* 0.00 - 105.00 a* -180.0 - 180.0 b* -180.0 - 180.0	Transmittances from 360 - 780 nm	2583	100, 300, 600
ICUMSA Color $GS1_{/3}$-7 (2011)	ICUMSA Methods Book $GS1_{/3}$-7 (2011)	Sugar with a color factor >250 $IU_{7.0}$ (raw sugar, strongly colored white sugar from plantations, partly refined brown sugar, sugar syrup)	0 - 50 000 $IU_{7.0}$	Absorption at 420 nm, sample adjusted to pH 7	2548	100, 300, 600
ICUMSA Color $GS2_{/3}$-9 (2005)	ICUMSA Methods Book $GS2_{/3}$-9 (2005)	Sugar with a color factor up to 600 $IU_{7.0}$ (crystalline white sugar, icing sugar, sugar syrup)	0 - 600 $IU_{7.0}$	Absorption at 420 nm, sample adjusted to pH 7	2549	100, 300, 600

II Overview of methods

Parameter	Standard	Sample material	Measuring range	Method principle	Method No.	Photometer Prove
ICUMSA Color $GS2_{/3}$-10 (2011)	ICUMSA Methods Book $GS2_{/3}$-10 (2011)	Sugar with a color factor up to 50 IU (crystalline white sugar, icing sugar, sugar syrup)	0 - 50 IU	Absorption at 420 nm	2550	100, 300, 600
ICUMSA Color $GS9_{/1/2/3}$-8 (2011)	ICUMSA Methods Book $GS9_{/1/2/3}$-8 (2011)	Sugar with a color factor up to 16000 $IU_{7.0}$ (raw sugar, white sugar from plantations, refined raw sugar)	0 - 20 000 $IU_{7.0}$	Absorption at 420 nm, sample adjusted to pH 7	2551	100, 300, 600
Iodine color number						
445 nm	DIN 6162, DGF C-IV 4 a, F-I 2 and H-II 3	Yellow to yellow-brown liquid samples	0.2 - 50.0	Absorption at 445 nm	21	100, 300, 600
340 nm	DIN 6162, DGF C-IV 4 a, F-I 2 and DGF H-II 3	Yellow to yellow-brown liquid samples, preferentially for weakly colored samples	0.010 - 3.00	Absorption at 340 nm	33	100, 300, 600
Klett color index	-	Clear, yellow to yellow-brown liquids	0 - 1000 Klett417	Absorption at 417 nm	311	100, 300, 600
Saybolt color measurement	ASTM D6045	Liquid samples, Petroleum products	-16.0 - 31.0 Saybolt (50-mm cell) -16.0 - 31.0 Saybolt (100-mm cell)	Transmittances from 380 - 780 nm	2563 2564	100, 300, 600
Spectral absorption coefficient						
254 nm (SAC α(254))	DIN 38404-3	Water from water-treatment plants, surface water	0.1 - 250 m^{-1}	Absorption at 254 nm filtered sample	300	300, 600
436 nm (SAC α(436))	DIN EN ISO 7887 - Verfahren B, deutsche Trinkwasserverordnung Anlage 3, No. 7, EU-Trinkwasserrichtlinie 98/83/EG	Water from water-treatment plants	0.1 - 250 m^{-1}	Absorption at 436 nm filtered sample	302	100, 300, 600
Spectral attenuation coefficient 254 nm						
254 nm (SAC μ(254))	DIN 38404-3	Water from water-treatment plants, surface water	0.1 - 250 m^{-1}	Absorption at 254 nm, unfiltered sample	301	300, 600
254 nm (SAC μ(254)), corrected	DIN 38404-3	Uncolored water from water-treatment plants, uncolored surface water	0.0 - 250 m^{-1}	Absorption at 254 and 550 nm, unfiltered, uncolored sample	2571	300, 600
Tint index	ASTM E313-15	Liquid samples	-6.00 - 3.00 TI_{10mm} (10-mm cell) -6.00 - 3.00 TI_{50mm} (50-mm cell)	Transmittances from 380 - 780 nm	2577 2578	100, 300, 600
Transmittances T_X, T_Y, T_Z	DIN EN 1557	Liquid samples	T_X 0.0 - 150.0 T_Y 0.0 - 150.0 T_Z 0.0 - 150.0	Transmittances from 380 - 780 nm	2579	100, 300, 600

Parameter	Standard	Sample material	Measuring range	Method principle	Method No.	Photometer Prove
UV-absorbing organic matter	APHA 5910	Water from water-treatment plants, surface water, seawater	0.0000 - 1.000 A/cm 0.0000 - 1.000 cm^{-1} 0.0 - 100 mm^{-1}	Absorption at 254 nm filtered sample	309	300, 600
UV absorption 254 nm	APHA 5910	Water from water-treatment plants, surface water, seawater	0.0000 - 3.000 A/cm 0.0000 - 3.000 cm^{-1} 0.00 - 300.0 m^{-1}	Absorption at 254 nm filtered sample	310	300, 600
UV irradiation						
UV absorption 254 nm	-	Water from water-treatment plants, surface water, seawater	0.0000 - 3.000 A/cm 0.0000 - 3.000 cm^{-1} 0.0 - 300.0 m^{-1}	Absorption at 254 nm unfiltered sample	310	300, 600
UV- tansmis-sion 254 nm	-	Water from water-treatment plants, surface water, seawater	0.00 - 105.00 %T/cm	Absorption at 254 nm unfiltered sample	2572	300, 600
Whiteness	ASTM E313-15	Liquid samples	40.0 - 220.0 WI_{10mm} (10-mm cell) 40.0 - 220.0 WI_{50mm} (50-mm cell)	Transmittances from 380 - 780 nm	2575 2576	100, 300, 600
Yellowness	ASTM E313-15	Colorless to yellowish liquid samples	0.0 - 30.0 YI_{10mm} (10-mm cell) 0.0 - 90.0 YI_{50mm} (50-mm cell)	Transmittances from 380 - 780 nm	2573 2574	100, 300, 600

III Typical areas of application

Parameter	Samples	Food and beverage		
		Beer	Sugar	Other products
ADMI color measurement	Liquid samples			
Anisidine value	Animal and vegetable fats and oils			
ASTM color measurement	Liquid samples, petroleum products			
CIE color distance	Liquid samples			X
CIELAB color space (brightness, chroma)	Liquid samples			X
CIELUV color space	Liquid samples			X
CIExyY color space	Liquid samples			X
Color (ASBC method)	Beers, worts, liquid malt substitutes	X		
Color (EBC method)	Beers, worts, liquid malt substitutes	X		
Color Hazen				
340 nm	Yellow to yellow-brownish liquid samples			
445 nm	Yellow to yellow-brownish liquid samples			
455 nm	Yellow to yellow-brownish liquid samples			
465 nm	Yellow to yellow-brownish liquid samples			
Color 410 acc. to EN 7887	Water from water-treatment plants			
Color – Spectral absorption coefficient acc. to DIN EN ISO 7887				
436 nm	Water from water-treatment plants			
SAK α(436)	Water from water-treatment plants			
525 nm	Water from water-treatment plants			
620 nm	Water from water-treatment plants			
EN 7887	Water from water-treatment plants			
Gardner color measurement	Clear, yellow to yellow-brownish liquid samples, products made of natural resins			
Hess-Ives color scale	Fat derivatives, surfactants			
Hunter color distance	Liquid samples			X
HunterLab color space	Liquid samples			X
ICUMSA Color GS1$_{/3}$-7 (2011)	Sugar with a color factor >250 IU$_{7.0}$ (raw sugar, strongly colored white sugar from plantations, partly refined brown sugar, sugar syrup)		X	
ICUMSA Color GS2$_{/3}$-9 (2005)	Sugar with a color factor up to 600 IU$_{7.0}$ (crystalline white sugar, icing sugar, sugar syrup)		X	
ICUMSA Color GS2$_{/3}$-10 (2011)	Sugar with a color factor up to 50 IU (crystalline white sugar, icing sugar, sugar syrup)		X	
ICUMSA Color GS9$_{/1/2/3}$-8 (2011)	Sugar with a color factor up to 16000 IU$_{7.0}$ (raw sugar, white sugar from plantations, refined raw sugar)		X	
Iodine color number				
445 nm	Yellow to yellow-brown liquid samples			
340 nm	Yellow to yellow-brown liquid samples, preferentially for weakly colored samples			
Klett color index	Clear, yellow to yellow-brown liquids			

Industry								Water				Others	
Fats and oils	Petroleum products	Surfactants	Resin	Solvents	Paints and coating materials	Cosmetic products	Other products	Water from wastewater-treatment plants	Surface water	Seawater	Wastewater	Other solutions	Bacterial cultures
							X	X	X	X	X	X	
X													
	X						X					X	
					X		X					X	
					X		X					X	
					X		X					X	
					X		X					X	
								X	X		x		
X	X	X	X	X	X			X	X	X	X		
X	X	X	X	X	X			X	X	X	X		
X	X	X	X	X	X			X	X	X	X		
X	X	X	X	X	X			X	X	X	X		
							X					X	
								X	X		X		
								X	X		X		
								X	X		X		
								X	X		X		
								X	X		X		
X	X	X	X	X	X		X	X	X			X	
X		X				X							
					X		X					X	
					X		X					X	
X	X		X	X	X								
X	X		X	X	X								
X	X	X	X	X	X	X	X					X	X

III Typical areas of application

Parameter	Samples	Food and beverage		
		Beer	Sugar	Other products
Saybolt color measurement	Liquid samples, petroleum products			
Spectral absorption coefficient				
254 nm (SAC α(254))	Water from water-treatment plants, surface water			
436 nm (SAC α(436))	Water from water-treatment plants			
Spectral attenuation coefficient				
254 nm (SAC μ(254))"	Water from water-treatment plants, surface water			
254 nm (SAC μ(254)), korrigiert"	Uncolored water from water-treatment plants, uncolored surface water			
Tint index	Liquid samples			
Transmittances T_X, T_Y, T_Z	Liquid samples			
UV-absorbing organic matter	Water from water-treatment plants, surface water, seawater			
UVabsorption 254 nm	Water from water-treatment plants, surface water, seawater			
UV irradiation	Water from water-treatment plants, surface water, seawater			
UV absorption 254 nm	Water from water-treatment plants, surface water, seawater			
UV transmission 254 nm	Water from water-treatment plants, surface water, seawater			
Whiteness	Liquid samples			
Yellowness	Colorless to yellowish liquid samples			

Industry								Water				Others	
Fats and oils	Petroleum products	Surfactants	Resin	Solvents	Paints and coating materials	Cosmetic products	Other products	Water from wastewater-treatment plants	Surface water	Seawater	Wastewater	Other solutions	Bacterial cultures
X	X		X		X								
								X	X		X		
								X	X		X		
								X	X		X		
								X	X		X		
X	X	X	X	X	X			X	X	X	X		
X	X	X	X	X	X			X	X		X		
								X	X	X	X		
								X	X	X	X		
								X	X	X	X		
								X	X	X	X		
X	X	X	X	X	X		X	X	X	X			
X	X	X	X	X	X		X	X	X			X	

Methods

1 ADMI color measurement

1.1 Method

The ADMI color scale originates from the "American Dye Manufacturers Institute" (ADMI) and is defined, just like the Pt/Co color scale, by the color of hexachloroplatinate solutions.
The ADMI value is determined by measuring the transmittances (transmittances) in the wavelength spectrum between 400 and 700 nm and subsequent calculation according to Allen (see literature reference[1]).
Since the last step in the calculation of the ADMI value is based on the ΔE value of the sample relative to water, this method can also be used to determine ADMI values for colors that lie beyond the yellow-orange range of the Pt/Co scale.
The method is analogous to the APHA 2120 F standard (see literature reference[2]).

1.2 Measuring range

Method 2518	ADMI 50	2.0 - 100.0 ADMI (50-mm rectangular cell)
Method 2517	ADMI 10	10 - 600 ADMI (10-mm rectangular cell)
Method 2518	ADMI 10	10 - 1000 ADMI (10-mm rectangular cell)

1.3 Sample material

Clear liquid samples
Turbid liquid samples after filtration

1.4 Reagents and auxiliaries

- Cat. No. 1.73016 - Spectroquant® VIS Spectrophotometer Prove 100 or
  Cat. No. 1.73017 - Spectroquant® UV/VIS Spectrophotometer Prove 300 or
  Cat. No. 1.73018 - Spectroquant® UV/VIS Spectrophotometer Prove 600
- Cat. No. 1.14946 - Rectangular cells 10 mm and/or
  Cat. No. 1.14944 - Rectangular cells 50 mm
- Cat. No. 1.16754 - Water for analysis EMSURE® or
  distilled water
- Cat. No. 1.00716 - Sulfuric acid 25% for analysis EMSURE® (optional)
- Cat. No. 1.05588 - Sodium hydroxide solution min. 10% for analysis EMSURE® (optional)
- Cat. No. 1.00246 - Platinum Cobalt Color Reference Solution (HAZEN 500) with 500 mg/l Pt (optional)
- Membrane filters, pore size max. 0.45 µm (optional)

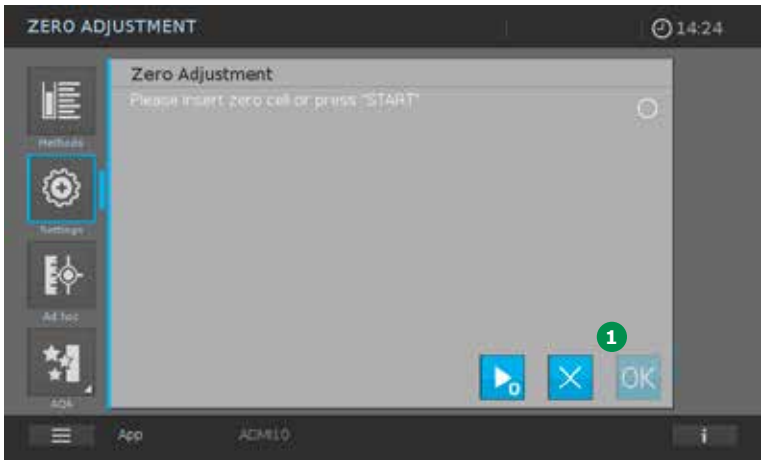
1.5 Preparation

- Filter **turbid sample solutions** over a membrane filter.
  To do this, prerinse the membrane filter with approx. 50 ml of water for analysis, then rerinse with approx. 50 ml of the sample solution and discard the filtrate.
  Filter a further 50 ml of the sample solution over the prerinsed membrane filter and use the filtrate for the analysis.
- Determination **at the original pH**: Filter turbid samples if necessary.
- Determination **at pH 7.0**: Filter turbid samples if necessary. Check the pH of the sample and, if necessary, adjust to pH 7.0 with sulfuric acid or sodium hydroxide solution.

1.6 Procedure and measurement

- Open the methods list (**<Methods>**) and select **Method No. 2516 resp. 2517 or 2518 „ADMI”**.

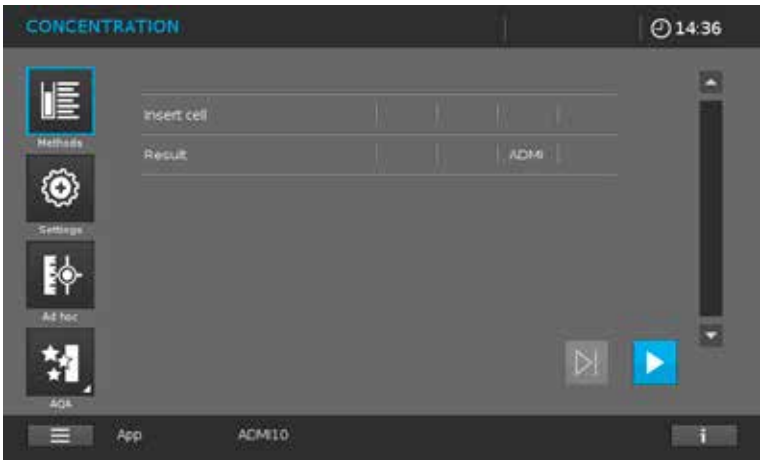
- **Zeroing the photometer:**
  - The photometer must be zeroed prior to each new measurement series.
  - It is advisable to zero the photometer using the same cell as the one used for the measurement sample or else a cell with identical optical characteristics and an identical absorption (matched pair). The zero-adjustment procedure for the measurement series is automatically prompted by the instrument.



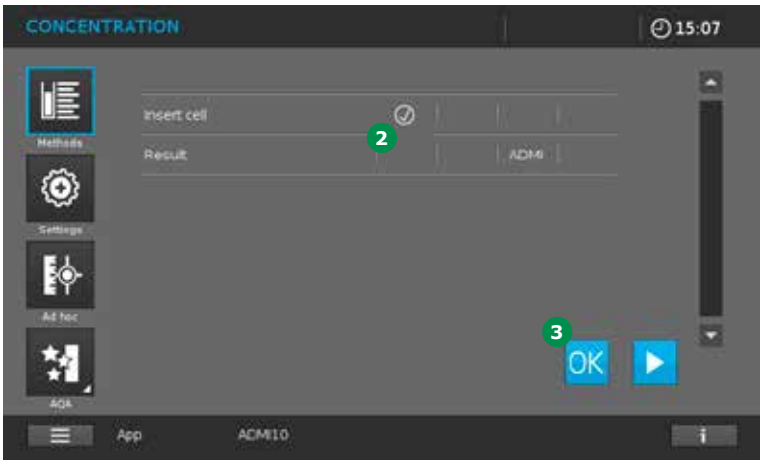
  - For the zero adjustment fill a corresponding rectangular cell with water for analysis.
  - After prompting, insert the filled rectangular cell into the cell compartment. The zero adjustment is performed automatically.
  - Confirm the performance of the zero-adjustment procedure by clicking on **<OK>** 1. The zero adjustment is valid for the entire measurement series.

- **Measurement:**

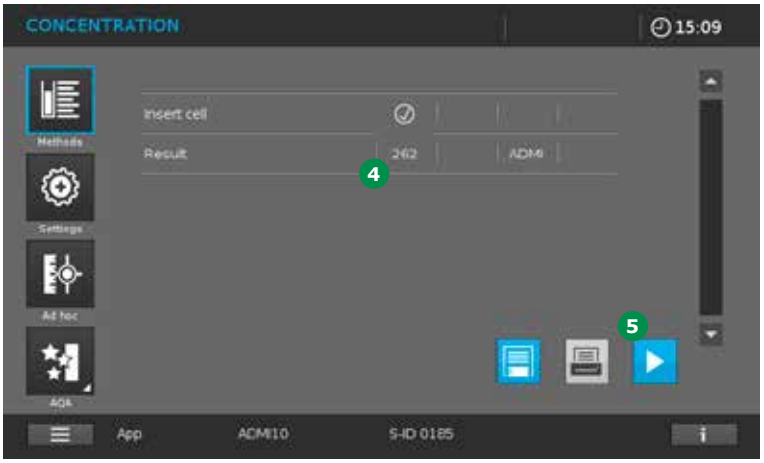
  Note
  It is advisable to measure the sample using the same cell as the one used for the zero adjustment or else a cell with identical optical characteristics and an identical absorption (matched pair).



  - Fill the sample solution into a corresponding rectangular cell and insert the cell into the cell compartment. The measurement is performed automatically.



A (✓) appears behind the cue "Insert cell" 2.
- Confirm the measurement by clicking on **<OK>** 3.



The measurement result appears in the photometer display 4.
- Click **<START>** 5 to start the measurement procedure for the next sample.
  A renewed zero adjustment is not necessary.

1.7 Evaluation

Statement of the results: ADMI Units

1.8 Method control

The method can be checked using Cat. No. 1.00246.0250 – Platinum cobalt color reference solution (HAZEN 500). Dilute this solution to a Hazen value in the middle of the measuring range with water for analysis or distilled water and analyze.

1.9 Adjustment (Method 2517 and 2518 only)

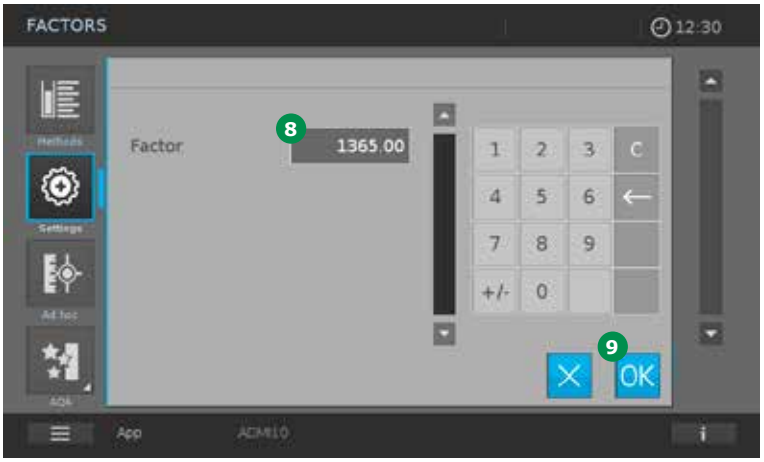
- The ADMI factor of 1365 used in the calculation of the measurement result can be adjusted by the user. The corrected ADMI factor must then be recalculated as follows:

ADMI factor corrected = ADMI factor x (specified method-check value / measured method-check value)

- To alther the ADMI factor, select Method 2517 or Method 2518 from **<Methods>**.

- Click **<Settings>** 6 and select the list **"FACTORS"** 7.

Adjustment is not possible in Method 2516, since this method uses a nonlinear function in the last stage of the calculation of the ADMI factor to ensure an extended measuring range up to ADMI factors of 1000.



- Tip on the input field **" Factor"** 8, enter the corrected ADMI factor, and confirm by clicking on **<OK>** 9.

1.10 Literature

1. Allen, W.; Prescott, W. B.; Derby, R. E.; Garland, C. E.; Peret, J. M.; Saltzman, M.; 1973. Determination of color of water and wastewater by means of ADMI color values. Proc. 28th Ind. Waste Conf., Purdue Univ., Eng. Ext. Ser. No. 142:661ff
2. Standard Methods for the Examination of Water and Wastewater (21th Edition); APHA Method 2120 Color -F. ADMI Weighted-Ordinate Spectrophotometric Method
3. McClaren; The Adams-Nickerson-Color Difference Formula; J. of the Society of Dyers and Columnists; 86, 354ff
4. Bridgeman; Inversion of the Munsell value equoation; J. of Optical Society of America; 1953; 499ff

2 Anisidine value

2.1 Method

The Anisidine value is a measure for the amount of α, β-unsaturated aldehydes (2-alkenals) in animal and vegetable fats and oils. It is defined as the 100-fold volume of the absorbance of a reaction solution measured at 350 nm in a 10-mm rectangular cell, relative to a concentration of the sample solution of 0.01 g/ml. In the analysis, the sample under investigation is dissolved in isooctane, followed by the addition of p-anisidine. After being left to react for 10 minutes, the absorbance is measured at 350 nm and the Anisidine Value is calculated.
The method is analogous to the ISO 6885 standard (see literature reference[1]) and to DGF C-VI 6e (see literature reference[2]).

2.2 Measuring range

Method 2587	Anisidine value	0.0 - 200.0 AV (Anisidine value) (10-mm rectangular cell)

2.3 Sample material

Animal and vegetable fats and oils

2.4 Reagents and auxiliaries

- Cat. No. 1.73016 - Spectroquant® VIS Spectrophotometer Prove 100 or
  Cat. No. 1.73017 - Spectroquant® UV/VIS Spectrophotometer Prove 300 or
  Cat. No. 1.73018 - Spectroquant® UV/VIS Spectrophotometer Prove 600
- Cat. No. 1.14946 - Rectangular cells 10 mm
- Cat. No. 1.04718 - Isooctane Uvasol®
- Cat. No. A88255 - p-Anisidine (**Caution! Carcinogenic!**)
- Cat. No. 1.06649 - Sodium sulfate anhydrous for analysis EMSURE®
- Cat. No. 1.00063 - Acetic acid (lacial) 100% anhydrous for analysis EMSURE®
- Cat. No. 1.06652 - Sodium sulfite anhydrous EMPROVE® (optional)
- Cat. No. 1.02186 - Charcoal activated for analysis (optional)
- Paper filters, medium pore size (optional)
- 25-ml volumetric flasks
- 50-ml volumetric flasks
- Heating bath or drying cabinet (optional)

Standard laboratory glassware (e.g. glass beakers) and pipettes

2.5 Preparing the solutions

- ***p*-Anisidine, anhydrous cream-colored crystals:**
  The *p*-anisidine must not show any color (gray or pink). If it is colored, the p-anisidine must be purified according to the ISO 6885 (see literature reference[1]) or the DGF C-VI 6e method (see literature reference[2]).

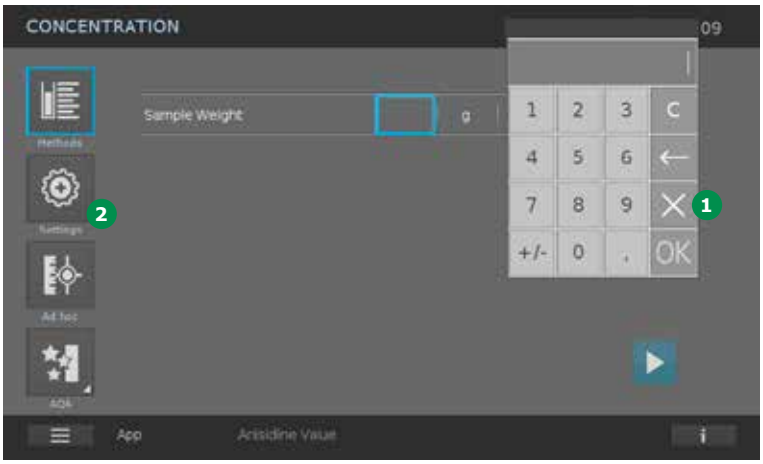
- **Anisidine reagent:**
  The reagent must be prepared freshly on each new working day according to the ISO 6885 (see literature reference[1]) or the DGF C-VI 6e method (see literature reference[2]).

2.6 Preparation

- If the **moisture content** of the sample is higher than w = 0.10%, the sample must be dried with sodium sulfate according to the ISO 6885 (see literature reference[1]) or the DGF C-VI 6e method (see literature reference[2]).
- Weigh in a sufficient quantity of the sample (generally 0.4 g - 4.0 g), accurately weighed to 1 mg, into a 25-ml volumetric flask, note the sample weight, dissolve in 5 - 10 ml of isooctane, and subsequently make up to the mark with isooctane. Solid samples can be heated up to a temperature 10 °C above their melting point before they are weighed.
  The instructions given in the ISO 6885 (see literature reference[1]) or the DGF C-VI 6e method (see literature reference[2]) must be followed.

2.7 Procedure and measurement

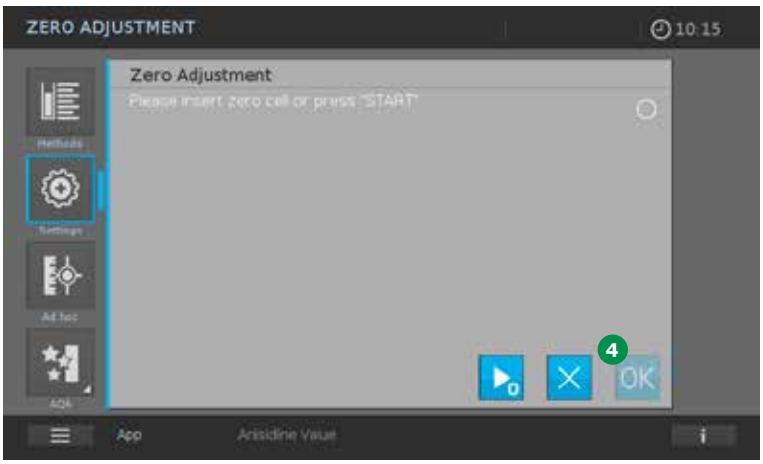
- **Pre-reaction test solution (A_0)**
  - Place 5 ml of the pretreated sample in a closeable vessel (e.g. a conical flask with a ground-glass stopper) and add 1 ml of acetic acid. Close the vessel and shake vigorously.
    Leave the mixture to stand at room temperature in a dark place for 8 minutes.
- **Post-reaction test solution (A_1)**
  - Place 5 ml of the pretreated sample in a closeable vessel (e.g. a conical flask with a ground-glass stopper) and add 1 ml of ansidine reagent acid. Close the vessel and shake vigorously.
    Leave the mixture to stand at room temperature in a dark place for 8 minutes.
- **Blank solution (A_2)**
  - Place 5 ml of sooctane in a closeable vessel (e.g. a conical flask with a ground-glass stopper) and add 1 ml of ansidine reagent acid. Close the vessel and shake vigorously.
    Leave the mixture to stand at room temperature in a dark place for 8 minutes.
- **Zeroing the photometer:**
  - It is advisable to zero the photometer at the start of each working day, using the same cell as the one used for the test solutions and the blank solution or else a cell with identical optical characteristics and an identical absorption (matched pair).
  - To perform the zero-adjustment procedure open the methods list (**<Methods>**) and select **Method No. 2587 „Anisidine Value"**.



A window with an input field to enter the sample weight pops up. Close the input field without entering a sample weight by clicking on **<X>** 1 and click on the button **<Settings>** 2.

After clicking on the button **<Settings>** a window with selection options pops up.

- **Select "ZERO ADJUSTMENT"** 3. The window changes.

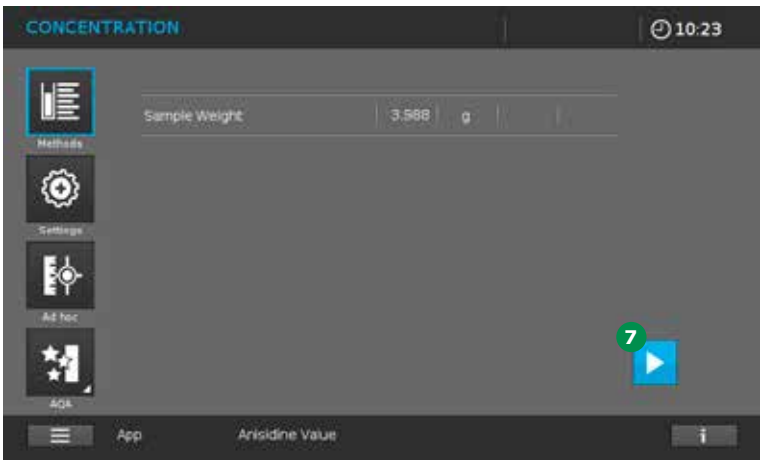


- For the zero adjustment fill a clean and dry 10-mm rectangular cell with isooctane.
- After prompting, insert the filled rectangular cell into the cell compartment. The zero adjustment is performed automatically.
- Confirm the performance of the zero-adjustment procedure by clicking on **<OK>** 4.

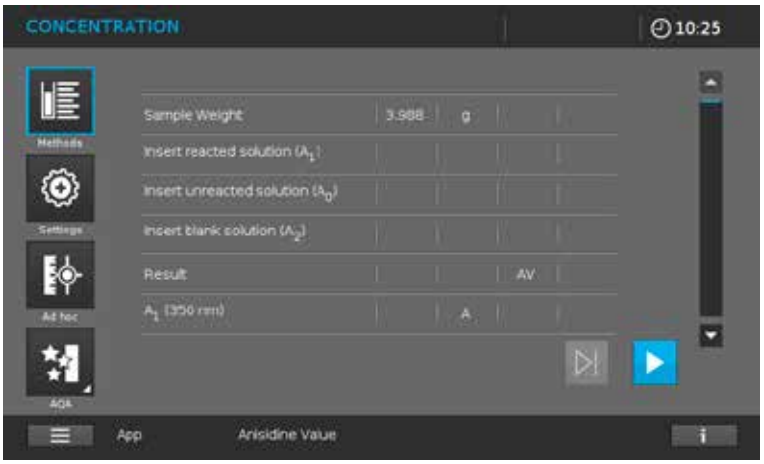
- **Measurement:**

  Note
  It is advisable to measure the test solutions and the blank solution using the same cell as the one used for the zero adjustment or else a cell with identical optical characteristics and an identical absorption (matched pair).

- Open the methods list (**<Methods>**) and select **Method No. 2587 „Anisidine Value”**. A window with an input field to enter the sample weight pops up.



- Enter the weight of the sample in grams (g), accurate to 0.001 grams (g) 5, confirm with **<OK>** 6, and click on **<START>** 7 to switch to the measurement procedure.



- Fill the post-reaction test solution (A_1) into a clean and dry 10-mm rectangular cell after the reaction time of 8 minutes; after the entire reaction time of 10 ± 1 minutes insert the cell into the cell compartment. The measurement is performed automatically. A (✓) symbol appears behind the cue "Insert eacted solution (A_1)" 8.
- Confirm the measurement by clicking on **<OK>** 9.

- Subsequently fill the pre-reaction test solution (A_0) into a clean and dry 10-mm rectangular cell after the reaction time of 8 minutes; after the entire reaction time of 10 ± 1 minutes insert the cell into the cell compartment. The measurement is performed automatically. A (✓) appears behind the cue "Insert unreacted solution (A_0)" 10.
- Confirm the measurement by clicking on **<OK>**.

- Finally fill the blank solution (A_2) into a clean and dry 10-mm rectangular cell after the reaction time of 8 minutes; after the entire reaction time of 10 ± 1 minutes insert the cell into the cell compartment. The measurement is performed automatically. A (✓) appears behind the cue "Insert blank solution (A_2)" 11.
- Confirm the measurement by clicking on **<OK>**.

The measurement result for the Anisidine value and the absorption values A_1, A_0, A_2 appear in the photometer display 12.

- Where applicable, use the scroll keys 13 to scroll down through the display to show other measurement results.
- Click **<START>** 14 to start the measurement procedure for the next sample.

2.8 Evaluation

Statement of the results: Anisidine value
Absorptions of test solutions A_1, A_0, A_2

2.9 Literature

1. ISO 6885:2016 Animal and vegetable fats and oils - Determination of anisidine value
2. DGF-Einheitsmethoden (2. Auflage einschließlich 14. Akt.-Lfg von 2009) - Abteilung Fette - C-VI 6e - Anisidinzahl

3 ASTM color measurement

3.1 Method

The ASTM color scale is used to evaluate the color of liquid petroleum products with a color darker than that of the Saybolt color scale. The scale spans the range from 0.5 (lightest color) to 8.0 (darkest color).
The value is determined by measuring the transmittances in the wavelength spectrum between 380 - 780 nm and subsequent calculation of the tristimulus values X, Y, Z. In further calculation steps according to the ASTM D6045 standard (see literature reference[1]) the tristimulus values are taken as a basis for the calculation of the ASTM color value.
The method is analogous to the ASTM D6045 procedure (see literature reference[1]).

3.2 Measuring range

Method 2562	ASTM Color	0.5 - 8.0 ASTM (10-mm rectangular cell)

3.3 Sample material

Liquid samples
Petroleum products (e.g. uncolored gasoline and aviation fuel, naphtha, kerosine, pharmaceutical white mineral oil, diesel oils, fuel oils, lubricant oils)

3.4 Reagents and auxiliaries

- Cat. No. 1.73016 - Spectroquant® VIS Spectrophotometer Prove 100 or
  Cat. No. 1.73017 - Spectroquant® UV/VIS Spectrophotometer Prove 300 or
  Cat. No. 1.73018 - Spectroquant® UV/VIS Spectrophotometer Prove 600
- Cat. No. 1.14946 - Rectangular cells 10 mm
- Cat. No. 1.16754 - Water for analysis EMSURE® or
  distilled water
- Ultrasound bath (optional)
- Heating bath (optional)
- Filter paper or centrifuge (optional)

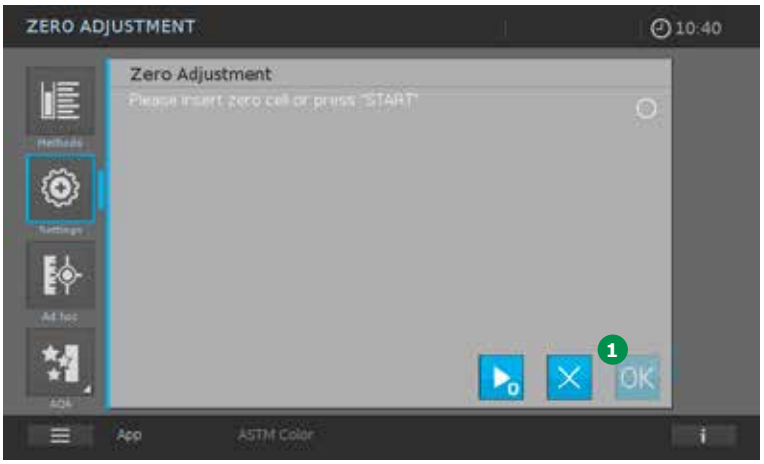
3.5 Preparation

- Eliminate any **air bubbles** present in the sample by degassing the sample in the ultrasound bath.
- Centrifuge **turbid samples** and use the supernatant or else filter over a paper filter and use the filtrate.
- **Melt solid** or **waxlike samples** in a water bath with gentle heating and subsequently homogenize by stirring. Take care not to overheat the sample in the melting process.

3.6 Procedure and measurement

- Open the methods list (**<Methods>**) and select **Method No. 2562 „ASTM Color"**.

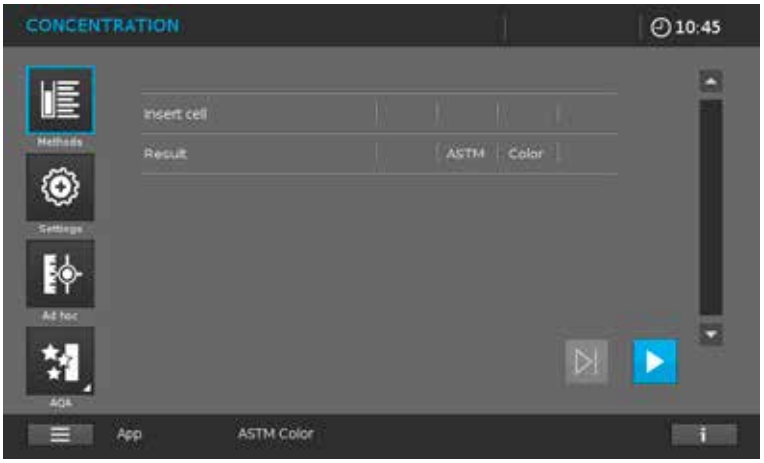
- **Zeroing the photometer:**
  - The photometer must be zeroed prior to each new measurement series.
  - It is advisable to zero the photometer using the same cell as the one used for the measurement sample or else a cell with identical optical characteristics and an identical absorption (matched pair).
    The zero-adjustment procedure for the measurement series is automatically prompted by the instrument.



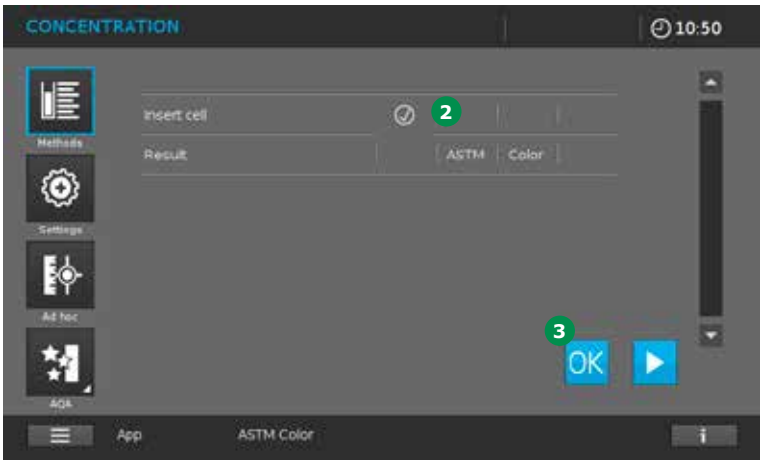
- For the zero adjustment fill a 10-mm rectangular cell with water for analysis.
- After prompting, insert the filled rectangular cell into the cell compartment. The zero adjustment is performed automatically.
- Confirm the performance of the zero-adjustment procedure by clicking on **<OK>** 1.
  The zero adjustment is valid for the entire measurement series.

- **Measurement:**

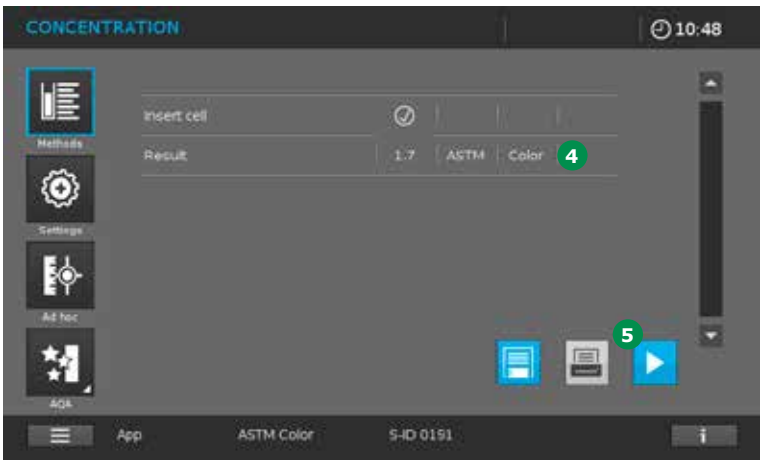
  Note
  It is advisable to measure the sample using the same cell as the one used for the zero adjustment or else a cell with identical optical characteristics and an identical absorption (matched pair).



- Fill the sample solution into a 10-mm rectangular cell and insert the cell into the cell compartment.
  The measurement is performed automatically.



A (✓) appears behind the cue "Insert cell" 2.
- Confirm the measurement by clicking on **<OK>** 3.



The measurement result appears in the photometer display 4.

- Click **<START>** 5 to start the measurement procedure for the next sample.
  A renewed zero adjustment is not necessary.

3.7 Evaluation

Statement of the results: ASTM Units

3.8 Literature

1. ASTM D6045-12, Standard Test Method for Color of Petroleum Products by the Automatic Tristimulus Method

4 CIE color distance

4.1 Method

Differences in color can be quantified by measuring the color distance ΔE^*_{ab} (also referred to as Delta E). The coordinates of the colorimetric loci (L*a*b*) of the samples to be compared are used to determine their positions in the color space (colorimetric loci). Subsequently the Euclidean distance between the colorimetric loci is calculated and the result is defined as the color distance (ΔE value). In the CIELAB color space (see section 5, "Chroma (CIELAB color space)"), the values for the brightness difference (ΔL*), the distance of the coordinates a*, b* (Δa* and Δb*), and the chromatic difference (ΔC^*_{ab}) also play a relevant role. These values are determined by the spectrophotometric measurement of a reference sample and an analysis sample. The transmittances for both samples in the wavelength spectrum between 360 and 780 nm are measured, and subsequently the color distance, the brightness difference, the distance of the coordinates a* and b*, and the chromatic difference are determined according to the methods of the DIN EN ISO 11664-4 standard (see literature reference 1).
This method is based on the DIN EN 11664-4 (see literature reference[1]) and DIN 5033-3 standards (see literature reference[2]).

4.2 Measuring range

Method 2584	CIE Color Distance D65/2°	ΔE^*_{ab} 0.00 - 200.00 ΔL* -200.00 - 200.00 Δa*-200.00 - 200.00 Δb*-200.00 - 200.00 ΔC^*_{ab} -200.00 - 200.00 (10-mm rectangular cell)

Note
The measurement values are determined for standard illuminant D65 and the 2° standard observer.

4.3 Sample material

Clear liquid samples
Turbid liquid samples after filtration

4.4 Reagents and auxiliaries

- Cat. No. 1.73016 - Spectroquant® VIS Spectrophotometer Prove 100 or
  Cat. No. 1.73017 - Spectroquant® UV/VIS Spectrophotometer Prove 300 or
  Cat. No. 1.73018 - Spectroquant® UV/VIS Spectrophotometer Prove 600
- Cat. No. 1.14946 - Rectangular cells 10 mm
- Cat. No. 1.16754 - Water for analysis EMSURE® or
  distilled water
- Membrane filters, pore size max. 0.45 µm (optional)

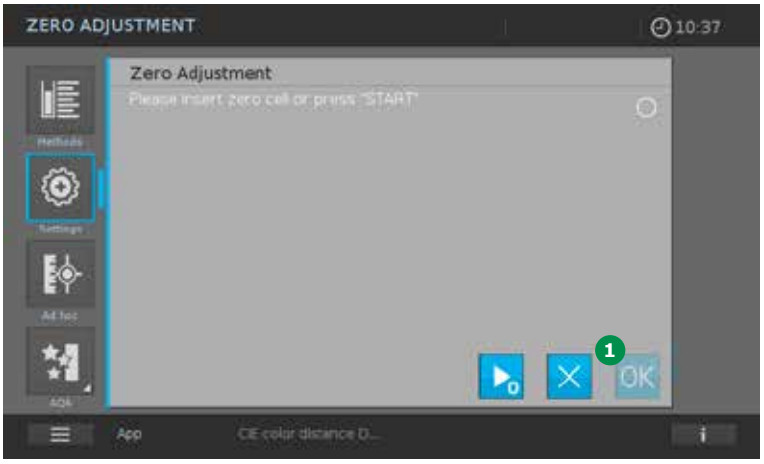
4.5 Preparation

- Filter **turbid sample solutions** over a membrane filter.
  To do this, prerinse the membrane filter with approx. 50 ml of water for analysis, then rerinse with approx. 50 ml of the sample solution and discard the filtrate.
  Filter a further 50 ml of the sample solution over the prerinsed membrane filter and use the filtrate for the analysis.

4.6 Procedure and measurement

- Open the methods list (**<Methods>**) and select **Method No. 2584 „CIE Color Distance D65/2°"**.

- **Zeroing the photometer:**
  - The photometer must be zeroed prior to each new measurement series.
  - It is advisable to zero the photometer using the same cell as the one used for the measurement sample or else a cell with identical optical characteristics and an identical absorption (matched pair).
    The zero-adjustment procedure for the measurement series is automatically prompted by the instrument.



  - For the zero adjustment fill a 10-mm rectangular cell with water for analysis.
  - 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>** 1.
    The zero adjustment is valid for the entire measurement series.

- **Measurement:**

  Note
  It is advisable to measure the reference solution and the measurement sample using the same cell as the one used for the zero adjustment or else a cell with identical optical characteristics and an identical absorption (matched pair).

  - Fill the reference solution into a 10-mm rectangular cell and insert the cell into the cell compartment.
    The measurement is performed automatically.

A (✓) appears behind the cue "Insert reference (R)" 2.
- Confirm the measurement by clicking on **<OK>** 3.
- Fill the sample solution into a 10-mm rectangular cell and insert the cell into the cell compartment. The measurement is performed automatically.

A (✓) appears behind the cue "Insert sample (T)" 4.
- Confirm the measurement by clicking on **<OK>** 5.

The measurement results appear in the photometer display 5.

- Where applicable, use the scroll keys 6 to scroll down through the display to show other measurement results.
- Click **<START>** 7 to start the measurement procedure for the next sample.
  A renewed zero adjustment is not necessary.

4.7 Evaluation

Statement of the results: ΔE^*_{ab} value
ΔL^* value
Δa^* value
Δb^* value
ΔC^*_{ab} value
L*a*b* values for the reference sample are shown with a lower-case "R" (e.g. L^*_R)
L*a*b* values for the analysis sample are shown with a lower-case "T" (e.g. L^*_T)

$C^*_{ab,R}$ value for the reference sample
$C^*_{ab,T}$ value for the analysis sample
determined for standard illuminant D65 and the 2° standard observer

4.8 Literature

1. DIN EN ISO 11664-4:2012-06, Colorimetry - Part 4: CIE 1976 L*a*b* Colour space
2. DIN 5033-3:1992-07, Colorimetry; Colorimetric measures
3. ASTM E-308-06, Standard Practice for Computing the Colors of Objects by Using the CIE System

5 CIELAB color space (brightness, chroma)

5.1 Method

The CIELAB color space, also known as CIE-L*a*b* or simply Lab, describes all perceivable colors and is the most widely used color space. The CIELAB color space is based on the XYZ model set up by the CIE organization in 1931 (CIE – Commission internationale de l'éclairage, International Commission on Illumination). This model uses the spectral characteristics of a color sample to calculate the so-called tristimulus values X, Y, Z, which stand in direct correlation to the intensity of the stimulation of the three types of color receptors (cone cells) of the human eye (red, green, blue). Since the XYZ model proved to be difficult to handle in the assessment of color differences, in 1976 the CIE published the CIELAB model. The CIELAB model is better capable of describing the human perception of color than the previous XYZ model, since color-perception differences are presented in Euclidean distances within a Cartesian coordinate system. In this coordinate system, each color can be defined by its coordinates L*, a*, and b*.
On the a* axis, green and red lie opposite each other, on the b* axis blue and yellow. Gray lies at the coordinate origin (a*=0 and b*=0). The L* axis stands in the coordinate origin vertically at the a*b* level and describes the brightness of the color, with values ranging between 0 and 100.
Negative a* values stand for green colors, positive a* values for red colors. On the b* axis, negative b* values describe blue colors, with positive b* values describing yellow colors.
In practice, the C*ab value – the chroma – is also frequently calculated. The chroma expresses the relative color effect of a sample in relation to a reference white.
The L*a*b* values and the chroma C*ab value are determined by measuring the transmittances in a wavelength spectrum between 360 and 780 nm and subsequently calculating the L*a*b* and chroma C*ab values according to the methods of the DIN EN ISO 11664-4 standard (see literature reference[1]).
The method is based on the DIN EN 11664-4 (see literature reference[1]) and DIN 5033-3 standards (see literature reference[2]).

5.2 Measuring range

Method 2580	CIELAB D65/2°	L* 0.00 - 105.00 a* -180.0 - 180.0 b* -180.0 - 180.0 C*ab 0.00 - 300.00 (10-mm rectangular cell)

Note
The measurement values are determined for standard illuminant D65 and the 2° standard observer.

5.3 Sample material

Clear liquid samples
Turbid liquid samples after filtration

5.4 Reagents and auxiliaries

- Cat. No. 1.73016 - Spectroquant® VIS Spectrophotometer Prove 100 or
  Cat. No. 1.73017 - Spectroquant® UV/VIS Spectrophotometer Prove 300 or
  Cat. No. 1.73018 - Spectroquant® UV/VIS Spectrophotometer Prove 600
- Cat. No. 1.14946 - Rectangular cells 10 mm
- Cat. No. 1.16754 - Water for analysis EMSURE® or distilled water
- Membrane filters, pore size max. 0.45 µm (optional)

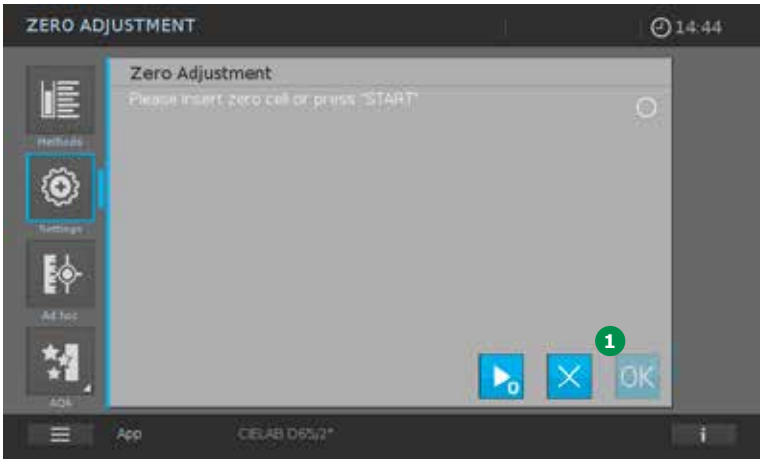
5.5 Preparation

- Filter **turbid sample solutions** over a membrane filter.
  To do this, prerinse the membrane filter with approx. 50 ml of water for analysis, then rerinse with approx. 50 ml of the sample solution and discard the filtrate.
  Filter a further 50 ml of the sample solution over the prerinsed membrane filter and use the filtrate for the analysis.

5.6 Procedure and measurement

- Open the methods list (**<Methods>**) and select **Method No. 2580 "CIELAB D65/2°"**.

- **Zeroing the photometer:**
  - The photometer must be zeroed prior to each new measurement series.
  - It is advisable to zero the photometer using the same cell as the one used for the measurement sample or else a cell with identical optical characteristics and an identical absorption (matched pair).
    The zero-adjustment procedure for the measurement series is automatically prompted by the instrument.

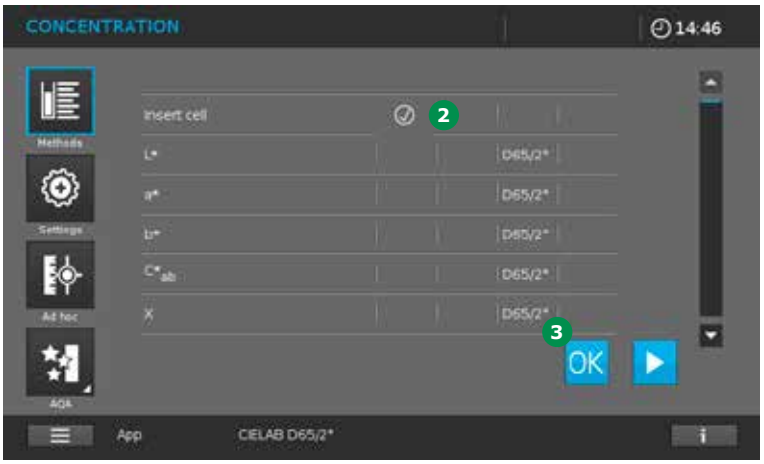


  - For the zero adjustment fill a 10-mm rectangular cell with water for analysis.
  - After prompting, insert the filled rectangular cell into the cell compartment. The zero adjustment is performed automatically.
  - Confirm the performance of the zero-adjustment procedure by clicking on **<OK>** 1.
    The zero adjustment is valid for the entire measurement series.

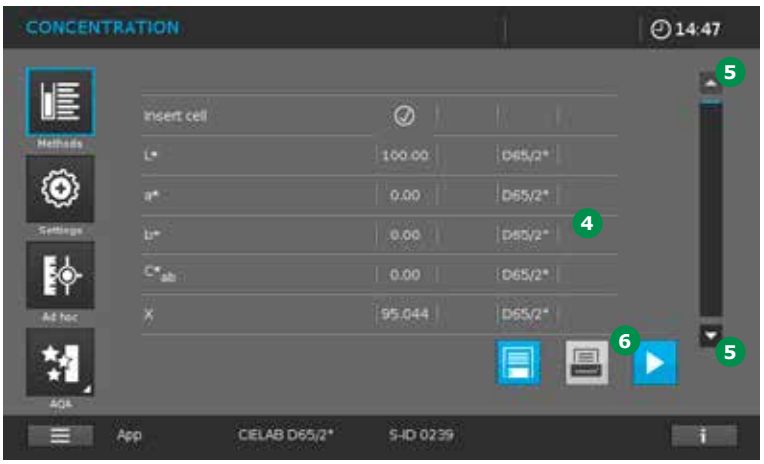
- **Measurement:**

  Note
  It is advisable to measure the sample using the same cell as the one used for the zero adjustment or else a cell with identical optical characteristics and an identical absorption (matched pair).

  - Fill the sample solution into a 10-mm rectangular cell and insert the cell into the cell compartment. The measurement is performed automatically.



A (✓) appears behind the cue "Insert cell" 2.
- Confirm the measurement by clicking on **<OK>** 3.



The measurement results appear in the photometer display 4.
- Where applicable, use the scroll keys 5 to scroll down through the display to show other measurement results.
- Click **<START>** 6 to start the measurement procedure for the next sample.
  A renewed zero adjustment is not necessary.

5.7 Evaluation

Statement of the results: L*a*b* values
C*ab value
Tristimulus values X, Y, Z
determined for standard illuminant D65 and the 2° standard observer

5.8 Literature

1. DIN EN ISO 11664-4:2012-06, Colorimetry - Part 4: CIE 1976 L*a*b* Colour space

2. DIN 5033-3:1992-07, Colorimetry; Colorimetric measures

3. ASTM E-308-06, Standard Practice for Computing the Colors of Objects by Using the CIE System

6 CIELUV color space

6.1 Method

The CIELUV color room, also referred to as CIE-L*u*v*, was developed in 1976 by the CIE organization and – similar to the CIELAB color space – describes all perceivable colors. Like the CIELAB color space, the CIELUV color room is based on the CIE's XYZ model from 1931. This model takes the spectral characteristics of a color sample to calculate the so-called tristimulus values X, Y, Z, which stand in direct correlation to the intensity of the stimulation of the three types of color receptors (cone cells) of the human eye (red, green, blue). The CIELUV color room is predominantly used for the measurement of light colors of luminescent objects and of the additive color mixture. Compared with the CIELab color room, the CIELUV color room possesses a reduced green spectrum and an enlarged blue spectrum.
In this coordinate system, each color can be defined by its coordinates L*, u*, and v*.
On the u* axis, green and red lie opposite each other, on the v* axis blue and yellow. Gray lies at the coordinate origin (u*=0 and v*=0). The L* axis stands in the coordinate origin vertically at the u*v* level and describes the brightness of the color, with values ranging between 0 and 100.
Negative u* values stand for green colors, positive u* values for red colors. On the v* axis, negative v* values describe blue colors, with positive v* values describing yellow colors.
In practice, the C*uv value – the chroma – as well as the S*uv value – the saturation – are also frequently calculated. The chroma expresses the relative color effect of a sample in relation to a reference white (white point). The saturation describes the distance of the colorimetric locus from the achromatic axis, on which lie all achromatic colors between white and black.
The L*u*v* values, the the chroma C*uv value, and the saturation S*uv value are determined by measuring the transmittances in a wavelength spectrum between 360 and 780 nm and subsequently calculating the L*u*v, the chroma C*uv, and the S*uv values according to the methods of the DIN 5033-3 (see literature reference[1]) and ISO CIE 11664-5 standards (see literature reference[2]).
The method is based on the DIN 5033-3 (see literature reference 1) and ISO CIE 11664-5 standards (see literature reference[2]).

6.2 Measuring range

Method 2581	CIELUV D65/2°	L* 0.00 - 105.00 u* -180.0 - 180.0 v* -180.0 - 180.0 C*uv 0.00 - 300.00 S*uv 0.000 - 200.000 (10-mm rectangular cell)

Note
The measurement values are determined for standard illuminant D65 and the 2° standard observer.

6.3 Sample material

Clear liquid samples
Turbid liquid samples after filtration

6.4 Reagents and auxiliaries

- Cat. No. 1.73016 - Spectroquant® VIS Spectrophotometer Prove 100 or
  Cat. No. 1.73017 - Spectroquant® UV/VIS Spectrophotometer Prove 300 or
  Cat. No. 1.73018 - Spectroquant® UV/VIS Spectrophotometer Prove 600
- Cat. No. 1.14946 - Rectangular cells 10 mm
- Cat. No. 1.16754 - Water for analysis EMSURE® or
  distilled water
- Membrane filters, pore size max. 0.45 µm (optional)

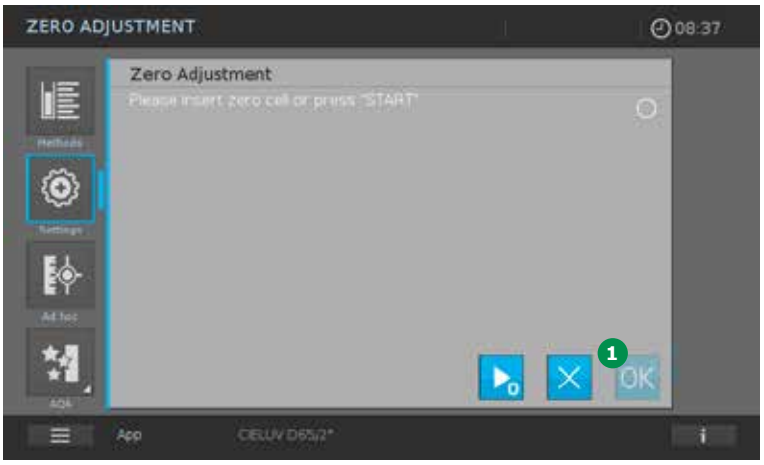
6.5 Preparation

- Filter **turbid sample solutions** over a membrane filter.
  To do this, prerinse the membrane filter with approx. 50 ml of water for analysis, then rerinse with approx. 50 ml of the sample solution and discard the filtrate.
  Filter a further 50 ml of the sample solution over the prerinsed membrane filter and use the filtrate for the analysis.

6.6 Procedure and measurement

- Open the methods list (**<Methods>**) and select **Method No. 2581 "CIELUV D65/2°"**.

- **Zeroing the photometer:**
  - The photometer must be zeroed prior to each new measurement series.
  - It is advisable to zero the photometer using the same cell as the one used for the measurement sample or else a cell with identical optical characteristics and an identical absorption (matched pair).
    The zero-adjustment procedure for the measurement series is automatically prompted by the instrument.

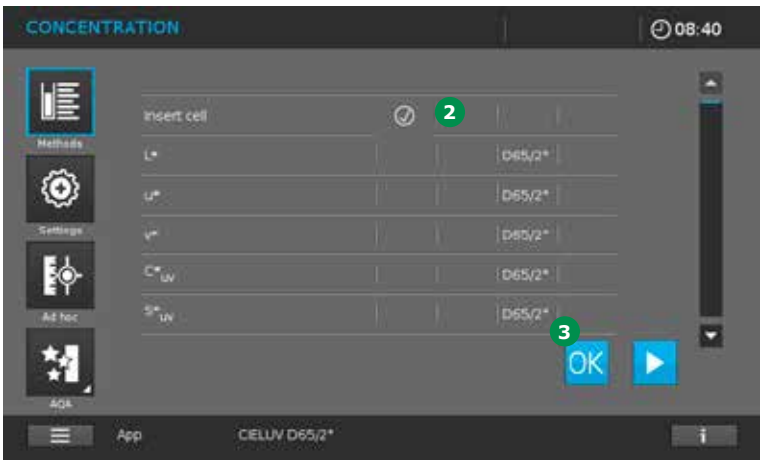


  - For the zero adjustment fill a 10-mm rectangular cell with water for analysis.
  - After prompting, insert the filled rectangular cell into the cell compartment. The zero adjustment is performed automatically.
  - Confirm the performance of the zero-adjustment procedure by clicking on **<OK>** (1).
    The zero adjustment is valid for the entire measurement series.

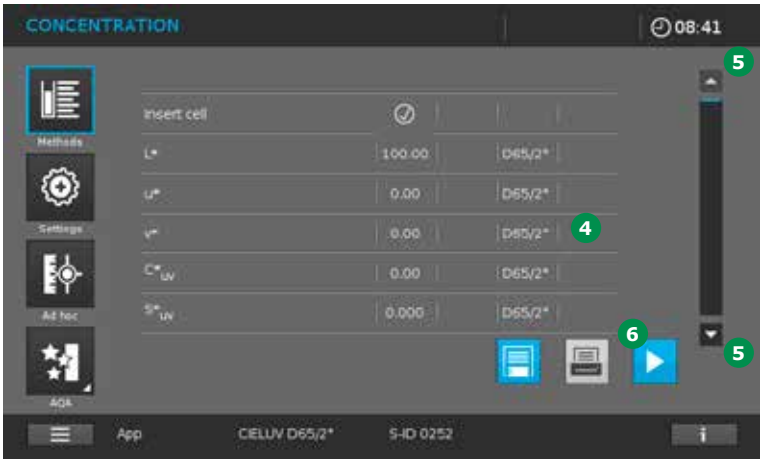
- **Measurement:**

  Note
  It is advisable to measure the sample using the same cell as the one used for the zero adjustment or else a cell with identical optical characteristics and an identical absorption (matched pair).

- Fill the sample solution into a 10-mm rectangular cell and insert the cell into the cell compartment. The measurement is performed automatically.



A (✓) appears behind the cue "Insert cell" 2.
- Confirm the measurement by clicking on **<OK>** 3.



The measurement results appear in the photometer display 4.
- Where applicable, use the scroll keys 5 to scroll down through the display to show other measurement results.
- Click **<START>** 6 to start the measurement procedure for the next sample.
  A renewed zero adjustment is not necessary.

6.7 Evaluation

Statement of the results: L*u*v* values
C*uv value
S*uv value
Tristimulus values X, Y, Z
determined for standard illuminant D65 and the 2° standard observer

6.8 Literature

1. DIN 5033-3:1992-07, Colorimetry; Colorimetric measures
2. ISO CIE 11664-5:2016(E), Colorimetry - Part 5: CIE 1976 L*u*v* colour space and u', v' uniform chromaticity scale diagram
3. ASTM E-308-06, Standard Practice for Computing the Colors of Objects by Using the CIE System

7 CIExyY color space

7.1 Method

The CIExyY color space is based on the CIE Chromacity Diagram from the year 1931 and is one of the oldest known color spaces. The CIExyY color space and the chromaticity diagram are derived from the CIE XYZ model. This model takes the spectral characteristics of a color sample to calculate the so-called tristimulus values X, Y, Z, which stand in direct correlation to the intensity of the stimulation of the three types of color receptors (cone cells) of the human eye (red, green, blue). The XYZ model exhibits a number of weakpoints when it comes to the assessment of color differences. The CIE subsequently developed a two-dimensional graph with x/y coordinates derived from the tristimulus values X, Y, Z. This produced a graphic model (the CIE Chromacity Diagram) with its characteristic horseshoe or shoesole shape, which can be used to define the location of a color or color space. In the CIExyY color space the value Y is also added, which corresponds to the brightness or the relative luminance of a color.
In the CIExyY color space x values stand for the red/purple axis and y values for the green axis. The values of the Y axis can be depicted only in the three-dimensional diagram.
The CIExyY values are determined by measuring the transmittances in a wavelength spectrum between 360 and 780 nm and subsequently calculating the xyY values according to the methods of CIE 15:2004, Technical Report - Colorimetry (see literature reference[1]).

7.2 Measuring range

Method 2582	CIExyY D65/2°	x 0.0000 - 0.8000 y 0.0000 - 0.8000 Y 0.000 - 200.000 (10-mm rectangular cell)

Note
The measurement values are determined for standard illuminant D65 and the 2° standard observer.

7.3 Sample material

Clear liquid samples
Turbid liquid samples after filtration

7.4 Reagents and auxiliaries

- Cat. No. 1.73016 - Spectroquant® VIS Spectrophotometer Prove 100 or
  Cat. No. 1.73017 - Spectroquant® UV/VIS Spectrophotometer Prove 300 or
  Cat. No. 1.73018 - Spectroquant® UV/VIS Spectrophotometer Prove 600
- Cat. No. 1.14946 - Rectangular cells 10 mm
- Cat. No. 1.16754 - Water for analysis EMSURE® or
  distilled water
- Membrane filters, pore size max. 0.45 µm (optional)

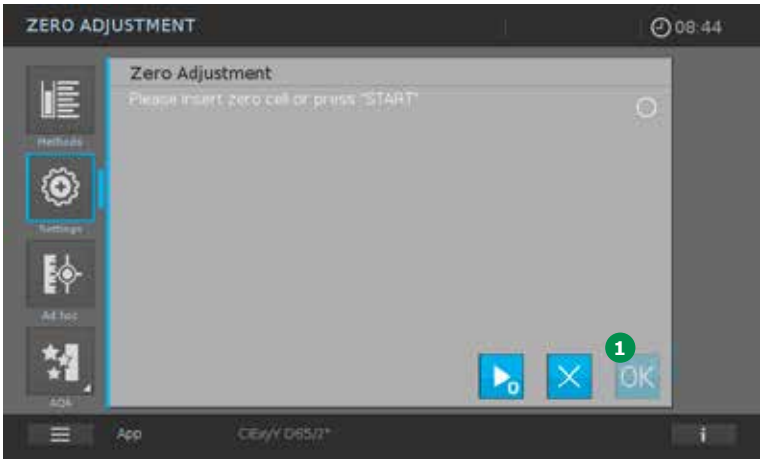
7.5 Preparation

- Filter **turbid sample solutions** over a membrane filter.
  To do this, prerinse the membrane filter with approx. 50 ml of water for analysis, then rerinse with approx. 50 ml of the sample solution and discard the filtrate.
  Filter a further 50 ml of the sample solution over the prerinsed membrane filter and use the filtrate for the analysis.

7.6 Procedure and measurement

- Open the methods list (**<Methods>**) and select **Method No. 2582 "CIExyY D65/2°"**.

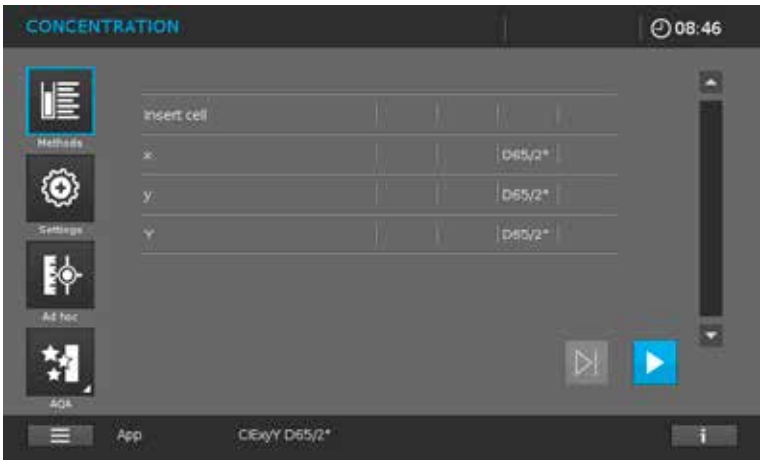
- **Zeroing the photometer:**
  - The photometer must be zeroed prior to each new measurement series.
  - It is advisable to zero the photometer using the same cell as the one used for the measurement sample or else a cell with identical optical characteristics and an identical absorption (matched pair).
    The zero-adjustment procedure for the measurement series is automatically prompted by the instrument.



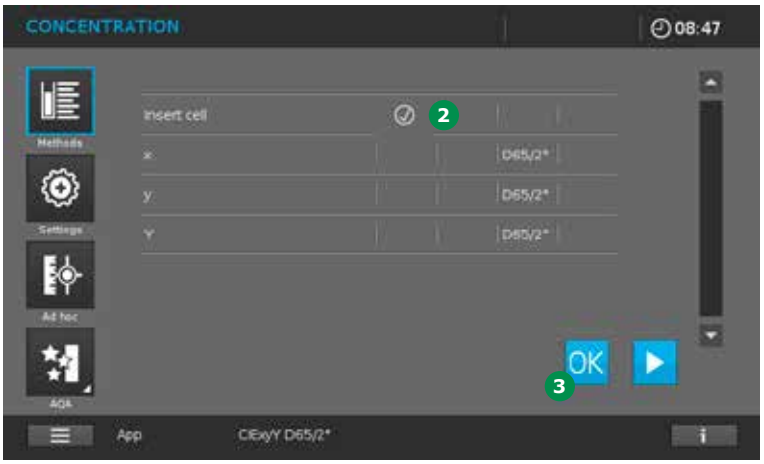
  - For the zero adjustment fill a 10-mm rectangular cell with water for analysis.
  - After prompting, insert the filled rectangular cell into the cell compartment. The zero adjustment is performed automatically.
  - Confirm the performance of the zero-adjustment procedure by clicking on **<OK>** 1 .
    The zero adjustment is valid for the entire measurement series.

- **Measurement:**

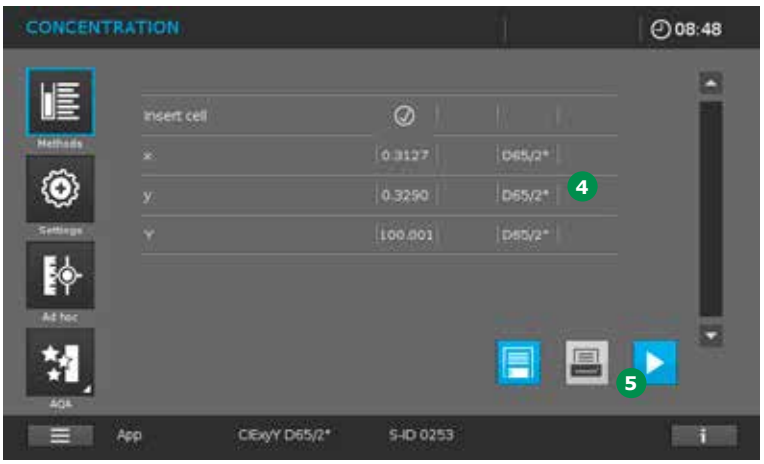
  Note
  It is advisable to measure the sample using the same cell as the one used for the zero adjustment or else a cell with identical optical characteristics and an identical absorption (matched pair).



  - Fill the sample solution into a 10-mm rectangular cell and insert the cell into the cell compartment. The measurement is performed automatically.



A (✓) appears behind the cue "Insert cell" 2.
- Confirm the measurement by clicking on **<OK>** 3.



The measurement results appear in the photometer display 4.
- Click **<START>** 5 to start the measurement procedure for the next sample.
  A renewed zero adjustment is not necessary.

7.7 Evaluation

Statement of the results: xyY values
determined for standard illuminant D65 and the 2° standard observer

7.8 Literature

1. CIE 15:2004, Technical Report - Colorimetry, ISBN 978-3-901906-33-6

2. ASTM E-308-06, Standard Practice for Computing the Colors of Objects by Using the CIE System

8 Color (ASBC method)

8.1 Method

The spectrophotometric method is an official method of the ASBC (American Society of Brewing Chemists) for determining the color of beers, worts, and liquid malt substitutes.
The color is determined by measuring the absorption of the sample at 430 nm and subsequently converting the result into °SRM using a factor specified in the literature (see literature references[1, 2]). Taking an additional measurement of the absorption at 700 nm enables the assessment of any potential turbidity of the sample.
The method is analogous to the ASBC Method Beer-10 (see literature reference[1]) and ASBC Method Wort-9 (see literature reference[2]).

8.2 Measuring range

Method 2633	Color - ASBC	0.0 - 50.0 °SRM (10-mm rectangular cell) 0.0 - 100.0 EBC Units (10-mm rectangular cell)

8.3 Sample material

Beers, production worts, laboratory worts, liquid malt substitutes

8.4 Reagents and auxiliaries

- Cat. No. 1.73016 - Spectroquant® VIS Spectrophotometer Prove 100 or
  Cat. No. 1.73017 - Spectroquant® UV/VIS Spectrophotometer Prove 300 or
  Cat. No. 1.73018 - Spectroquant® UV/VIS Spectrophotometer Prove 600
- Cat. No. 1.14946 - Rectangular cells 10 mm
- Cat. No. 1.16754 - Water for analysis EMSURE® or
  distilled water
- Cat. No. 1.07910 - Kieselguhr GR for analysis (optional)
- Membrane filters, pore size max. 0.45 µm (optional)
- Paper filters (optional)

8.5 Preparation

- Degas the sample to remove any carbon dioxide.
- Filter the sample over a membrane filter; filtration can be dispensed with in the case that the ratio of the absorption values from 700 nm to 430 nm is ≤ 0.039 ($A_{700\ nm}$ / $A_{430\ nm}$) (the absorption values at 700 nm and 430 nm and the quotient "$A_{700\ nm}$ / $A_{430\ nm}$" are also shown together with the result after the measurement).
- If necessary, clarify the sample by adding 0.1% kieselguhr (Kieselguhr GR, Cat. No. 1.07910) and filtration before the membrane-filtration step
- In the case of a result °SRM Units > 50.0, dilute the sample in such a way that its color is within the measurement range, noting the dilution factor.
- **Worts** must be filtered at 5 - 8°C directly after taking the sample or otherwise preserved prior to filtration (by pasteurization or storage in a refrigerator). After filtration, add 5 g of kieselguhr to 100 ml of filtered wort, swirl to mix thoroughly, and leave to stand for 5 min. Subsequently filter the suspension over a paper filter. Refilter the first 30 - 40 ml and transfer the collected filtrate in a clean vessel until required for analysis.

8.6 Procedure and measurement

- **Zeroing the photometer:**
  - It is advisable to zero the photometer at the start of each working day, using the same cell as the one used for the test solutions or else a cell with identical optical characteristics and an identical absorption (matched pair).
  - To perform the zero-adjustment procedure open the methods list (**<Methods>**) and select **Method No. 2633 "Color - ASBC"**.

A window with an input field to enter the dilution factor pops up. Close the input field without entering a ilution factor by clicking on **<X>** 1 and click on the button **<Settings>** 2.

After clicking on the button **<Settings>** a window with selection options pops up.

- Select **"ZERO ADJUSTMENT"** 3. The window changes.

- For the zero adjustment fill a 10-mm rectangular cell with water for analysis.
- 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>** 4.

- **Measurement:**

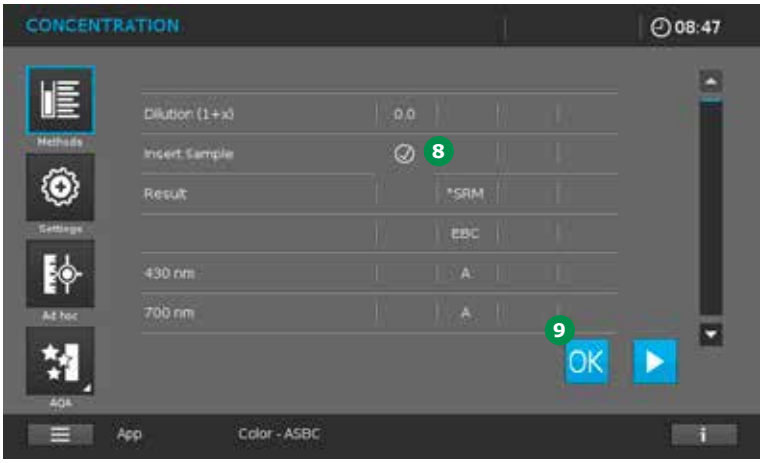
  Note
  It is advisable to measure the sample solution using the same cell as the one used for the zero adjustment or else a cell with identical optical characteristics and an identical absorption (matched pair).

  - Open the methods list (**<Methods>**) and select **Method No. 2633 "Color - ASBC"**. A window with an input field to enter the dilution factor pops up.

  - Samples with a value > 50.0 °SRM must be diluted with water.
    Enter the dilution factor in the proportion of 1 part sample + x parts water 5 and confirm by clicking on **<OK>** 6 (e.g. 1 + **9**, when 10 ml of sample is mixed with 90 ml of water).
    If an undiluted sample is being measured, enter the value "0" and confirm with**<OK>** 6.

- Click on **<START>** 7 to switch to the measurement procedure.

- Fill the sample solution into a 10-mm rectangular cell and insert the cell into the cell compartment. The measurement is performed automatically.



A (✓) appears behind the cue "Insert cell" 8.

- Confirm the measurement by clicking on **<OK>** 9.

The measurement results in the units °SRM and EBC as well as the absorptions at 430 nm and 700 nm and also the quotient "$A_{700\ nm}$ / $A_{430\ nm}$" appear in the photometer display 10.

- Where applicable, use the scroll keys 11 to scroll down through the display to show other measurement results.
- Click **<START>** 12 to start the measurement procedure for the next sample.

8.7 Evaluation

Statement of the results: °SRM
EBC Units
Absorption at 430 nm and 700 nm
Quotient of the absorptions at 700 nm and 430 nm ($A_{700\ nm}$ / $A_{430\ nm}$)

Note
If the quotient "$A_{700\ nm}$ / $A_{430\ nm}$" is at a value ≥ 0.039, the sample must be filtered (see section 8.5, "Preparation").

Note
A spectrophotometric absorption curve does not reflect the color impression of the human eye, since light of the same intensity in different parts of the spectrum has different effects on the eye. In addition, the absorption curves at 430 nm are very steep, meaning that measurement errors can easily happen. What is more, there are differences that occur in the comparison of light beers with diluted dark beers.

8.8 Literature

1. ASBC Methods of Analysis , online. Beer-10, Color, A. Spectrophotometric color method [Release date 1958, revised 1975, reviewed 2015].
   American society of brewing Chemists, St. Paul, Mn, U.S.A. doi: 10.1094/ASBCMOA-Beer-10
2. ASBC Methods of Analysis , online. Wort-9, Wort Color and Sample Preparation, A. Celite [Release date 1969, revised 1976, reviewed 2010].
   American society of brewing Chemists, St. Paul, Mn, U.S.A. doi: 10.1094/ASBCMOA-Wort-9

9 Color (EBC method)

9.1 Method

This spectrophotometric method counts as the official method of the EBC (European Brewery Convention) for determining the color of beers, worts, and liquid malt substitutes.
The color is determined by measuring the absorption of the sample at 430 nm and subsequently converting the result into EBC units using a factor specified in the literature (see literature references[1, 2, 3]).
This method is analogous to the MEBAK Method 2.13.2 (see literature reference[1]), EBC Method 8.5 (see literature reference[2]), and EBC Method 9.6 (see literature reference[3]).

9.2 Measuring range

Method 2602	Color - EBC	0.0 - 60.0 EBC Units (10-mm rectangular cell)

9.3 Sample material

Beers, production worts, laboratory worts, liquid malt substitutes

9.4 Reagents and auxiliaries

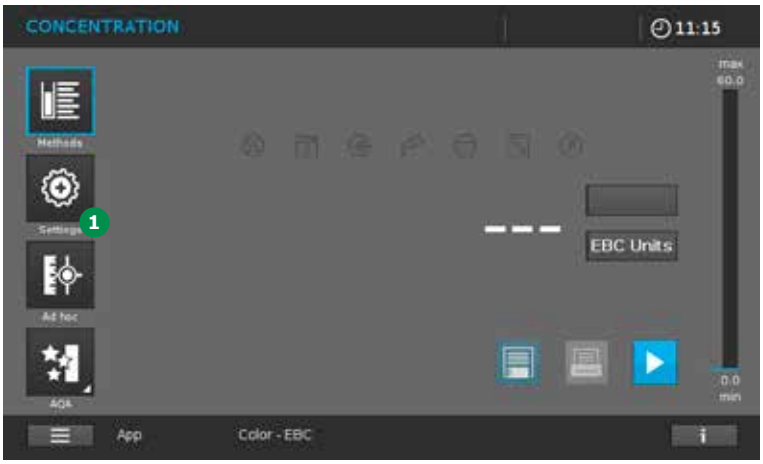
- Cat. No. 1.73016 - Spectroquant® VIS Spectrophotometer Prove 100 or
  Cat. No. 1.73017 - Spectroquant® UV/VIS Spectrophotometer Prove 300 or
  Cat. No. 1.73018 - Spectroquant® UV/VIS Spectrophotometer Prove 600
- Cat. No. 1.14946 - Rectangular cells 10 mm
- Cat. No. 1.16754 - Water for analysis EMSURE® or
  distilled water
- Cat. No. 1.07910 - Kieselguhr GR for analysis (optional)
- Membrane filters, pore size max. 0.45 µm (optional)

9.5 Preparation

- Degas the sample to remove any carbon dioxide.
- Filter the sample over a membrane filter; filtration can be dispensed with in the case that the turbidity of the diluted sample is below 1 EBC turbidity units.
- If necessary, clarify the sample by adding 0.1% kieselguhr (Kieselguhr GR, Cat. No. 1.07910) and filtration before the membrane-filtration step
- In the case of a result EBC Units > 60.0, dilute the sample in such a way that its color is within the measurement range; include the dilution factor when calculating the final result (see Note “Dilution”, section 9.6).

9.6 Procedure and measurement

- **Zeroing the photometer:**
  - It is advisable to zero the photometer at the start of each working day, using the same cell as the one used for the test solutions or else a cell with identical optical characteristics and an identical absorption (matched pair).
  - To perform the zero-adjustment procedure open the methods list (**<Methods>**) and select **Method No. 2602 „Color - EBC”**.
    If there is no valid zero adjustment available for the method, the window for the zero-adjustment procedure opens automatically.

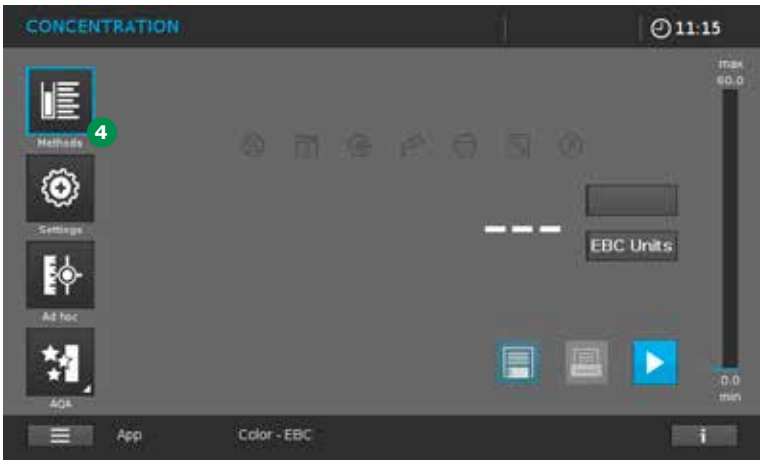


If a valid zero adjustment is already available, the Methods window opens.
The zero-adjustment procedure must then be selected by opening **<Settings>** 1 and clicking on the selection button **"ZERO ADJUSTMENT"** 2.

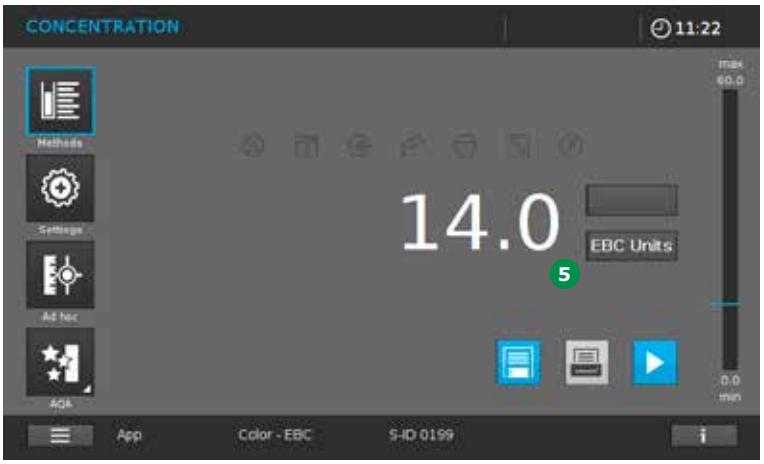
- For the zero adjustment fill a 10-mm rectangular cell with water for analysis.
- After prompting, insert the filled rectangular cell into the cell compartment. The zero adjustment is performed automatically.
- Confirm the performance of the zero-adjustment procedure by clicking on **<OK>** 3.

- **Measurement:**

  Note
  It is advisable to measure the sample solution using the same cell as the one used for the zero adjustment or else a cell with identical optical characteristics and an identical absorption (matched pair).



- Open the methods list (**<Methods>**) 4 and select **Method No. 2602 „Color - EBC"**.

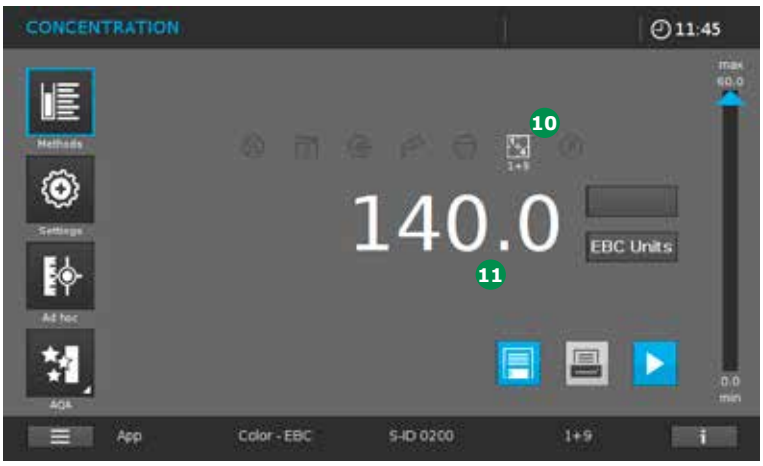


- Fill the sample solution into a 10-mm rectangular cell and insert the cell into the cell compartment. The measurement is performed automatically and the result appears in the display 5.

Note „Dilution"
If the sample exhibits a color stronger than 60.0 EBC, it must be diluted with water for analysis until the color is within the measurement range. The dilution factor must be taken into account in the calculation of the result and can be entered into the photometer.

Do this by clicking on the button **<Settings>** 6 and subsequently selecting the field **"DILUTION"** 7.

A window with an input field to enter the dilution factor is opened.
Activate the input field behind the **"+"** character 8 and enter the dilution factor in the ratio of 1 part sample + x parts water and confirm by clicking on **<OK>** 9 (e.g. 1 + **9**, when 10 ml of sample is mixed with 90 ml of water).



The window changes to the methods display. The activated dilution factor appears in the display 10 and is automatically taken into account in the calculation of the result 11.

9.7 Evaluation

Statement of the results: EBC Units

Note
A spectrophotometric absorption curve does not reflect the color impression of the human eye, since light of the same intensity in different parts of the spectrum has different effects on the eye. In addition, the absorption curves at 430 nm are very steep, meaning that measurement errors can easily happen. What is more, there are differences that occur in the comparison of light beers with diluted dark beers.

9.8 Literature

1. MEBAK Brautechnische Analysemethoden 4. Auflage 2002, Band II, Method 2.13.2, Seite 88ff

2. Analytica-EBC, section 8 Wort, Method 8.5 (2000-10)

3. Analytica-EBC, section 9 Beer, Method 9.6 (2000-10)

10 Color Hazen

10.1 Method

The color according to Hazen, also known as the Hazen color index, APHA color, or Pt/Co color index, is used to assess the color of clear liquids that possess color characteristics similar to those shown on the platinum/cobalt scale.
This method was developed by Allen Hazen in 1892 and was originally based on a visual comparison of the color of the sample solution with a defined color standard prepared from platinum and cobalt salts in acidic solution.
The method is described in various regulations and is referenced in many technical textbooks. The originally visual color comparison has meanwhile been replaced by photometric methods, since these enable a far higher degree of accuracy to be achieved.
The regulations and technical textbooks describe a broad variety of measurement conditions. An aspect common to all sources of reference, however, is that the measurement results achieved under the respective measurement conditions must be referenced and traceable to a defined color standard consisting of platinum and cobalt salts in acidic solution.
The "Color Hazen" method can be run on the Spectroquant® Prove spectrophotometers at various wavelengths:

- 465 nm (analogous to DIN EN ISO 6271 - see literature reference[1], analogous to APHA 2120C - see literature reference[2], analogous to ASTM D 1209-05 - see literature reference[3])
- 455 nm (analogous to DIN EN ISO 6271 - see literature reference[1], analogous to APHA 2120C - see literature reference[2], analogous to ASTM D 1209-05 - see literature reference[3])
- 445 nm (analogous to DIN EN ISO 6271 - see literature reference[1], analogous to ASTM D 1209-05 - see literature reference[3])
- 340 nm

The measurement result can be expressed in CU (color units) or Hazen units, with the unit being is defined as mg of platinum per litre of solution. The regulations and technical textbooks also use units such as mg/l Pt/Co and mg/l Pt. The conversion factor between the units is 1.

10.2 Measuring range

Method 32	Color Hazen 340	0.2 - 100.0 CU (50-mm rectangular cell)
		1 - 250 CU (20-mm rectangular cell)
		1 - 500 CU (10-mm rectangular cell)
Method 179	Color Hazen 445	1 - 1000 CU (50-mm rectangular cell)
Method 180	Color Hazen 455	1 - 1000 CU (50-mm rectangular cell)
Method 181	Color Hazen 465	1 - 1000 CU (50-mm rectangular cell)

10.3 Sample material

Clear liquid samples with color characteristics similar to those on the Pt/Co color scale (= yellow to yellow-brown)
Turbid liquid samples with color characteristics after filtration similar to those on the Pt/Co color scale (= yellow to yellow-brown)

10.4 Reagents and auxiliaries

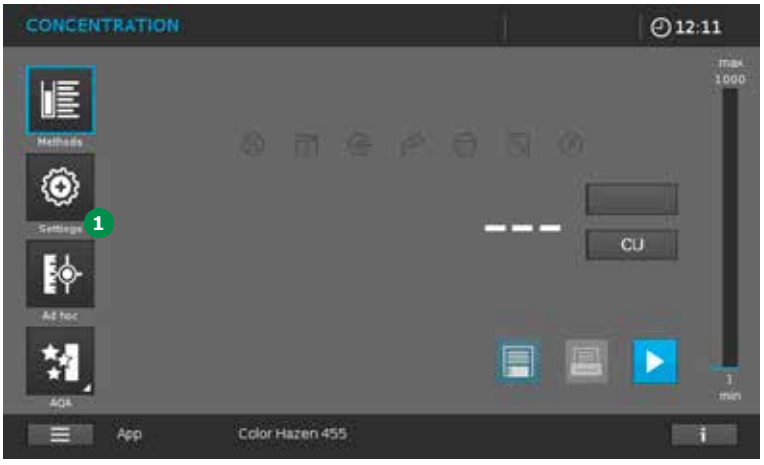
- Cat. No. 1.73016 - Spectroquant® VIS Spectrophotometer Prove 100 or
  Cat. No. 1.73017 - Spectroquant® UV/VIS Spectrophotometer Prove 300 or
  Cat. No. 1.73018 - Spectroquant® UV/VIS Spectrophotometer Prove 600
- Cat. No. 1.14946 - Rectangular cells 10 mm and/or
  Cat. No. 1.14947 - Rectangular cells 20 mm and/or
  Cat. No. 1.14944 - Rectangular cells 50 mm
- Cat. No. 1.16754 - Water for analysis EMSURE® or
  distilled water
- Cat. No. 1.00246 - Platinum Cobalt Color Reference Solution (HAZEN 500) with 500 mg/l Pt (optional)
- Membrane filters, pore size max. 0.45 µm (optional)

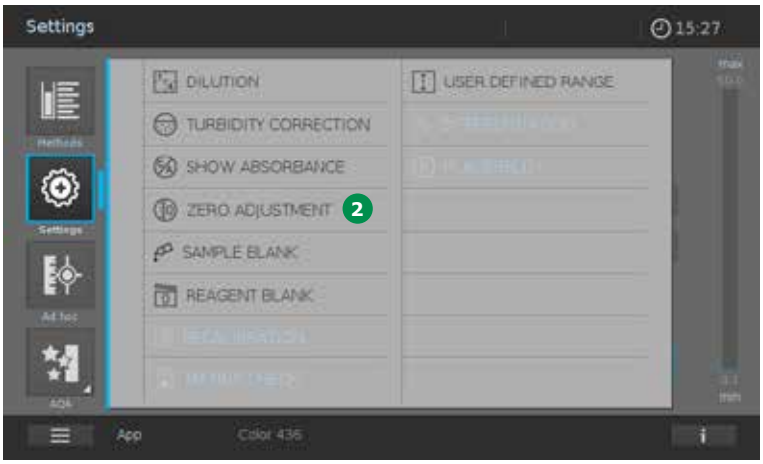
10.5 Preparation

- Filter **turbid sample solutions** over a membrane filter.
  To do this, prerinse the membrane filter with approx. 50 ml of water for analysis, then rerinse with approx. 50 ml of the sample solution and discard the filtrate.
  Filter a further 50 ml of the sample solution over the prerinsed membrane filter and use the filtrate for the analysis.

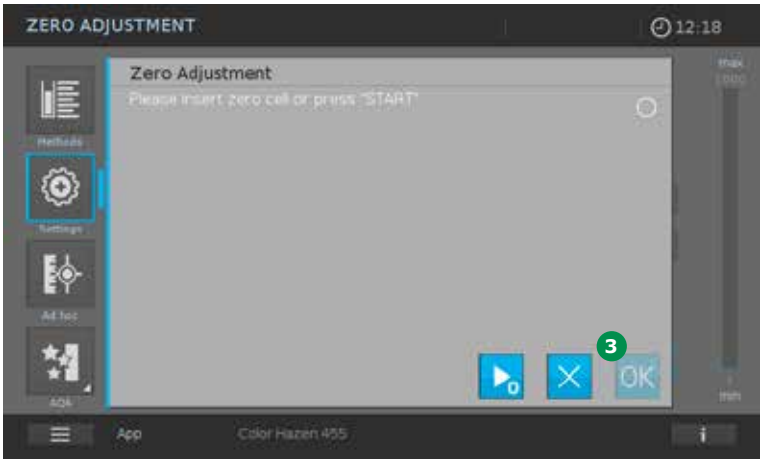
10.6 Procedure and measurement

- **Zeroing the photometer:**
  - It is advisable to zero the photometer at the start of each working day, using the same cell as the one used for the test solutions or else a cell with identical optical characteristics and an identical absorption (matched pair).
  - To perform the zero-adjustment procedure open the methods list (**<Methods>**) and select **Method No. 32 "Color Hazen 340" resp. No. 179 "Color Hazen 445" or No. 180 "Color Hazen 455" or No. 181 "Color Hazen 465"**.
    If there is no valid zero adjustment available for the method, the window for the zero-adjustment procedure opens automatically.





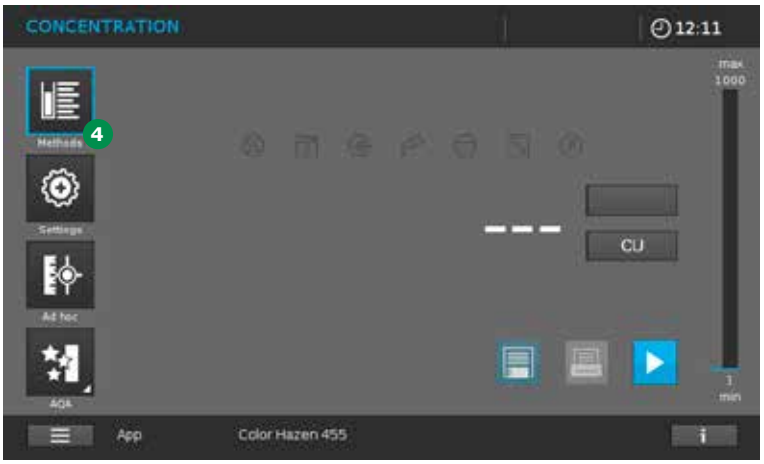
If a valid zero adjustment is already available, the Methods window opens.
The zero-adjustment procedure must then be selected by opening **<Settings>** 1 and clicking on the selection button **"ZERO ADJUSTMENT"** 2.



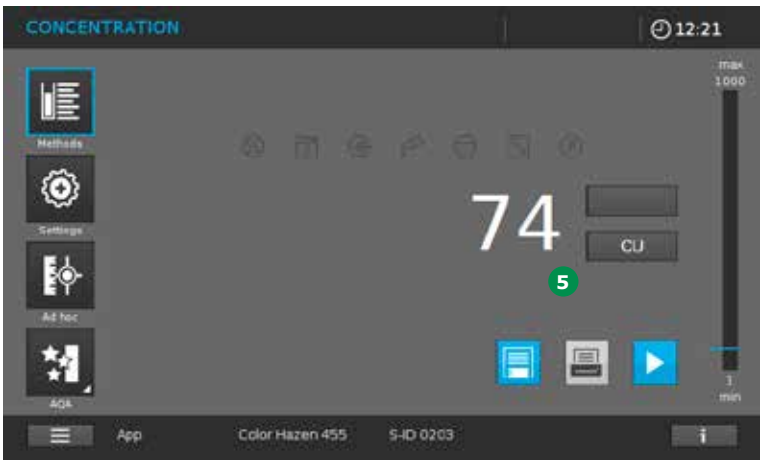
- For the zero adjustment fill a suitable rectangular cell with water for analysis.
- After prompting, insert the filled rectangular cell into the cell compartment. The zero adjustment is performed automatically.
- Confirm the performance of the zero-adjustment procedure by clicking on **<OK>** 3.

- **Measurement:**

  Note
  It is advisable to measure the sample solution using the same cell as the one used for the zero adjustment or else a cell with identical optical characteristics and an identical absorption (matched pair).



- Open the methods list (**<Methods>**) 4 and select **Method No. 32 "Color Hazen 340" resp. No. 179 "Color Hazen 445" or No. 180 "Color Hazen 455" or No. 181 "Color Hazen 465"**.



- Fill the sample solution into a corresponding rectangular cell and insert the cell into the cell compartment. The measurement is performed automatically and the result appears in the display 5.

10.7 Evaluation

Statement of the results: CU or
Hazen or
mg/l Pt/Co or
mg/l Pt

10.8 Method control

The method can be checked using Cat. No. 1.00246.0250 – Platinum cobalt color reference solution (HAZEN 500). Dilute this solution to a Hazen value in the middle of the measuring range with water for analysis or distilled water and analyze.

10.9 Recalibration

The methods can be recalibrated using Cat. No. 1.00246.0250 – Platinum cobalt color reference solution (HAZEN 500). Recalibration can be done by measuring value pairs, by entering value pairs, or by entering coefficients of a calibration function. Please refer to the Operating Manual of your spectrophotometer for details on the recalibration procedure.

10.10 Literature

1. DIN EN ISO 6271 - Clear liquids - Estimation of colour by the platinum-cobalt colour scale (ISO 6271:2015); German version EN ISO 6271:2015
2. Standard Methods for the Examination of Water and Wastewater (21th Edition), APHA 2120 Color - C. Spectrophotometric - Single-Wavelength Method
3. ASTM D 1209-00 - Standard Test Method for Color of Clear Liquids (Platinum-Cobalt-Scale)
4. Water Research Vol. 30, No.11, 2771-2775, 1996 - Hongve and Akesson, Spectrophotometric Determination of Water Colour in Hazen Units

11 Color 410 acc. to EN 7887

11.1 Method

The examination and determination of color 410 according to the EN 7887 standard serves the assessment of water quality. This procedure determines the true color of a filtered water sample caused by dissolved substances.
The measurement is made at a wavelength of 410 nm. This is the shortest wavelength at which the absorption spectrum of a natural water sample with a color factor of 100 mg/l Pt overlaps with that of a corresponding color reference solution.
The method is referenced and traceable to a defined color standard prepared from platinum and cobalt salts in acidic solution (also known as the Hazen standard).
According to DIN EN ISO 7887, the measurement result is expressed as mg/l Pt. The technical literature, however, also uses the units mg/l Pt/Co and CU (Color Unit). The conversion factor between the units is 1.
The method is analogous to the standard DIN EN ISO 7887:2011 - Method C (see literature reference[1]).

11.2 Measuring range

Method 303	Color 410 EN7887	2 - 500 CU (50-mm rectangular cell) 5 - 1250 CU (20-mm rectangular cell) 10 - 2500 CU (10-mm rectangular cell)

11.3 Sample material

Water from water-treatment plants (crude water, drinking water, weakly colored industrial wastewater)

11.4 Reagents and auxiliaries

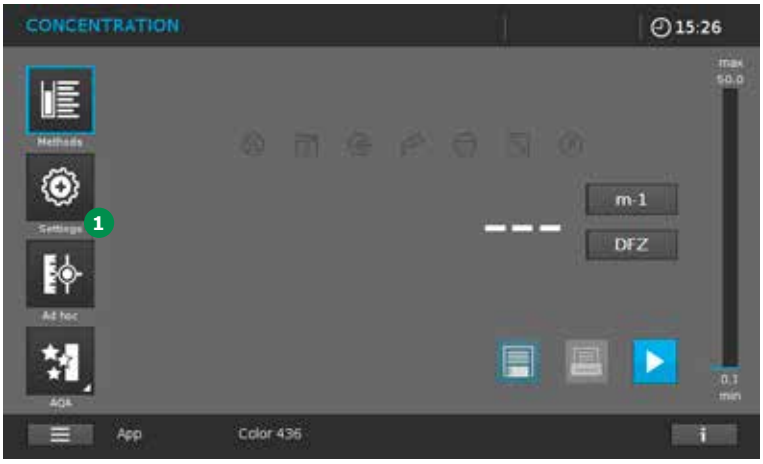
- Cat. No. 1.73016 - Spectroquant® VIS Spectrophotometer Prove 100 or
  Cat. No. 1.73017 - Spectroquant® UV/VIS Spectrophotometer Prove 300 or
  Cat. No. 1.73018 - Spectroquant® UV/VIS Spectrophotometer Prove 600
- Cat. No. 1.14946 - Rectangular cells 10 mm and/or
  Cat. No. 1.14947 - Rectangular cells 20 mm and/or
  Cat. No. 1.14944 - Rectangular cells 50 mm
- Cat. No. 1.16754 - Water for analysis EMSURE® or
  distilled water
- Cat. No. 1.00246 - Platinum Cobalt Color Reference Solution (HAZEN 500) with 500 mg/l Pt (optional)
- Membrane filters, pore size max. 0.45 µm (optional)

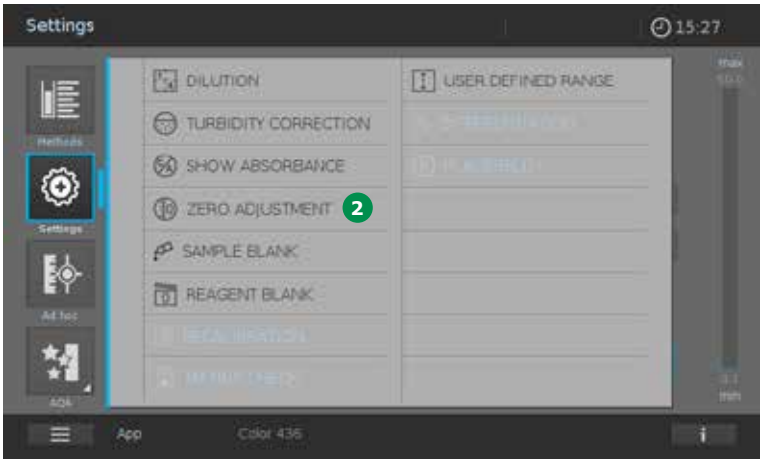
11.5 Preparation

- Filter **turbid sample solutions** over a membrane filter.
  To do this, prerinse the membrane filter with approx. 50 ml of water for analysis, then rerinse with approx. 50 ml of the sample solution and discard the filtrate.
  Filter a further 50 ml of the sample solution over the prerinsed membrane filter and use the filtrate for the analysis.

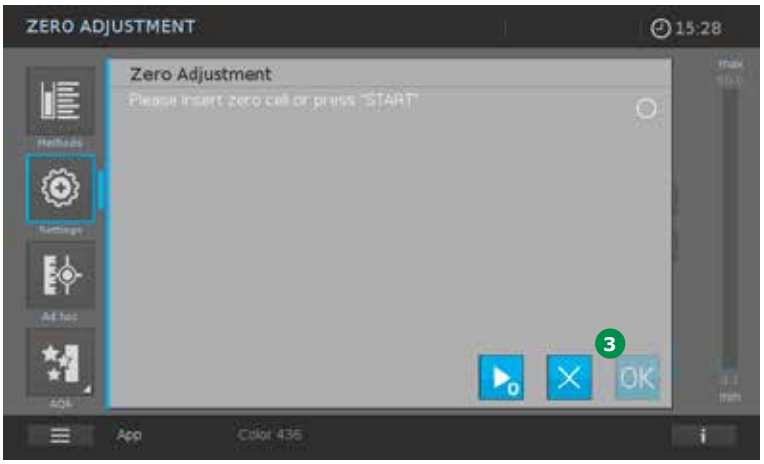
11.6 Procedure and measurement

- **Zeroing the photometer:**
  - It is advisable to zero the photometer at the start of each working day, using the same cell as the one used for the test solutions or else a cell with identical optical characteristics and an identical absorption (matched pair).
  - To perform the zero-adjustment procedure open the methods list (**<Methods>**) and select **Method No. 303 „Color 410 EN7887”**.
    If there is no valid zero adjustment available for the method, the window for the zero-adjustment procedure opens automatically.





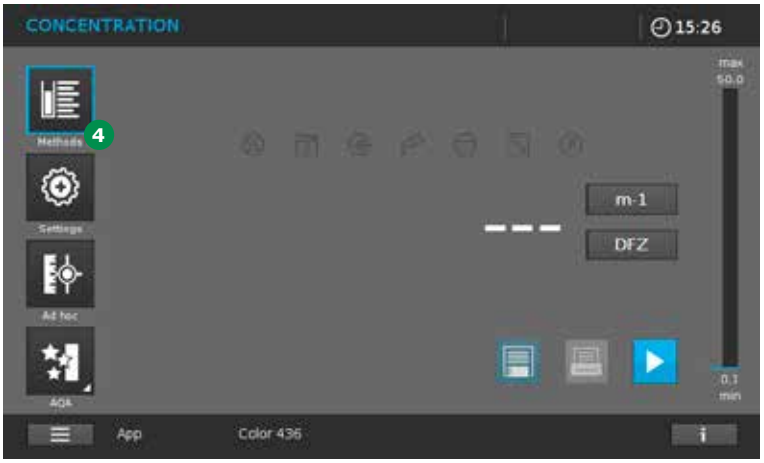
If a valid zero adjustment is already available, the Methods window opens.
The zero-adjustment procedure must then be selected by opening **<Settings>** 1 and clicking on the selection button **“ZERO ADJUSTMENT”** 2.



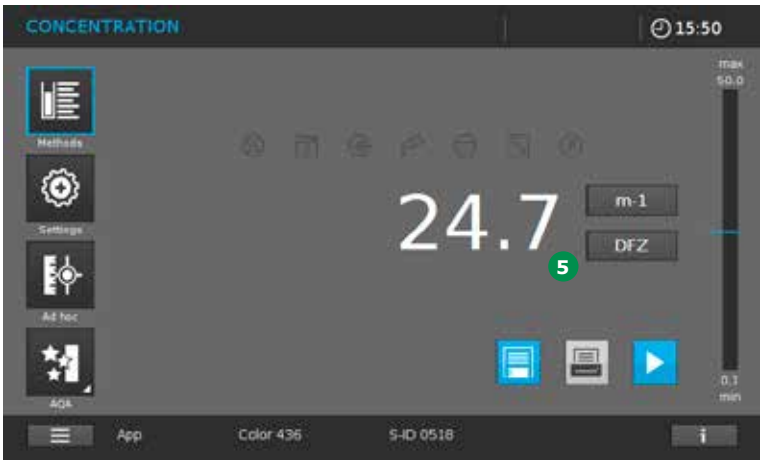
- For the zero adjustment fill a suitable rectangular cell with water for analysis.
- After prompting, insert the filled rectangular cell into the cell compartment. The zero adjustment is performed automatically.
- Confirm the performance of the zero-adjustment procedure by clicking on **<OK>** 3.

- **Measurement:**

  Note
  It is advisable to measure the sample solution using the same cell as the one used for the zero adjustment or else a cell with identical optical characteristics and an identical absorption (matched pair).



- Open the methods list (**<Methods>**) 4 and select **Method No. 303 "Color 410 EN7887"**.



- Fill the sample solution into a corresponding rectangular cell and insert the cell into the cell compartment. The measurement is performed automatically and the result appears in the display 5.

11.7 Evaluation

Statement of the results: mg/l Pt or
mg/l Pt/Co or
CU

11.8 Method control

The method can be checked using Cat. No. 1.00246.0250 – Platinum cobalt color reference solution (HAZEN 500). When using a 50-mm rectangular cell, this solution must be diluted to a value in the middle of the measuring range with water for analysis or distilled water and analyzed.

11.9 Recalibration

The methods can be recalibrated using Cat. No. 1.00246.0250 – Platinum cobalt color reference solution (HAZEN 500). Recalibration can be done by measuring value pairs, by entering value pairs, or by entering coefficients of a calibration function. Please refer to the Operating Manual of your spectrophotometer for details on the recalibration procedure.

11.10 Literature

1. DIN EN ISO 7887:2011 - Water quality - Examination and determination of colour (ISO 7887:2011); German version EN ISO 7887:2011

12 Color - Spectral absorption coefficient acc. to DIN EN ISO 7887

12.1 Method

The examination and determination of color is used in the assessment of water quality. This procedure determines the true color of a filtered water sample caused by dissolved substances.
The maximum absorption of a sample is dependent on its color (e.g. yellow, red, or green). This is why the spectral absorption coefficient should be determined according to the standard DIN EN ISO 7887 - Method B at three different wavelengths (436 nm, 525 nm, 620 nm).
The measurement results for the wavelengths and the respective spectral absorption coefficients are expressed in the unit m^{-1}.
The methods are analogous to the standard DIN EN ISO 7887:2011 - Method B (see literature reference[1]).
Methods Nos. 15 "Color 436" and 302 "SAC α(436)" are identical and differ solely in the method designation. Furthermore, the two methods are both analogous to the procedures prescribed in the German "Trinkwasserverordnung" (Drinking Water Ordinance) Annex 3, No. 7 (see literature reference[2]).

12.2 Measuring range

Method 15 (mono-wavelength method, 436 nm)	Color 436	0.1 - 50.0 m^{-1} (50-mm rectangular cell) 0.3 - 125.0 m^{-1} (20-mm rectangular cell) 1.0 - 250 m^{-1} (10-mm rectangular cell)
Method 302 (mono-wavelength method, 436 nm)	SAC α(436)	0.1 - 50.0 m^{-1} (50-mm rectangular cell) 0.3 - 125.0 m^{-1} (20-mm rectangular cell) 1 - 250 m^{-1} (10-mm rectangular cell)
Method 61 (mono-wavelength method, 525 nm)	Color 525	0.1 - 50.0 m^{-1} (50-mm rectangular cell) 0.3 - 125.0 m^{-1} (20-mm rectangular cell) 1.0 - 250 m^{-1} (10-mm rectangular cell)
Method 78 (mono-wavelength method, 620 nm)	Color 620	0.1 - 50.0 m^{-1} (50-mm rectangular cell) 0.3 - 125.0 m^{-1} (20-mm rectangular cell) 1.0 - 250 m^{-1} (10-mm rectangular cell)

Method 2588 (multi-wave-length method, 436 nm, 525 nm, 620 nm)	Color EN 7887	0.0 - 50.0 m^{-1} (50-mm rectangular cell) 0.0 - 125.0 m^{-1} (20-mm rectangular cell) 0.0 - 250.0 m^{-1} (10-mm rectangular cell)

Note
The colorimetric measurement can be performed with a multi-wavelength method or consecutively with mono-wavelength methods.

12.3 Sample material

Water from water-treatment plants (crude water, drinking water, weakly colored industrial wastewater)

12.4 Reagents and auxiliaries

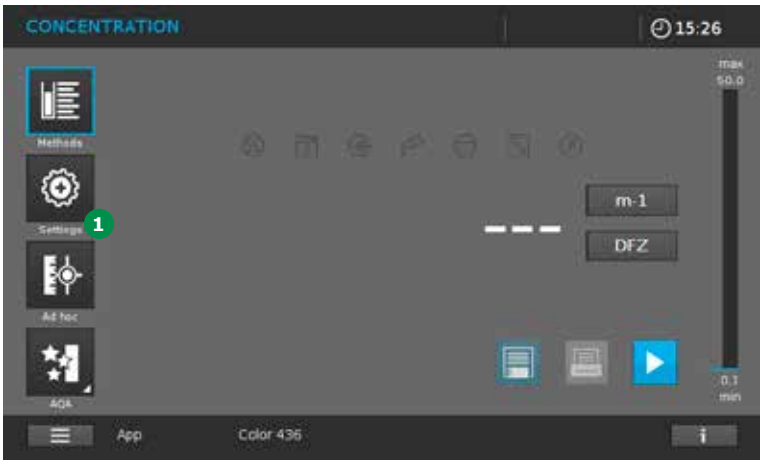
- Cat. No. 1.73016 - Spectroquant® VIS Spectrophotometer Prove 100 or
  Cat. No. 1.73017 - Spectroquant® UV/VIS Spectrophotometer Prove 300 or
  Cat. No. 1.73018 - Spectroquant® UV/VIS Spectrophotometer Prove 600
- Cat. No. 1.14946 - Rectangular cells 10 mm and/or
  Cat. No. 1.14947 - Rectangular cells 20 mm and/or
  Cat. No. 1.14944 - Rectangular cells 50 mm
- Cat. No. 1.16754 - Water for analysis EMSURE® or
  distilled water
- Membrane filters, pore size max. 0.45 µm (optional)

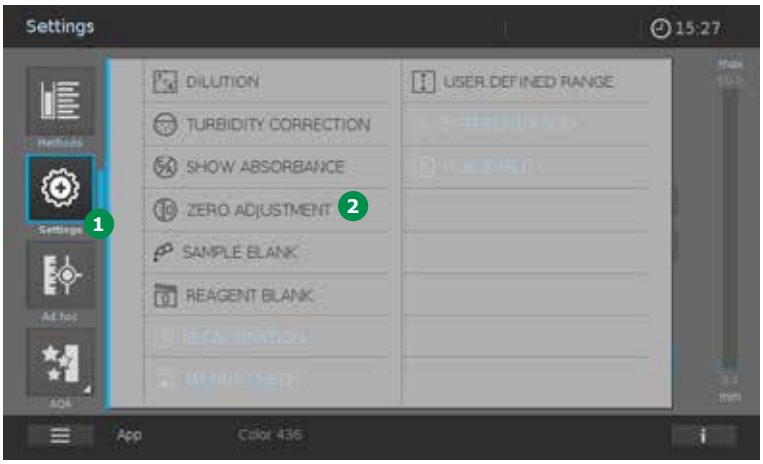
12.5 Preparation

- Filter **turbid sample solutions** over a membrane filter.
  To do this, prerinse the membrane filter with approx. 50 ml of water for analysis, then rerinse with approx. 50 ml of the sample solution and discard the filtrate.
  Filter a further 50 ml of the sample solution over the prerinsed membrane filter and use the filtrate for the analysis.

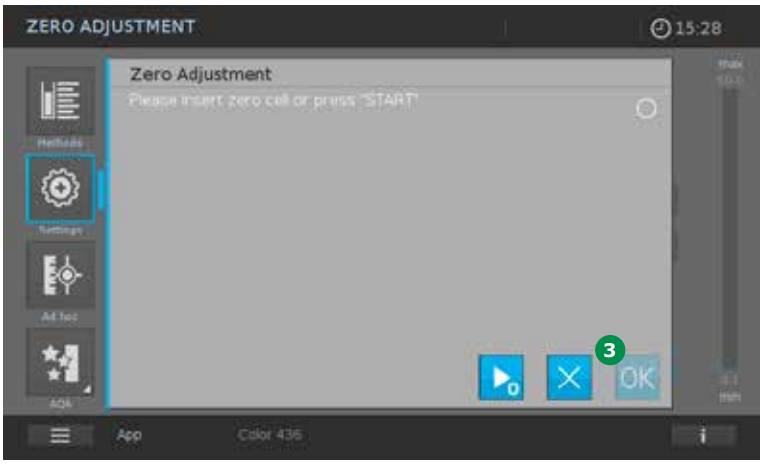
12.6 Procedure and measurement - <u>Mono-wavelength methods</u>

- **Zeroing the photometer:**
  - It is advisable to zero the photometer at the start of each working day, using the same cell as the one used for the test solutions or else a cell with identical optical characteristics and an identical absorption (matched pair).
  - To perform the zero-adjustment procedure open the methods list (**<Methods>**) and select **Method No. 15 "Color 436" resp. 302 "SAC α(436)" or 61 "Color 525" or 78 "Color 620"**.
    If there is no valid zero adjustment available for the method, the window for the zero-adjustment procedure opens automatically.





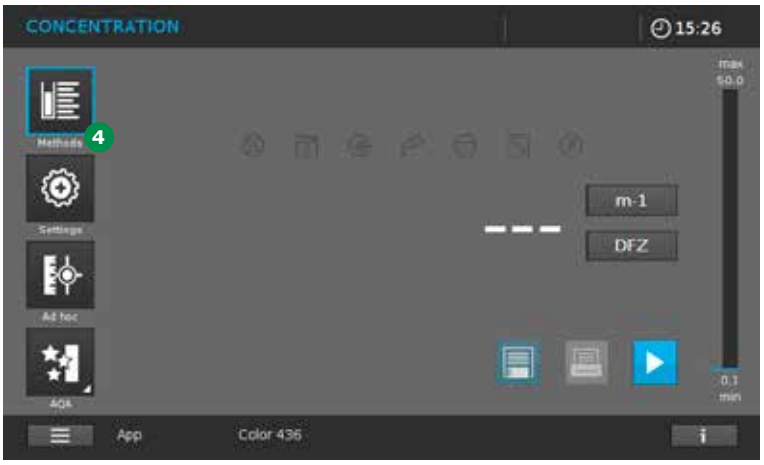
If a valid zero adjustment is already available, the Methods window opens.
The zero-adjustment procedure must then be selected by opening **<Settings>** 1 and clicking on the selection button **"ZERO ADJUSTMENT"** 2.



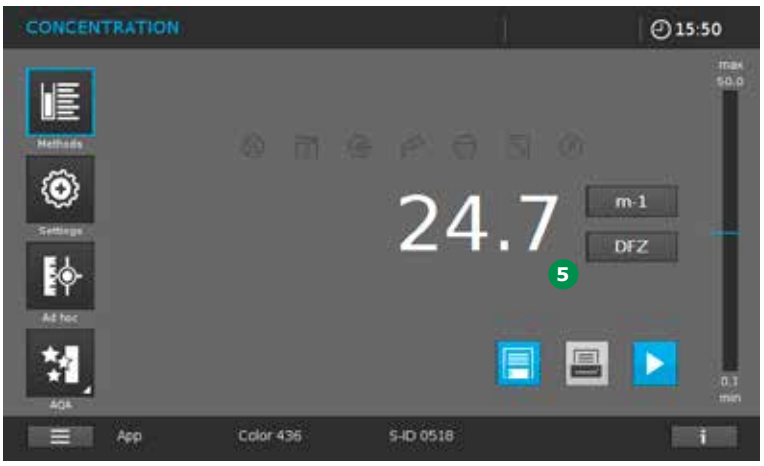
- For the zero adjustment fill a suitable rectangular cell with water for analysis.
- After prompting, insert the filled rectangular cell into the cell compartment. The zero adjustment is performed automatically.
- Confirm the performance of the zero-adjustment procedure by clicking on **<OK>** 3.

- **Measurement:**

  Note
  It is advisable to measure the sample solution using the same cell as the one used for the zero adjustment or else a cell with identical optical characteristics and an identical absorption (matched pair).



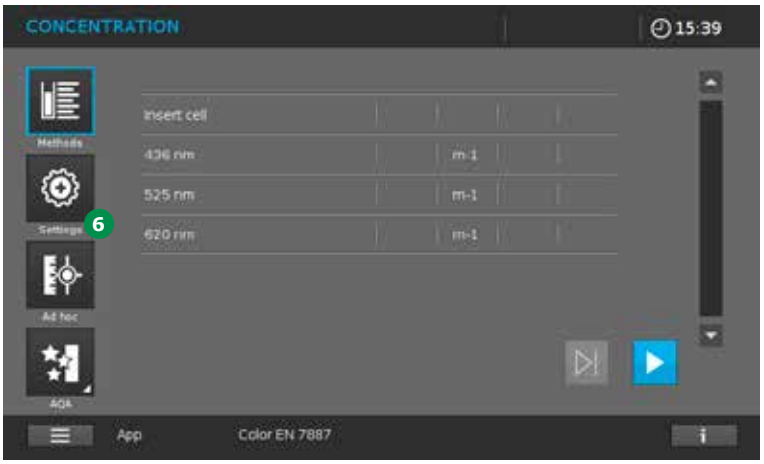
- Open the methods list (**<Methods>**) 4 and select **Method No. 15 "Color 436" resp. 302 "SAC α(436)" or 61 "Color 525" or 78 "Color 620"**.



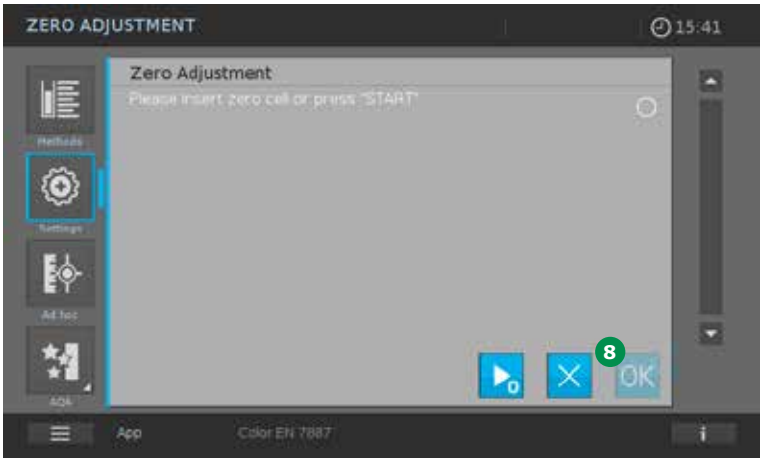
- Fill the sample solution into a corresponding rectangular cell and insert the cell into the cell compartment. The measurement is performed automatically and the result appears in the display 5.

12.7 Procedure and measurement - Multiwavelength method

- **Zeroing the photometer:**
  - It is advisable to zero the photometer at the start of each working day, using the same cell as the one used for the test solutions or else a cell with identical optical characteristics and an identical absorption (matched pair).
  - To perform the zero-adjustment procedure open the methods list (**<Methods>**) and select **Method No. 2588 "Color EN 7887"**.
    If there is no valid zero adjustment available for the method, the window for the zero-adjustment procedure opens automatically.



If a valid zero adjustment is already available, the Methods window opens.
The zero-adjustment procedure must then be selected by opening **<Settings>** 6 and clicking on the selection button **"ZERO ADJUSTMENT"** 7.

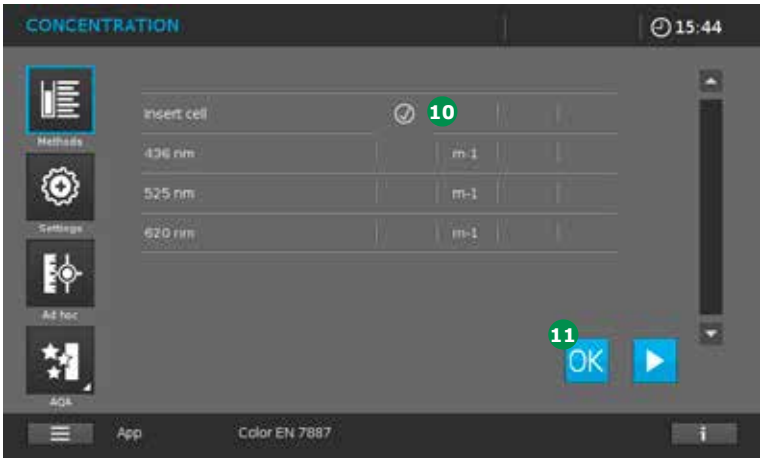


- For the zero adjustment fill a suitable rectangular cell with water for analysis.
- After prompting, insert the filled rectangular cell into the cell compartment. The zero adjustment is performed automatically.
- Confirm the performance of the zero-adjustment procedure by clicking on **<OK>** 8.

- **Measurement:**

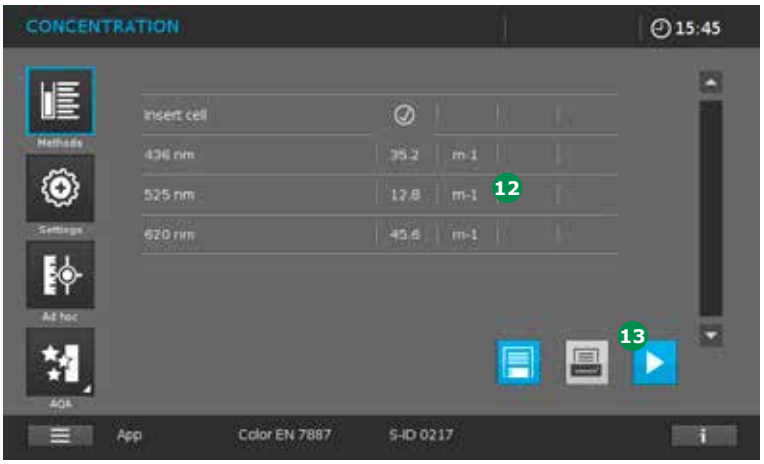
  Note
  It is advisable to measure the sample solution using the same cell as the one used for the zero adjustment or else a cell with identical optical characteristics and an identical absorption (matched pair).

- Open the methods list (**<Methods>**) 9 and select **Method No. 2588 "Color EN 7887"**.
- Fill the sample solution into a corresponding rectangular cell and insert the cell into the cell compartment. The measurement is performed automatically.



A (✓) appears behind the cue "Insert cell" 10.

- Confirm the measurement by clicking on **<OK>** 11.



The measurement results at the wavelengths 436 nm, 525 nm, and 620 nm appear in the photometer display 12.

- Click **<START>** 13 to start the measurement procedure for the next sample.

12.8 Evaluation

Statement of the results: m^{-1}

12.9 Literature

1. DIN EN ISO 7887:2011 - Water quality - Examination and determination of colour (ISO 7887:2011); German version EN ISO 7887:2011
2. Deutsche Trinkwasserverordnung - TrinkwV Anlage 3, No. 7

13 Gardner color measurement

13.1 Method

The Gardner Color Scale is used to assess the color of clear, yellow to yellow-brownish liquids. The scale spans a spectrum ranging from 1.0 (lightest color) to 18.0 (darkest color).
The color index is determined by measuring the transmittances of the sample in a wavelength spectrum between 360 and 780 nm and subsequently calculating the tristimulus values X, Y, Z and the chromaticity coordinates x and y. These chromaticity coordinates x and y values are then used to calculate the Gardner Color Index according to the methods of the DIN EN ISO 4630-2 (see literature reference[1]) and ASTM D6166 standards (see literature reference[2]).
The method is analogous to the DIN EN ISO 4630-2 (see literature reference[1]) and ASTM D6166 standards (see literature reference[2]).

13.2 Measuring range

Method 2561	Gardner Color	1.0 - 18.0 Gardner (10-mm rectangular cell)

13.3 Sample material

Clear yellow to yellow-brown liquids
Products made of natural resins (e.g. tall oils, tall-oil fatty acids, paints, oils)
Surfactants

13.4 Reagents and auxiliaries

- Cat. No. 1.73016 - Spectroquant® VIS Spectrophotometer Prove 100 or
  Cat. No. 1.73017 - Spectroquant® UV/VIS Spectrophotometer Prove 300 or
  Cat. No. 1.73018 - Spectroquant® UV/VIS Spectrophotometer Prove 600
- Cat. No. 1.14946 - Rectangular cells 10 mm
- Cat. No. 1.16754 - Water for analysis EMSURE® or
  distilled water
- Ultrasound bath (optional)
- Heating bath (optional)
- Filter paper or centrifuge (optional)

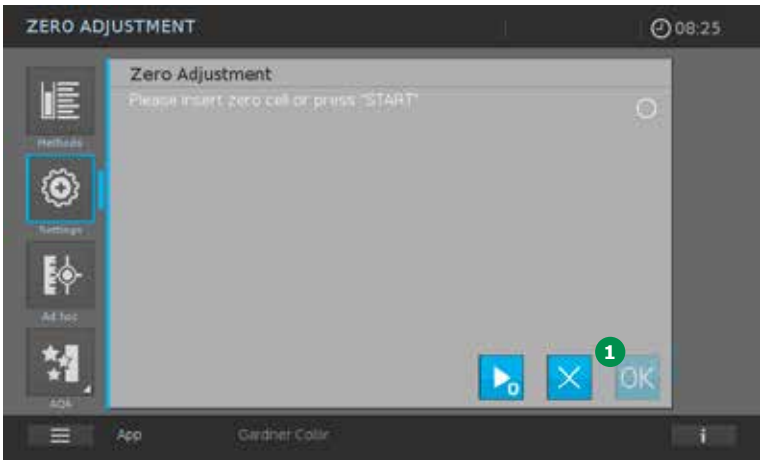
13.5 Preparation

- Eliminate any **air bubbles** present in the sample by degassing the sample in the ultrasound bath.
- Centrifuge **turbid samples** and use the supernatant or else filter over a paper filter and use the filtrate.
- **Melt solid** or **waxlike samples** in a water bath with gentle heating and subsequently homogenize by stirring. Take care not to overheat the sample in the melting process.

13.6 Procedure and measurement

- Open the methods list (**<Methods>**) and select **Method No. 2561 "Gardner Color"**.

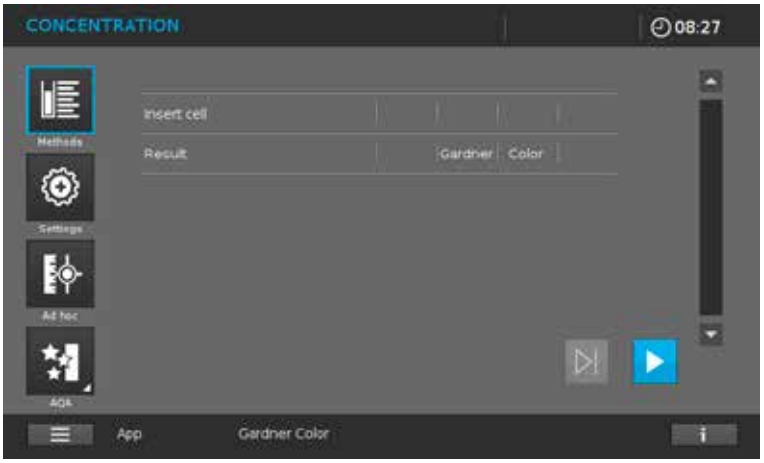
- **Zeroing the photometer:**
  - The photometer must be zeroed prior to each new measurement series.
  - It is advisable to zero the photometer using the same cell as the one used for the measurement sample or else a cell with identical optical characteristics and an identical absorption (matched pair).
    The zero-adjustment procedure for the measurement series is automatically prompted by the instrument.



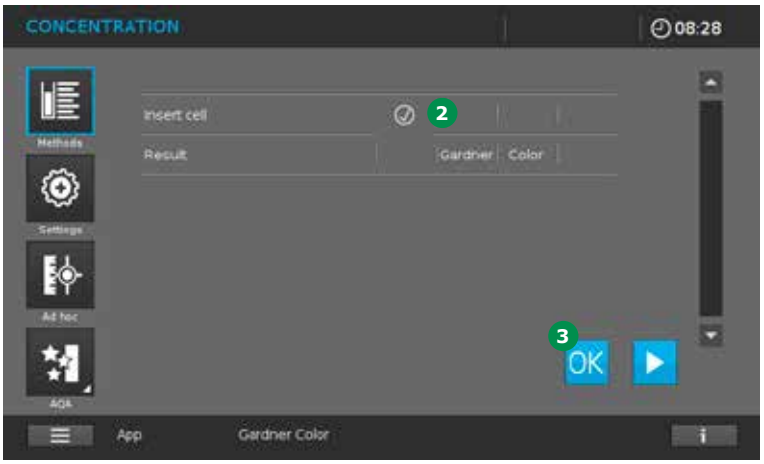
- For the zero adjustment fill a 10-mm rectangular cell with water for analysis.
- After prompting, insert the filled rectangular cell into the cell compartment. The zero adjustment is performed automatically.
- Confirm the performance of the zero-adjustment procedure by clicking on **<OK>** 1.
  The zero adjustment is valid for the entire measurement series.

- **Measurement:**

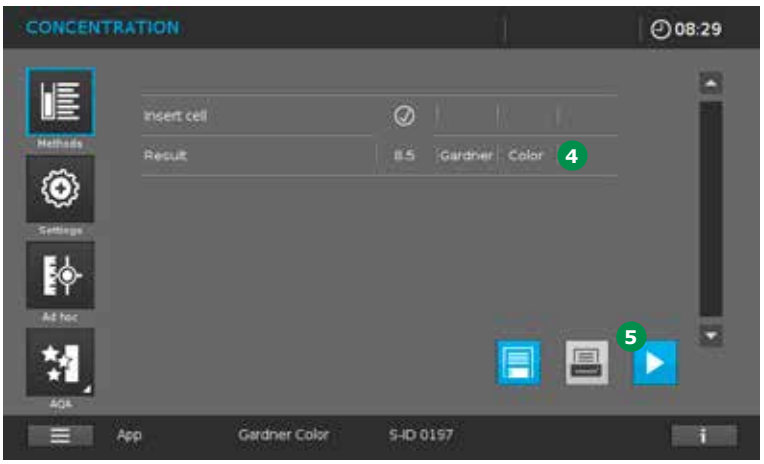
  Note
  It is advisable to measure the sample using the same cell as the one used for the zero adjustment or else a cell with identical optical characteristics and an identical absorption (matched pair).



- Fill the sample solution into a 10-mm rectangular cell and insert the cell into the cell compartment. The measurement is performed automatically.



A (✓) appears behind the cue "Insert cell" 2.
- Confirm the measurement by clicking on **<OK>** 3.



The measurement result appears in the photometer display 4.

- Click **<START>** 5 to start the measurement procedure for the next sample.
  A renewed zero adjustment is not necessary.

13.7 Evaluation

Statement of the results: Gardner Units

13.8 Literature

1. DIN EN ISO 4630-2:2016-05, Clear liquids - Estimation of colour by the Gardner colour scale - Part 2: Spectrophotometric method
2. ASTM D6166-12, Standard Test Method for Color of Pine Chemicals and Related Products
3. ASTM D1544-04, Standard Test Method for Color of Transparent Liquids (Gardner Color Scale)

14 Hess-Ives color scale

14.1 Method

The Hess-Ives color scale serves to assess the color of fat derivatives and is used in the cosmetics industry. The color index is determined from the weighted color intensities that correspond to the red, green, and blue color components of the sample.
The index is determined by measuring the absorption at the wavelengths 460 nm, 470 nm, 560 nm, and 640 nm and subsequent calculations according to the procedure of DGK Test Method F 050.2.
The method is analogous to DGK Test Method F 050.2 (see literature reference[1]).

14.2 Measuring range

Method 2586	Hess-Ives Color	0 - 400 H-I (10-mm rectangular cell) 0.0 - 80.0 H-I (50-mm rectangular cell)

14.3 Sample material

Fat derivatives, surfactants

14.4 Reagents and auxiliaries

- Cat. No. 1.73016 - Spectroquant® VIS Spectrophotometer Prove 100 or
  Cat. No. 1.73017 - Spectroquant® UV/VIS Spectrophotometer Prove 300 or
  Cat. No. 1.73018 - Spectroquant® UV/VIS Spectrophotometer Prove 600
- Cat. No. 1.14946 - Rectangular cells 10 mm and/or
  Cat. No. 1.14944 - Rectangular cells 50 mm
- Cat. No. 1.16754 - Water for analysis EMSURE® or
  distilled water
- Ultrasound bath (optional)
- Heating bath (optional)
- Filter paper or centrifuge (optional)

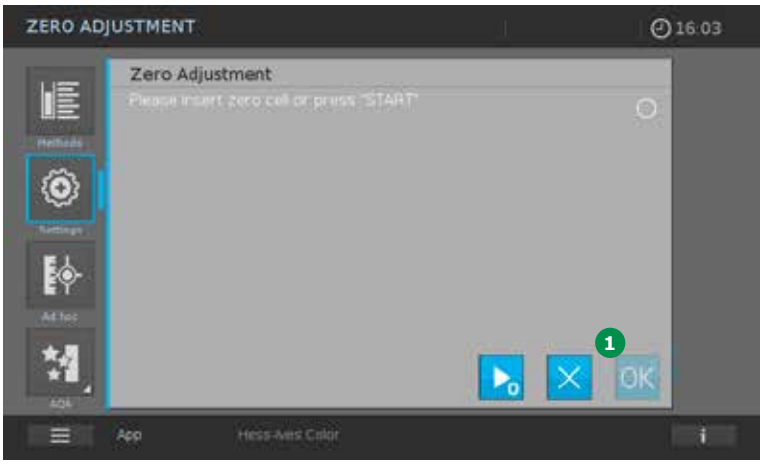
14.5 Preparation

- Eliminate any **air bubbles** present in the sample by degassing the sample in the ultrasound bath.
- Centrifuge **turbid samples** and use the supernatant or else filter over a paper filter and use the filtrate.
- Melt **solid** or **waxlike samples** in a water bath with gentle heating and subsequently homogenize by stirring. Take care not to overheat the sample in the melting process.

14.6 Procedure and measurement

- Open the methods list (**<Methods>**) and select Method No. Methodnliste (**<Methodn (Methods)>**) öffnen and **Method No. 2586 "Hess-Ives Color"**.

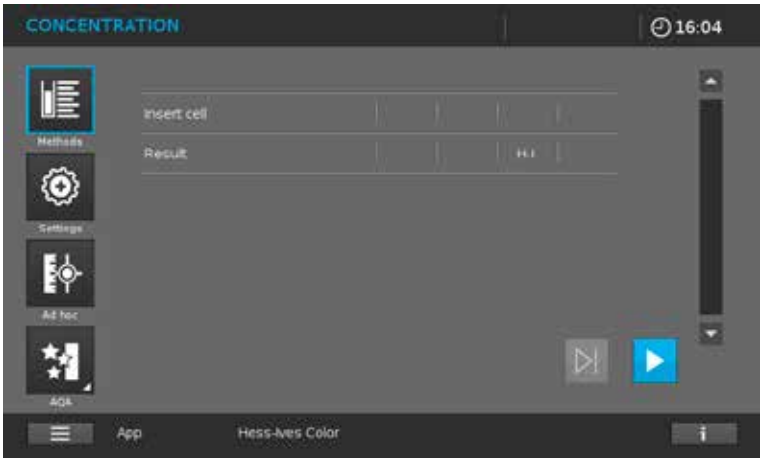
- **Zeroing the photometer:**
  - The photometer must be zeroed prior to each new measurement series.
  - It is advisable to zero the photometer using the same cell as the one used for the measurement sample or else a cell with identical optical characteristics and an identical absorption (matched pair).
    The zero-adjustment procedure for the measurement series is automatically prompted by the instrument.



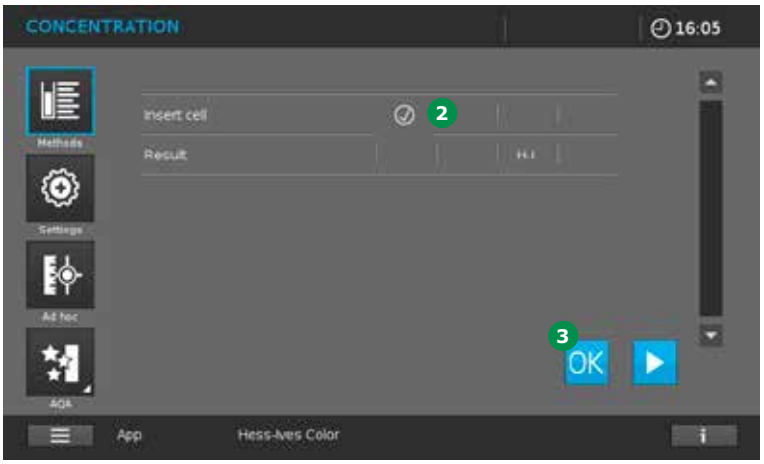
- For the zero adjustment fill a suitable rectangular cell with water for analysis.
- After prompting, insert the filled rectangular cell into the cell compartment. The zero adjustment is performed automatically.
- Confirm the performance of the zero-adjustment procedure by clicking on **<OK>** 1.
  The zero adjustment is valid for the entire measurement series.

- **Measurement:**

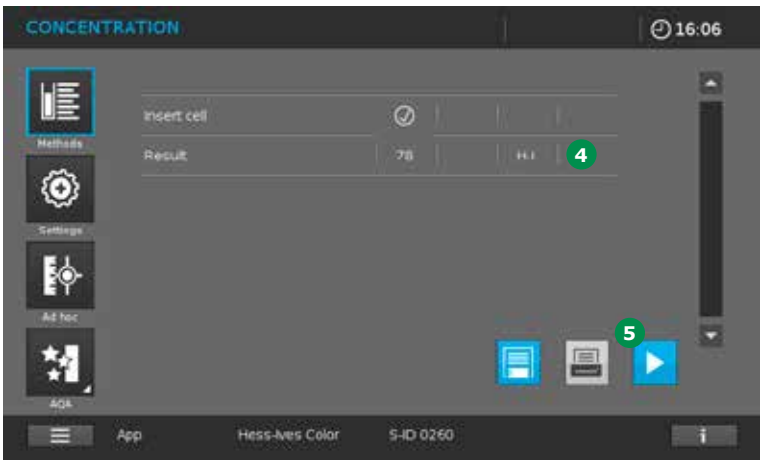
  Note
  It is advisable to measure the sample using the same cell as the one used for the zero adjustment or else a cell with identical optical characteristics and an identical absorption (matched pair).



- Fill the sample solution into a corresponding rectangular cell and insert the cell into the cell compartment. The measurement is performed automatically.



A (✓) appears behind the cue "Insert cell" 2.
- Confirm the measurement by clicking on **<OK>** 3.



The measurement result appears in the photometer display 4.
- Click **<START>** 5 to start the measurement procedure for the next sample.
  A renewed zero adjustment is not necessary.

14.7 Evaluation

Statement of the results: Hess-Ives (H-I) Units

14.8 Literature

1. DGK PrüfMethod F 050.2 (Deutsche Gesellschaft für wissenschaftliche and angewandte Kosmetik e.V.)

15 Hunter color distance

15.1 Method

The color differences can be quantified by means of the color distance ΔE (also referred to as Delta E). The coordinates of the colorimetric loci (L*a*b*) of the samples to be compared are used to determine their position in the color space. Subsequently the Euclidean distance between the colorimetric loci is calculated and the result is defined as the color distance (ΔE value). In the Hunter color space (see section 16, Hunter-Lab color space) the values for the brightness difference (ΔL*) and the distance of the coordinates a*, b* (Δa* and Δb*) also play a relevant role.
These values are determined by the spectrophotometric measurement of a reference sample and an analysis sample. The transmittances for both samples in the wavelength spectrum between 360 and 780 nm is measured, and subsequently the color distance, the brightness difference, and the distance of the coordinates a* and b* are determined according to the methods of HunterLab Application Note Vol. 8, No. 9, 06/08 (see literature reference[1]).

15.2 Measuring range

Method 2585	Hunter Color Distance D65/2°	ΔE*H 0.00 - 200.00 ΔL* -200.00 - 200.00 Δa*-200.00 - 200.00 Δb*-200.00 - 200.00 (10-mm rectangular cell)

Note
The measurement values are determined for standard illuminant D65 and the 2° standard observer.

15.3 Sample material

Clear liquid samples
Turbid liquid samples after filtration

15.4 Reagents and auxiliaries

- Cat. No. 1.73016 - Spectroquant® VIS Spectrophotometer Prove 100 or
  Cat. No. 1.73017 - Spectroquant® UV/VIS Spectrophotometer Prove 300 or
  Cat. No. 1.73018 - Spectroquant® UV/VIS Spectrophotometer Prove 600
- Cat. No. 1.14946 - Rectangular cells 10 mm
- Cat. No. 1.16754 - Water for analysis EMSURE® or
  distilled water
- Membrane filters, pore size max. 0.45 µm (optional)

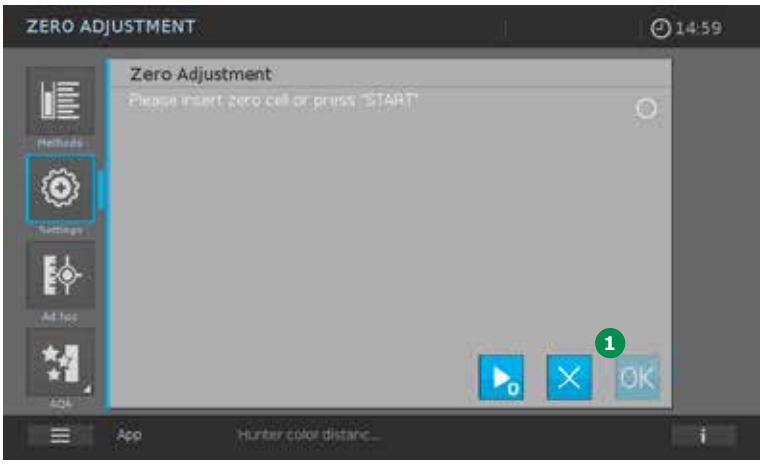
15.5 Preparation

- Filter **turbid sample solutions** over a membrane filter.
  To do this, prerinse the membrane filter with approx. 50 ml of water for analysis, then rerinse with approx. 50 ml of the sample solution and discard the filtrate.
  Filter a further 50 ml of the sample solution over the prerinsed membrane filter and use the filtrate for the analysis.

15.6 Procedure and measurement

- Open the methods list (**<Methods>**) and select **Method No. 2585 "Hunter Color Distance D65/2°"**.

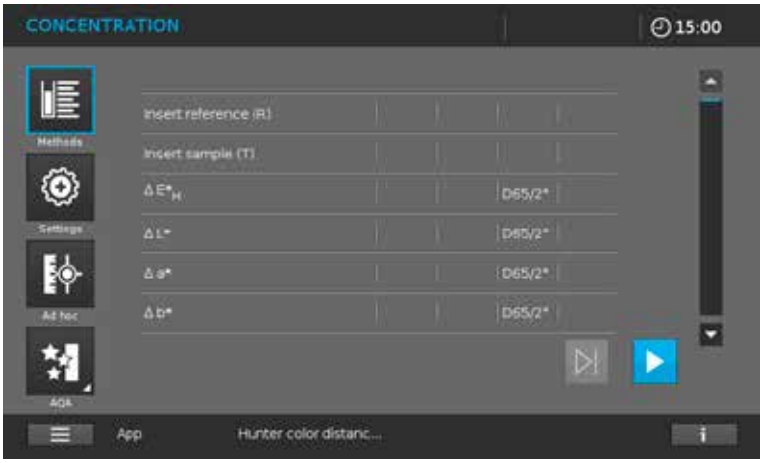
- **Zeroing the photometer:**
  - The photometer must be zeroed prior to each new measurement series.
  - It is advisable to zero the photometer using the same cell as the one used for the measurement sample or else a cell with identical optical characteristics and an identical absorption (matched pair).
    The zero-adjustment procedure for the measurement series is automatically prompted by the instrument.



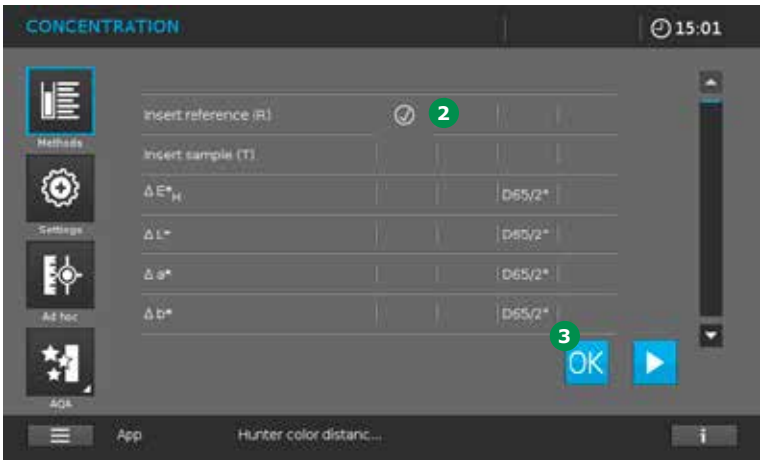
  - For the zero adjustment fill a 10-mm rectangular cell with water for analysis.
  - After prompting, insert the filled rectangular cell into the cell compartment. The zero adjustment is performed automatically.
  - Confirm the performance of the zero-adjustment procedure by clicking on **<OK>** 1.
    The zero adjustment is valid for the entire measurement series.

- **Measurement:**

  Note
  It is advisable to measure the reference solution and the measurement sample using the same cell as the one used for the zero adjustment or else a cell with identical optical characteristics and an identical absorption (matched pair).

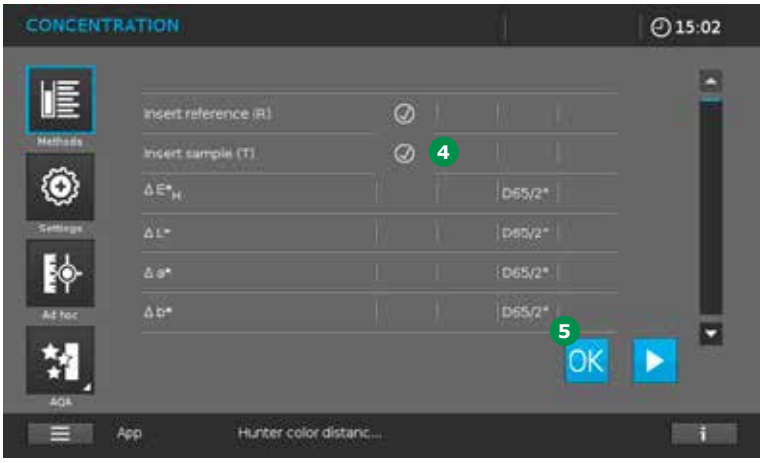


  - Fill the reference solution into a 10-mm rectangular cell and insert the cell into the cell compartment.
    The measurement is performed automatically.



A (✓) appears behind the cue "Insert reference (R)" 2.

- Confirm the measurement by clicking on **<OK>** 3 .
- Fill the sample solution into a 10-mm rectangular cell and insert the cell into the cell compartment. The measurement is performed automatically.



A (✓) appears behind the cue "Insert sample (T)" 4.

- Confirm the measurement by clicking on **<OK>** 5.

The measurement results appear in the photometer display 6.

- Where applicable, use the scroll keys 7 to scroll down through the display to show other measurement results.
- Click **<START>** 8 to start the measurement procedure for the next sample.
  A renewed zero adjustment is not necessary.

15.7 Evaluation

Statement of the results: ΔE^*_H value
ΔL* value
Δa* value
Δb* value
L*a*b* values for the reference sample are shown with a lower-case "R" (e.g. L^*_R)
L*a*b* values for the analysis sample are shown with a lower-case "T" (e.g. L^*_T)
determined for standard illuminant D65 and the 2° standard observer

15.8 Literature

1. HunterLab Application Note Vol. 8, No. 9, 06/08, www.hunterlab.com

2. ASTM E-308-06, Standard Practice for Computing the Colors of Objects by Using the CIE System

16 HunterLab color space

16.1 Method

The HunterLab color space describes all perceivable colors and, like the CIELAB color space, is based on the CIE's XYZ model from 1931. This model takes the spectral characteristics of a color sample to calculate the so-called tristimulus values X, Y, Z, which stand in direct correlation to the intensity of the stimulation of the three types of color receptors (cone cells) of the human eye (red, green, blue). Since the XYZ model proved to be difficult to handle in the assessment of color differences, various scientists worked on other models that were better capable of imaging the human color perception than the XYZ model. These endeavours resulted in the establishment of the HunterLab model in the 1960s. The HunterLab model is a cube-shaped coordinate system with the coordinates L*, a*, and b*.
On the a* axis, green and red lie opposite each other, on the b* axis blue and yellow. Gray lies at the coordinate origin (a*=0 and b*=0). The L* axis stands in the coordinate origin vertically at the a*b* level and describes the brightness of the color, with values ranging between 0 and 100.
Negative a* values stand for green colors, positive a* values for red colors. On the b* axis, negative b* values describe blue colors, with positive b* values describing yellow colors.
The Hunter L*a*b* values are determined by measuring the transmittances in a wavelength spectrum between 360 - 780 nm and subsequently calculating the L*a*b* values according to the methods of HunterLab Application Note Vol. 8, No. 9, 06/08 (see literature reference[1]).

16.2 Measuring range

Method 2583	Hunter Lab D65/2°	L* 0,00 - 105,00 a* -180,0 - 180,0 b* -180,0 - 180,0 (10-mm rectangular cell)

Note
The measurement values are determined for standard illuminant D65 and the 2° standard observer.

16.3 Sample material

Clear liquid samples
Turbid liquid samples after filtration

16.4 Reagents and auxiliaries

- Cat. No. 1.73016 - Spectroquant® VIS Spectrophotometer Prove 100 or
  Cat. No. 1.73017 - Spectroquant® UV/VIS Spectrophotometer Prove 300 or
  Cat. No. 1.73018 - Spectroquant® UV/VIS Spectrophotometer Prove 600
- Cat. No. 1.14946 - Rectangular cells 10 mm
- Cat. No. 1.16754 - Water for analysis EMSURE® or
  distilled water
- Membrane filters, pore size max. 0.45 µm (optional)

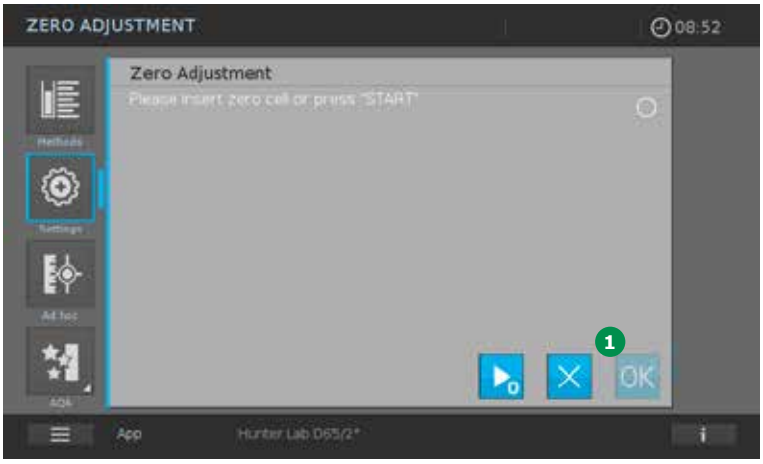
16.5 Preparation

- Filter **turbid sample solutions** over a membrane filter.
  To do this, prerinse the membrane filter with approx. 50 ml of water for analysis, then rerinse with approx. 50 ml of the sample solution and discard the filtrate.
  Filter a further 50 ml of the sample solution over the prerinsed membrane filter and use the filtrate for the analysis.

16.6 Procedure and measurement

- Open the methods list (**<Methods>**) and select **Method No. 2583 "Hunter Lab D65/2°"**.

- **Zeroing the photometer:**
  - The photometer must be zeroed prior to each new measurement series.
  - It is advisable to zero the photometer using the same cell as the one used for the measurement sample or else a cell with identical optical characteristics and an identical absorption (matched pair).
    The zero-adjustment procedure for the measurement series is automatically prompted by the instrument.

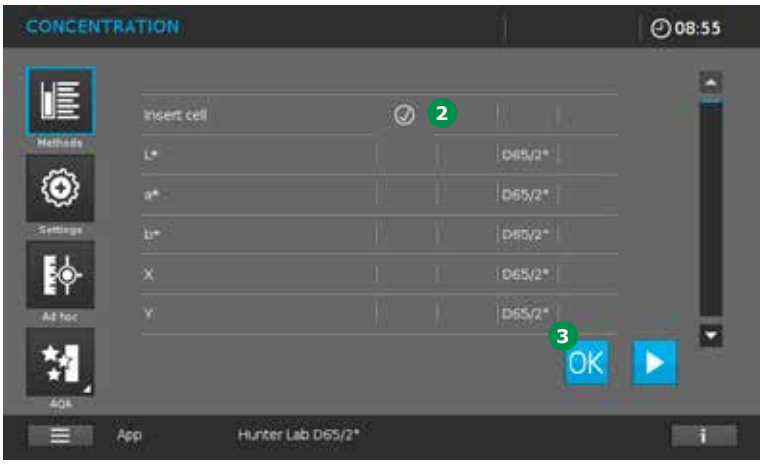


  - For the zero adjustment fill a 10-mm rectangular cell with water for analysis.
  - After prompting, insert the filled rectangular cell into the cell compartment. The zero adjustment is performed automatically.
  - Confirm the performance of the zero-adjustment procedure by clicking on **<OK>** (1).
    The zero adjustment is valid for the entire measurement series.

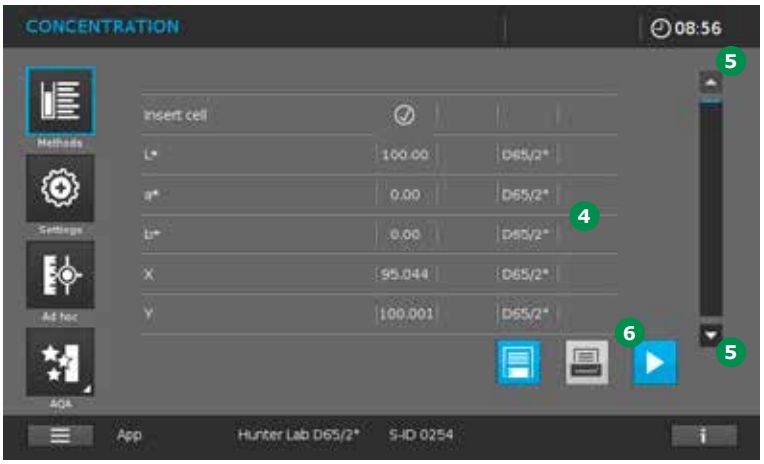
- **Measurement:**

  Note
  It is advisable to measure the sample using the same cell as the one used for the zero adjustment or else a cell with identical optical characteristics and an identical absorption (matched pair).

  - Fill the sample solution into a 10-mm rectangular cell and insert the cell into the cell compartment. The measurement is performed automatically.



A (✓) appears behind the cue "Insert cell" 2.
- Confirm the measurement by clicking on **<OK>** 3.



The measurement results appear in the photometer display 4.
- Where applicable, use the scroll keys 5 to scroll down through the display to show other measurement results.
- Click **<START>** 6 to start the measurement procedure for the next sample.
  A renewed zero adjustment is not necessary.

16.7 Evaluation

Statement of the results: Lab values
Tristimulus values X, Y, Z
determined for standard illuminant D65 and the 2° standard observer

16.8 Literature

1. HunterLab Application Note Vol. 8, No. 9, 06/08, www.hunterlab.com

2. ASTM E-308-06, Standard Practice for Computing the Colors of Objects by Using the CIE System

17 ICUMSA Color $GS1_{/3}$-7 (2011)

17.1 Method

The color of sugars and its solutions is generally determined using theofficial methods of the ICUMSA (International Commission for Uniform Methods of Sugar Analysis). The ICUMSA has described detailed procedures for various types of sugar and different degrees of color.
The ICUMSA Color $GS1_{/3}$-7 (2011) method is one for the determination of the color of solutions of raw sugar, brown sugar, or sugar syrup.
In the analysis, the sample under investigation is dissolved in water and adjusted to a pH of 7.0. Subsequently the dry mass is measured by refractometry and the absorption of the prepared sample is determined photometrically at 420 nm, with the results being used to calculate the ICUMSA color.
The ICUMSA color is expressed in ICUMSA units at pH 7.0 ($IU_{7.0}$).
The method is analogous to the ICUMSA Methods Book $GS1_{/3}$-7 (2011) (see literature reference[1]).

17.2 Measuring range

Method 2548	ICUMSA Color GS1/3-7	0 - 50000 $IU_{7.0}$ (10-mm rectangular cell)
		0 - 25000 $IU_{7.0}$ (20-mm rectangular cell)
		0 - 10000 $IU_{7.0}$ (50-mm rectangular cell)

17.3 Sample material

Sugar with a color index > 250 $IU_{7.0}$ (raw sugar, strongly colored white plantation sugar, partly refined brown sugar, sugar syrup)

17.4 Reagents and auxiliaries

- Cat. No. 1.73016 - Spectroquant® VIS Spectrophotometer Prove 100 or
  Cat. No. 1.73017 - Spectroquant® UV/VIS Spectrophotometer Prove 300 or
  Cat. No. 1.73018 - Spectroquant® UV/VIS Spectrophotometer Prove 600
- Cat. No. 1.14946 - Rectangular cells 10 mm and/or
  Cat. No. 1.14947 - Rectangular cells 20 mm and/or
  Cat. No. 1.14944 - Rectangular cells 50 mm
- Cat. No. 1.16754 - Water for analysis EMSURE® or
  distilled water
- Cat. No. 1.09060 - Hydrochloric acid 0.1 mol/l Titripur®
- Cat. No. 1.09141 - Sodium hydroxide solution 0.1 mol/l Titripur®
- Membrane filters made of cellulose nitrate, pore size 0.45 µm
- pH-Meter
- Refractometer
- Ultrasound bath
- 250-ml conical flasks
- 500-ml volumetric flasks

Standard laboratory glassware (e.g. glass beakers) and pipettes

17.5 Preparation

The sample must be prepared according to ICUMSA Methods Book GS1$_{/3}$-7 (2011), chapter 7.1 (see literature reference[1]).

17.6 Procedure and measurement

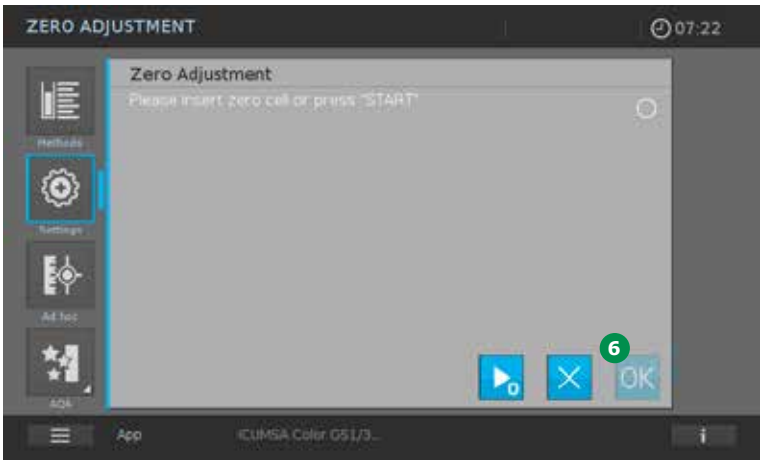
- Open the methods list (**<Methods>**) and select **Method No. 2548 "ICUMSA Color GS1/3-7"**.

- **Entry of the RDS factor:**

  - Enter the RDS factor of the sample in %, accurate to 0.1 % (1), confirm with "OK" (2), and change to the measurement procedure by clicking on "START" (3).

- **Zeroing the photometer:**
  - The photometer must be zeroed prior to each new measurement series.
  - It is advisable to zero the photometer using the same cell as the one used for the measurement sample or else a cell with identical optical characteristics and an identical absorption (matched pair). The zero-adjustment procedure for the measurement series is automatically prompted by the instrument after the entry of the refractometric dry substance factor (RDS) of the first analytical sample.

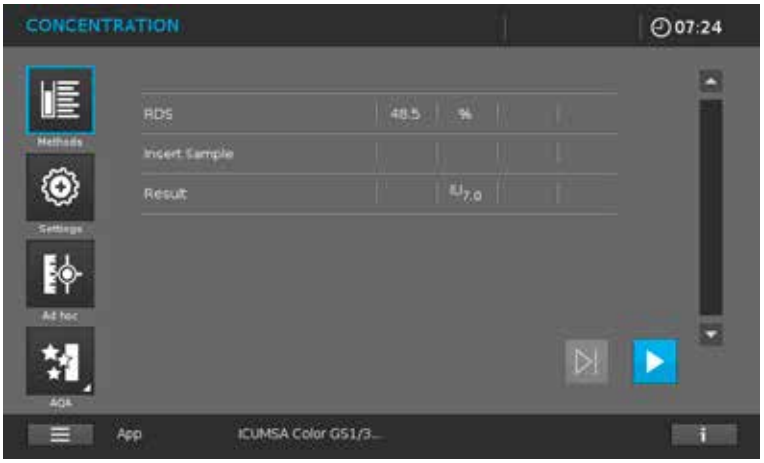
Note
Alternatively, the zero-adjustment procedure can be carried out before the RDS factor is entered. Do this by clicking on "X" (4) to close the input mask and then click on the key "Settings" (5). This opens a window with various selection options.
Subsequently click on the key "ZERO ADJUSTMENT".



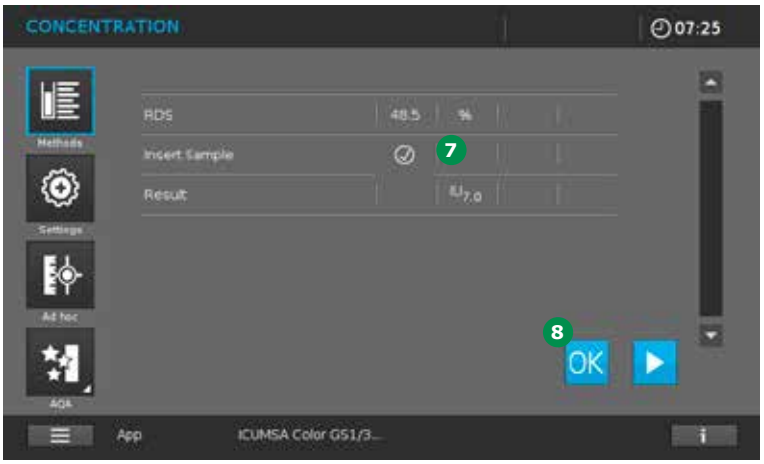
- For the zero adjustment fill a 10-mm rectangular cell with water for analysis.
- After prompting, insert the filled rectangular cell into the cell compartment. The zero adjustment is performed automatically.
- Confirm the performance of the zero-adjustment procedure by clicking on **<OK>** 6.
  The zero adjustment is valid for the entire measurement series.

- **Measurement:**

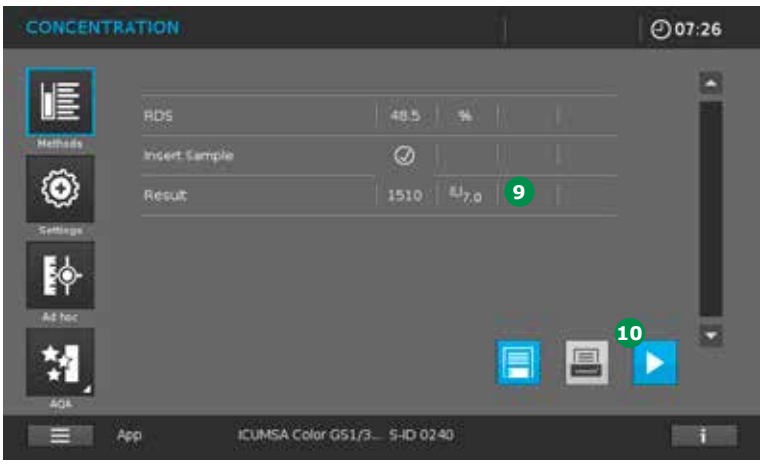
  Note
  It is advisable to measure the sample using the same cell as the one used for the zero adjustment or else a cell with identical optical characteristics and an identical absorption (matched pair).



- Fill the sample solution into a 10-mm rectangular cell and insert the cell into the cell compartment. The measurement is performed automatically.



A (✓) appears behind the cue "Insert sample" 7.
- Confirm the measurement by clicking on **<OK>** 8.



The measurement result in the units $IU_{7.0}$ appears in the photometer display. 9.
- Click**<START>** 10 to start the measurement procedure for the next sample.
  A renewed zero adjustment is not necessary.

Note
According to ICUMSA Method $GS1_{/3}$-7 (2011) the method checks automatically if the measured absorption is below 2.500 A. If the absorption is not in this range, a pop-up message appears: "Condition not met – Absorbance > 2.5".
In these cases, the sample preparation needs to be adjusted. Use an appropriate cell length, sample and water weight according to recommendations of Table 1.

17.7 Evaluation

Statement of the results: ICUMSA units at pH 7.0 ($IU_{7.0}$)

17.8 Literature

1. ICUMSA Methods Book 2013 - ISBN 978-3-87040-555-7, Method ICUMSA Color $GS1_{/3}$-7 (2011)

18 ICUMSA Color $GS2_{/3}$-9 (2005)

18.1 Method

The color of sugars and sugar solutions is generally determined using the official methods of the ICUMSA (International Commission for Uniform Methods of Sugar Analysis). The ICUMSA has described detailed procedures for various types of sugar and different degrees of color.
The ICUMSA Color $GS2_{/3}$-9 (2005) method is one for the determination of the color of solutions of white sugar or highly pure sugar syrup with a color index up to 600 IU.
In the analysis, the sample under investigation is dissolved in a buffer with a pH of 7.0.
Subsequently the dry mass is measured by refractometry and the absorption of the prepared sample is determined photometrically at 420 nm, with the results being used to calculate the ICUMSA color.
The ICUMSA color is expressed in ICUMSA units at pH 7.0 ($IU_{7.0}$).
The method is analogous to the ICUMSA Methods Book $GS2_{/3}$-9 (2005) (see literature reference[1]).

18.2 Measuring range

Method 2549	ICUMSA Color GS2/3-9	0 - 600 $IU_{7.0}$ (50-mm rectangular cell)
		0 - 600 $IU_{7.0}$ (100-mm rectangular cell, **only Prove 600**)

18.3 Sample material

Sugar with a color index up to 600 $IU_{7.0}$ (crystalline white sugar, icing sugar, sugar syrup)

18.4 Reagents and auxiliaries

- Cat. No. 1.73016 - Spectroquant® VIS Spectrophotometer Prove 100 or
  Cat. No. 1.73017 - Spectroquant® UV/VIS Spectrophotometer Prove 300 or
  Cat. No. 1.73018 - Spectroquant® UV/VIS Spectrophotometer Prove 600
- Cat. No. 1.14944 - Rectangular cells 50 mm and/or
  Cat. No. 1.74011 - Rectangular cells 100 mm (**only for Prove 600**)
- Cat. No. 1.16754 - Water for analysis EMSURE® or
  distilled water
- Cat. No. 1.09060 - Hydrochloric acid 0.1 mol/l Titripur®
- Cat. No. 1.08379 - Triethanolamine (TEA) GR for analysis
- Membrane filters made of cellulose nitrate, pore size 0.45 µm
- pH-Meter
- Refractometer
- Ultrasound bath
- 250-ml conical flasks
- 500-ml volumetric flasks

Standard laboratory glassware (e.g. glass beakers) and pipettes

18.5 Preparing the solutions

- **TEA buffer solution (pH 7.0):**
  The buffer must be prepared according to ICUMSA Methods Book $GS2_{/3}$-9 (2005), chapter 5.1 - 5.3 (see literature reference[1]).

18.6 Preparation

The sample must be prepared according to ICUMSA Methods Book $GS2_{/3}$-9 (2005), chapter 7.1 (see literature reference[1]).

18.7 Procedure and measurement

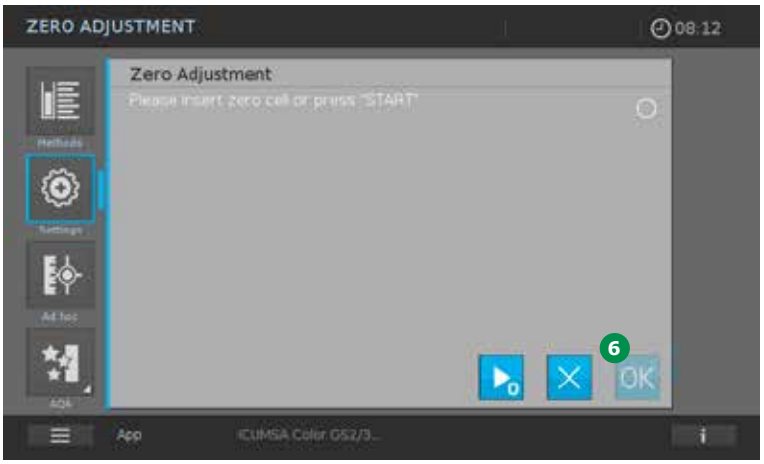
- Open the methods list (**<Methods>**) and select **Method No. 2549** "**ICUMSA Color GS2/3-9**".

- **Entry of the RDS factor:**

  - Enter the RDS factor of the sample in %, accurate to 0.1% (1), confirm with "OK" (2), and change to the measurement procedure by clicking on "START" (3).

- **Zeroing the photometer:**
  - The photometer must be zeroed prior to each new measurement series.
  - It is advisable to zero the photometer using the same cell as the one used for the measurement sample or else a cell with identical optical characteristics and an identical absorption (matched pair). The zero-adjustment procedure for the measurement series is automatically prompted by the instrument after the entry of the refractometric dry substance factor (RDS) of the first analytical sample.

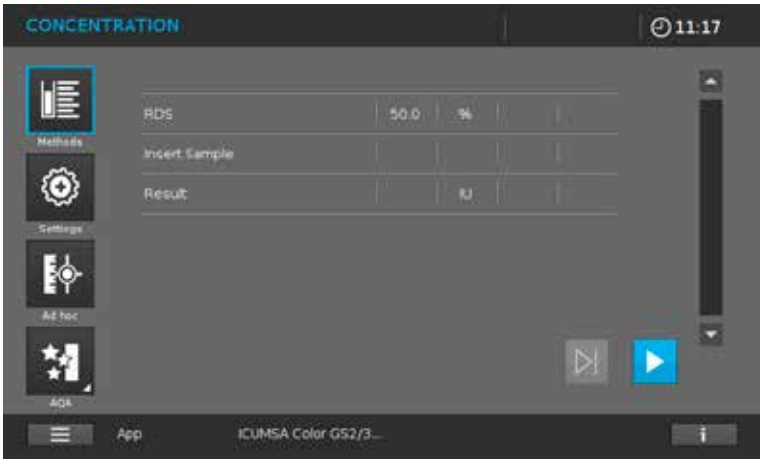
Note
Alternatively, the zero-adjustment procedure can be carried out before the RDS factor is entered. Do this by clicking on "X" (4) to close the input mask and then click on the key "Settings" (5). This opens a window with various selection options.
Subsequently click on the key "ZERO ADJUSTMENT".



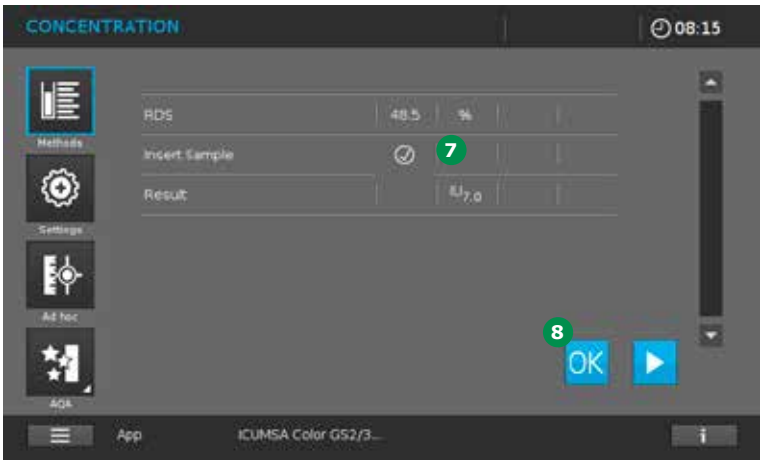
- For the zero adjustment fill a suitable rectangular cell with water for analysis.
- After prompting, insert the filled rectangular cell into the cell compartment. The zero adjustment is performed automatically.
- Confirm the performance of the zero-adjustment procedure by clicking on **<OK>** 6.
  The zero adjustment is valid for the entire measurement series.

- **Measurement:**

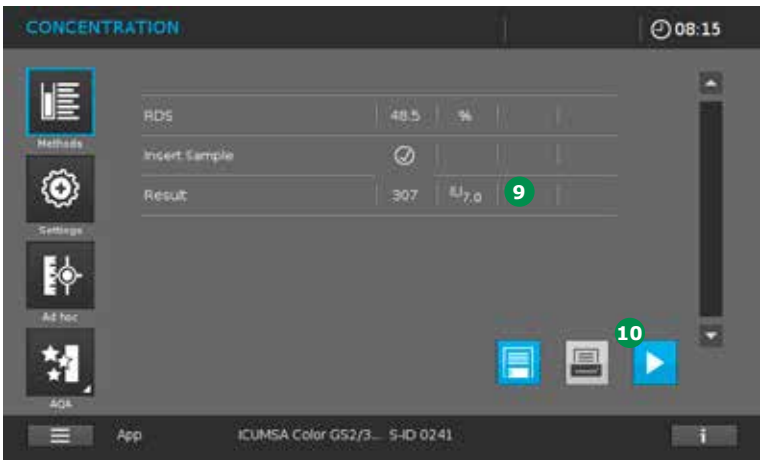
  Note
  It is advisable to measure the sample using the same cell as the one used for the zero adjustment or else a cell with identical optical characteristics and an identical absorption (matched pair).



- Fill the sample solution into a corresponding rectangular cell and insert the cell into the cell compartment. The measurement is performed automatically.



A (✓) appears behind the cue "Insert sample" 7.
- Confirm the measurement by clicking on **<OK>** 8.



The measurement result in the units $IU_{7.0}$ appears in the photometer display 9.
- Click **<START>** 10 to start the measurement procedure for the next sample.
  A renewed zero adjustment is not necessary.

18.8 Evaluation

Statement of the results: ICUMSA units at pH 7.0 ($IU_{7.0}$)

18.9 Literature

1. ICUMSA Methods Book 2013 - ISBN 978-3-87040-555-7, Method ICUMSA Color $GS2_{/3}$-9 (2005)

19 ICUMSA Color $GS2_{/3}$-10 (2011)

19.1 Method

The color of sugars and its solutions is generally determined using the official methods of the ICUMSA (International Commission for Uniform Methods of Sugar Analysis). The ICUMSA has described detailed procedures for various types of sugar and different degrees of color.
The ICUMSA Color $GS2_{/3}$-10 (2011) method is one for the determination of the color of solutions of white sugar with a color index up to 50 IU.
In the analysis, the sample under investigation is dissolved in water.
Subsequently the dry mass is measured by refractometry and the absorption of the prepared sample is determined photometrically at 420 nm, with the results being used to calculate the ICUMSA color.
The method is analogous to the ICUMSA Methods Book $GS2_{/3}$-10 (2011) (see literature reference[1]).

19.2 Measuring range

Method 2550	ICUMSA Color GS2/3-10	0 - 50 IU (50-mm rectangular cell)
		0 - 50 IU (100-mm rectangular cell, **only Prove 600**)

19.3 Sample material

Sugar with a color index up to 50 IU (crystalline white sugar, icing sugar, sugar syrup)

19.4 Reagents and auxiliaries

- Cat. No. 1.73016 - Spectroquant® VIS Spectrophotometer Prove 100 or
  Cat. No. 1.73017 - Spectroquant® UV/VIS Spectrophotometer Prove 300 or
  Cat. No. 1.73018 - Spectroquant® UV/VIS Spectrophotometer Prove 600
- Cat. No. 1.14944 - Rectangular cells 50 mm and/or
  Cat. No. 1.74011 - Rectangular cells 100 mm (**only for Prove 100**)
- Cat. No. 1.16754 - Water for analysis EMSURE® or
  distilled water
- Membrane filters made of cellulose nitrate, pore size 0.45 µm
- Refraktometer
- Ultrasound bath
- 250-ml conical flasks

Standard laboratory glassware (e.g. glass beakers) and pipettes

19.5 Preparation

The sample must be prepared according to ICUMSA Methods Book $GS2_{/3}$-10 (2011), chapter 7.1 (see literature reference[1]).

19.6 Procedure and measurement

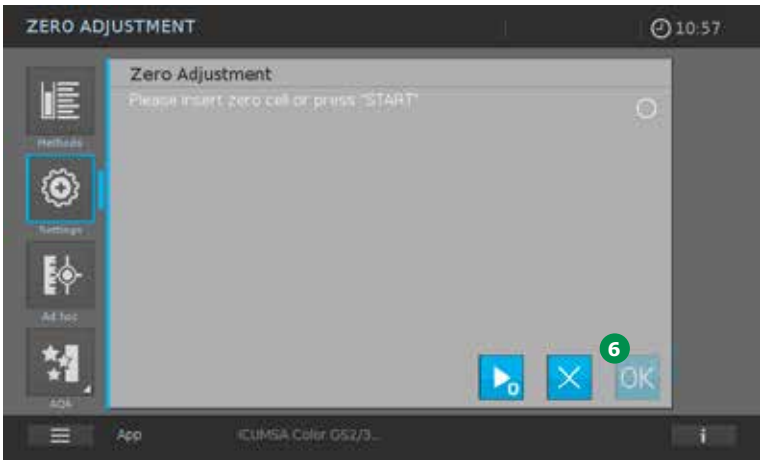
- Open the methods list (**<Methods>**) and select **Method No. 2550 "ICUMSA Color GS2/3-10"**.

- **Entry of the RDS factor:**

  - Enter the RDS factor of the sample in %, accurate to 0.1% (1), confirm with "OK" (2), and change to the measurement procedure by clicking on "START" (3).

- **Zeroing the photometer:**
  - The photometer must be zeroed prior to each new measurement series.
  - It is advisable to zero the photometer using the same cell as the one used for the measurement sample or else a cell with identical optical characteristics and an identical absorption (matched pair).
    The zero-adjustment procedure for the measurement series is automatically prompted by the instrument after the entry of the refractometric dry substance factor (RDS) of the first analytical sample.

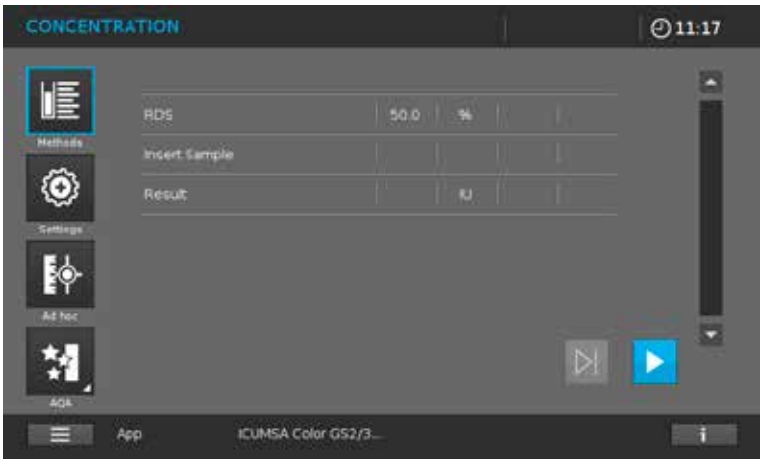
Note
Alternatively, the zero-adjustment procedure can be carried out before the RDS factor is entered. Do this by clicking on "X" (4) to close the input mask and then click on the key "Settings" (5). This opens a window with various selection options.
Subsequently click on the key "ZERO ADJUSTMENT".



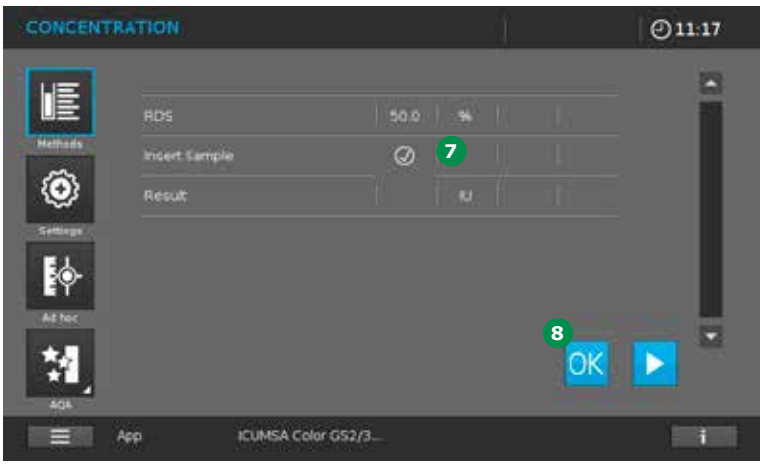
  - For the zero adjustment fill a suitable rectangular cell with water for analysis.
  - After prompting, insert the filled rectangular cell into the cell compartment. The zero adjustment is performed automatically.
  - Confirm the performance of the zero-adjustment procedure by clicking on **<OK>** (6).
    The zero adjustment is valid for the entire measurement series.

- **Measurement:**

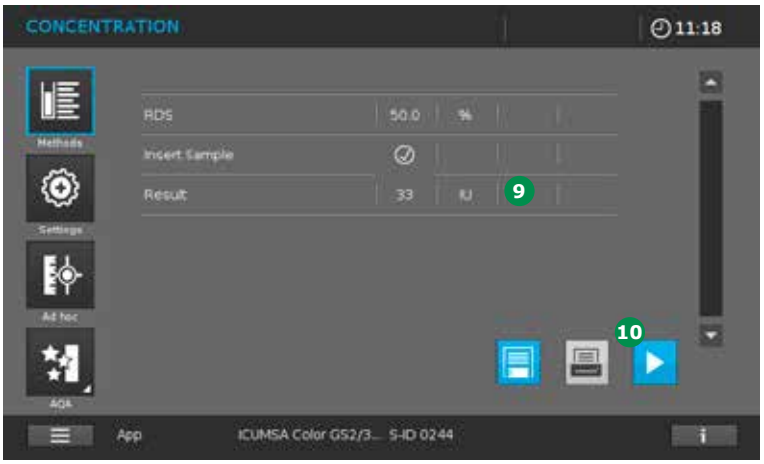
  Note
  It is advisable to measure the sample using the same cell as the one used for the zero adjustment or else a cell with identical optical characteristics and an identical absorption (matched pair).



- Fill the sample solution into a corresponding rectangular cell and insert the cell into the cell compartment. The measurement is performed automatically.



A (✓) appears behind the cue "Insert sample" 7.
- Confirm the measurement by clicking on **<OK>** 8.



The measurement result in the units IU appears in the photometer display 9.

- Click**<START>** 10 to start the measurement procedure for the next sample.
  A renewed zero adjustment is not necessary.

19.7 Evaluation

Statement of the results: ICUMSA units (IU)

19.8 Literature

1. ICUMSA Methods Book 2013 - ISBN 978-3-87040-555-7, Method ICUMSA Color $GS2_{/3}$-10 (2011)

20 ICUMSA Color GS9$_{/1/2/3}$-8 (2011)

20.1 Method

The color of sugars and its solutions is generally determined using the official methods of the ICUMSA (International Commission for Uniform Methods of Sugar Analysis). The ICUMSA has described detailed procedures for various types of sugar and different degrees of color.
The ICUMSA Color GS9$_{/1/2/3}$-8 (2011) method is one for the determination of the color of solutions of raw sugar, white sugar, brown sugar, or plantation sugar.
In the analysis, the sample under investigation is dissolved in water and a buffer with a pH of 7.0. Subsequently the absorption of the prepared sample is determined photometrically at 420 nm, with the results being used to calculate the ICUMSA color.
The ICUMSA color is expressed in ICUMSA units at pH 7.0 (IU$_{7.0}$).
The method is analogous to the ICUMSA Methods Book GS9$_{/1/2/3}$-8 (2011) (see literature reference[1]).

20.2 Measuring range

Method 2551	ICUMSA Color GS9/1/2/3-8	0 - 20000 IU$_{7.0}$ (10-mm rectangular cell)
		0 - 10000 IU$_{7.0}$ (20-mm rectangular cell)
		0 - 4000 IU$_{7.0}$ (50-mm rectangular cell)

20.3 Sample material

Sugar with a color index up to 16000 IU7.0 (raw sugar, plantation white sugar, refined raw sugar)

20.4 Reagents and auxiliaries

- Cat. No. 1.73016 - Spectroquant® VIS Spectrophotometer Prove 100 or
  Cat. No. 1.73017 - Spectroquant® UV/VIS Spectrophotometer Prove 300 or
  Cat. No. 1.73018 - Spectroquant® UV/VIS Spectrophotometer Prove 600
- Cat. No. 1.14946 - Rectangular cells 10 mm and/or
  Cat. No. 1.14947 - Rectangular cells 20 mm and/or
  Cat. No. 1.14944 - Rectangular cells 50 mm
- Cat. No. 1.16754 - Water for analysis EMSURE® or
  distilled water
- Cat. No. 1.09137 - Sodium hydroxide solution 1 mol/l, Titripur®
- Cat. No. 475898 - MOPS, free Acid, ULTROL® grade
- Cat. No. SLHA025NB - Membrane filters Millex-HA, 0.45 µm pore size, 25 mm diameter, Luer-Lock fitting inlet
- Cat. No. SLAA025NB - Membrane filters prefilter unit, 0.80 µm pore size, 25 mm diameter, Luer-Lock fitting inlet
- Cat. No. XX1102012 Plastic syringes 10 - 50 ml with Luer-Lock fitting outlet
- pH-Meter
- Refractometer
- Ultrasound bath
- 100-ml and 1000-ml volumetric flasks
- 250-ml conical flasks

Standard laboratory glassware (e.g. glass beakers) and pipettes

20.5 Preparing the solutions

- **MOPS buffer solution:**
  The buffer must be prepared according to ICUMSA Methods Book $GS9_{/1/2/3}$-8 (2011), chapter 5.2 (see literature reference[1]).

- **Reference solution for the zero-adjustment procedure:**
  according to ICUMSA Methods Book $GS9_{/1/2/3}$-8 (2011), chapter 7.2 (see literature reference[1]).

20.6 Preparation

The sample must be prepared according to ICUMSA Methods Book $GS9_{/1/2/3}$-8 (2011), chapter 7 (see literature reference[1]).

20.7 Procedure and measurement

- Open the methods list (**<Methods>**) and select **Method No. 2551 "ICUMSA Color GS9/1/2/3-8"**.

- **Entering the sample weight:**

  - Enter the weight of the sample in grams (g), accurate to 0.1 grams (g) (1), confirm with "OK" (2), and change to the measurement procedure by clicking on "START" (3).

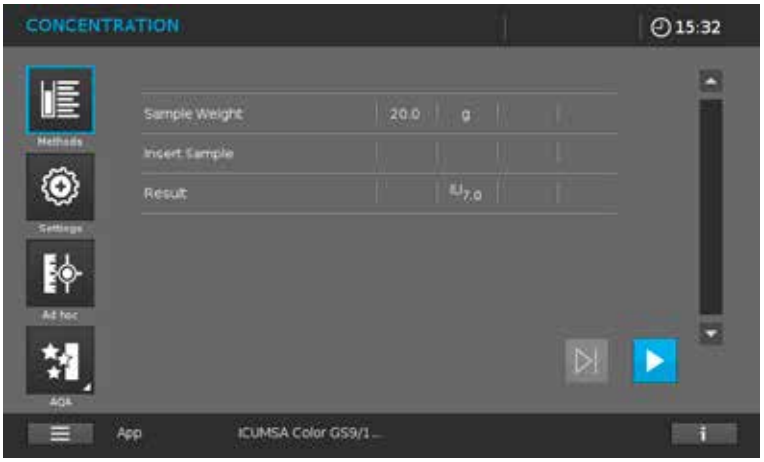
- **Zeroing the photometer:**
  - The photometer must be zeroed prior to each new measurement series.
  - It is advisable to zero the photometer using the same cell as the one used for the measurement sample or else a cell with identical optical characteristics and an identical absorption (matched pair).
    The zero-adjustment procedure for the measurement series is automatically prompted by the instrument after the entry of the weight of the first analytical sample.

Note
Alternatively, the zero-adjustment procedure can be carried out before the sample weight is entered. Do this by clicking on "X" (4) to close the input mask and then click on the key "Settings" (5). This opens a window with various selection options.
Subsequently click on the key "ZERO ADJUSTMENT".

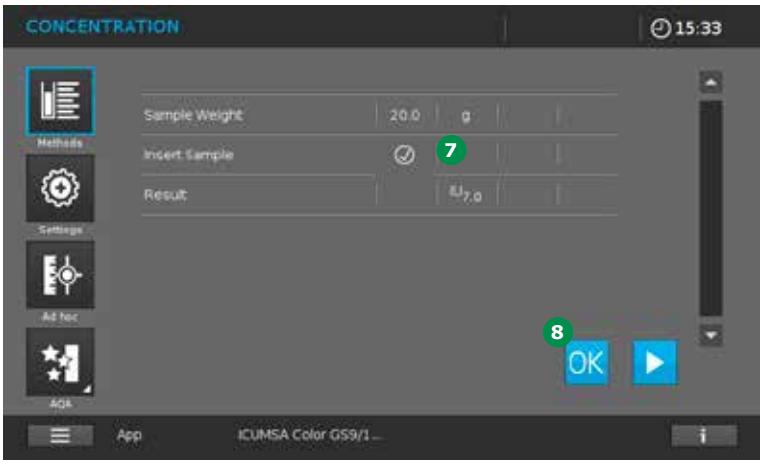
- For the zero adjustment fill a suitable rectangular cell with water for analysis.
- After prompting, insert the filled rectangular cell into the cell compartment. The zero adjustment is performed automatically.
- Confirm the performance of the zero-adjustment procedure by clicking on **<OK>** 6.
  The zero adjustment is valid for the entire measurement series.

- **Measurement:**

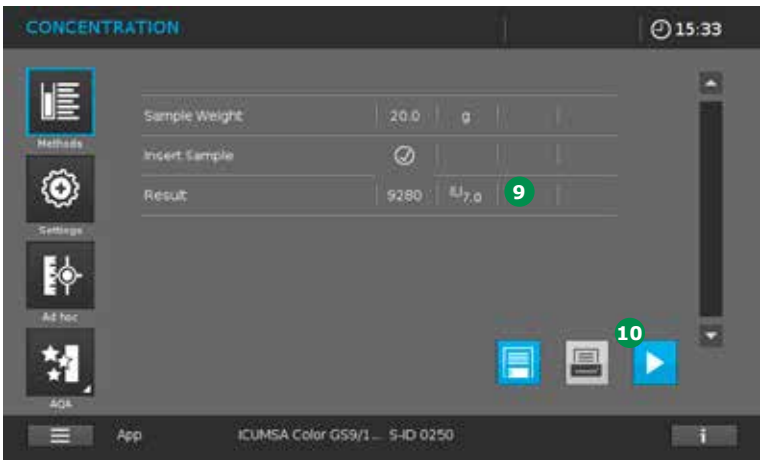
  Note
  It is advisable to measure the sample using the same cell as the one used for the zero adjustment or else a cell with identical optical characteristics and an identical absorption (matched pair).



- Fill the sample solution into a corresponding rectangular cell and insert the cell into the cell compartment. The measurement is performed automatically.



A (✓) appears behind the cue "Insert sample" 7.
- Confirm the measurement by clicking on **<OK>** 8.



The measurement result in the units $IU_{7.0}$ appears in the photometer display 9.
- Click **<START>** 10 to start the measurement procedure for the next sample.
  A renewed zero adjustment is not necessary.

Note
According to ICUMSA Method $GS9_{/1/2/3}$-8 (2011) the method checks automatically if the measured absorption is below 2.500 A. If the absorption is not in this range, a pop-up message appears: "Condition not met – Absorbance > 2.5".
In these cases, the sample preparation needs to be adjusted. Use an appropriate cell length, sample and water weight according to recommendations of Table 1.

20.8 Evaluation

Statement of the results: ICUMSA units at pH 7.0 ($IU_{7.0}$)

20.9 Literature

1. ICUMSA Methods Book 2013 - ISBN 978-3-87040-555-7, Method ICUMSA Color $GS9_{/1/2/3}$-8 (2011)

21 Iodine color number

21.1 Method

The iodine color number is used to assess the color of clear liquids that possess color characteristics similar to those of the iodine color scale.
The method was originally based on the visual comparison of the color of the sample solution with defined iodine-color standards. Meanwhile, however, in practice the photometric principle has become the predominantly used method for determining the iodine color, since it enables a substantially higher degree of precision to be achieved.
The measurement is made in the wavelength spectrum in which the yellow to yellow-brown standard solutions of the iodine color scale absorb light. The measurement results are referenced to the respective measurement conditions and are traceable to a defined color standard prepared from iodine and potassium iodide in aqueous solution.
The "iodine color number" method can be performed in the Prove spectrophotometers at the wavelengths 445 nm and 340 nm. At the 445 nm wavelength, the typical range of applications of the method – the assessment of the color of clear liquids, e.g. solvents, resins, oils, and fatty acids – shows a good comparability of the photometric method with the visual method. At 340 nm – a wavelength that is still just within the so-called VIS spectrum, but is no longer visible to the human eye – the iodine color number standards show their highest absorption in the VIS spectrum. This wavelength can be practically used for the assessment of weakly colored samples. Alternatively, weakly colored samples can also be analyzed using the Pt/Co color index (see "Color Hazen", section 10).
The methods are analogous to DIN 6162 (see literature reference[1]), DGF C-IV 4 a (see literature reference[2]), DGF F-I 2 (see literature reference[3]), and DGF H-II 3 (see literature reference[4]).

21.2 Measuring range

Method 21	Iodine color number 445	0.2 - 10.0 (50-mm rectangular cell)
		0.5 - 25.0 (20-mm rectangular cell)
		1.0 - 50.0 (10-mm rectangular cell)
Method 33	Iodine color number 340	0.010 - 0.600 (50-mm rectangular cell)
		0.03- 1.50 (50-mm rectangular cell)
		0.05 - 3.00 (50-mm rectangular cell)

21.3 Sample material

Clear liquid samples with color characteristics similar to those on the iodine color number scale (= yellow to yellow-brown)
Turbid liquid samples with color characteristics after filtration similar to those on the iodine color number scale (= yellow to yellow-brown)
e.g. solvents, plasticizers, resins, resin solutions, oils, fatty acids, lecithins, surfactants

21.4 Reagents and auxiliaries

- Cat. No. 1.73016 - Spectroquant® VIS Spectrophotometer Prove 100 or
  Cat. No. 1.73017 - Spectroquant® UV/VIS Spectrophotometer Prove 300 or
  Cat. No. 1.73018 - Spectroquant® UV/VIS Spectrophotometer Prove 600
- Cat. No. 1.14946 - Rectangular cells 10 mm and/or
  Cat. No. 1.14947 - Rectangular cells 20 mm and/or
  Cat. No. 1.14944 - Rectangular cells 50 mm
- Cat. No. 1.16754 - Water for analysis EMSURE® or
  distilled water
- Cat. No. 1.08331 - Toluene Uvasol® for spectroscopy (optional)
- Membrane filters, pore size max. 0.45 µm (optional)

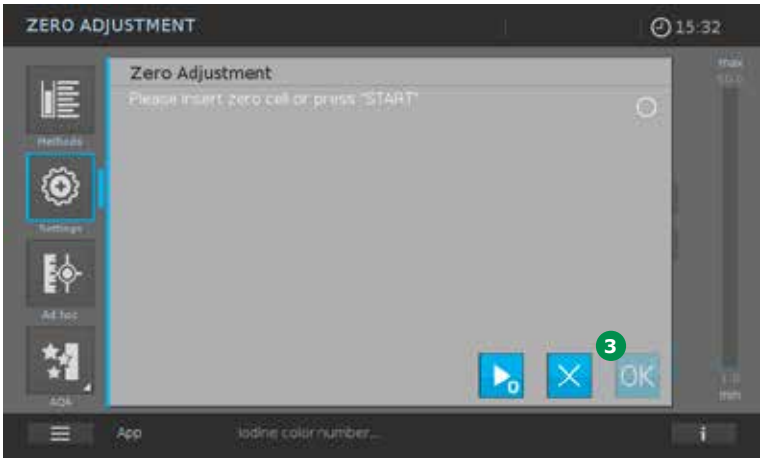
21.5 Preparation

- Filter **turbid sample solutions** over a membrane filter.
  To do this, prerinse the membrane filter with approx. 50 ml of water for analysis, then rerinse with approx. 50 ml of the sample solution and discard the filtrate.
  Filter a further 50 ml of the sample solution over the prerinsed membrane filter and use the filtrate for the analysis.
- Prior to the determination, heat **solid samples** to a few degrees Kelvin above melting point, homogenize by stirring gently, taking care to avoid air bubbles. Analyze the sample immediately.
- Where necessary, homogenize **lecithins** by gentle melting.
  Dissolve 10 g of the sample in 70 ml of toluene, transfer to a 100 ml volumetric flask, amd make up to the mark with toluene. Use this solution for the analysis, expressing the result for a 10% solution.

21.6 Procedure and measurement

- **Zeroing the photometer:**
  - It is advisable to zero the photometer at the start of each working day, using the same cell as the one used for the test solutions or else a cell with identical optical characteristics and an identical absorption (matched pair).
  - To perform the zero-adjustment procedure open the methods list (**<Methods>**) and select **Method No. 21 "Iodine color number 445" resp. No. 33 "Iodine color number 340"**.
    If there is no valid zero adjustment available for the method, the window for the zero-adjustment procedure opens automatically.

If a valid zero adjustment is already available, the Methods window opens.
The zero-adjustment procedure must then be selected by opening **<Settings>** 1 and clicking on the selection button **"ZERO ADJUSTMENT"** 2.



- For the zero adjustment fill a suitable rectangular cell with water for analysis.
- 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>** 3.

- **Measurement:**

  Note
  It is advisable to measure the sample solution using the same cell as the one used for the zero adjustment or else a cell with identical optical characteristics and an identical absorption (matched pair).

- Open the methods list (**<Methods>**) 4 and select **Method No. 21 "Iodine color number 445" resp. No. 33 "Iodine color number 340"**.

- Fill the sample solution into a corresponding rectangular cell and insert the cell into the cell compartment. The measurement is performed automatically and the result appears in the display 5.

21.7 Evaluation

Statement of the results: IFZ (= Iodfarbzahl (Iodine color number))

21.8 Method control

The method can be checked using iodine color number standard according to the DIN 6162 standard.

21.9 Recalibration

The methods can be recalibrated using iodine color number standards according to the DIN standards. Recalibration can be done by measuring value pairs, by entering value pairs, or by entering coefficients of a calibration function. Please refer to the Operating Manual of your spectrophotometer for details on the recalibration procedure.

21.10 Literature

1. DIN 6162:2014-09 - Determination of iodine colour number
2. DGF Einheitsmethoden (2. Auflage einschließlich 14. Akt.-Lfg von 2009) - Abteilung Fette - C-IV 4 - Farbmessung
3. DGF Einheitsmethoden (2. Auflage einschließlich 14. Akt.-Lfg von 2009) - Abteilung Fettbegleitstoffe - F-I 2 - Farbe von Lecithinen
4. DGF Einheitsmethoden (2. Auflage einschließlich 14. Akt.-Lfg von 2009) - Abteilung Tenside - H-II 3 - Farbe

22 Klett color index

22.1 Method

The Klett color index is one of the oldest known color indices. It has been measured using special filter photometers, the Klett Summerson colorimeters, since about 1930 right up to the present day. These photometers use exchangeable filters, each with characteristic transmittances in various wavelength spectrums. The most frequently used filter is the KS-42 blue filter, for the measurement of yellow colors. The filter allows light to pass through in the 400 - 450 nm wavelength spectrum, showing its greatest light transmission at about 420 nm. The Klett color scale itself is based on the measured absorption in the wavelength spectrum of the filter being used. The Klett color number is calculated by multiplying the measured absorption by a factor of 500. The optical path length of the cell used is not used in the calculation. The Klett color scale is defined for the range 0 - 1000.
In modern-day spectrophotometers, the Klett color number is frequently measured at the wavelength of the highest light transmission of the corresponding filter. For the KS-42 filter, this is at 417 nm. In this case, the Klett color number is determined using an empirically defined factor. In practice, this factor is determined by comparatively measuring the absorption of a platinum/cobalt color-reference solution at the selected wavelength of the spectrophotometer (417 nm) and also determining the Klett color index yielded by a Klett-Summerson colorimeter using a KS-42 filter. Care must be taken to ensure that the results of both methods for colors of the Pt/Co scale are absolutely comparable. If samples with deviating colors for the platinum/cobalt solution are analyzed, there may be slight differences in the results yielded by measurement at 417 nm and by the use of the KS-42 filter. For example: the Klett color index of a yellow chromate solution measured at 417 nm is roughly 5% below the result measured with the KS-42 filter.
The Spectroquant® Prove spectrophotometers determine the Klett color index by measuring the absorption at the 417 nm wavelength and subsequent calculation of the Klett color index. The result is expressed in the unit $Klett_{417}$. The optical path length of the cell used is also given as a citation form.

22.2 Measuring range

Method 311	Klett Color	0 - 1000 $Klett_{417}$ (50-mm rectangular cell)

22.3 Sample material

Clear yellow to yellow-brown liquids

22.4 Reagents and auxiliaries

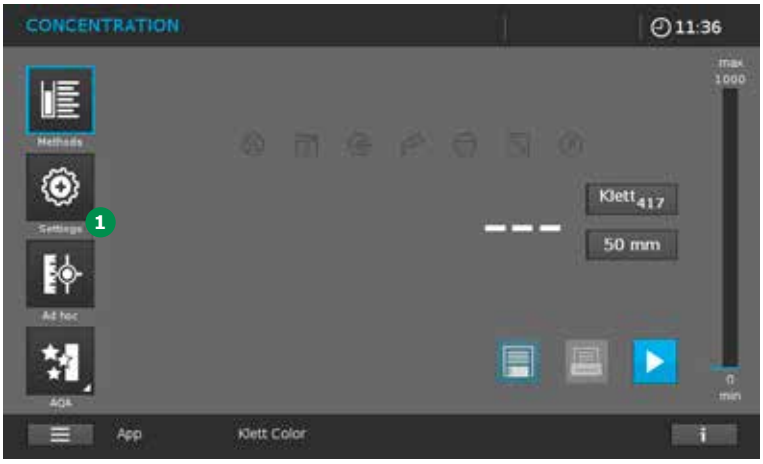
- Cat. No. 1.73016 - Spectroquant® VIS Spectrophotometer Prove 100 or
  Cat. No. 1.73017 - Spectroquant® UV/VIS Spectrophotometer Prove 300 or
  Cat. No. 1.73018 - Spectroquant® UV/VIS Spectrophotometer Prove 600
- Cat. No. 1.14944 - Rectangular cells 50 mm
- Cat. No. 1.16754 - Water for analysis EMSURE® or
  distilled water
- Ultrasound bath (optional)
- Heating bath (optional)
- Filter paper or centrifuge (optional)

22.5 Preparation

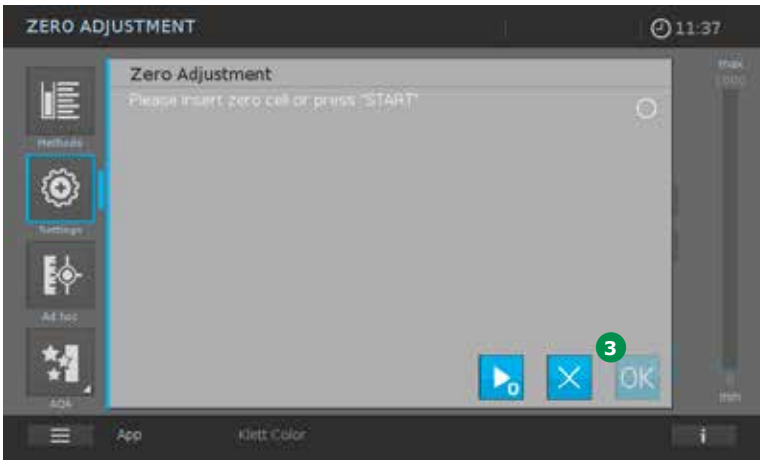
- Eliminate any **air bubbles** present in the sample by degassing the sample in the ultrasound bath.
- Centrifuge **turbid samples** and use the supernatant or else filter over a paper filter and use the filtrate.
- **Melt solid** or **waxlike samples** in a water bath with gentle heating and subsequently homogenize by stirring. Take care not to overheat the sample in the melting process.

22.6 Procedure and measurement

- **Zeroing the photometer:**
  - It is advisable to zero the photometer at the start of each working day, using the same cell as the one used for the test solutions or else a cell with identical optical characteristics and an identical absorption (matched pair).
  - To perform the zero-adjustment procedure open the methods list (**<Methods>**) and select **Method No. 311 "Klett Color"**.
    If there is no valid zero adjustment available for the method, the window for the zero-adjustment procedure opens automatically.



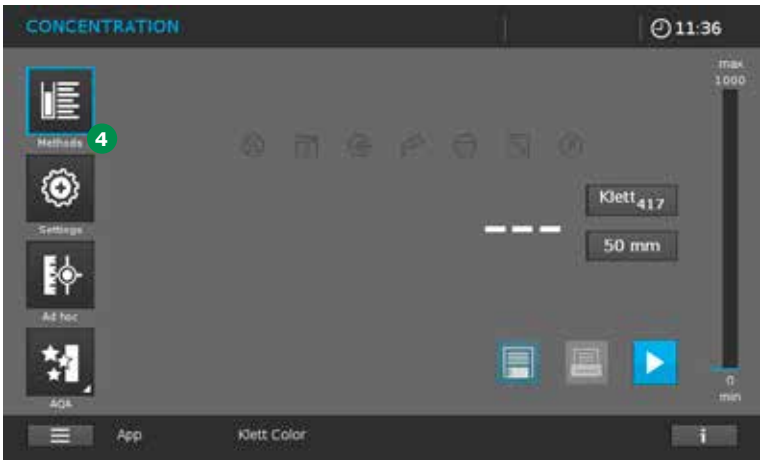
If a valid zero adjustment is already available, the Methods window opens.
The zero-adjustment procedure must then be selected by opening **<Settings>** 1 and clicking on the selection button **"ZERO ADJUSTMENT"** 2.



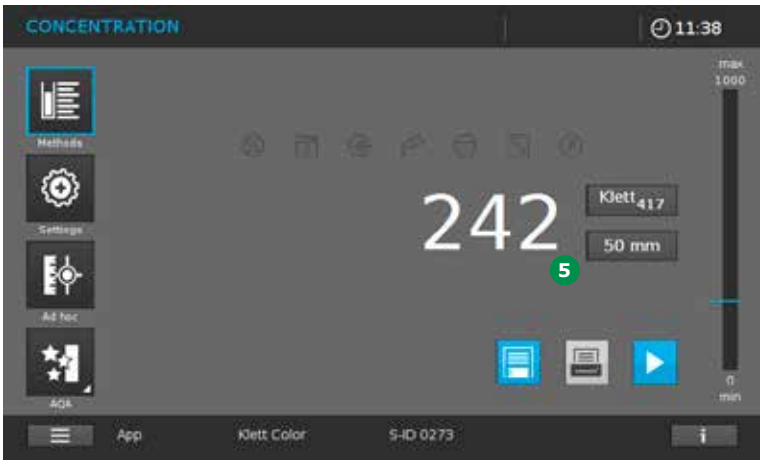
- For the zero adjustment fill a 50-mm rectangular cell with water for analysis.
- After prompting, insert the filled rectangular cell into the cell compartment. The zero adjustment is performed automatically.
- Confirm the performance of the zero-adjustment procedure by clicking on **<OK>** 3.

- **Measurement:**

  Note
  It is advisable to measure the sample solution using the same cell as the one used for the zero adjustment or else a cell with identical optical characteristics and an identical absorption (matched pair).



- Open the methods list (**<Methods>**) 4 and select **Method No. 311 "Klett Color"**.



- Fill the sample solution into a 50-mm rectangular cell and insert the cell into the cell compartment.. The measurement is performed automatically and the result appears in the display 5.

22.7 Evaluation

Statement of the results: $Klett_{417}$, 50 mm

22.8 Literature

none

23 Saybolt color measurement

23.1 Method

The Saybolt color scale serves the assessment of the color of clear, liquid petroleum products. The scale ranges from -16 (darkest color) to +30 (lightest color).
The value is determined by measuring the transmittances in the wavelength spectrum between 380 - 780 nm and subsequent calculation of the tristimulus values X, Y, Z. In further calculation steps according to the ASTM D6045 standard (see literature reference[1]) the tristimulus values are taken as a basis for the calculation of the Saybolt color number.
The method is analogous to ASTM D6045 (see literature reference[1]).

23.2 Measuring range

Method 2563	Saybolt Color 50 mm	-16,0 - 31,0 Saybolt (50-mm rectangular cell)
Method 2564	Saybolt Color 100 mm	-16,0 - 31,0 Saybolt (100-mm rectangular cell, **only Prove 600**)

23.3 Sample material

Clear yellow to yellow-brown liquids
Products made of natural resins (e.g. tall oils, tall-oil fatty acids, paints, oils)
Surfactants

23.4 Reagents and auxiliaries

- Cat. No. 1.73016 - Spectroquant® VIS Spectrophotometer Prove 100 or
  Cat. No. 1.73017 - Spectroquant® UV/VIS Spectrophotometer Prove 300 or
  Cat. No. 1.73018 - Spectroquant® UV/VIS Spectrophotometer Prove 600
- Cat. No. 1.14944 - Rectangular cells 50 mm
- Cat. No. 1.74011 - Rectangular cells 100 mm (**only for Prove 600**)
- Cat. No. 1.16754 - Water for analysis EMSURE® or
  distilled water
- Ultrasound bath (optional)
- Heating bath (optional)
- Filter paper or centrifuge (optional)

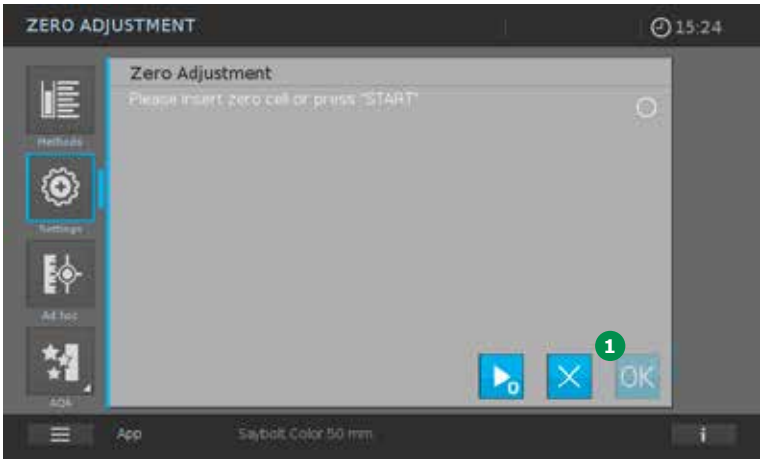
23.5 Preparation

- Eliminate any **air bubbles** present in the sample by degassing the sample in the ultrasound bath.
- Centrifuge **turbid samples** and use the supernatant or else filter over a paper filter and use the filtrate.
- **Melt solid** or **waxlike samples** in a water bath with gentle heating and subsequently homogenize by stirring. Take care not to overheat the sample in the melting process.

23.6 Procedure and measurement

- Open the methods list (**<Methods>**) and select **Method No. 2563 resp. 2564 "Saybolt Color"**.

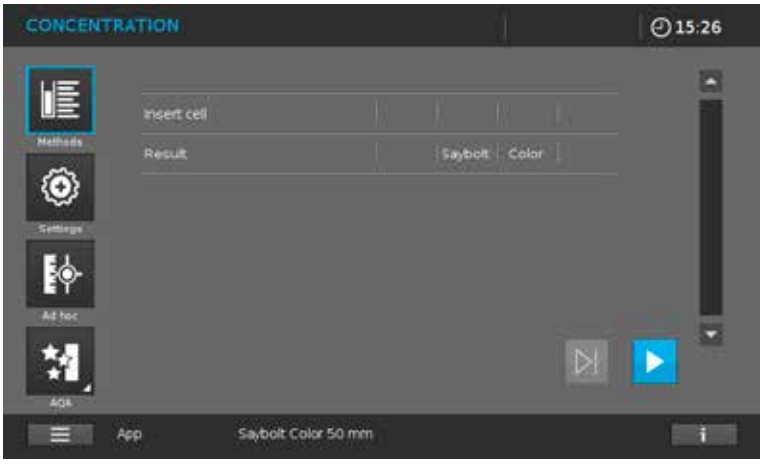
- **Zeroing the photometer:**
  - The photometer must be zeroed prior to each new measurement series.
  - It is advisable to zero the photometer using the same cell as the one used for the measurement sample or else a cell with identical optical characteristics and an identical absorption (matched pair).
    The zero-adjustment procedure for the measurement series is automatically prompted by the instrument.



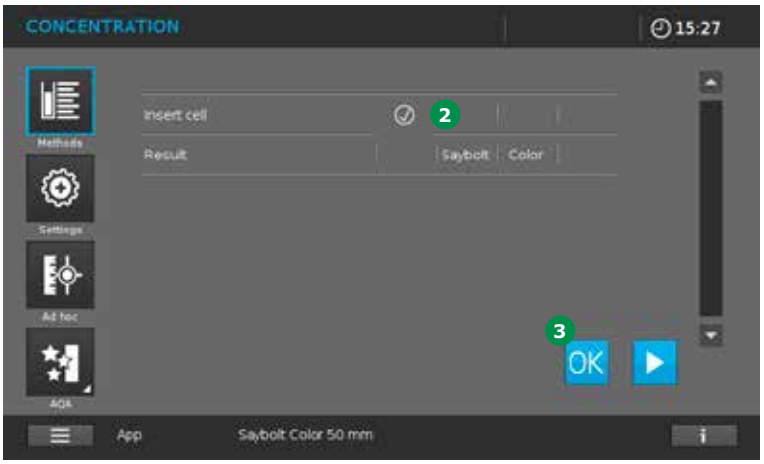
  - For the zero adjustment fill a suitable rectangular cell with water for analysis.
  - After prompting, insert the filled rectangular cell into the cell compartment. The zero adjustment is performed automatically.
  - Confirm the performance of the zero-adjustment procedure by clicking on **<OK>** 1.
    The zero adjustment is valid for the entire measurement series.

- **Measurement:**

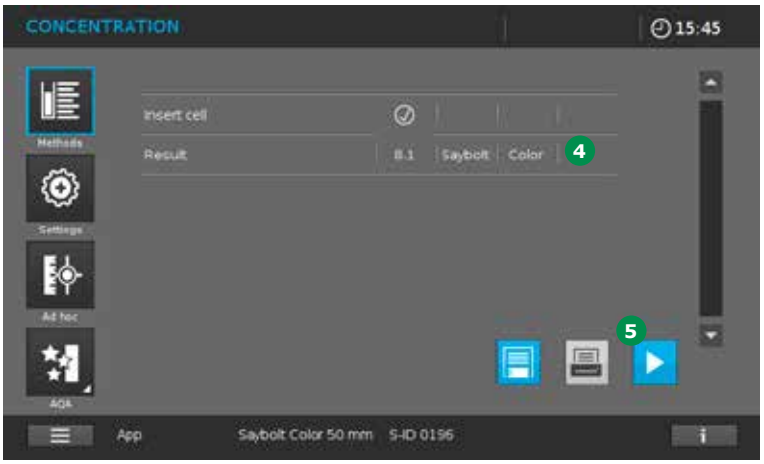
  Note
  It is advisable to measure the sample using the same cell as the one used for the zero adjustment or else a cell with identical optical characteristics and an identical absorption (matched pair).



  - Fill the sample solution into a corresponding rectangular cell and insert the cell into the cell compartment. The measurement is performed automatically.



A (✓) appears behind the cue "Insert cell" 2.
- Confirm the measurement by clicking on **<OK>** 3.



The measurement result appears in the photometer display 4.

- Click **<START>** 5 to start the measurement procedure for the next sample.
  A renewed zero adjustment is not necessary.

23.7 Evaluation

Statement of the results: Saybolt Units

23.8 Literature

1. ASTM D6045-12, Standard Test Method for Color of Petroleum Products by the Automatic Tristimulus Method

24 Spectral absorption coefficient, SAC α(254)

24.1 Method

The spectral absorption coefficient at 254 nm is a parameter for the degree of water pollution caused by dissolved organic substances. These substances include inter alia humic matter from the soil, aromatic compounds, and metabolic products of microorganisms.
The spectral absorption coefficient is measured by transmitting light with a wavelength of 254 nm through a filtered sample.
The spectral absorption coefficient at 254 nm is expressed in the unit m^{-1} and in accordance with the definition of the DIN 38404-3 standard is based on the absorption of UV light caused by organic matter dissolved in the sample.
The method is analogous to DIN 38404-3 (see literature reference[1]).

24.2 Measuring range

Method 300	SAC α(254)	0.1 - 50.0 m^{-1} (50-mm rectangular cell quartz)
		0.3 - 125.0 m^{-1} (20-mm rectangular cell quartz)
		1 - 250 m^{-1} (10-mm rectangular cell quartz)

24.3 Sample material

Water from water-treatment plants (crude water, drinking water, weakly colored industrial wastewater)
Surface water

24.4 Reagents and auxiliaries

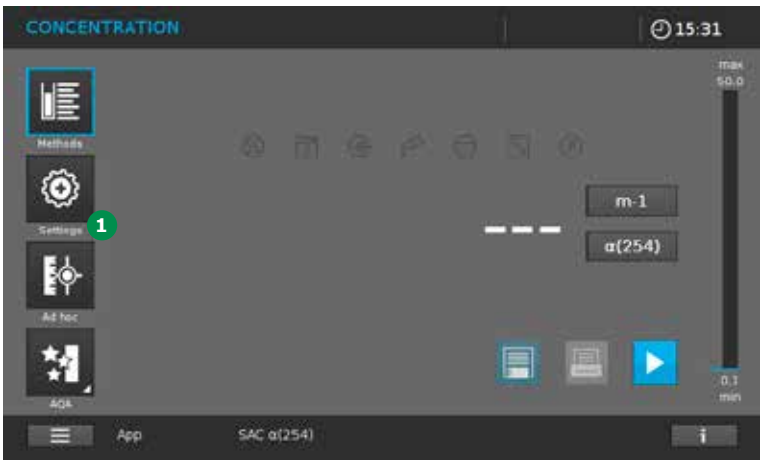
- Cat. No. 1.73017 - Spectroquant® UV/VIS Spectrophotometer Prove 300 or
  Cat. No. 1.73018 - Spectroquant® UV/VIS Spectrophotometer Prove 600
- Cat. No. 1.00784 - Rectangular cells 10 mm quartz and/or
  Rectangular cells 20 mm quartz and/or
  Rectangular cells 50 mm quartz
- Cat. No. 1.16754 - Water for analysis EMSURE® or
  distilled water
- Membrane filters, pore size max. 0.45 µm (optional)

24.5 Preparation

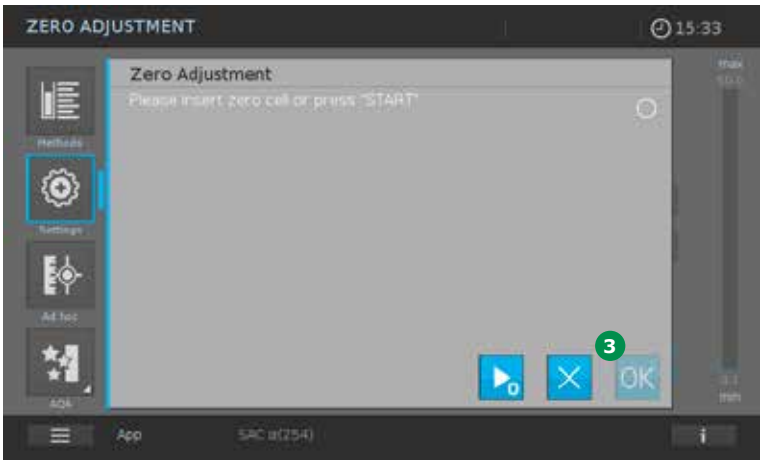
- Filter **turbid sample solutions** over a membrane filter.
  To do this, prerinse the membrane filter with approx. 50 ml of water for analysis, then rerinse with approx. 50 ml of the sample solution and discard the filtrate.
  Filter a further 50 ml of the sample solution over the prerinsed membrane filter and use the filtrate for the analysis.

24.6 Procedure and measurement

- **Zeroing the photometer:**
  - It is advisable to zero the photometer at the start of each working day, using the same cell as the one used for the test solutions or else a cell with identical optical characteristics and an identical absorption (matched pair).
  - To perform the zero-adjustment procedure open the methods list (**<Methods>**) and select **Method No. 300 "SAC α(254)"**.
    If there is no valid zero adjustment available for the method, the window for the zero-adjustment procedure opens automatically.



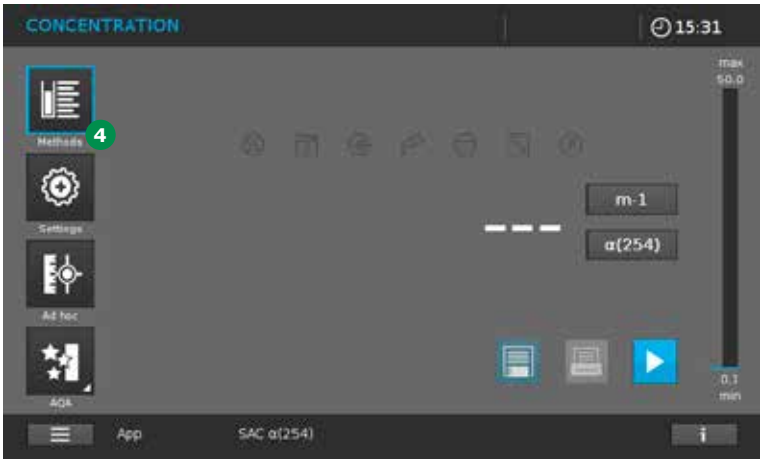
If a valid zero adjustment is already available, the Methods window opens.
The zero-adjustment procedure must then be selected by opening **<Settings>** 1 and clicking on the selection button **"ZERO ADJUSTMENT"** 2.



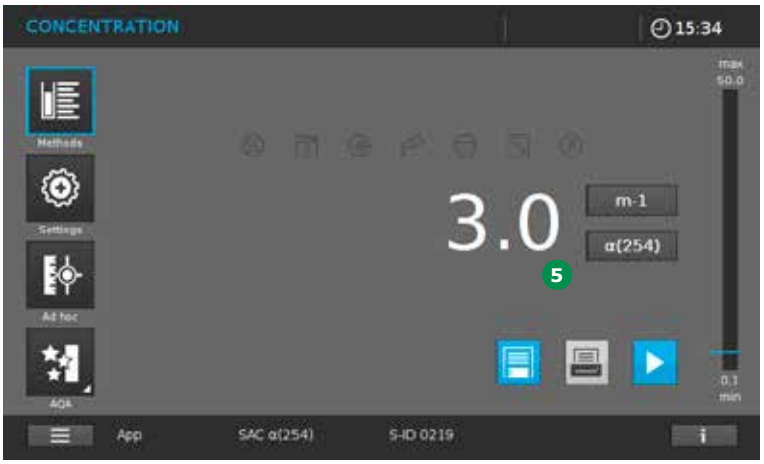
- For the zero adjustment fill a corresponding rectangular quartz cell with water for analysis.
- After prompting, insert the filled rectangular cell into the cell compartment. The zero adjustment is performed automatically.
- Confirm the performance of the zero-adjustment procedure by clicking on **<OK>** 3.

- **Measurement:**

  Note
  It is advisable to measure the sample solution using the same cell as the one used for the zero adjustment or else a cell with identical optical characteristics and an identical absorption (matched pair).



- Open the methods list (**<Methods>**) 4 and select **Method No. 300 "SAC α(254)"**.



- Fill the sample solution into a corresponding rectangular quartz cell and insert the cell into the cell compartment. The measurement is performed automatically and the result appears in the display 5.

24.7 Evaluation

Statement of the results: m^{-1}

24.8 Literature

1. DIN 38404-3:2005-07 - German standard methods for the examination of water, waste water and sludge - Physical and physicalchemical parameters (group C) - Part 3: Determination of absorption in the range of the ultraviolet radiation, Spectral absorptions coefficient (C 3)

25 Spectral absorption coefficient, SAC α(436)

25.1 Method

The spectral absorption coefficient at 436 nm is a parameter of the German Drinking Water Ordinance and the EU Drinking Water Directive. This parameter is used to assess yellow to yellow-brown colors (true color) of a filtered water sample. These discolorations of a water sample are in most cases due to dissolved humic matter and also to iron and manganese compounds.
The method is analogous to German Drinking Water Ordinance, Annex 3, No. 7 (see literature reference[1]) and the EU Drinking Water Directive 98/83/EU (see literature reference[2]). The method is analogous to a part of DIN EN ISO 7887 - Method B (see literature reference[3]).

25.2 Measuring range

Method 302	SAC α(436)	0.1 - 50.0 m^{-1} (50-mm rectangular cell)
		0.3 - 125.0 m^{-1} (20-mm rectangular cell)
		1 - 250 m^{-1} (10-mm rectangular cell)

25.3 Sample material

Water from water-treatment plants (crude water, drinking water, weakly colored industrial wastewater)

25.4 Reagents and auxiliaries

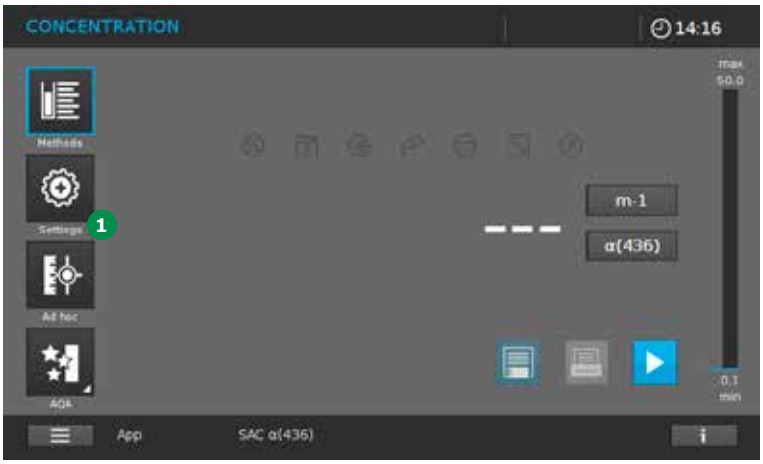
- Cat. No. 1.73016 - Spectroquant® VIS Spectrophotometer Prove 100 or
  Cat. No. 1.73017 - Spectroquant® UV/VIS Spectrophotometer Prove 300 or
  Cat. No. 1.73018 - Spectroquant® UV/VIS Spectrophotometer Prove 600
- Cat. No. 1.14946 - Rectangular cells 10 mm and/or
  Cat. No. 1.14947 - Rectangular cells 20 mm and/or
  Cat. No. 1.14944 - Rectangular cells 50 mm
- Cat. No. 1.16754 - Water for analysis EMSURE® or
  distilled water
- Membrane filters, pore size max. 0.45 µm (optional)

25.5 Preparation

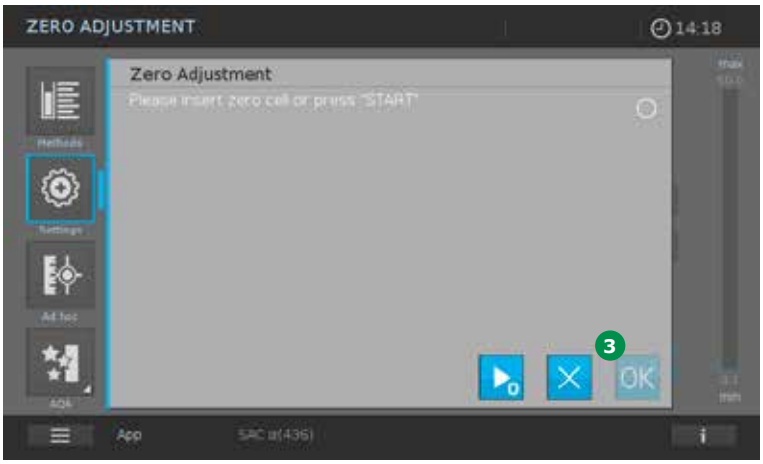
- Filter **turbid sample solutions** over a membrane filter.
  To do this, prerinse the membrane filter with approx. 50 ml of water for analysis, then rerinse with approx. 50 ml of the sample solution and discard the filtrate.
  Filter a further 50 ml of the sample solution over the prerinsed membrane filter and use the filtrate for the analysis.

25.6 Procedure and measurement

- **Zeroing the photometer:**
  - It is advisable to zero the photometer at the start of each working day, using the same cell as the one used for the test solutions or else a cell with identical optical characteristics and an identical absorption (matched pair).
  - To perform the zero-adjustment procedure open the methods list (**<Methods>**) and select **Method No. 302 "SAC α(436)"**.
    If there is no valid zero adjustment available for the method, the window for the zero-adjustment procedure opens automatically.



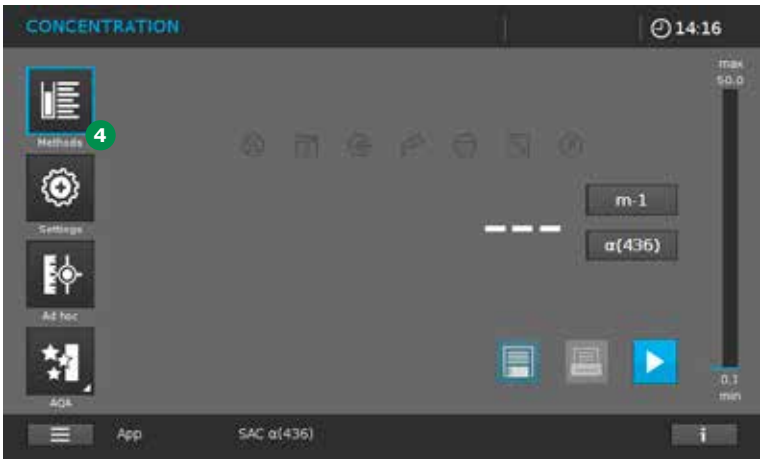
If a valid zero adjustment is already available, the Methods window opens.
The zero-adjustment procedure must then be selected by opening **<Settings>** 1 and clicking on the selection button **"ZERO ADJUSTMENT"** 2.



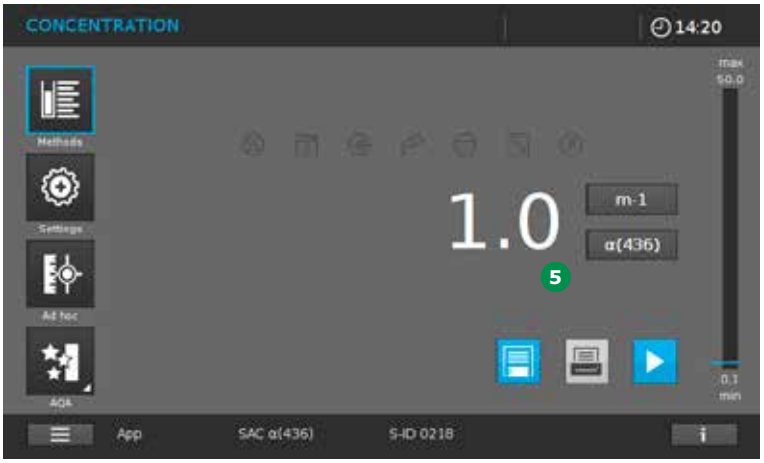
- For the zero adjustment fill a suitable rectangular cell with water for analysis.
- After prompting, insert the filled rectangular cell into the cell compartment. The zero adjustment is performed automatically.
- Confirm the performance of the zero-adjustment procedure by clicking on **<OK>** 3.

- **Measurement:**

  Note
  It is advisable to measure the sample solution using the same cell as the one used for the zero adjustment or else a cell with identical optical characteristics and an identical absorption (matched pair).



- Open the methods list (**<Methods>**) 4 and select **Method No. 302 "SAC α(436)"**.



- Fill the sample solution into a corresponding rectangular cell and insert the cell into the cell compartment. The measurement is performed automatically and the result appears in the display 5.

25.7 Evaluation

Statement of the results: m^{-1}

25.8 Literature

1. Deutsche Trinkwasserverordnung - TrinkwV Anlage 3, No. 7
2. EU-Trinkwasserrichtlinie 98/83/EG
3. DIN EN ISO 7887:2011 - Water quality - Examination and determination of colour (ISO 7887:2011); German version EN ISO 7887:2011

26 Spectral attenuation coefficient, SAC μ(254)

26.1 Method

The spectral attenuation coefficient at 254 nm for the degree of water pollution caused by particulate matter and dissolved organic substances. These substances include inter alia suspended matter such as solid mineral or organic substances, sediment matter, humic matter from the soil, aromatic compounds, and metabolic products of microorganisms.
The spectral attenuation coefficient is measured by transmitting light with a wavelength of 254 nm through a filtered sample.
The spectral attenuation coefficient at 254 nm is expressed in the unit m^{-1} and in accordance with the definition of the DIN 38404-3 standard is calculated from the sum of the absorption and the diffusion of the UV light caused by particulate matter and organic matter dissolved in the sample.
The method is analogous to the DIN 38404-3 standard (see literature reference[1]).

26.2 Measuring range

Method 301	SAC μ(254)	0.1 - 50.0 m^{-1} (50-mm rectangular cell quartz)
		0.3 - 125.0 m^{-1} (20-mm rectangular cell quartz)
		1 - 250 m^{-1} (10-mm rectangular cell quartz)

26.3 Sample material

Water from water-treatment plants (crude water, drinking water, weakly colored industrial wastewater)
Surface water

26.4 Reagents and auxiliaries

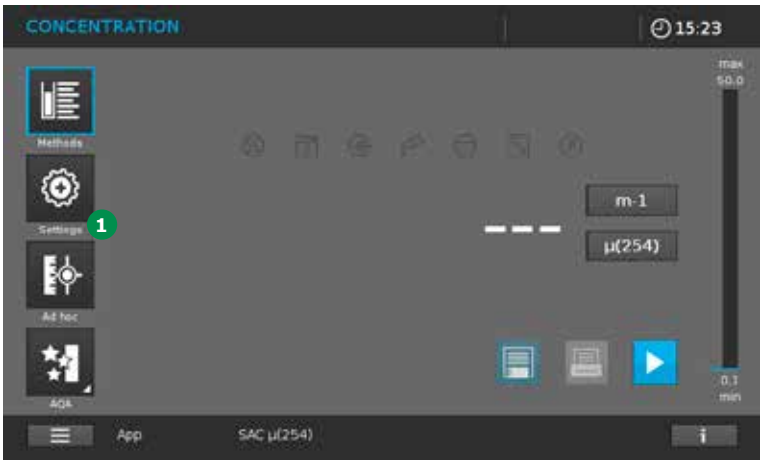
- Cat. No. 1.73017 - Spectroquant® UV/VIS Spectrophotometer Prove 300 or
  Cat. No. 1.73018 - Spectroquant® UV/VIS Spectrophotometer Prove 600
- Cat. No. 1.00784 - Rectangular cells 10 mm quartz and/or
  Rectangular cells 20 mm quartz and/or
  Rectangular cells 50 mm quartz
- Cat. No. 1.16754 - Water for analysis EMSURE® or
  distilled water

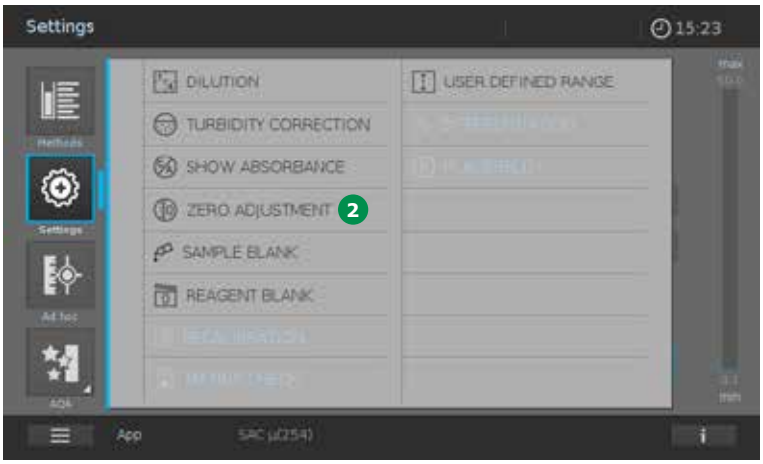
26.5 Preparation

- Shake the unfiltered sample to resuspend any suspended or turbidity-causing matter evenly in the sample.
- Measure the sample immediately after resuspension.

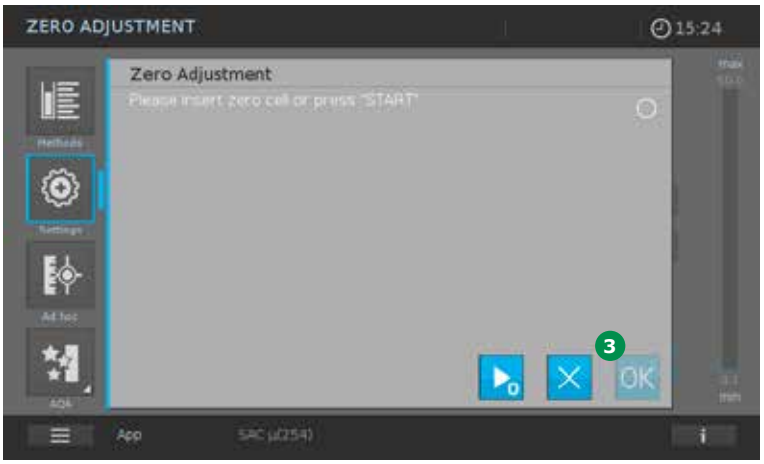
26.6 Procedure and measurement

- **Zeroing the photometer:**
  - It is advisable to zero the photometer at the start of each working day, using the same cell as the one used for the test solutions or else a cell with identical optical characteristics and an identical absorption (matched pair).
  - To perform the zero-adjustment procedure open the methods list (**<Methods>**) and select **Method No. 301 "SAC µ(254)"**.
    If there is no valid zero adjustment available for the method, the window for the zero-adjustment procedure opens automatically.





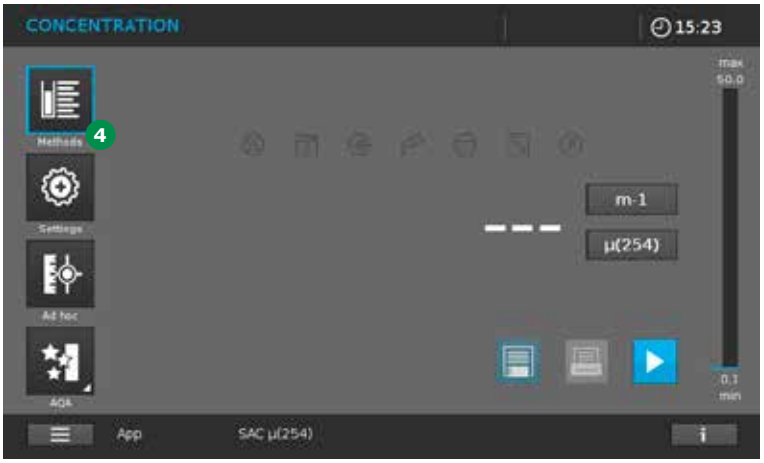
If a valid zero adjustment is already available, the Methods window opens.
The zero-adjustment procedure must then be selected by opening **<Settings>** 1 and clicking on the selection button **"ZERO ADJUSTMENT"** 2.



- For the zero adjustment fill a corresponding rectangular quartz cell with water for analysis.
- 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>** 3.

- **Measurement:**

  Note
  It is advisable to measure the sample solution using the same cell as the one used for the zero adjustment or else a cell with identical optical characteristics and an identical absorption (matched pair).



- Open the methods list (**<Methods>**) 4 and select **Method No. 301 "SAC µ(254)"**.

- Fill the sample solution into a corresponding rectangular quartz cell and insert the cell into the cell compartment. The measurement is performed automatically and the result appears in the display 5.

26.7 Evaluation

Statement of the results: m^{-1}

26.8 Literature

1. DIN 38404:2005-07 - German standard methods for the examination of water, waste water and sludge - Physical and physicalchemical parameters (group C) - Part 3: Determination of absorption in the range of the ultraviolet radiation, Spectral absorptions coefficient (C 3)

27 Spectral attenuation coefficient, SAC μ(254) - corrected

27.1 Method

The corrected spectral attenuation coefficient at 254 nm is a parameter for the degree of water pollution caused by dissolved organic substances. These substances include inter alia humic matter from the soil, aromatic compounds, and metabolic products of microorganisms.
The spectral absorption coefficient is measured by transmitting light with a wavelength of 254 nm through an unfiltered and **uncolored** sample.
Any particulate matter present in the sample, e.g. solid mineral or organic substances or sediment matter, result in an additional attenuation of the UV light. To compensate the contribution of such matter to the spectral attenuation coefficient, in a further measurement light with a wavelength of 550 nm is transmitted through the sample. Light with this wavelength is attenuated by particulate matter present in the sample in a similar way as light with a wavelength of 254 nm, but is not absorbed by dissolved organic matter.
The corrected spectral attentuation coefficient at 254 nm is expressed in the unit m^{-1} and in accordance with the definition of the DIN 38404-3 standard is based on the attenuation of UV light with a wavelength of 254 nm, corrected by the contribution of light with a wavelength of 550 nm.
The method is analogous to the DIN 38404-3 standard (see literature reference[1]).

27.2 Measuring range

Method 2571	SAC μ(254), korr	0.1 - 50.0 m^{-1} (50-mm rectangular cell quartz)
		0.3 - 125.0 m^{-1} (20-mm rectangular cell quartz)
		1 - 250 m^{-1} (10-mm rectangular cell quartz)

27.3 Sample material

Uncolored water from water-treatment plants (crude water, drinking water, weakly colored industrial waste-water)
Uncolored surface water

27.4 Reagents and auxiliaries

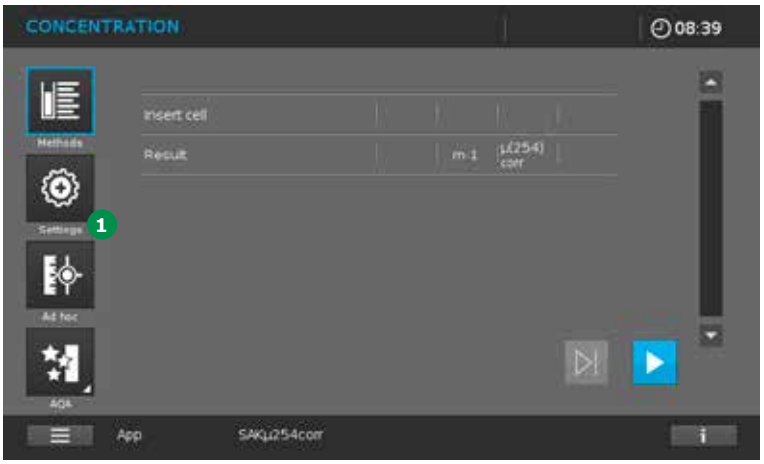
- Cat. No. 1.73017 - Spectroquant® UV/VIS Spectrophotometer Prove 300 or
  Cat. No. 1.73018 - Spectroquant® UV/VIS Spectrophotometer Prove 600
- Cat. No. 1.00784 - Rectangular cells 10 mm quartz and/or
  Rectangular cells 20 mm quartz and/or
  Rectangular cells 50 mm quartz
- Cat. No. 1.16754 - Water for analysis EMSURE® or
  distilled water

27.5 Preparation

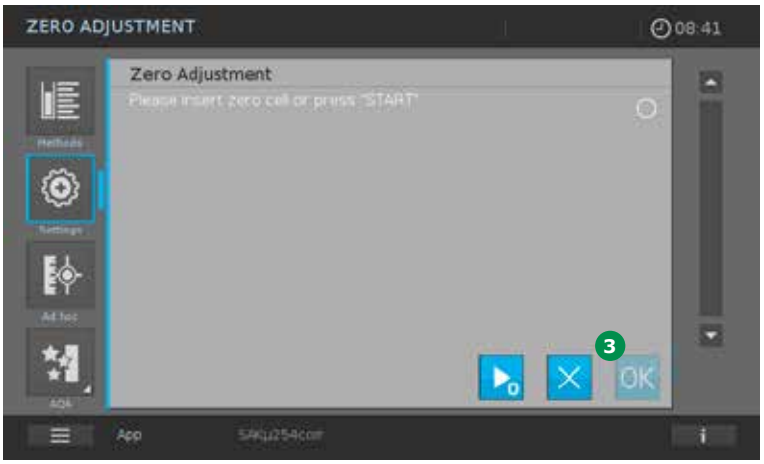
- Shake the unfiltered sample to resuspend any suspended or turbidity-causing matter evenly in the sample.
- Measure the sample immediately after resuspension.

27.6 Procedure and measurement

- **Zeroing the photometer:**
  - It is advisable to zero the photometer at the start of each working day, using the same cell as the one used for the test solutions or else a cell with identical optical characteristics and an identical absorption (matched pair).
  - To perform the zero-adjustment procedure open the methods list (**<Methods>**) and select **Method No. 2571 "SAC µ(254), korr"**.
    If there is no valid zero adjustment available for the method, the window for the zero-adjustment procedure opens automatically.



If a valid zero adjustment is already available, the Methods window opens.
The zero-adjustment procedure must then be selected by opening **<Settings>** 1 and clicking on the selection button **"ZERO ADJUSTMENT"** 2.

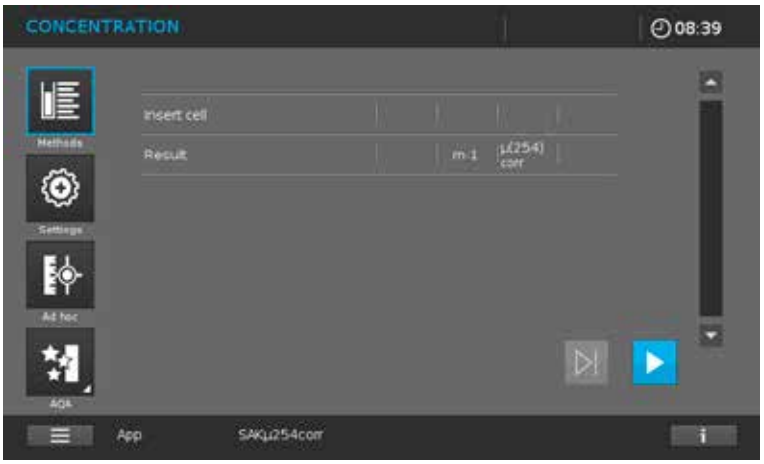


- For the zero adjustment fill a corresponding rectangular quartz cell with water for analysis.
- After prompting, insert the filled rectangular cell into the cell compartment. The zero adjustment is performed automatically.
- Confirm the performance of the zero-adjustment procedure by clicking on **<OK>** 3.

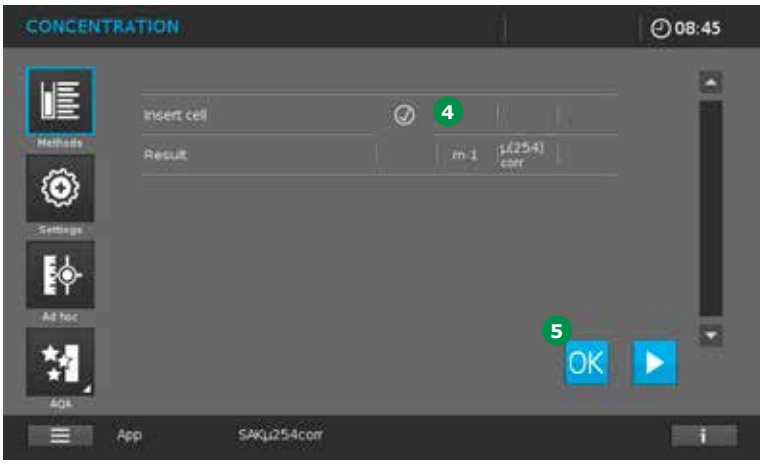
- **Measurement:**

  Note
  It is advisable to measure the sample solution using the same cell as the one used for the zero adjustment or else a cell with identical optical characteristics and an identical absorption (matched pair).

  - Open the methods list (**<Methods>**) and select **Method No. 2571 "SAC µ(254), korr"**.

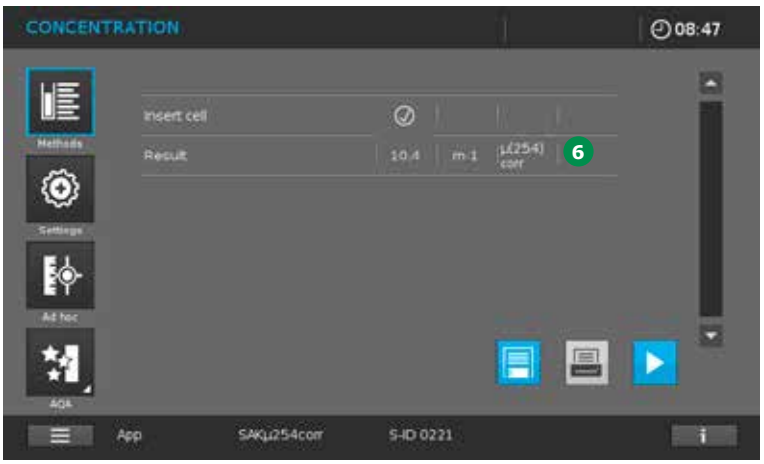


  - Fill the sample solution into a corresponding rectangular quartz cell and insert the cell into the cell compartment. The measurement is performed automatically.



A (✓) appears behind the cue "Insert cell" 4.

- Confirm the measurement by clicking on **<OK>** 5.



The measurement result appears in the photometer display 6.

27.7 Evaluation

Statement of the results: m^{-1}

27.8 Literature

1. DIN 38404:2005-07 - German standard methods for the examination of water, waste water and sludge - Physical and physicalchemical parameters (group C) - Part 3: Determination of absorption in the range of the ultraviolet radiation, Spectral absorptions coefficient (C 3)

28 Tint index

28.1 Method

The tint index is frequently determined together with the whiteness of a material (see also section 32, "Whiteness"). In materials that are not colored, the color index lies at "0". Greenish colors are presented as values in the positive range, reddish colors as ones in the negative range. The higher the value, the stronger the color (color cast).
The tint index is determined by measuring the transmittances of the sample in a wavelength spectrum between 380 and 780 nm and subsequent calculation of the tristimulus values X, Y, Z. The tristimulus values are then used to calculate the color index according to the methods of the ASTM E313-15 standard.
The method is analogous to the ASTM E313-15 method (see literature reference[1]).

28.2 Measuring range

Method 2577	Tint Index	-6.00 - 3.00 TI_{10mm} (10-mm rectangular cell)
Method 2578	Tint Index	-6.00 - 3.00 TI_{50mm} (50-mm rectangular cell)

Note
The tint index is determined for standard illuminant C and the 2° standard observer.

28.3 Sample material

Clear liquid samples
Turbid liquid samples after filtration

28.4 Reagents and auxiliaries

- Cat. No. 1.73016 - Spectroquant® VIS Spectrophotometer Prove 100 or
  Cat. No. 1.73017 - Spectroquant® UV/VIS Spectrophotometer Prove 300 or
  Cat. No. 1.73018 - Spectroquant® UV/VIS Spectrophotometer Prove 600
- Cat. No. 1.14946 - Rectangular cells 10 mm
- Cat. No. 1.16754 - Water for analysis EMSURE® or
  distilled water
- Membrane filters, pore size max. 0.45 µm (optional)

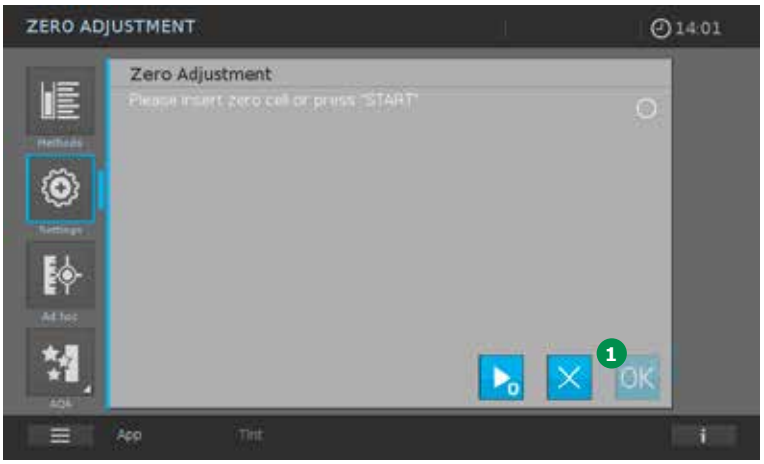
28.5 Preparation

- Filter **turbid sample solutions** over a membrane filter.
  To do this, prerinse the membrane filter with approx. 50 ml of water for analysis, then rerinse with approx. 50 ml of the sample solution and discard the filtrate.
  Filter a further 50 ml of the sample solution over the prerinsed membrane filter and use the filtrate for the analysis.

28.6 Procedure and measurement

- Open the methods list (**<Methods>**) and select **Method No. 2577 resp. 2578 "Tint Index"**.

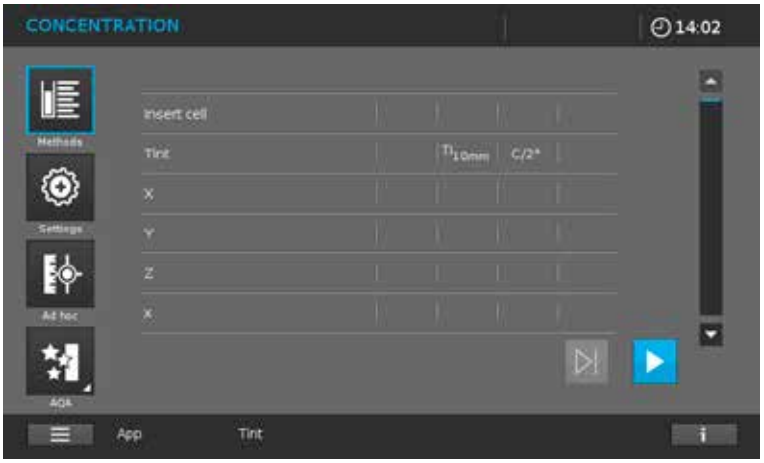
- **Zeroing the photometer:**
  - The photometer must be zeroed prior to each new measurement series.
  - It is advisable to zero the photometer using the same cell as the one used for the measurement sample or else a cell with identical optical characteristics and an identical absorption (matched pair).
    The zero-adjustment procedure for the measurement series is automatically prompted by the instrument.



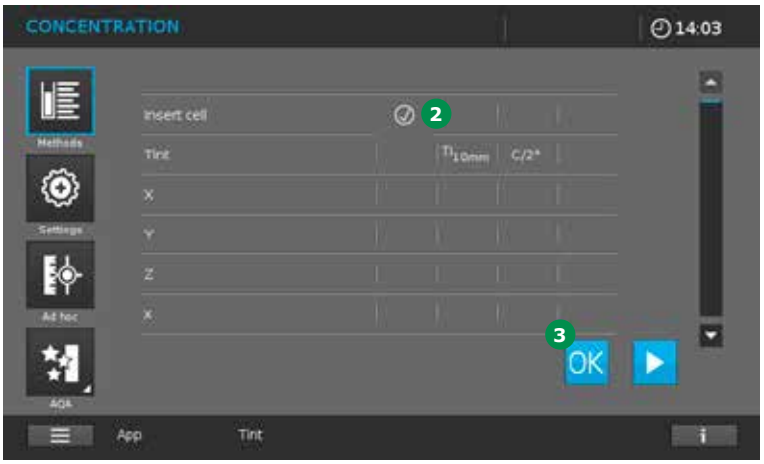
- For the zero adjustment fill a suitable rectangular cell with water for analysis.
- After prompting, insert the filled rectangular cell into the cell compartment. The zero adjustment is performed automatically.
- Confirm the performance of the zero-adjustment procedure by clicking on **<OK>** 1.
  The zero adjustment is valid for the entire measurement series.

- **Measurement:**

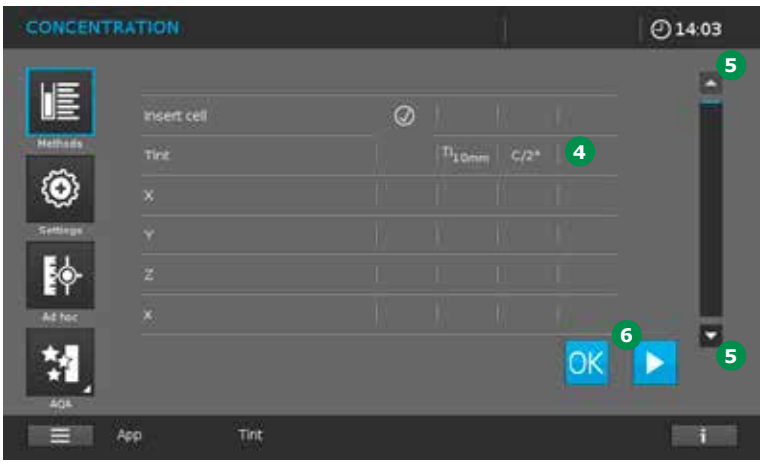
  Note
  It is advisable to measure the sample using the same cell as the one used for the zero adjustment or else a cell with identical optical characteristics and an identical absorption (matched pair).



- Fill the sample solution into a corresponding rectangular cell and insert the cell into the cell compartment. The measurement is performed automatically.



A (✓) appears behind the cue "Insert cell" 2.
- Confirm the measurement by clicking on **<OK>** 3.



The measurement results appear in the photometer display 4.
- Where applicable, use the scroll keys 5 to scroll down through the display to show other measurement results.
- Click **<START>** 6 to start the measurement procedure for the next sample.
  A renewed zero adjustment is not necessary.

28.7 Evaluation

Statement of the results: Tint Index (TI)
Tristimulus values X, Y, Z
Chromaticity coordinates x, y
determined for standard illuminant C and the 2° standard observer

28.8 Literature

1. ASTM E313-15, Standard Practice for Calculating Yellowness and Whiteness Indices from Instrumentally Measured Color Coordinates

29 Transmittances T_X, T_Y, T_Z

29.1 Method

The transmittances T_X, T_Y, T_Z serve the colorimetric characterization of clear liquids. The transmittances T_X, T_Y, T_Z were originally determined with broadband X, Y, Z standard color filters and simple filter photometers. Today they are generally determined by spectrophotometry.
The values are determined by measuring the transmittances in the wavelength spectrum between 380 - 780 nm and subsequent calculation of the transmittances T_X, T_Y, T_Z according to the methods of the DIN EN 1557 standard.
The method is analogous to the DIN EN 1557 standard (see literature reference[1]).

29.2 Measuring range

Method 2579	Transmittances T_X, T_Y, T_Z	0,0 - 150,0 (10-mm rectangular cell)

Note
The Transmittances T_X, T_Y, T_Z is determined for standard illuminant C and the 2° standard observer.

29.3 Sample material

Clear liquid samples
Turbid liquid samples after filtration

29.4 Reagents and auxiliaries

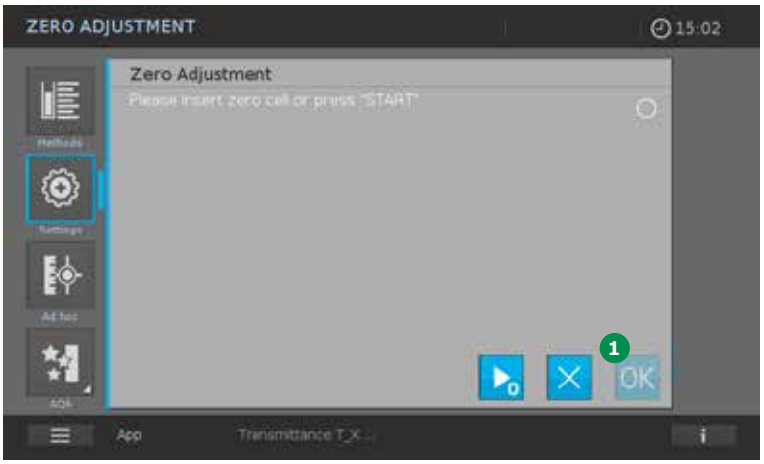
- Cat. No. 1.73016 - Spectroquant® VIS Spectrophotometer Prove 100 or
  Cat. No. 1.73017 - Spectroquant® UV/VIS Spectrophotometer Prove 300 or
  Cat. No. 1.73018 - Spectroquant® UV/VIS Spectrophotometer Prove 600
- Cat. No. 1.14946 - Rectangular cells 10 mm
- Cat. No. 1.16754 - Water for analysis EMSURE® or
  distilled water
- Membrane filters, pore size max. 0.45 µm (optional)

29.5 Preparation

- Filter **turbid sample solutions** over a membrane filter.
  To do this, prerinse the membrane filter with approx. 50 ml of water for analysis, then rerinse with approx. 50 ml of the sample solution and discard the filtrate.
  Filter a further 50 ml of the sample solution over the prerinsed membrane filter and use the filtrate for the analysis.

29.6 Procedure and measurement

- Open the methods list (**<Methods>**) and select **Method No. 2579 "Transmittances T_X, T_Y, T_Z"**.
- **Zeroing the photometer:**
  - The photometer must be zeroed prior to each new measurement series.
  - It is advisable to zero the photometer using the same cell as the one used for the measurement sample or else a cell with identical optical characteristics and an identical absorption (matched pair).
    The zero-adjustment procedure for the measurement series is automatically prompted by the instrument.

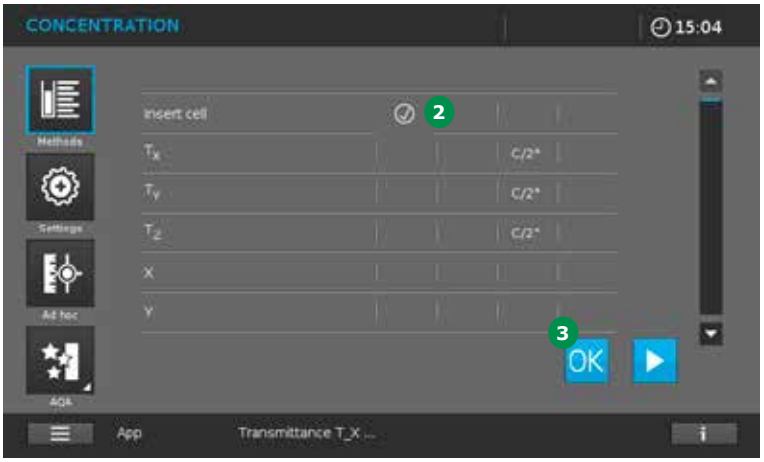


- For the zero adjustment fill a 10-mm rectangular cell with water for analysis.
- After prompting, insert the filled rectangular cell into the cell compartment. The zero adjustment is performed automatically.
- Confirm the performance of the zero-adjustment procedure by clicking on **<OK>** 1.
  The zero adjustment is valid for the entire measurement series.

- **Measurement:**

  Note
  It is advisable to measure the sample using the same cell as the one used for the zero adjustment or else a cell with identical optical characteristics and an identical absorption (matched pair).

- Fill the sample solution into a 10-mm rectangular cell and insert the cell into the cell compartment. The measurement is performed automatically.



A (✓) appears behind the cue "Insert cell" 2.
- Confirm the measurement by clicking on **<OK>** 3.

The measurement results appear in the photometer display 4.
- Where applicable, use the scroll keys 5 to scroll down through the display to show other measurement results.
- Click **<START>** 6 to start the measurement procedure for the next sample.
  A renewed zero adjustment is not necessary.

29.7 Evaluation

Statement of the results: Transmittances T_X, T_Y, T_Z
Tristimulus values X, Y, Z
Chromaticity coordinates x, y
determined for standard illuminant C and the 2° standard observer

29.8 Literature

1. DIN EN 1557:1997-03, Surface active agents - Colorimetric characterization of optically clear coloured liquids (products) as X, Y, Z tristimulus values in transmission
2. DIN 5033-2:1992-05, Colorimetry; Standard colorimetric systems
3. DIN 5033-3:1992-07, Colorimetry; Colorimetric measures
4. ISO 7724-1:1984-10, Paints and varnishes - Colorimetry - Part 1: Principles
5. ISO CIE 10527:1991-12, CIE standard colorimetric observers
6. DIN EN ISO 11664-1:2011-07, Colorimetry - Part 1: CIE standard colorimetric observers (ISO 11664-1:2007); German version EN ISO 11664-1:2011

30 UV-absorbing organic matters (UV absorption 254)

30.1 Method

Certain types of organic matter dissolved in water, for example humic matter from the soil, aromatic compounds such as lignin or tannin from the timber-processing industry, metabolic products of microorganisms, or other aromatic compounds are capable of absorbing UV light. The measurement of the absorption in the UV spectrum can accordingly be an indicator of the possible presence of such substances in a water sample. Besides the measurement of the spectral absorption coefficient 254 nm according to DIN 38404-3 (see section 24, "Spectral absorption coefficient, SAC α(254)"), another method frequently used to determine UV-absorbing organic matter is the APHA 5910 method. In technical circles, this method is frequently referred to as the UV absorption method.
In this method, UV light with a wavelength of 254 nm is transmitted through a filtered sample. The result of the UV absorption can be expressed in a variety of units, such as A/cm or cm^{-1} or m^{-1}.
The methods are analogous to APHA 5910 (see literature reference[1]). The description of the APHA 5910 method mentions that the pH of the sample may have an impact on the UV absorption. The risk of potential interferences by other matter contained in the sample is also mentioned.

30.2 Measuring range

Method 309	UV Absorbing Organic Constituents	0.0000 - 0.1000 A/cm 0.0000 - 0.1000 cm^{-1} 0.0 - 10.0 m^{-1} (100-mm rectangular cell quartz, **only Prove 600**)
		0.000 - 0.200 A/cm 0.000 - 0.200 cm^{-1} 0 - 20 m^{-1} (50-mm rectangular cell quartz)
		0.000 - 0.500 A/cm 0.000 - 0.500 cm^{-1} 0 - 50 m^{-1} (20-mm rectangular cell quartz)
		0.000 - 1.000 A/cm 0.000 - 1.000 cm^{-1} 0 - 100 m^{-1} (10-mm rectangular cell quartz)
Method 310	UV Absorption 254	0.0000 - 0.3000 A/cm 0.0000 - 0.3000 cm^{-1} 0.00 - 30.00 m^{-1} (100-mm rectangular cell quartz, **only Prove 600**)
		0.000 - 0.600 A/cm 0.000 - 0.600 cm^{-1} 0.0 - 60.0 m^{-1} (50-mm rectangular cell quartz)
		0.000 - 1.500 A/cm 0.000 - 1.500 cm^{-1} 0.0 - 150.0 m^{-1} (20-mm rectangular cell quartz)
		0.000 - 3.000 A/cm 0.000 - 3.000 cm^{-1} 0.0 - 300.0 m^{-1} (10-mm rectangular cell quartz)

Note
The definition of the upper measuring-range limit of Method 309 is based on the recommendation given in APHA 5910 that samples with an absorption of > 1.0 Abs should be diluted for analysis. If this absorption limit is exceeded in the analysis procedure, when Method 309 is used the result "HI" appears in the display (= result lies above the upper measuring-range limit). In such a case the sample must be diluted with distilled water/water for analysis and the analysis procedure repeated.
In Method 310, the upper measurement-range limit is based on a maximum value of 3.0 Abs and is correspondingly higher. When Method 310 is used for determining UV-absorbing organic matter, it is advisable to also display the absorption and, in the case of absorption values > 1.0 Abs, to follow the recommendations of APHA 5910 regarding dilution.
Instructions on how to display the absorption during the measurement procedure and how to include the dilution factor in the calculation of the final result can be found in the Operating Manual for the spectrophotometer.

30.3 Sample material

Water from water-treatment plants (crude water, drinking water, weakly colored industrial wastewater)
Surface water
Seawater

30.4 Reagents and auxiliaries

- Cat. No. 1.73017 - Spectroquant® UV/VIS Spectrophotometer Prove 300 or
  Cat. No. 1.73018 - Spectroquant® UV/VIS Spectrophotometer Prove 600
- Cat. No. 1.00784 - Rectangular cells 10 mm quartz and/or
  Rectangular cells 20 mm quartz and/or
  Rectangular cells 50 mm quartz
  Rechteckküvetten 100 mm quartz
- Cat. No. 1.16754 - Water for analysis EMSURE® or
  distilled water
- Cat. No. 109535 - MQuant® pH-indicator strips 0 - 14 universal indicator
- Cat. No. 1.09141 - Sodium hydroxide solution 0.1 mol/l Titripur® (optional)
- Cat. No. 1.09060 - Hydrochloric acid 0.1 mol/l Titripur® (optional)

Standard laboratory glassware (e.g. glass beakers) and pipettes

30.5 Preparation

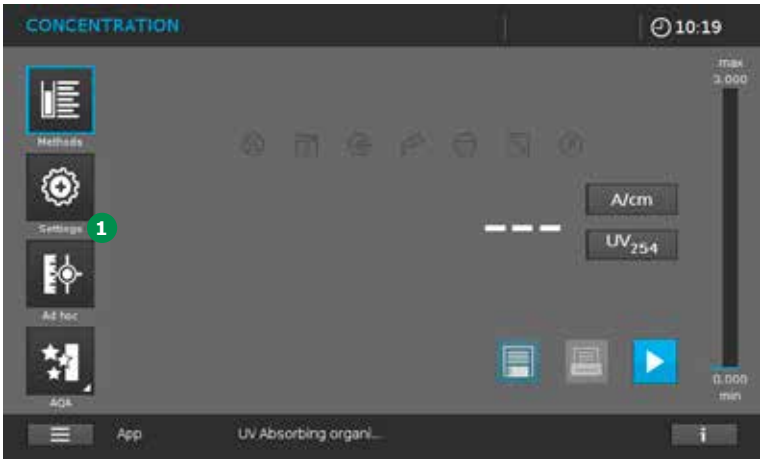
- Filter **turbid sample solutions** over a membrane filter.
  To do this, prerinse the membrane filter with approx. 50 ml of water for analysis, then rerinse with approx. 50 ml of the sample solution and discard the filtrate.
  Filter a further 50 ml of the sample solution over the prerinsed membrane filter and use the filtrate for the analysis.
- Check the pH of the sample. If the pH of the sample is below 4 or above 10, it is recommended to adjust the pH to a value within the pH range 4 -10 using sodium hydroxide solution 0.1 mol/l or hydrochloric acid 0.1 mol/l.

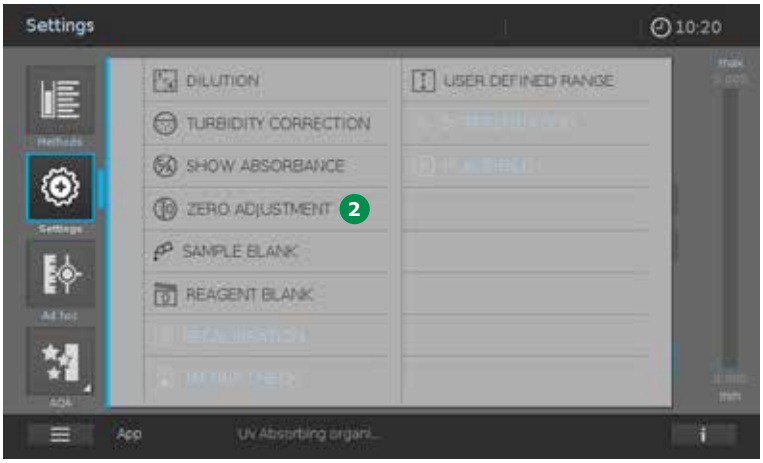
30.6 Influence of foreign agents / interferences

Particulate matter and UV-absorbing inorganic matter may have an effect on the measurement of the UV absorption. Any particulate matter present in the sample must generally be removed by filtration.
UV-absorbing inorganic components may take the form of naturally occurring substances or other substances occurring in wastewater, e.g. iron-containing compounds, nitrates, nitrites, bromides, as well as compounds used or occurring in wastewater-treatment processes such as ozone, chlorates, chlorites, chloramines, and thiosulfates.
The presence of UV-absorbing inorganic components can be tested by recording an absorption spectrum of the sample in the 200 - 400 nm wavelength spectrum. Such compounds generally appear in the spectrum as relatively sharp peaks.
UV-absorbing inorganic components, by contrast, usually produce an unformed absorption curve, with the absorption increasing as the wavelength diminishes.

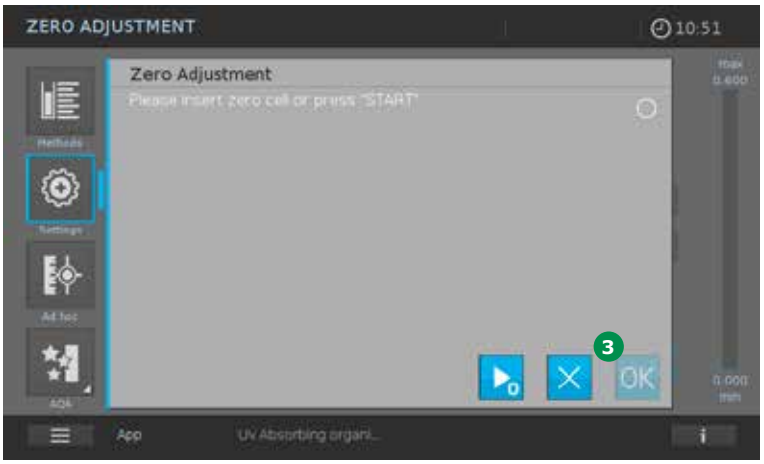
30.7 Procedure and measurement

- **Zeroing the photometer:**
  - It is advisable to zero the photometer at the start of each working day, using the same cell as the one used for the test solutions or else a cell with identical optical characteristics and an identical absorption (matched pair).
  - To perform the zero-adjustment procedure open the methods list (**<Methods>**) and select **Method No. 309 "UV Absorbing Organic Constituents" resp. No. 310 "UV Absorption 254"**.
    If there is no valid zero adjustment available for the method, the window for the zero-adjustment procedure opens automatically.





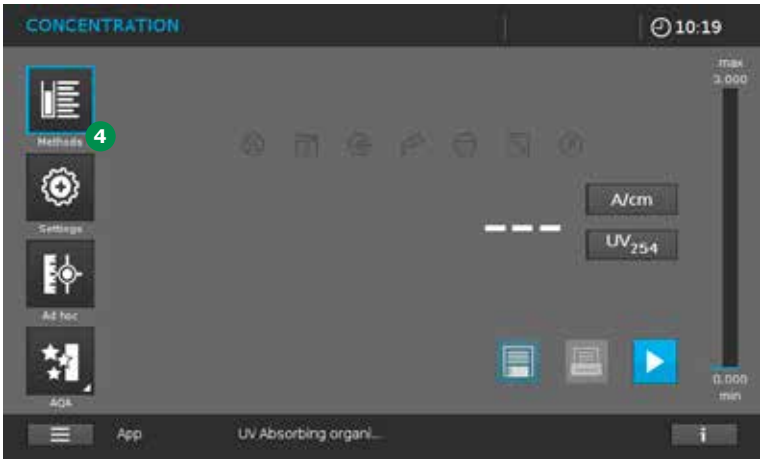
If a valid zero adjustment is already available, the Methods window opens.
The zero-adjustment procedure must then be selected by opening **<Settings>** 1 and clicking on the selection button **"ZERO ADJUSTMENT"** 2.



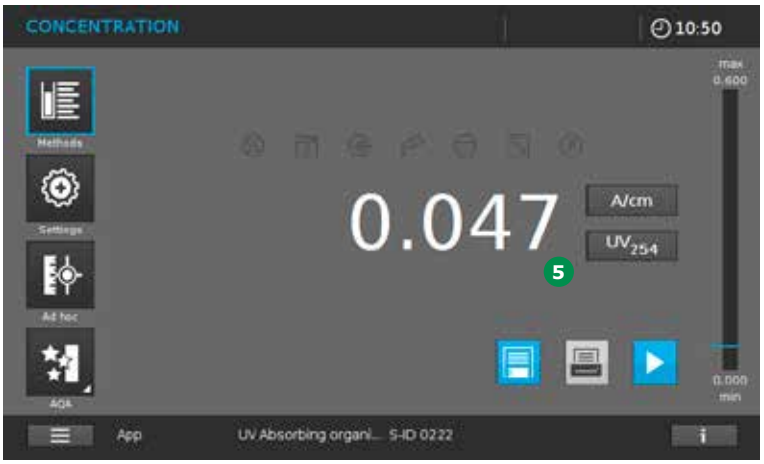
- For the zero adjustment fill a corresponding rectangular quartz cell with water for analysis.
- After prompting, insert the filled rectangular cell into the cell compartment. The zero adjustment is performed automatically.
- Confirm the performance of the zero-adjustment procedure by clicking on **<OK>** 3.

- **Measurement:**

  Note
  It is advisable to measure the sample solution using the same cell as the one used for the zero adjustment or else a cell with identical optical characteristics and an identical absorption (matched pair).



- Open the methods list (**<Methods>**) 4 and select **Method No. 309 "UV Absorbing Organic Constituents" resp. No. 310 "UV Absorption 254"**.



- Fill the sample solution into a corresponding rectangular quartz cell and insert the cell into the cell compartment. The measurement is performed automatically and the result appears in the display 5.

30.8 Evaluation

Statement of the results: A/cm or
cm^{-1} or
m^{-1}

30.9 Literature

1. Standard Methods for the Examination of Water and Wastewater (21th edition), APHA 5910 UV-Absorbing Organic Constituents - B. Ultraviolet Absorption Method

31 UV irradiation (UV absorption 254 - UV transmission 254)

31.1 Method

UV irradiation is a method used in the water-treatment sector for disinfection purposes. The method is based on the DNA- and RNA-changing and thus reproduction-inhibiting effect of UV light of varying wavelengths on microorganisms.
UV irradiation is usually carried out continuously in flow-metering systems.
The success of the disinfectant effect depends on the UV irradiance and the duration of the irradiation process and also on the quality of the water itself.
Various components present in the water, for example hardness-forming substances, iron-containing compounds, halogenides, organic matter, or microorganisms, can lead to the formation of deposits on the UV irradiation lamp. These deposits have a negative impact on the irradiance and thus on the effectivenesss of the procedure.
Other sources of influence are turbidities present in the water, which may lead to a diffusion of the UV light, and dissolved organic matter capable of absorbing UV light and thus of impairing the effectiveness of the procedure.
The presence of turbidities or dissolved organic compounds can be determined by spectrophotometric measurement at 254 nm. This method is widely used in the practical area to monitor any impact on the effectiveness of UV irradiation measures.
In this method, UV light with a wavelength of 254 nm is transmitted through an unfiltered sample.
The measurement results are usually expressed as the transmission or absorption relative to an optical path length of 1 cm.

31.2 Measuring range

Method 310	UV Absorption 254	0.0000 - 0.3000 A/cm 0.000 - 0.300 cm^{-1} 0.00 - 30.00 m^{-1} (100-mm rectangular cell quartz, **only Prove 600**)
		0.000 - 0.600 A/cm 0.000 - 0.600 cm^{-1} 0.0 - 60.0 m^{-1} (50-mm rectangular cell quartz)
		0.000 - 1.500 A/cm 0.000 - 1.500 cm^{-1} 0.0 - 150.0 m^{-1} (20-mm rectangular cell quartz)
		0.000 - 3.000 A/cm 0.000 - 3.000 cm^{-1} 0.0 - 300.0 m^{-1} (10-mm rectangular cell quartz)
Method 2572	UV Transmission 254	0.00 - 105.00 %T/cm (100-mm rectangular cell quartz, **only Prove 600**)
		0.00 - 105.00 %T/cm (50-mm rectangular cell quartz)
		0.00 - 105.00 %T/cm (20-mm rectangular cell quartz)
		0.00 - 105.00 %T/cm (10-mm rectangular cell quartz)

31.3 Sample material

Water from water-treatment plants (crude water, drinking water, weakly colored industrial wastewater)
Surface water
Seawater

31.4 Reagents and auxiliaries

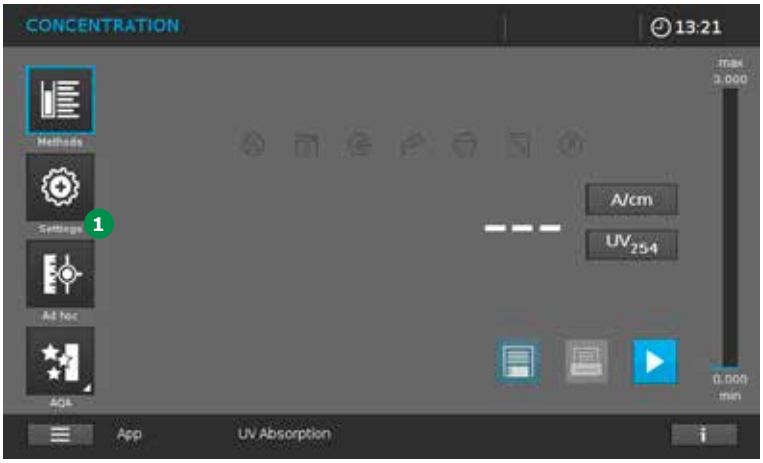
- Cat. No. 1.73017 - Spectroquant® UV/VIS Spectrophotometer Prove 300 or
  Cat. No. 1.73018 - Spectroquant® UV/VIS Spectrophotometer Prove 600
- Cat. No. 1.00784 - Rectangular cells 10 mm quartz and/or
  Rectangular cells 20 mm quartz and/or
  Rectangular cells 50 mm quartz
  Rectangular cells 100 mm quartz
- Cat. No. 1.16754 - Water for analysis EMSURE® or
  distilled water

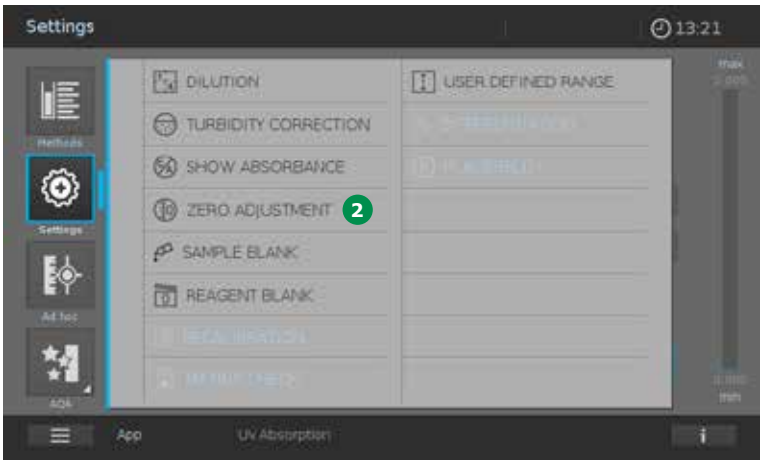
31.5 Preparation

- Shake the unfiltered sample to resuspend any suspended or turbidity-causing matter evenly in the sample.
- Measure the sample immediately after resuspension.

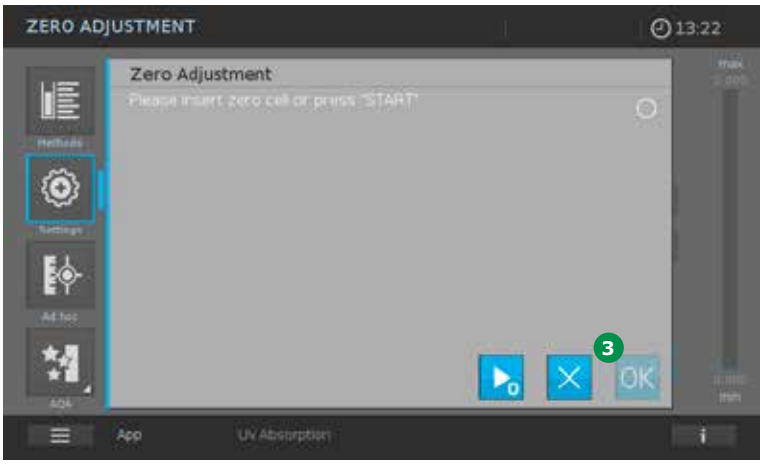
31.6 Procedure and measurement - Method 310 "UV Absorption 254"

- **Zeroing the photometer:**
  - It is advisable to zero the photometer at the start of each working day, using the same cell as the one used for the test solutions or else a cell with identical optical characteristics and an identical absorption (matched pair).
  - To perform the zero-adjustment procedure open the methods list (**<Methods>**) and select **Method No. 310 "UV Absorption 254"**.
    If there is no valid zero adjustment available for the method, the window for the zero-adjustment procedure opens automatically.





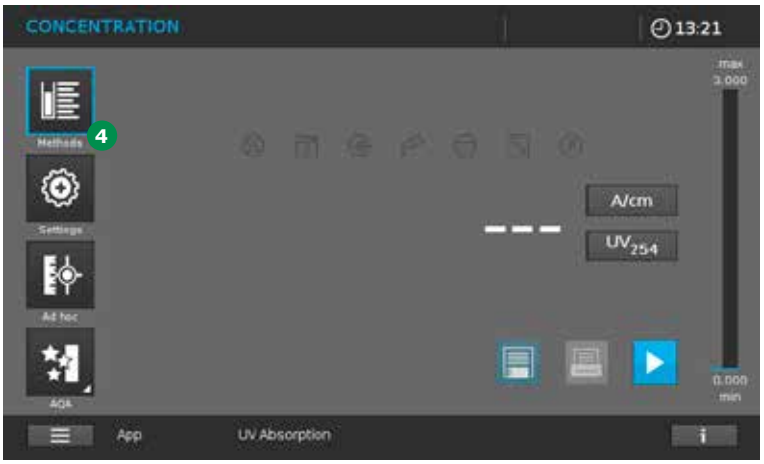
If a valid zero adjustment is already available, the Methods window opens.
The zero-adjustment procedure must then be selected by opening **<Settings>** 1 and clicking on the selection button **"ZERO ADJUSTMENT"** 2.



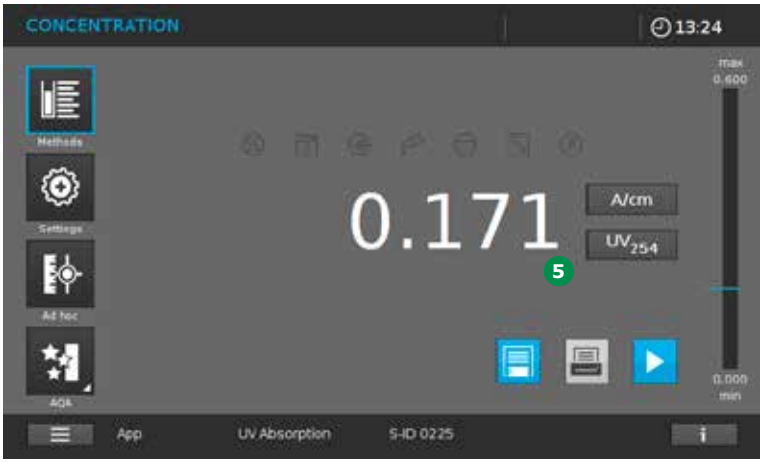
- For the zero adjustment fill a corresponding rectangular quartz cell with water for analysis.
- After prompting, insert the filled rectangular cell into the cell compartment. The zero adjustment is performed automatically.
- Confirm the performance of the zero-adjustment procedure by clicking on **<OK>** 3.

- **Measurement:**

  Note
  It is advisable to measure the sample solution using the same cell as the one used for the zero adjustment or else a cell with identical optical characteristics and an identical absorption (matched pair).



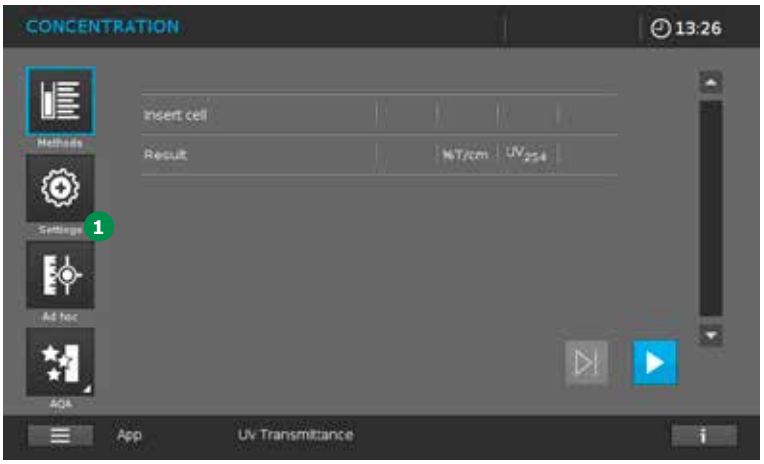
- Open the methods list (**<Methods>**) 4 and select **Method No. 310 "UV Absorption 254"**.



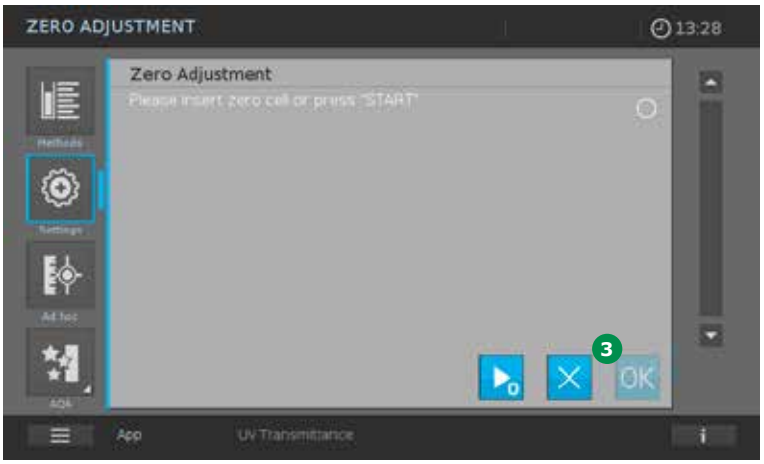
- Fill the sample solution into a corresponding rectangular quartz cell and insert the cell into the cell compartment. The measurement is performed automatically and the result appears in the display 5.

31.7 Procedure and measurement - Method 2572 "UV Transmission 254"

- **Zeroing the photometer:**
  - It is advisable to zero the photometer at the start of each working day, using the same cell as the one used for the test solutions or else a cell with identical optical characteristics and an identical absorption (matched pair).
  - To perform the zero-adjustment procedure open the methods list (<Methods>) and select Method No**. 2572 "UV Transmission 254"**.
    If there is no valid zero adjustment available for the method, the window for the zero-adjustment procedure opens automatically.



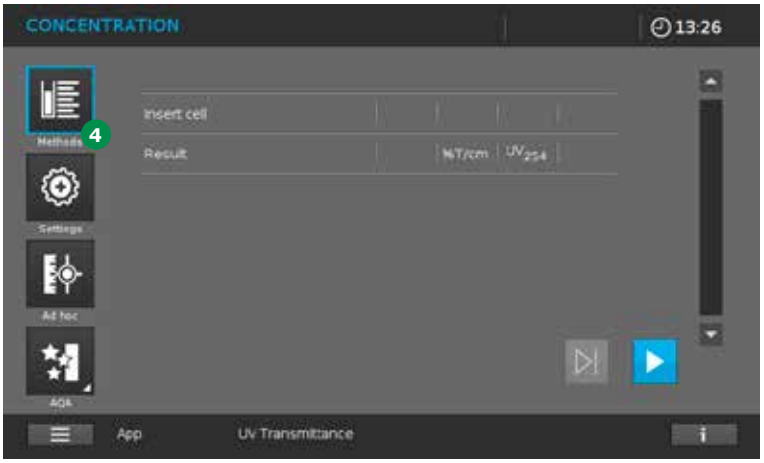
If a valid zero adjustment is already available, the Methods window opens.
The zero-adjustment procedure must then be selected by opening **<Settings>** 1 and clicking on the selection button **"ZERO ADJUSTMENT"** 2.



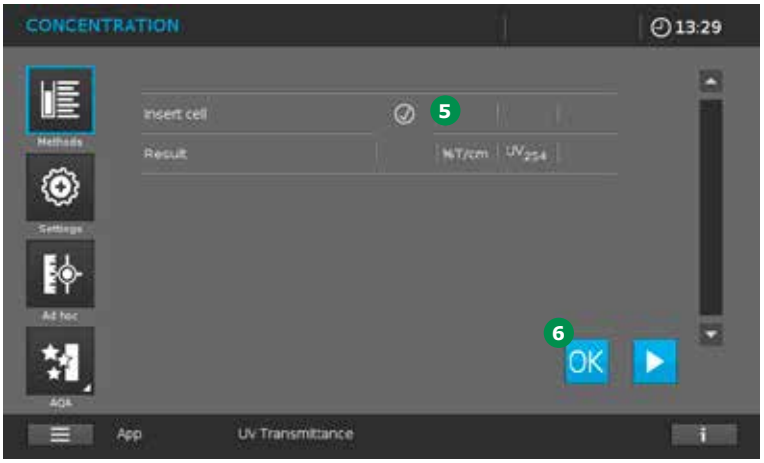
- For the zero adjustment fill a corresponding rectangular quartz cell with water for analysis.
- After prompting, insert the filled rectangular cell into the cell compartment. The zero adjustment is performed automatically.
- Confirm the performance of the zero-adjustment procedure by clicking on **<OK>** 3.

- **Measurement:**

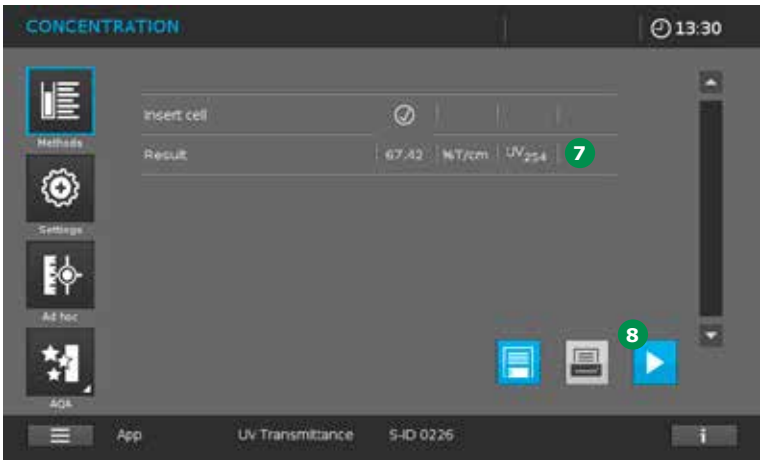
  Note
  It is advisable to measure the sample solution using the same cell as the one used for the zero adjustment or else a cell with identical optical characteristics and an identical absorption (matched pair).



- Open the methods list (**<Methods>**) 4 and select **Method No. 572 "UV Transmission 254"**.
- Fill the sample solution into a corresponding rectangular quartz cell and insert the cell into the cell compartment. The measurement is performed automatically.



A (✓) appears behind the cue "Insert sample" 5.
- Confirm the measurement by clicking on **<OK>** 6.



The measurement result appears in the photometer display 7.

- Click **<START>** 8 to start the measurement procedure for the next sample.

31.8 Evaluation

Statement of the results:	Method 310 "UV Absorption 254":	A/cm or cm^{-1} or m^{-1}
	Method 2572 "UV Transmission 254":	%T/cm

31.9 Literature

1. Ultraviolet light disinfection in the use of individual water purification devices; U.S. Army Public Health Command; Retrieved 2014-01-08
2. The Basic Principles of UV-Disinfection of Water; Meulemans, C. C. E.; Ozone: Science & Engineering. Vol.9, 1987, issue 4: 299-313

32 Whiteness

32.1 Method

The whiteness is a numerical parameter for the degree of whiteness of a surface or the transmission capacity of a clear liquid. The whiteness is primarily used in connection with the testing of solid materials, e.g. paper, to determine any changes in color. The method can also be used to record color changes in clear liquids. The greater the intensity of the color of a material (color cast), the lower the whiteness value.
If any discolorations are detected, in many cases the tint index of the material is also determined (see section 28, "Tint index").
The whiteness value is determined by measuring the transmittances in the wavelength spectrum between 380 - 780 nm and subsequent calculation of the tristimulus values X, Y, Z. The tristimulus values are then taken as a basis for the calculation of the whiteness value according to the methods of ASTM E313-15.
The method is analogous to ASTM E313-15 (see literature reference[1]).

32.2 Measuring range

Method 2575	Whiteness	40.0 - 220.0 WI_{10mm} (10-mm rectangular cell)
Method 2576	Whiteness	40.0 - 220.0 WI_{50mm} (50-mm rectangular cell)

Note
The whiteness value is determined for standard illuminant C and the 2° standard observer.

32.3 Sample material

Clear liquid samples
Turbid liquid samples after filtration

32.4 Reagents and auxiliaries

- Cat. No. 1.73016 - Spectroquant® VIS Spectrophotometer Prove 100 or
  Cat. No. 1.73017 - Spectroquant® UV/VIS Spectrophotometer Prove 300 or
  Cat. No. 1.73018 - Spectroquant® UV/VIS Spectrophotometer Prove 600
- Cat. No. 1.14946 - Rectangular cells 10 mm
- Cat. No. 1.16754 - Water for analysis EMSURE® or
  distilled water
- Membrane filters, pore size max. 0.45 µm (optional)

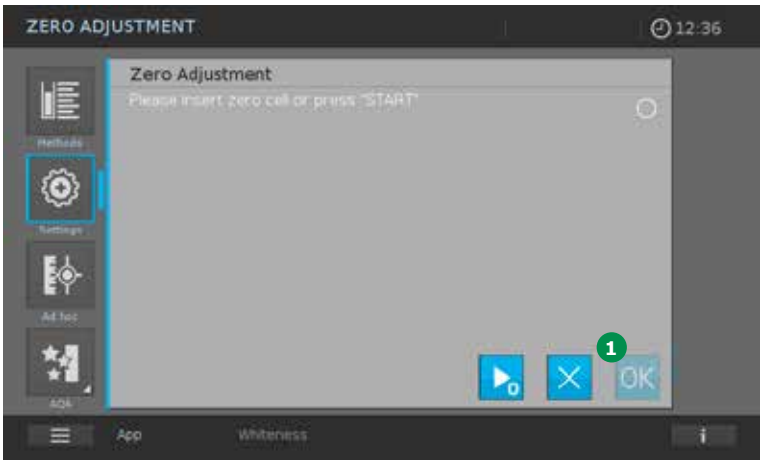
32.5 Preparation

- Filter **turbid sample solutions** over a membrane filter.
  To do this, prerinse the membrane filter with approx. 50 ml of water for analysis, then rerinse with approx. 50 ml of the sample solution and discard the filtrate.
  Filter a further 50 ml of the sample solution over the prerinsed membrane filter and use the filtrate for the analysis.

32.6 Procedure and measurement

- Open the methods list (**<Methods>**) and select **Method No. 2575 resp. 2576 "Whiteness"**.

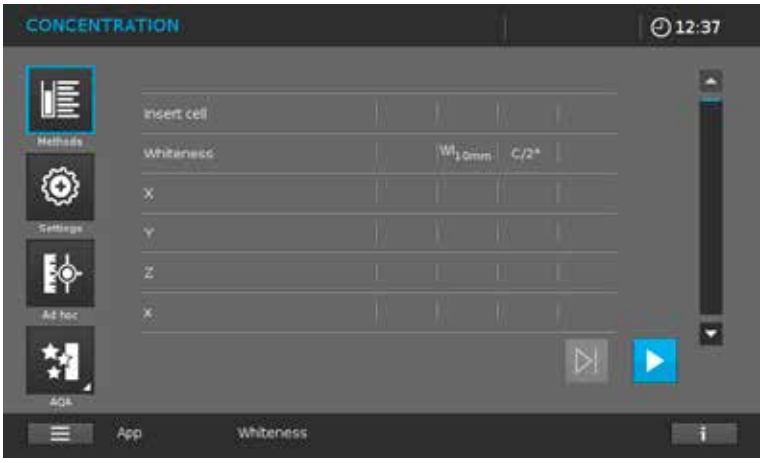
- **Zeroing the photometer:**
  - The photometer must be zeroed prior to each new measurement series.
  - It is advisable to zero the photometer using the same cell as the one used for the measurement sample or else a cell with identical optical characteristics and an identical absorption (matched pair).
    The zero-adjustment procedure for the measurement series is automatically prompted by the instrument.



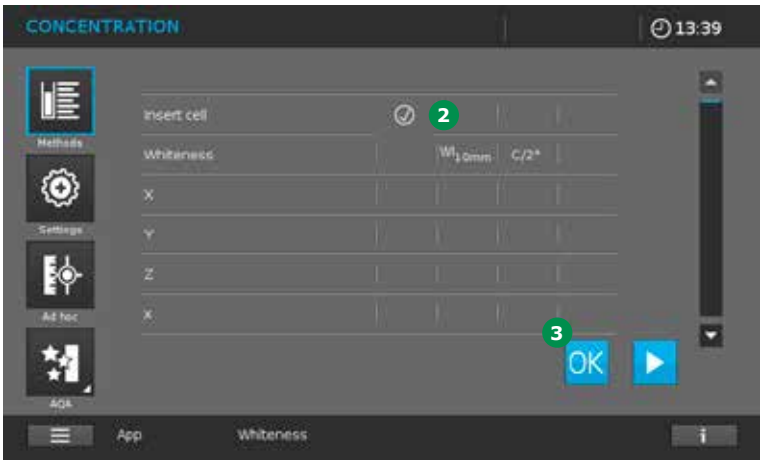
- For the zero adjustment fill a suitable rectangular cell with water for analysis.
- After prompting, insert the filled rectangular cell into the cell compartment. The zero adjustment is performed automatically.
- Confirm the performance of the zero-adjustment procedure by clicking on **<OK>** 1.
  The zero adjustment is valid for the entire measurement series.

- **Measurement:**

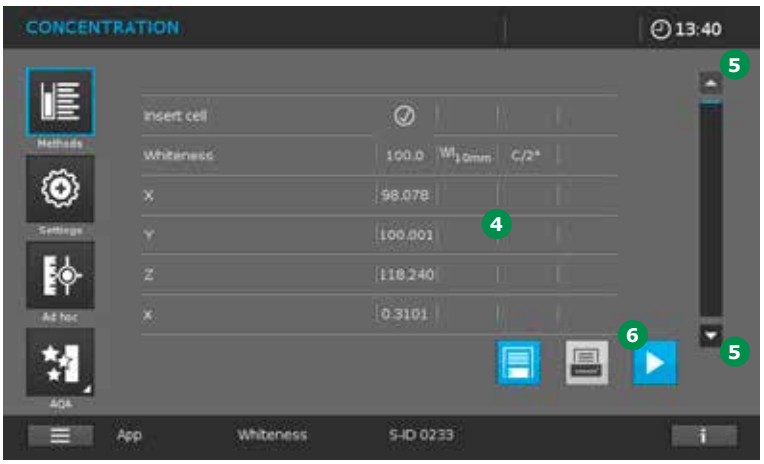
  Note
  It is advisable to measure the sample using the same cell as the one used for the zero adjustment or else a cell with identical optical characteristics and an identical absorption (matched pair).



- Fill the sample solution into a corresponding rectangular cell and insert the cell into the cell compartment. The measurement is performed automatically.



A (✓) appears behind the cue "Insert cell" 2.
- Confirm the measurement by clicking on **<OK>** 3.



The measurement results appear in the photometer display 4.
- Where applicable, use the scroll keys 5 to scroll down through the display to show other measurement results.
- Click **<START>** 6 to start the measurement procedure for the next sample.

32.7 Evaluation

Statement of the results: Whiteness (TI)
Tristimulus values X, Y, Z
Chromaticity coordinates x, y
determined for standard illuminant C and the 2° standard observer

32.8 Literature

1. ASTM E313-15, Standard Practice for Calculating Yellowness and Whiteness Indices from Instrumentally Measured Color Coordinates

33 Yellowness

33.1 Method

White and colorless materials can take on a yellow tint due to a number of external influences, e.g. light, sunlight, temperature, moisture, or chemical reactions.
These changes in color are usually determined by measuring the so-called yellowness index of the material in question at regular intervals. The greater the yellowing effect, the higher the yellowness index of the material.
The yellowness index is determined by measuring the transmittances of the sample in a wavelength spectrum between 380 and 780 nm and subsequently calculating the tristimulus values X, Y, Z. The tristimulus values are then used to calculate the yellowness index according to the methods of the ASTM E313-15 standard.
The method is analogous to the ASTM E313-15 standard (see literature reference[1]).

33.2 Measuring range

Method 2573	Yellowness	0.0 - 30.0 YI_{10mm} (10-mm rectangular cell)
Method 2574	Yellowness	0.0 - 90.0 YI_{50mm} (50-mm rectangular cell)

Note
The yellowness value is determined for standard illuminant C and the 2° standard observer and is specified only for yellow colors.

33.3 Sample material

Colorless to yellowish clear liquid samples
Colorless to yellowish turbid liquid samples after filtration

33.4 Reagents and auxiliaries

- Cat. No. 1.73016 - Spectroquant® VIS Spectrophotometer Prove 100 or
  Cat. No. 1.73017 - Spectroquant® UV/VIS Spectrophotometer Prove 300 or
  Cat. No. 1.73018 - Spectroquant® UV/VIS Spectrophotometer Prove 600
- Cat. No. 1.14946 - Rectangular cells 10 mm and/or
  Cat. No. 1.14944 - Rectangular cells 50 mm
- Cat. No. 1.16754 - Water for analysis EMSURE® or
  distilled water
- Membrane filters, pore size max. 0.45 µm (optional)

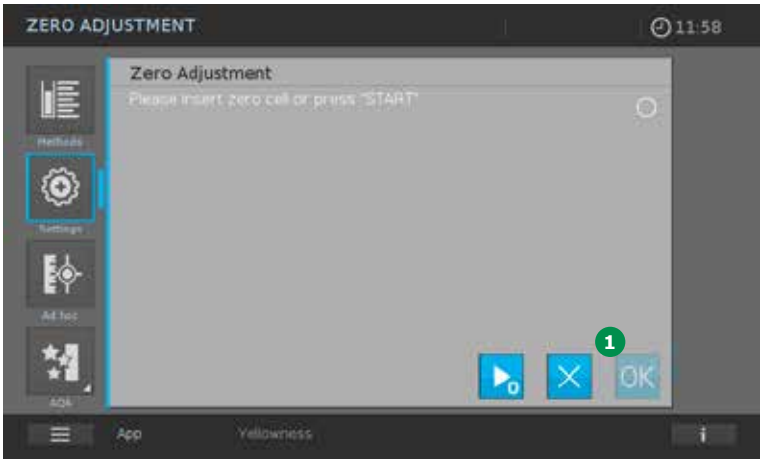
33.5 Preparation

- Filter **turbid sample solutions** over a membrane filter.
  To do this, prerinse the membrane filter with approx. 50 ml of water for analysis, then rerinse with approx. 50 ml of the sample solution and discard the filtrate.
  Filter a further 50 ml of the sample solution over the prerinsed membrane filter and use the filtrate for the analysis.

33.6 Procedure and measurement

- Open the methods list (**<Methods>**) and select **Method No. 2573 resp. 2574 "Yellowness"**.

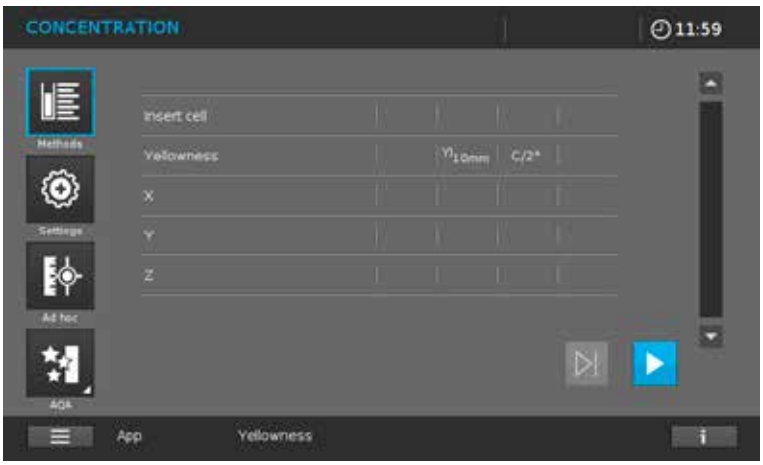
- **Zeroing the photometer:**
  - The photometer must be zeroed prior to each new measurement series.
  - It is advisable to zero the photometer using the same cell as the one used for the measurement sample or else a cell with identical optical characteristics and an identical absorption (matched pair).
    The zero-adjustment procedure for the measurement series is automatically prompted by the instrument.



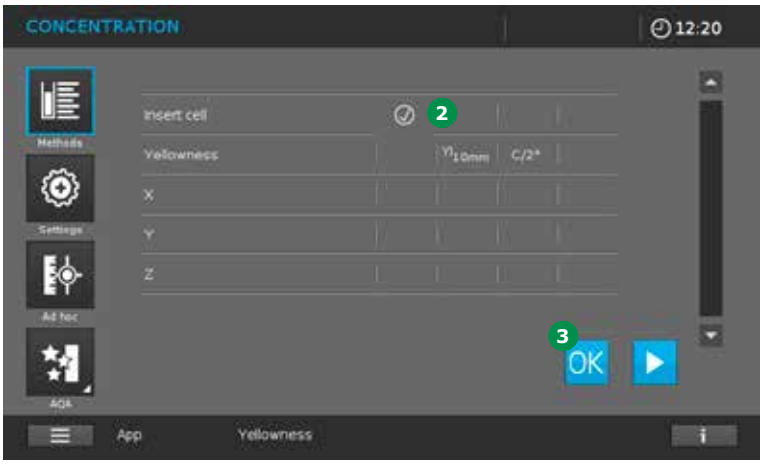
  - For the zero adjustment fill a suitable rectangular cell with water for analysis.
  - After prompting, insert the filled rectangular cell into the cell compartment. The zero adjustment is performed automatically.
  - Confirm the performance of the zero-adjustment procedure by clicking on **<OK>** 1.
    The zero adjustment is valid for the entire measurement series.

- **Measurement:**

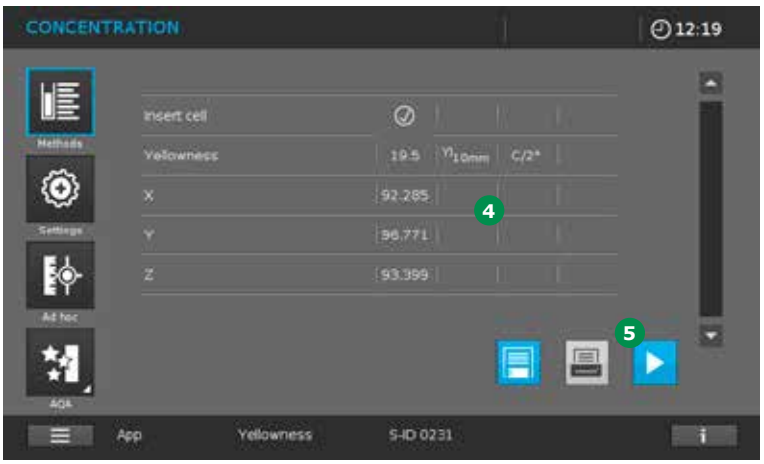
  Note
  It is advisable to measure the sample using the same cell as the one used for the zero adjustment or else a cell with identical optical characteristics and an identical absorption (matched pair).



  - Fill the sample solution into a corresponding rectangular cell and insert the cell into the cell compartment. The measurement is performed automatically.



A (✓) appears behind the cue "Insert cell" 2.
- Confirm the measurement by clicking on **<OK>** 3.



The measurement results appear in the photometer display 4.
- Click **<START>** 5 to start the measurement procedure for the next sample.
  A renewed zero adjustment is not necessary.

33.7 Evaluation

Statement of the results: Yellowness (YI)
Tristimulus values X, Y, Z
determined for standard illuminant C and the 2° standard observer

33.8 Literature

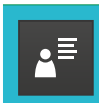
1. ASTM E313-15, Standard Practice for Calculating Yellowness and Whiteness Indices from Instrumentally Measured Color Coordinates
2. DIN 6167:1980-01, Description of yellowness of near-white or near-colourless materials

List of smart icons on display

Main menu Buttons	Description
	**Method list** List of all methods, irrespective of mode
	**Settings** This button is used to activate method-specific settings (e.g. sample dilution, turbidity correction, zero adjustment, sample blank, reagent blank)
	**Ad hoc** For performing measurements (absorbance/transmission, spectrum, kinetics) Allows measurements to be performed without the need to create methods
	**AQA** Overview and list of all Analytical Quality Assurance (AQA) modes
	**Results list** List of all stored results
	**System – instrument setup** This button is for optional instrument settings (e.g. date, time, updates etc)
	**Login/logout** Check on users in and out
	**Timer list** List of stopwatch functions

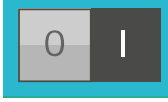
Info Buttons	Description
	**Methods information**
	**Main menu selection button – switches between 2 main menu overviews**
	**Switch between different citations (NH_4, NH_3 etc)**
	**Switch between different units (mg/l, ppm etc)**

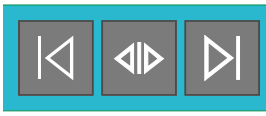
Sub-menu Buttons	Description
	**Absorbance/Transmission Mode** Ad hoc submenu: perform absorbance or transmission measurements Result list: filter concentration mode
	**Concentration** Method list: create methods -> Concentration Mode Result list: filter Ad Hoc ABS/Trans measurements
	**Spectrum Mode** Ad hoc submenu: record spectrum Method list: create methods -> Spectrum Mode Result list: filter spectrum mode

Sub-menu Buttons	Description
	**Kinetic Mode** Ad hoc submenu: perform kinetic measurement Method list: create methods -> Kinetic Mode Result list: filter kinetic mode
	**AQA Status 1&2** AQA submenus: Status display of the period of validity and the outcome (passed / failed)
	**AQA1** AQA submenu: List of AQA1 methods
	**AQA2** AQA submenu: List of AQA2 methods
	**Pipette check** AQA submenu: List of pipette checking methods
	**Information** System submenu displays the following information about the device: Software/method versions, device class, lamp counter and serial number
	**Interface** System submenu displays the following settings options – and standard settings: Audible signals – ON, Backlight – 100 %, Print to pdf – ON
	**Region** System submenu displays the following settings options – and standard settings: Language, date, time and country zone EU/US, decimal separator – "." (dot)
	**Quality** System submenu displays the following settings options – and standard settings: Quick zero – OFF, AQA1 and AQA2 lock – OFF, Zero Adjustment expiry – ON (interval: 7 days), Use expired reagents – OFF, Service reminder – ON
	**Automation** System submenu displays the following settings options – and standard settings: Energy saving mode – ON (10 minutes), Auto Power off – OFF, Auto log off – OFF, Auto store – ON, Auto print – OFF, Sample ID popup – OFF
	**User management** System submenu displays the following settings options – and standard settings: Activation of user management and administrator settings, User login required – OFF
	**Service** System submenu displays the following settings options: Various service functions such as backup, restore, export of log or system data and import of methods
	**Update** System submenu displays the option for performing software and method updates

Sub-menu Buttons	Description
	**Network** This submenu of the "Instrument settings" menu displays the setting options for connecting the Prove device with a network
	**Prove Connect** This submenu of the "Instrument settings" menu displays the setting options for connecting the Prove device with Prove Connect
Selection & Action Icons	**Description**
	**Start**
	**Start zero** Start zero adjustment for a method
	**Apply**
	**Save**
	**Stop**
	**Close**
	**Logout** User logout
	**Search method**
	**Reset resp. clear filter options**
	**Edit** For editing parameters
	**Create method**
	**Duplicate/copy** The selected method is duplicated/copied
	**Print**

Selection & Action Icons	Description
	**Export button** All selected methods are exported to an external memory device
	**Import button** Updates/methods are imported from an external memory device into the instrument
	**Delete** The selected items are deleted
Notification Icons in Menu "Settings"	**Description**
	**Dilution** Activate and notify predilution
	**Turbidity on** Activate and notify the turbidity correction
	**Show absorbance** Activate and notify display of absorbance value in the result screen
	**Zero adjustment** Perform zero adjustment
	**Sample blank value** Activate and notify Sample blank value
	**Reagent blank** Activate and notify user-defined Reagent blank
	**Recalibrate** Activate and notify user-defined recalibration
	**MatrixCheck** Activate MatrixCheck
	**User defined measurement range** Activate user-defined lower and upper limit of the measuring range

Toggle Button	Description
	**OFF/ON Button** 0 = Off, I = On – the part displayed in light grey is active – here: 0 = OFF
	**Date/measurement** Switch between date or measurement interval (AQA2); active here: measurement interval
	**Absorbance/transmission** Switch between absorbance or transmission mode; active here: transmission mode
	**Spiking/dilution** Switch between spiking and dilution (MatrixCheck); active here: dilution
Action Icons on Datepicker/Keyboard/ Calculator	**Description**
	**Back**
	**Close**
	**Clear**
	**Delete**
	**Apply**
	**Add**
Radio Buttons/ Checkboxes	**Description**
	**Warning** Warnig symbol check info box
	**Barcode scanner deactivated** The barcode scanner for reading out the Live ID barcode on round cells and AutoSelectors has been deactivated
	**Locked** Change password
	**Choosen** Check mark

Selection & Action Icons, e.g. Result List	Description
	**Search list** Search function, search criterion: method number, method name or article number (first 6 digits)
	**Set date/date filter**
	**Sample ID** Search/results list. Search function, search criterion: sample ID
	**Select all/select none**
	**Panorama view** Graphic representation of measurement series (control card, control chart, for trend analyses)
Selection & Action Icons e.g. User-defined Methods	**Description**
	**Set value pair(s) for method calibration**
	**Set formula for method calibration**
	**Show graphic view**
Selection & Action Icons e.g. Spectrum Kinetic	**Description**
	**Table view of values**
	**Return to the recorded spectrum**
	**Next left/Step/next right**
	**Zoom out**
	**Zoom in**
	**View of peak max of a spectrum**

Selection & Action Icons e.g. Spectrum Kinetic	Description
	**View of peak min of a spectrum**
	**Calculate and show sum of spectra**
	**Calculate and show difference of spectra**
	**Overlay of spectra**
	**First-order derivative of a spectrum**
	**Navigation in graphic view**

Status Icons	Description
	**Attention** Warning symbol check info box
	**Time** Time Stamp
	**Passed** Status of a check; ✓ = passed
	**Off** Status of a check; ○ = inactive
	**Failed** Status of a check; - = failed
	**Expired** Status of a check; ! = overdue
	**Progress** The instrument is in progress
	**Progress** The instrument is in progress

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