



Available Online at <http://www.jart.ma>

Journal of
Atlantic
Research and
Technology

Validation of a Modified MBAS Method for Anionic Surfactants: Dichloromethane as a Safer Extraction Alternative to Chloroform

Ihssan Labib^a, Majda Flayou^b, Brahim Kers^b, Abdelilah Belhaj^b, Abdurabuh Alraae^a, Khalihena Groune^c, Mouatamid El Hazzat^a, Mohammed Dahhou^{a*}

^a Laboratory of Materials, Nanotechnologies and Environnement, Faculty of Sciences, Mohammed V University in Rabat, Morocco

^b Direction of Water Quality Control, National Office of Water and Electricity, Rabat, Morocco

^c Research Unity of Wastes and Materials Valorization, Department of Chemistry, Faculty of Sciences and Techniques, University of Nouakchott, BP 880, Nouakchott, Mauritania.

ARTICLE INFO

Article history:

Received 25th September, 2025

Received in revised form 5th December, 2025

Accepted 9th December, 2025

Available online 31th December, 2025

Keywords:

Anionic surfactants

Methylene Blue Active Substances

Spectrophotometry

Water Analysis

Liquid-Liquid Extraction

ABSTRACT

The objective of this work is the elaboration and validation of a simple, rapid, and low-cost analytical method for the quantification of anionic surfactants in various aqueous matrices. In accordance with the Moroccan standard NM 03.07.124, we validated a spectrophotometric method based on the formation of a colored complex between anionic surfactants and methylene blue, measured at 650 nm after liquid-liquid extraction. The results showed excellent linearity ($R^2 > 0.998$) across a concentration range of 0.1 to 0.7 mg/L. We also confirmed the method's accuracy through recovery tests on both treated water and wastewater, establishing limits of quantification (LOQ) at 0.025 mg/L and 0.07 mg/L, respectively. Notably, our comparison suggests that dichloromethane is a safer alternative to chloroform for the extraction process, as it does not compromise analytical performance. Supported by a satisfactory Z-score (< 1) from inter-laboratory comparisons, this method proves to be a robust and practical tool for environmental monitoring.

1. Introduction

Anionic surfactants constitute a class of chemical compounds extensively utilized in various industrial and domestic sectors, ranging from cleaning products to cosmetics [1]. Their amphiphilic nature, while essential for their detergent properties, contributes significantly to their persistence in the aquatic ecosystem following their discharge via wastewater [1]. Among these compounds, sodium dodecyl sulfate (SDS) and linear alkylbenzene sulfonates (LAS) are particularly prevalent due to their effectiveness and low cost. However, the incomplete elimination of these substances during wastewater treatment processes can generate serious ecological problems, including eutrophication, the formation of foam, and direct toxicity to aquatic fauna [2]. Consequently, the development of accurate, sensitive, and accessible analytical methods for their quantification in aqueous matrices proves to be imperative for environmental

monitoring and the sustainable management of water resources.

In this regard, the monitoring of surfactant concentrations is of primordial importance. Although sophisticated instrumental techniques, such as chromatography, exist for surfactant analysis, their high cost, complexity, and the duration of analysis constitute major limitations for routine application and high-throughput screening [3]. These constraints necessitate the use of simpler and more accessible analytical techniques. The spectrophotometric method based on Methylene Blue Active Substances (MBAS) remains the reference approach in this field. The principle of this method relies on the formation of a stable ion-pair between the cationic methylene blue dye and the anionic surfactant, followed by an extraction into an organic solvent and a quantification via absorbance measurement [4]. Due to its rapidity, low cost, and simplicity, the MBAS method represents a valuable tool for environmental surveillance.

*Corresponding author.

Over the last decades, numerous works have focused on the optimization of the MBAS method to enhance its efficiency and sensitivity. These efforts have targeted the reduction of analysis time and solvent volumes [5], the optimization of dye-solvent systems to lower detection limits [6], and the automation of the procedure via flow-injection analysis to improve repeatability [7; 8]. Furthermore, recent applications have adapted this protocol for complex matrices, ranging from atmospheric aerosols to food products [9; 10], as well as for the monitoring of degradation processes [11; 12]. Nevertheless, two persistent challenges remain: the reliance on hazardous chlorinated solvents, notably chloroform, and the necessity of a rigorous validation in accordance with specific regional standards to guarantee reliability and regulatory compliance.

Although the MBAS assay has evolved globally, a gap persists between the principles of Green Chemistry and the strict application of regional regulations. Specifically, the substitution of hazardous chloroform with dichloromethane has not been fully validated in conformity with the Moroccan standard NM 03.07.124. Moreover, this modified protocol has not been subjected to inter-laboratory testing to ensure its transferability. Consequently, the current literature lacks a unified framework ensuring that this "safer alternative" maintains the analytical rigor required for official environmental monitoring. To remedy this situation, the present study focuses on the elaboration and validation of a spectrophotometric method for the determination of anionic surfactants. The specific objectives of this work are: (i) the evaluation of the method's linearity, precision, and accuracy; (ii) the determination of the limit of quantification (LOQ) in wastewater matrices; (iii) the statistical confirmation that dichloromethane constitutes a compliant and safer alternative to chloroform; and (iv) the verification of the method's external reliability through an inter-laboratory comparison.

2. Materials and Methods

2.1. Reagents and Standards

All chemicals used were of analytical grade. Reagent solutions were prepared using ultra-pure water. A stock solution of methylene blue (0.35 g/L, Scharlau) was prepared for use in the analytical procedure. The alkaline methylene blue solution was prepared by mixing the neutral methylene blue solution with a pH 10 buffer, which consisted of equal parts of a 19 g/L sodium tetraborate ($\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$, Oxford) solution and a 0.1 N sodium hydroxide (NaOH, Oxford) solution. The acidic methylene blue solution was prepared by adding 6.5 mL of concentrated sulfuric acid (H_2SO_4 , Sigma Aldrich) to 1 L of the neutral methylene blue solution. Chloroform (CHCl_3 , Sigma Aldrich) was used as the primary extraction solvent, while dichloromethane (CH_2Cl_2 , Sigma Aldrich) was evaluated as an alternative. A primary stock standard of sodium dodecyl sulfate (SDS, Sigma

Aldrich 99%) at 500 mg/L was prepared by dissolving the appropriate mass of SDS in ultra-pure water. This stock was used to prepare an intermediate standard of 10 mg/L, from which working calibration standards were freshly prepared for each analysis.

2.2. Instrumentation

Spectrophotometric analysis was conducted on a XD 7500 UV-Visible spectrophotometer (Lovibond, Amesbury, UK) set to a fixed wavelength of 650 nm. Standard 10 mm path length glass cuvettes were used for all absorbance readings. Standard solutions and reagents were prepared using masses obtained from a KERN analytical balance (ALJ model) with a readability of ± 0.0001 g. The liquid-liquid extraction step was performed in 500 mL glass separatory funnels, with agitation provided by a magnetic stirrer and Teflon-coated stir bars. All sample and standard dilutions were performed using Class A volumetric glassware, including 25 mL and 100 mL volumetric flasks and graduated pipettes, to ensure measurement accuracy. Phase separation was facilitated by filtration through Whatman phase separator filter paper.

2.3. Analytical Procedure

The determination of anionic surfactants was performed according to the Moroccan standard NM 03.07.124, with specific steps detailed below.

2.3.1. Sample Extraction

A test portion of 100 mL of the aqueous sample (or ultra-pure water for the reagent blank) was introduced into a 250 mL glass flask. Subsequently, 15 mL of the alkaline methylene blue solution and 20 mL of chloroform were added. The mixture was subjected to vigorous agitation for 1 minute using a magnetic stirrer. The resulting emulsion was quantitatively transferred to a 500 mL separatory funnel and left to settle for 2 minutes to permit a complete separation of the phases.

The organic phase (lower layer), containing the extracted MBAS complex, was recovered in a second 250 mL flask. A second extraction was then realized by adding 110 mL of ultra-pure water and 5.0 mL of the acidic methylene blue solution to the same flask. This mixture was agitated for 1 minute, transferred to the separatory funnel, and allowed to decant for another 2 minutes. The organic phase was recovered and combined with the first extract. The obtained organic phase was then filtered through a Whatman phase separator paper directly into a 25 mL volumetric flask. Finally, the volume was completed to the mark with chloroform.

2.3.2. Calibration and Quantification

For each series of analyses, a calibration curve was established. A range of standard solutions, with concentrations varying from 0.1 to 0.7 mg/L, was prepared

by dilution of the intermediate SDS standard solution (10 mg/L) with ultra-pure water. A reagent blank (0 mg/L) was prepared using 100 mL of ultra-pure water. Each standard solution, as well as the blank, was subjected to the same extraction protocol described in section 2.3.1.

The measurement of the absorbance of the obtained organic phases was realized at a wavelength of 650 nm against a chloroform blank. The calibration curve was plotted by representing the absorbance values (corrected by the blank) as a function of the corresponding concentrations. The determination of the anionic surfactant concentration in the samples was calculated using the linear regression equation obtained from the calibration curve. All results are expressed in mg/L equivalent of SDS.

Furthermore, dichloromethane was evaluated as an alternative extraction solvent to chloroform. To this end, the linearity and accuracy of the method using dichloromethane were assessed and compared with the results obtained using chloroform.

2.3.3. Calculations and Expression of Results

The determination of the concentration of anionic surfactants in each sample was realized using the linear regression equation obtained from the calibration curve established daily. The absorbance of the reagent blank was deducted from the absorbance measured for each sample.

Given that the calibration was carried out using sodium dodecyl sulfate (SDS), the obtained results represent the concentration of Methylene Blue Active Substances, expressed in mg/L equivalent of SDS. In order to express the results according to the international standard unit for DBSSS (Sodium Dodecyl Sulfate Standard), a conversion factor was applied. Taking into account the molar masses, the concentration was calculated according to the following formula:

$$\text{DBSSS (mg/L)} = \text{SDS (mg/L)} \times 1.2084$$

2.4. Method Validation

The validation of the analytical method was carried out in conformity with the Moroccan standard NM 03.07.124. The performance characteristics evaluated in this study include linearity, accuracy, precision (repeatability and intermediate precision), the limit of quantification (LOQ), and robustness. The acceptability criteria retained for these parameters are defined as follows:

- **Linearity:** The linearity of the calibration curve was evaluated by the coefficient of determination (R^2). The method is judged linear if $R^2 \geq 0.995$.
- **Accuracy:** This parameter was evaluated via recovery tests realized on samples of treated water and wastewater at three concentration levels (0.1, 0.4, and 0.7 mg/L). The method is considered accurate if the mean recovery rate is comprised between 80% and 120%.
- **Precision:** Repeatability (intra-day precision) was evaluated by the analysis of spiked samples realized the same day, whereas intermediate precision (inter-day

precision) was assessed over different days. Precision is expressed in terms of the relative standard deviation (%RSD), which must be inferior or equal to 15%. For duplicate measurements, the relative difference between the results must be inferior or equal to 10%.

- **Limit of Quantification (LOQ):** The LOQ was determined experimentally as the lowest concentration of SDS that can be quantified with a precision and accuracy responding to the aforementioned criteria.
- **Robustness:** This parameter was evaluated through participation in an inter-laboratory proficiency test organized by BIPEA. A performance is judged satisfactory if the Z-score of $|z| \leq 2$.

3. Results and discussion

3.1. Linearity

The evaluation of the linearity was realized to ensure the proportionality between the analyte concentration and the spectrophotometric response. To this end, calibration curves were established over several days by representing the absorbance (corrected by the blank) as a function of the SDS concentrations, covering a range from 0.1 to 0.7 mg/L. Figure 1 presents a representative set of calibration curves obtained over three different days. The visual examination of these curves reveals a clear linear trend. The linearity of the method was quantitatively confirmed by the coefficient of determination (R^2). The obtained values were consistently superior or equal to 0.998 for all realized calibrations. This result satisfies the pre-established acceptability criterion ($R^2 \geq 0.995$), attesting to an excellent linearity across the studied analytical range. Furthermore, these performance levels are comparable, or even superior, to those reported in the literature for other modern spectrophotometric methods [5, 8].

Table 1

Summary of relative bias (%) from calibration data obtained on different days. The acceptance criteria for relative bias were $\leq 20\%$ for the 0.1 mg/L standard and $\leq 10\%$ for all other standards. All runs met these criteria.

Concentration	0.1	0.2	0.4	0.5	0.7
Run N°1	7.0	1.5	3.7	0.4	2.0
Run N°2	10.0	4.0	6.5	6.8	0.3
Run N°3	15.0	3.5	5.0	2.6	0.4
Run N°4	13.0	2.0	1.7	1.4	0.7
Run N°5	10.0	2.5	1.2	1.2	0.6

In order to evaluate the accuracy of the calibration model more precisely, the relative bias was calculated for each point of the standard range across five independent analytical series. The obtained results are grouped in Table 1. This analysis permits a detailed evaluation of the deviation from the theoretical value at each concentration level. The relative bias, representing the percentage of deviation between the calculated concentration and the theoretical concentration, is situated well within the acceptance limits of the laboratory (i.e., $\leq 20\%$ for the lowest point and $\leq 10\%$ for all other points). For example, the maximum relative bias observed is 15%, which is in

conformity with the established criteria. This result confirms that the method is not only linear but also ensures an accurate quantification, even at concentration levels close to the limit of quantification. Finally, the consistency of these results across multiple series reinforces the robustness of the calibration protocol.

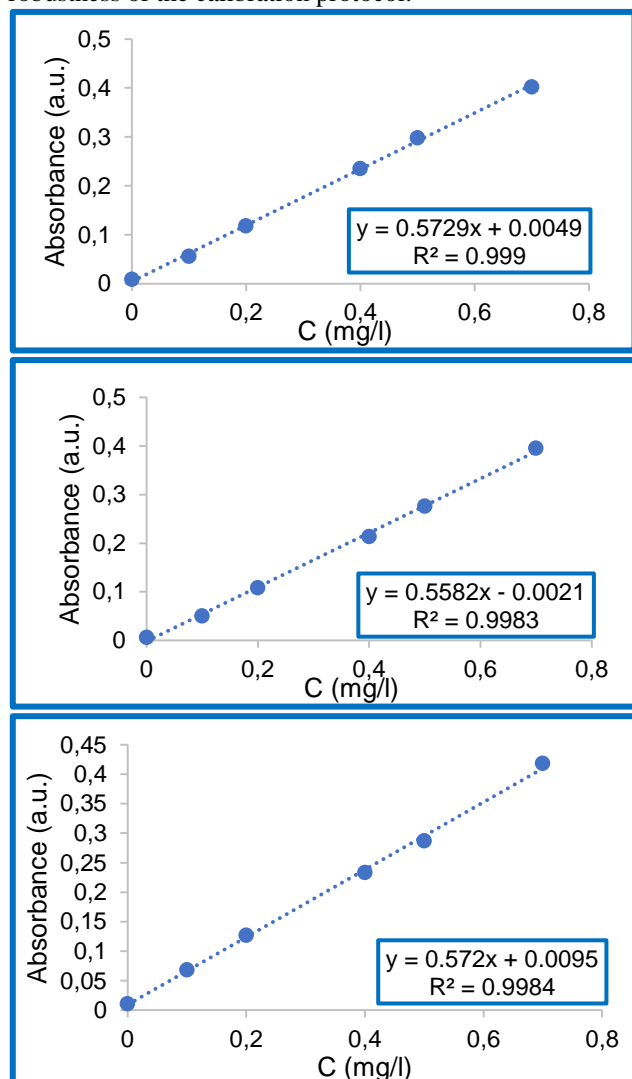


Fig. 1. Representative calibration curves for the determination of anionic surfactants (as SDS) obtained on three different days.

3.2. Accuracy and Precision

The evaluation of the accuracy and precision was realized to assess the performance of the method applied to complex matrices. To this end, recovery tests were carried out on two representative matrices: treated water and wastewater. The samples were spiked at three distinct concentration levels (0.1, 0.4, and 0.7 mg/L) and analyzed across five independent analytical series, with two replicates per series.

The accuracy of the method, expressed in terms of mean recovery percentage, is presented in Figure 2. For all concentration levels and for both matrices studied (treated water and wastewater), the mean recovery rates obtained are comprised between 98.7% and 107.5%. These values

are situated well within the pre-established acceptability interval of 80% to 120%. This result confirms that the method provides accurate results and attests to a minimal influence of matrix effects.

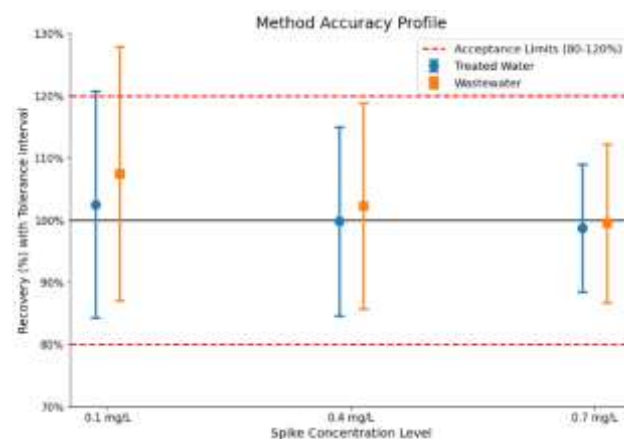


Fig. 2. Accuracy results from spike recovery experiments in treated water and wastewater matrices.

The precision of the method, assessed as both repeatability (intra-run) and intermediate precision (inter-run), was evaluated using the same spiked samples. The results are expressed as the percentage relative standard deviation (%RSD) and are presented in Table 2.

Table 2

Precision results (as %RSD) from spiked sample analysis in treated water and wastewater.

Matrix	Spike Level (mg/L)	Repeatability (%RSD)	Intermediate Precision (%RSD)
Treated Water	0.1	3.4	8.9
	0.4	2.5	7.6
	0.7	1.8	5.2
Wastewater	0.1	4.1	9.5
	0.4	3.1	8.1
	0.7	2.2	6.4

The intermediate precision, which accounts for variations across different days, was found to be excellent, with %RSD values not exceeding 9.5%. Repeatability was even better, with all %RSD values below 4.1%. All precision results comfortably meet the acceptance criterion of $\leq 15\%$ RSD. This high degree of precision indicates that the method is reliable and produces consistent results, even when analyzing complex matrices over an extended period. The normalized error (EN) for all experiments was also calculated and found to be negligible (≤ 0.03), further confirming that there is no significant bias in the method.

3.3. Limit of quantification (LOQ)

The determination of the Limit of Quantification (LOQ) was realized experimentally in order to establish the lowest concentration of anionic surfactants that the method can measure with acceptable accuracy and precision. This evaluation was carried out on two distinct matrices: treated

water and wastewater. The obtained results demonstrate an excellent sensitivity of the method, although the LOQ remains dependent on the nature of the matrix. For treated water, the LOQ was established at 0.025 mg/L. This value testifies to a high sensitivity, comparable to the performances obtained by automated flow-injection systems [14], and constitutes a significant improvement compared to the older manual versions of the method. Concerning the wastewater matrix, the LOQ is slightly higher, reaching 0.07 mg/L. This increase is attributed to significant matrix effects, notably the elevated turbidity, the suspended matter, and the presence of competing organic substances, which contribute to the background noise and can potentially hinder the efficiency of the ion-pair extraction. The validation data relating to the LOQ levels, including accuracy and precision, are grouped in Table 3. These results confirm that, even at these low concentrations, the performance of the method remains in conformity with the pre-established acceptability criteria. Indeed, the mean recovery rates are comprised between 95% and 105%, while the relative standard deviations (RSD) for intermediate precision are inferior to 10%. These low LOQ values indicate that the validated method is highly sensitive and is suitable for the quantitative determination of anionic surfactants at the trace levels typically found in environmental monitoring programs, including the analysis of both low-contamination surface waters and higher-concentration effluents.

3.4. Alternative Solvent: Dichloromethane

The principal objective of this study includes the reduction of environmental and health risks inherent to the standard MBAS method, which relies on the use of chloroform. This solvent is considered particularly hazardous due to its severe hepatotoxicity and the risk of phosgene gas formation. Although the IARC classifies dichloromethane as "probably carcinogenic" (Group 2A)—a stricter category than that of chloroform ("possibly carcinogenic", Group 2B)—it constitutes a widely preferred alternative in modern laboratories. This preference is justified by its significantly lower acute toxicity and higher permissible exposure limits, offering a much safer option for operators handling samples on a daily basis [13].

In order to ensure that this substitution does not compromise the quality of the analytical data, an evaluation of the linearity and accuracy was realized using dichloromethane. The method presented excellent performance: the established calibration curve (0.1–0.7 mg/L) showed a coefficient of determination R^2 of 0.997. This value is directly comparable to that obtained with chloroform ($R^2 \geq 0.998$ and is situated well within the acceptance limits. Furthermore, the slope of the curve proved to be very similar to that of chloroform,

demonstrating that the extraction efficiency of the surfactant complex remains consistent. The accuracy was equally high, with a mean recovery rate of 99.1% obtained in treated water (Table 4).

Finally, a rigorous statistical analysis was carried out to confirm these observations. An analysis of covariance (ANCOVA, $p > 0.05$) revealed no significant difference in sensitivity (slope) between the two solvents. In parallel, a two-tailed Student's t-test confirmed the absence of a significant difference in terms of accuracy. These results provide definitive statistical proof that dichloromethane is not only safer but also analytically equivalent to chloroform.

Consequently, the obtained results demonstrate that dichloromethane constitutes a viable and effective alternative to chloroform in this analytical procedure. It provides a statistically equivalent performance in terms of linearity and accuracy, while offering significant advantages regarding the reduction of toxicity and environmental impact. This modification represents a successful application of "Green Chemistry" principles to the standard method without compromising its analytical reliability. This approach aligns with the general objectives of Green Analytical Chemistry, aiming to substitute hazardous chlorinated solvents in established analytical protocols [15].

3.5. Robustness

The evaluation of the robustness of the analytical method was realized to assess its reliability under normal conditions of use. In order to provide a rigorous and objective assessment of the performance, the laboratory participated in an inter-laboratory proficiency test (PT) organized by BIPEA (Bureau Interprofessionnel d'Etudes Analytiques). This test constitutes a powerful external validation, allowing to benchmark the laboratory's results against a consensus value established by a group of peer laboratories.

The proficiency test involved the analysis of a wastewater sample presenting an unknown concentration of Methylene Blue Active Substances (MBAS). By applying the validated protocol, the concentration determined by the laboratory was 0.49 mg/L. In comparison, the assigned value, derived from the robust statistical analysis of all participant results, was 0.46 mg/L. The performance was evaluated quantitatively using the Z-score, a standardized indicator measuring the deviation of the result relative to the consensus value. The Z-score was calculated according to the following formula:

$$Z\text{-score} = (\text{Lab Result} - \text{Assigned Value}) / \text{Standard Deviation for Proficiency Assessment}$$

Table 3

Validation of the Limit of Quantification (LOQ) in Treated Water and Wastewater.

Matrix	LOQ Level (mg/L)	Mean Recovery (%)	Intermediate Precision (%RSD)
Treated Water	0.025	102.0	7.5
Wastewater	0.070	98.6	8.1

Table 4
Performance Comparison Between Chloroform and Dichloromethane as Extraction Solvents.

Performance Parameter	Chloroform (Validated Method)	Dichloromethane (Alternative)	Conclusion
Linearity (R^2)	≥ 0.998	0.997	Performance is statistically equivalent.
Accuracy (Mean Recovery %)	99.8% (at 0.4 mg/L)	99.1% (at 0.4 mg/L)	Performance is statistically equivalent.
Extraction Efficiency	High (indicated by slope)	High (indicated by similar slope)	Dichloromethane effectively extracts the complex.

For the result obtained by our laboratory, the calculated Z-score is 0.61. In conformity with international standards, a performance is judged satisfactory if the absolute value of the Z-score ($|Z|$) is ≤ 2 . The obtained value (0.61) is situated well below this limit, indicating a high concordance with the consensus value. The obtaining of this satisfactory Z-score constitutes a tangible proof of the robustness of the method. It demonstrates that the accuracy and reliability, established during the internal validation, are transferable and maintained during the analysis of an external blind sample under real conditions. Consequently, the successful participation in the BIPEA proficiency test ensures a high level of confidence regarding the capacity of the validated method to generate accurate and reproducible data for routine environmental monitoring.

4. Conclusion

The present work allowed the elaboration and rigorous validation of a simple, rapid, and cost-effective spectrophotometric method for the quantification of anionic surfactants, in conformity with the Moroccan standard NM 03.07.124. The obtained results demonstrated excellent performance characteristics across different aqueous matrices, notably treated water and wastewater. Indeed, the validation criteria were consistently satisfied, revealing an excellent linearity ($R^2 > 0.998$), a high accuracy with mean recovery rates comprised between 98.7% and 107.5%, and a precision characterized by a relative standard deviation (%RSD) inferior to 10%. Furthermore, the low limits of quantification determined (0.025 mg/L for treated water and 0.07 mg/L for wastewater) attest to the suitability of the method for sensitive environmental analysis. A major contribution of this study lies in the successful validation of dichloromethane as a safer and more ecological alternative to the traditionally utilized chloroform. It was demonstrated that this substitution can be realized without altering the analytical integrity of the method, providing a linearity and accuracy comparable to the standard protocol. Consequently, this modification is in line with the modern principles of Green Analytical Chemistry, thereby reducing health risks and the environmental impact associated with routine laboratory analyses. Finally, the robustness of the validated protocol was confirmed by the successful

participation in an inter-laboratory proficiency test organized by BIPEA, with the obtaining of a satisfactory Z-score of 0.61. This external verification constitutes a guarantee of the reliability of the method and its capacity to generate accurate and reproducible data under real conditions of use.

Conflicts of interest statement

The authors declare no competing financial interest.

References

- [1] M. Jozanović, N. Sakač, M. Karnaš, M. Medvidović-Kosanović. Potentiometric sensors for the determination of anionic surfactants – a review. *Crit. Rev. Anal. Chem.* 51(2) (2021) 115–137.
- [2] J.C.P. Penteado, O.A. El Seoud, L.R.F. de Carvalho. Alquilbenzeno sulfonato linear: uma abordagem ambiental e analítica. *Quím. Nova* 29(5) (2006) 1038–1046.
- [3] V. Gomez, L. Ferreres, E. Pcurull, F. Borrull. Determination of non-ionic and anionic surfactants in environmental water matrices. *Talanta* 84(3) (2011) 859–866.
- [4] E. Matthijs. Analysis of Anionic Surfactants. In *Anionic Surfactants: Organic Chemistry*. CRC Press, 2019. pp. 77–100.
- [5] M. Koga, Y. Yamamichi, Y. Nomoto, M. Irie, T. Tanimura, T. Yoshinaga. Rapid Determination of Anionic Surfactants by Improved Spectrophotometric Method Using Methylene Blue. *Anal. Sci.* 15(6) (1999) 563–568.
- [6] W.-H. Ho. A Spectrophotometric Determination of Anionic Surfactant with Methylene Blue. *Anal. Sci.* 7(Supple) (1991) 61–64.
- [7] S. Motomizu, M. Oshima, T. Kuroda. Spectrophotometric determination of anionic surfactants in water after solvent extraction coupled with flow injection. *Analyst* 113 (1988) 747–753.
- [8] E. Ródenas-Torralba, B.F. Reis, A. Morales-Rubio, M. de la Guardia. An environmentally friendly multicommutated alternative to the reference method for anionic surfactant determination in water. *Talanta* 66(3) (2005) 591–599.
- [9] N.B. Abd Wahid, H.A. Razak, I.I.M. Isa, M.T. Latif, N. Mohamad, T. Srithawirat, T.N.A.T. Azhar. Methylene blue active substances (MBAS) and linear alkylbenzene

sulphonates (LAS) in urban and suburban atmospheric aerosol. *Environ. Ecol. Res.* 9(4) (2021) 159–165.

[10] Z. Mori, F. Tokiwa. An Improved Method for the Determination of Residual ABS in Tomato Juice. *Food Hyg. Saf. Sci.* 13(2) (1972) 141–146.

[11] M.H. Dehghani, A. Zarei, M. Yousefi. Efficiency of ultrasound for degradation of an anionic surfactant from water: Surfactant determination using methylene blue active substances method. *MethodsX* 6 (2019) 805–814.

[12] M.S. Islam, M.S.B. Avick, J. Hossain, M.S. Alam, M.H. Uddin. Sonochemical Analysis of Methylene Blue With Additives and ZnO Nanoparticles in Aqueous Medium. *Int. Res. J. Pure Appl. Chem.* 25(2) (2024) 1–10.

[13] B. Wyrwas, A. Zgoła-Grześkowiak. Continuous flow methylene blue active substances method for the determination of anionic surfactants in river water and biodegradation test samples. *J. Surfactants Deterg.* 17(1) (2014) 191–198.

[14] P.M. Nowak, F. Wietecha-Posłuszny, J. Pawliszyn. White Analytical Chemistry: An approach to reconcile the principles of Green Analytical Chemistry and functionality. *TrAC Trends Anal. Chem.* 138 (2021) 116223.

[15] F.P. Byrne, S. Jin, G. Paggiola, T.H. Petchey, J.H. Clark, T.J. Farmer, J. Sherwood. Tools and techniques for solvent selection: green solvent selection guides. *Sustain. Chem. Process.* 4(1) (2016) 7.