

TRACE LEVEL DETERMINATION OF SODIUM CHLORIDE AND SODIUM SULFATE CONTENT IN SODIUM LAURETH SULFATE RAW MATERIAL USING COUNTER CATION-EXCHANGE HPLC WITH INDIRECT ULTRAVIOLET DETECTION

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ABSTRACT

Objective: A novel study on a new liquid chromatographic approach has been developed and validated for simultaneous determination of trace level determination of sodium chloride and sodium sulfate measures its impurities using counter cation-exchange high-performance liquid chromatography with indirect ultraviolet (UV) detection.

Methods: Chromatographic separation is developed and validated on a Hamilton PRP-X100 column with a mobile phase contained a mixture of the para-hydroxybenzoic acid buffer with a pH of 9.0 and methanol. Chromatography is developed at a flow rate of 2.0 mL/min with an indirect UV determination at 310 nm at a sensitivity level of 0.5%. The optimized method was validated as per the ICH Q2 guidelines.

Results: The retention times of chloride and sulfate were about 2.8 and 7.6 min, respectively. The resolution between chloride and sulfate peaks is >4. Regression analysis confers a correlation coefficient for the stated compounds that are found to be >0.999.

Conclusion: A novel analytical method was validated as per the ICH method validation guidelines and found to be selective. Hence, the validated analytical method was precise, specific, and accurate, and it is more economic and simple for the determination of inorganic impurities.

Keywords: Counter cation-exchange reverse phase high-performance liquid chromatography, Sodium chloride, Sodium sulfate, Sodium laureth sulfate, Raw material.

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INTRODUCTION

Sodium laureth sulfate (SLS/sodium dodecyl sulfate), 70% is a raw material, and the appearance of the material has the flowable paste/powder form and transparent to yellowish color. SLS is the key material for the manufacture of liquid dishwashing and technical agents as well as a liquid light duty detergents. Due to its excellent foam characteristic and the natural thickening with salt, the product is also suited as a primary surfactant for cosmetic cleansing preparation such as shampoo, shower gel, and foam baths. During the processing of SLS, the material diluted with water to form gel structure which is typical of ether sulfates. After the addition of water, the viscosity first increases rather rapidly, and after a reduction of the active substance to a level below 30%, it decreases considerably. Liquid and stable solutions are obtained onto 28% of the active substance. At higher concentrations, the product becomes pasty. SLS has extremely low salt content and when diluted with water to the normal use concentration, which shows a very low viscosity which can be adjusted accordingly. In this way, the viscosity of dilute solutions of SLS with approximately 5–28% of washing active substances can be easily increased to the desired value. Sodium chloride is used as a thickening agent, and it is used to incorporate into the formulation in the cold state. The required amount of sodium chloride has to be diluted in the smallest quantity of water that is necessary for obtaining a solution (preparation of table salt solution). This salt solution is added to the undiluted SLS while stirring, and stirring is continued until the mixtures have become more fluid. Refer to the graphic abstract presented in GA1.

The literature describes only one method of determination using the conventional gravimetric method in United States Pharmacopeia (USP) [1] and the content of sodium chloride and sodium sulfate is determined by the potentiometric titration which involves precipitation

titration leads to the endpoint when titrated with standardized silver nitrate volumetric solution. There were some instrumental methods published for chloride determinations in oil [2] and few other applications [3-7], namely, soil, paper devices, and food samples and similarly recorded for individual sulfate [8] determination. Simultaneous determination of chloride and sulfate is published in soil and some sodium bisulfite solution [9,10]. There is one harmonized method [11] of analysis that is published using high-performance liquid chromatography (HPLC) with charged aerosol detection technique. There was no other selective chromatographic method of analysis for simultaneous [12-19] determination of components of interest that was published in a unique HPLC method with ultraviolet detection. Hence, a method was developed and validated a high-performance liquid chromatographic technique with indirect ultraviolet detection for accurate and precise trace level determination of sodium chloride and sodium sulfate in SLS raw material using counter cation-exchange column.

EXPERIMENTAL

Chemicals and types of equipment

The purity of sodium chloride and sodium sulfate used as an analytical grade (>95%) in chromatographic development. HPLC-grade methanol purchased from Honeywell, USA. High-purity water prepared using a Milli-Q Plus water purification system (Millipore, Milford, MA, USA). Hamilton PRP X100 (anion exchange) column obtained from Hamilton Inc. the USA. The chromatography technique developed with Waters HPLC Alliance (model 2698) equipped with ultraviolet (UV) detector.

Chromatographic conditions

The method was developed using column 250 mm, i.d.4.6 mm, 10 µm particle size with a mobile phase containing 0.005 M p-hydroxybenzoic acid buffer adjusted the pH to 9.90 (±0.05) with 15% NaOH solution

and methanol in the ratio of 1950:50 (v/v). The diluent used as MilliQ water. The flow rate of the mobile phase is 2.0 mL/min. The column and detector temperatures set at 40°C. The injection volume is 10 µL, and chromatographic run time is 10 min. The chromatogram shall be converted and processed from negative peak mode to positive peak mode which is called indirect UV determination.

Working standard preparation

The composite concentration of sodium chloride and sodium sulfate in the mixed standard solution was prepared with a final concentration of 0.5 mg/mL and 1.0 mg/mL, respectively, using the diluent as MilliQ water. Representative chromatograms of the blank and working standard preparation are shown in Figs. 1 and 2. The system suitability of the chromatographic analysis is presented in Table 1.

Sample preparation

Accurately weigh and transfer about 2000 mg of test substance into a 20 mL volumetric flask. To that, add 10 mL of MilliQ water and sonicate to dissolve and dilute to volume with diluent and mix well. The chromatogram of the control sample is shown in Fig. 3.

RESULTS AND DISCUSSION

Method development

The initial method optimization is started using an anionic chromatography column which is supplied by Hamilton columns, and the columns are

the chemical bonding phase of polystyrene divinyl benzene cross-linked with trimethyl ammonium which acts as a counter cation exchanger. The method development is started with weak organic salt primarily used as a parahydroxybenzoic acid at about 0.1 M and sample diluent used as water. The sample preparation is made at an absolute concentration of about 10 mg/mL. Due to the high foam characteristics of sodium lauryl sulfate, the dissolution of the sample is performed using sonication. Initial chromatographic data reveal that there are two negatively distorted peaks observed at differential retention times within the run time of 15 min as the exchange capacity in the column chemistry is dependent on the pH of the mobile phase. The selectivity of the weak buffer, from pH 3.0 to pH 11.0, was optimized to verify the resolution of peaks of interest and as well as its symmetry. As the mobile phase acidity decreases (pH increases), the peak of interest found to be less retention and vice versa. The column chemistry of the anion exchange chromatography, the stationary bed, has an ionically positive (+) charged surface, while the sample ions are of negative (-) charge. This technique is used almost exclusively with ionic or ionizable samples. The stronger the negative charge on the sample, the stronger it will be attracted to the positive charge on the stationary phase, and thus, the longer it will take to elute. From the optimized pH at 9.9, there is a good separation between the chloride and sulfate peaks and also eluted within 15 min of total retention. To further improve and sustain its peak symmetry, the addition of organic solvent (methanol) is optimized as a peak modifier, elutes the components of interest within 10 min. No other unknown peaks were observed from the subject material in the sample chromatogram.

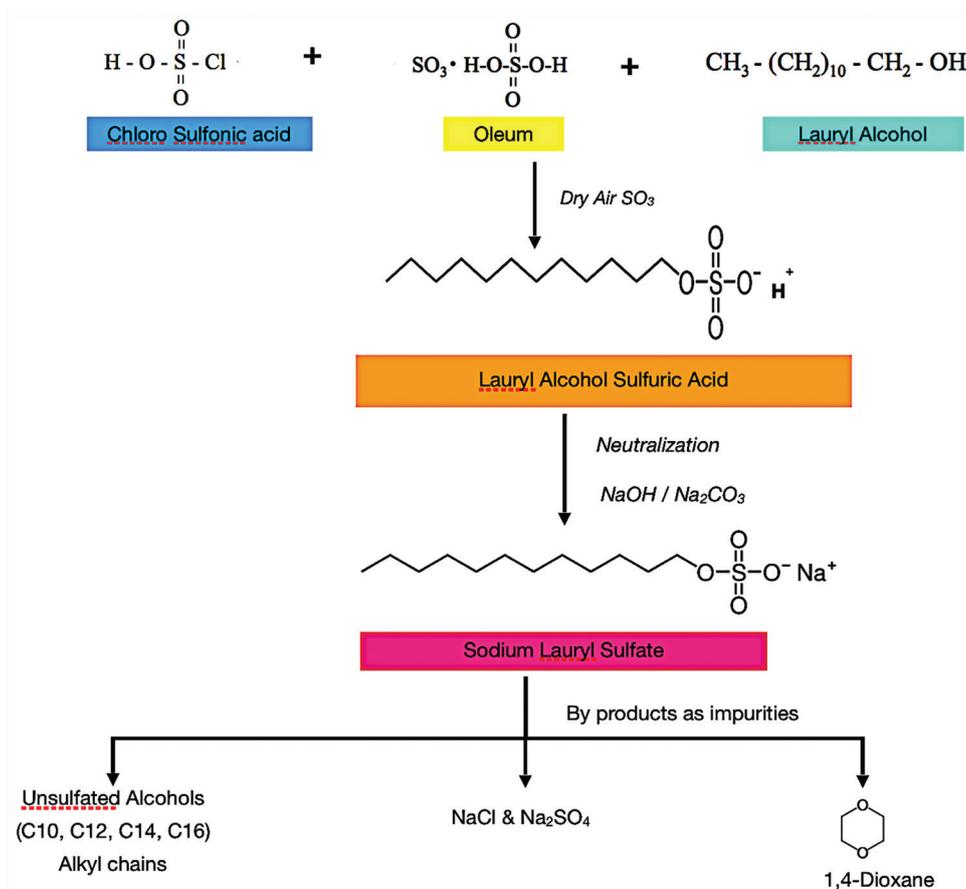


Table 1: System suitability criteria

Component	Retention time (min)	Relative retention time (RRT)	USP resolution [†]	RSD [†]
Chloride	2.718	0.37		NMT 1.5
Sulfate	7.285	1.00	NLT 3	NMT 1.5

[†]For six replicate standard injections

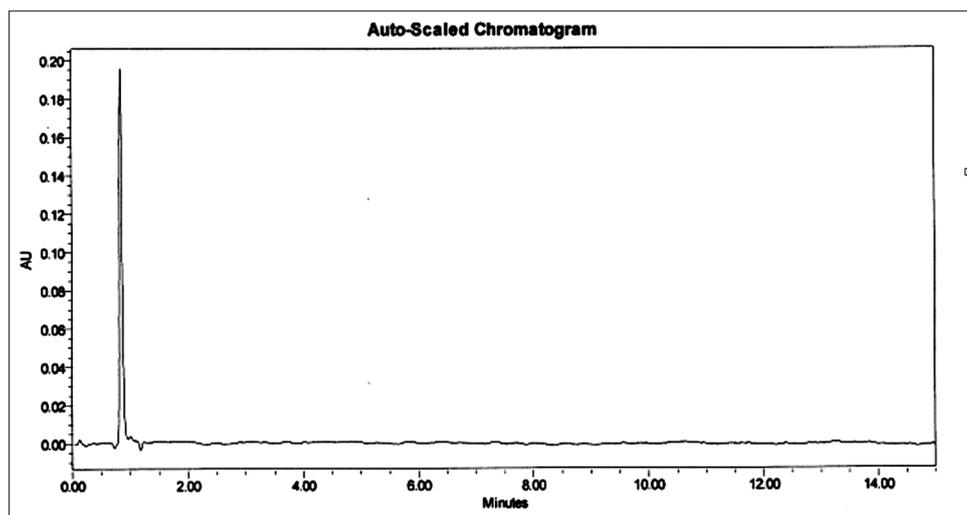


Fig. 1: Blank chromatogram

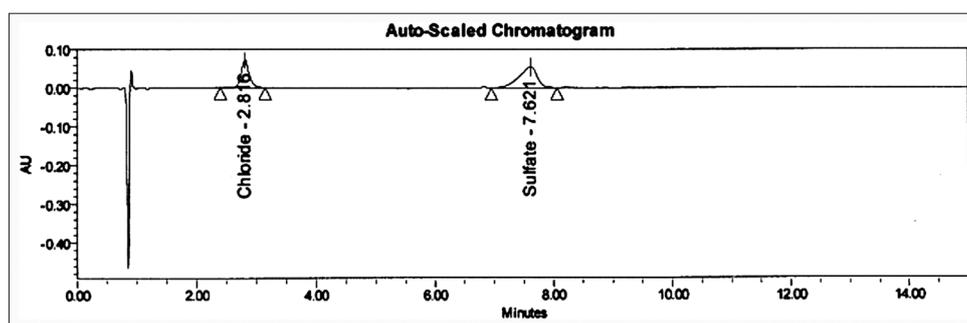


Fig. 2: Working standard chromatogram

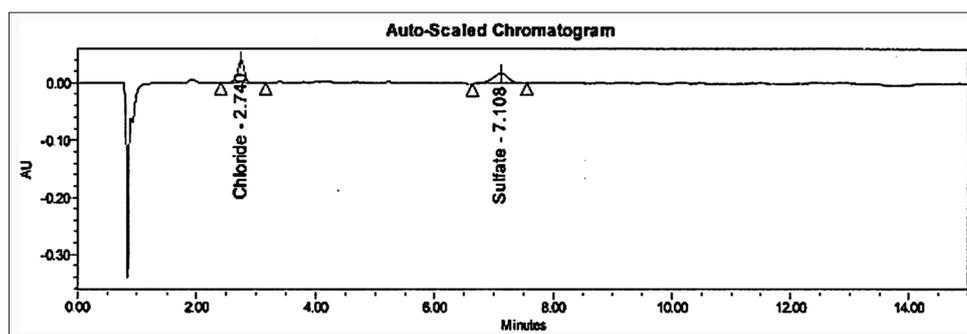


Fig. 3: Control sample chromatogram

From the organic phase optimization, 2.5% of the methanol found to be symmetric peaks of chloride and sulfate as determined as negative peaks with an indirect UV method. The peak integration is carried out using empower software to flip into a positive chromatographic scale.

Validation of the method

The proposed method validated as per ICH guidelines [20] and USP Compendia [21], along with references literature on method validation [12-19] studies in the current industry practices.

Method precision

Method precision/repeatability was performed by analyzing six sample preparations of SLS, raw material spiked with sodium chloride, and sodium sulfate stock standard solution at a targeted specification level of 0.5% and 1.0%, respectively. A control sample preparation is analyzed to correct the % recovery in spiked samples with known amounts of sodium

chloride, and sodium sulfate detected in the control sample. The results for % recovery of chloride and sulfate in spiked sample preparations are presented in Table 2. The representative chromatogram of control sample preparations from method precision study is presented in Fig. 4.

Table 2: Method precision and accuracy evaluation

Accuracy level	Recovery (%)			
	Sodium chloride		Sodium sulfate	
	Average	RSD (%)	Average	RSD (%)
LOQ at 30 %	101.2	2.5	105.5	4.8
100	97.0	1.6	101.1	1.6
150	104.6	3.1	102.8	4.7

LOQ: Limit of quantitation

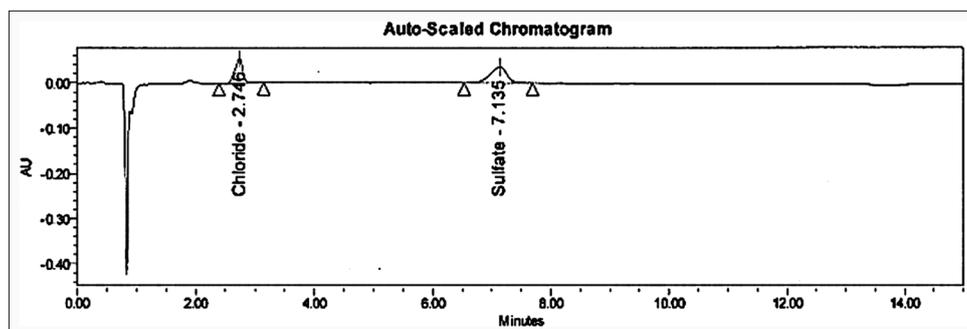


Fig. 4: Limit of quantitation spiked sample

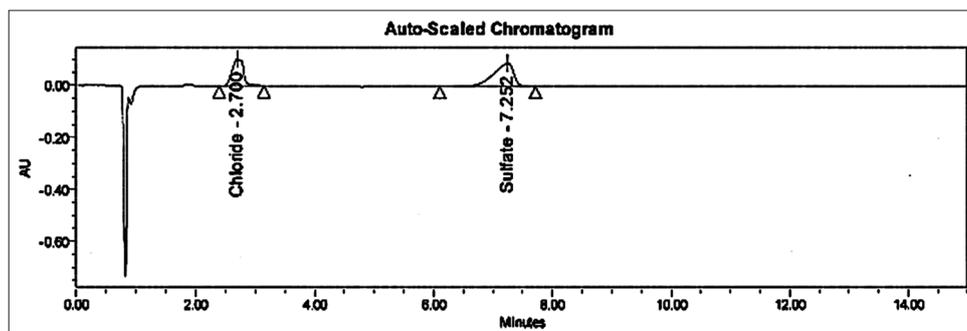


Fig. 5: 150% spiked sample

Specificity

The specificity of the method was demonstrated by injecting blank, individual injections of sodium chloride and sodium sulfate, and system suitability information presented in Table 1.

Accuracy

Accuracy was performed by preparing and analyzing three sample preparations of SLS, raw material spiked with sodium chloride stock standard, and sodium sulfate stock standard at specification levels 30% (limit of quantitation [LOQ]), 100%, and 150% to the target specification limits. A control sample preparation is analyzed to correct the % recovery in spiked samples with known amounts of sodium chloride and sodium sulfate detected. Accuracy was determined by spiking known concentrations of sodium chloride and sodium sulfate stock standards in the control sample. The obtained recoveries are presented in Table 2. Representative chromatograms for the accuracy sample preparations at LOQ and 150% level are shown in Figs. 4 and 5.

Limits of detection (LOD) and LOQ

The LOQ and LOD standards are prepared for sodium chloride and sodium sulfate as per the sample concentration. The percentage recovery and signal to the noise ratio at LOQ level for sodium chloride and sodium sulfate are found to be within the acceptance limit of 70.0–130.0% and not <10, respectively.

Linearity

The linearity of the method was demonstrated by injecting series of standard solutions of sodium chloride and sodium sulfate at five different concentration levels ranging from LOQ level (to 150% of the targeted specification limit). The correlation coefficient for sodium chloride and sodium sulfate found to be 0.99878 and 0.9994, respectively.

Stability of solutions

The stability of the solutions is determined to establish a duration, for which the components of interest are stable under specified storage conditions in the working standard and sample solution. The working

standard and sample solutions were analyzed at an initial hour, 24 h, 48 h, and 72 h, which are stored at room temperature (RT) and refrigerated (RF) conditions. Based on the percentage recovery, results obtained from the aged sample solution and similarity factor results obtained from aged working standard solution concluded that the working standard and sample solution are stable for three (3) days at RT and one (1) day at RF, respectively.

CONCLUSION

A novel analytical method was validated as per the ICH method validation guidelines and found to meet the requirements. Hence, the validated analytical method was precise, specific, and accurate, and it is more economic and simple for the determination of inorganic impurities using HPLC with UV detection technique.

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AUTHORS' CONTRIBUTIONS

The author has solely contributed to the design, development, review, and finalization of the contents of the manuscript.

CONFLICTS OF INTEREST

The author confirms that this article content has no conflicts of interest.

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