RESEARCH ARTICLE

Development and validation of a capillary electrophoresis method for salicylic acid determination in pharmaceutical and cosmetic formulations

Șoimița Emiliana Măgrerușan[1], Gabriel Hancu[1], Elenora Mircia[2]

1. Department of Pharmaceutical Chemistry, Faculty of Pharmacy, "George Emil Palade" University of Medicine, Pharmacy, Science and Technology of Târgu Mureș, Târgu Mureș, Romania
2. Department of Pharmaceutical Industry and Biotechnologies, Faculty of Pharmacy, "George Emil Palade" University of Medicine, Pharmacy, Science and Technology of Târgu Mureș, Târgu Mureș, Romania

Abstract

The current study reports on the development and validation of a new capillary electrophoresis (CE) method for the quantification of salicylic acid in pharmaceutical and cosmetic preparations. During preliminary analysis, capillary zone electrophoresis (CZE) using phosphate, borate, and mixed phosphate-borate buffers and micellar electrokinetic chromatography (MEKC), were evaluated; borate background electrolyte (BGE) led to better peak shape and was therefore selected for further method development. Separation was achieved in a fused-silica capillary (40 cm total length, 32 cm effective length, 50 µm i.d.) using an aqueous sodium borate BGE at pH 9.30, with an applied voltage of +20 kV, a temperature of 20 °C, hydrodynamic injection at the anodic end (50 mbar/1 sec.), and UV–DAD detection at 300 nm. The method was linear over 0.03-1.00 mg/mL (R^2 0.994) calibration range. The limit of detection (LOD) was 0.01 mg/mL, and the limit of quantification (LOQ) was 0.03 mg/mL. Mean recoveries in spiked matrices were between 98.5-101.2%. Small deliberate variations of BGE concentration, pH, voltage, and temperature did not significantly affect responses, confirming robustness. The procedure is simple, solvent efficient, and suitable for routine quality control of cosmetic and pharmaceutical products containing salicylic acid.

Keywords: salicylic acid; capillary electrophoresis; cosmetic products; quality control; validation

Received: 12.11.2025 / Accepted: 18.05.2026

Introduction

Salicylic acid (2-hydroxybenzoic acid) is a beta-hydroxy acid having a benzene ring substituted with a carboxyl group (-COOH) and a phenolic hydroxyl group (-OH) in the ortho position. The chemical structure of salicylic acid is presented in Figure 1. It occurs as a white, needle-like, odorless crystalline powder. It is slightly soluble in cold water (2 g/L at 20°C), soluble in alcohol, ether, acetone, chloroform; aqueous solubility increases in alkaline solutions (forming salicylates) [1,2].

Salicylic acid has antiseborrheic, keratolytic, and weak anti-inflammatory effects when applied topically. At concentrations >2%, it has a keratolytic effect causing desquamation of the stratum corneum by solubilizing the intercellular cement and decreasing the cohesion of corneocytes, while at lower concentrations <2%, it has a keratoplastic effect normalizing the cornification process, with a subsequent anti-seborrheic effect. It also has a weak antimicrobial and antifungal effect, by modifying the pH and denaturing microbial proteins [3,4].

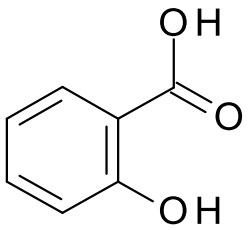

Figure 1. Salicylic acid (2-hydroxybenzoic acid) chemical structure

It is one of the most widely used acids in dermatology and cosmetology for the treatment of acne, psoriasis, ichthyosis, warts, and dandruff. It is also used as a preservative and mild antiseptic in pharmaceutical and cosmetic formulations [5].

Salicylic acid is used in chemical peeling as a lipophilic agent, having a keratolytic, seborrheic and anti-inflammatory effect, being recommended in the treatment of acne, hyperpigmentation and skin photoaging [3,5].

Capillary electrophoresis (CE) is an advanced analytical method, based on the migration of ionized compounds in an applied electric field in a capillary filled with background electrolyte (BGE). In pharmaceutical analysis, the technique is used for the determination of active substances, metabolites and impurities, as well as for solving chirality problems, being particularly valuable in quality control and stability studies [6]. In the cosmetics industry, CE offers the possibility to characterize bioactive ingredients,

* Correspondence to: Gabriel Hancu
E-mail: gabriel.hancu@umfst.ro

preservatives, colorants or fragrances, but also to detect counterfeit or non-compliant products. Due to its sensitivity and versatility, this technique contributes to increasing the safety and quality of pharmaceutical and cosmetic products, in line with current regulatory and consumer protection requirements [7].

The determination of salicylic acid by CE has been studied over the last three decades, with the literature highlighting the advantages of the method over conventional chromatographic techniques, in particular short analysis time, low solvent consumption and high resolution. Various types of CE techniques, such as capillary zone electrophoresis (CZE), micellar electrokinetic chromatography (MEKC) or CE with cyclodextrin (CD) additives, have been applied for the quantification of salicylic acid in pharmaceutical formulations, cosmetic products and biological samples. Studies have demonstrated the ability of CE to separate salicylic acid from metabolites, impurities or excipients, as well as its applicability in quality control and product safety monitoring [7].

Gomez et al. developed and validated a CZE method for the simultaneous determination of salicylic acid, chloramphenicol and resorcinol in pharmaceutical products for the treatment of acne. Using a 50 mM borate-phosphate BGE at pH 9.0, the method achieved efficient baseline separation within 6 minutes, with high reproducibility. The method demonstrated satisfactory detection limits (salicylic acid - LOD: 0.42 mg/mL, LOQ: 1.42 mg/mL), wide linearity ranges, and adequate precision. The method was successfully applied to commercial preparations without requiring additional sample pretreatment [8].

Liu et al. developed a cyclodextrin-modified capillary electrophoresis (CE-CD) method, optimized by chemometric design of experiments (DoE) (fractional factorial followed by central composite design), for the simultaneous determination of seven cosmetically relevant acids: glycolic, lactic, tartaric, malic, citric, mandelic and salicylic. The optimized method employed a 150 mM phosphate BGE at pH 7.0, containing 0.5 mM cetyltrimethylammonium bromide (CTAB), 3 mM β-CD and 25% methanol, achieving complete separation in less than 10 minutes, with salicylic acid LOD of 625 nM (0.086 mg/L), and was successfully applied to various commercial cosmetic products (gels, lotions, creams), confirming the concentrations declared by the manufacturers [9].

Wang et al. developed and validated a micellar electrokinetic chromatography (MEKC) method for the simultaneous determination of eleven preservatives used in cosmetic products, including salicylic acid, parabens and phenoxyethanol. Using a BGE composed of 20 mM borate at pH 9.30, 100 mM sodium dodecyl sulfate (SDS) and 15% acetonitrile, the method achieved complete and reproducible separation in less than 20 minutes. Good linearity was obtained over the 10-200 mg/L range, with adequate sensitivity for salicylic acid (LOD 20 μg/g) and satisfactory precision, being successfully applied for the analysis of commercial cosmetic products [10].

Chen et al. applied central composite design to optimize a CE method with UV detection for the determination of exfoliating agents in cosmetic products, including salicylic acid and other α-hydroxy acids. The optimized conditions, consisting of a 25 mM phosphate BGE at pH 7.0, 0.5 mM CTAB, and 15% acetonitrile, enabled complete separation with good reproducibility. The method demonstrated adequate sensitivity, with a salicylic acid LOD of 0.5 μg/mL, and was successfully used on commercial cosmetic products, highlighting the usefulness of DoE in analytical method development [11].

Jin et al. developed a MEKC method with amperometric detection for the determination of phenolic bleaching agents in cosmetic products, including salicylic acid. The optimized method employed a 40 mM phosphate-borate BGE at pH 9.0 containing 10 mM SDS allowing the separation of six phenolic compounds within a short analysis time. Amperometric detection using glassy carbon electrode operated at +1.0 V provided enhanced sensitivity and selectivity toward phenolic analytes. For salicylic acid, the method showed a LOD of 0.45 mg/mL, and successful application on commercial cosmetic products confirmed both its accuracy and suitability for quality control purposes [12].

Xue et al. developed a CE method with UV detection, coupled with dispersive liquid–liquid microextraction (DLLME) as a preconcentration procedure, for the simultaneous determination of seven preservatives in cosmetic products, including salicylic acid, parabens and phenoxyethanol. Using a 20 mM borate BGE at pH 9.3, complete separation of the analytes was achieved in less than 15 minutes. The DLLME step significantly enhanced method sensitivity, resulting in low LODs (LOD 0.018 μg/mL). The method also demonstrated good linearity, precision and reproducibility, and was successfully applied to commercial cosmetic samples, with results in agreement with manufacturer declarations [13].

The aim of our study is to develop and validate a new CE method for the determination of salicylic acid in pharmaceutical and cosmetic preparations, with a focus on optimizing experimental conditions and evaluating sensitivity, reproducibility and applicability in the quality control of commercial products.

Methods

Instrument and analytes

The electrophoretic determinations were performed on an Agilent 1600 CE system equipped with a diode-array detector (DAD) (Agilent Technologies, Germany). Electropherograms were recorded using ChemStation 7.01 software (Agilent Technologies). Analyses were carried out using fused silica capillaries (Agilent Technologies, Germany) with a total length of 40 cm (effective length of 32 cm) and an internal diameter (I.D.) of 50 μm. The pH of

the buffer solutions was measured with a Terminal 740 pH meter (Inolab, Germany).

The robustness of the method was assessed through a Plackett–Burman design using Design Expert software (Stat-Ease Inc., Minneapolis, USA).

Pharmaceutical grade salicylic acid was obtained from Fagron (Greece). Analytical-grade reagents were used in all determinations: sodium dihydrogen phosphate, disodium hydrogen phosphate, sodium tetraborate, sodium dodecyl sulfate (Merck, Germany), methanol, sodium hydroxide (Lach-Ner, Czech Republic). Double distilled, deionized water (Millipore) was used throughout experiments. Various pharmaceutical and cosmetic preparations were purchased from local pharmacies.

Electrophoretic conditions

Capillaries were conditioned with 1 N NaOH for 30 minutes, followed by 0.1 N NaOH for 15 minutes, and rinsed with water for 15 minutes. Prior to each determination, the capillaries were preconditioned with 0.1 N NaOH for 2 minutes, water for 1 minute, and subsequently with the BGE for 1 minute.

The BGE solutions were prepared by dissolving the required amounts of the components in purified water, and the pH was adjusted with 1 N NaOH when necessary.

Standard salicylic acid solutions were prepared in a methanol: water (1:1, v/v) mixture. A stock solution of 1 mg/mL was prepared and further diluted with the BGE to obtain the desired working concentrations.

All samples and BGEs were homogenized in an ultrasonic bath for 3 minutes and filtered through 0.45 µm PTFE membranes (Millipore, USA) prior to use.

In the preliminary analysis the following electrophoretic conditions were used: 25 mM BGE concentration, temperature 20 °C, voltage +20kV, hydrodynamic injection with 50 mbar for 1 sec. at the anodic end. UV detection was performed at the cathodic end at three wavelengths: 210 nm (used as a control wavelength), 230 nm (where salicylic acid exhibits significant absorption but with lower selectivity), and 300 nm (corresponding to the maximum absorption of salicylic acid, providing higher specificity).

Sample preparation

Commercial peeling formulations and cosmetic concentrates containing salicylic acid were analyzed. The products investigated included:

- Purifying Peel (Toskani) - containing alcohol, propylene glycol, azelaic acid (14%), PEG-8, isopropyl alcohol, aqua, salicylic acid (2%), sodium lactate; pH 3.5.
- Radiance Peel (Toskani) - containing glycolic acid (34%), alcohol, aqua, citric acid (10%), lactic acid (10%), ammonium hydroxide, kojic acid (5%), salicylic acid (3%), hexylresorcinol, propylene glycol, hydroxyethylcellulose, ascorbyl glucoside, phenoxyethanol, ethylhexylglycerin; pH 2.5.
- Salicylic Peel (Toskani) - containing alcohol, PEG-8, propylene glycol, salicylic acid (10%), aqua, triethanolamine, sodium lactate; pH 3.0.
- Clarity Concentrate (Dr. Belter) - containing aqua, alcohol, salicylic acid, hydroxypropyl guar hydroxypropyltrimonium chloride, Melaleuca alternifolia (tea tree) leaf oil, glycerin, sodium hydroxide, caprylic/capric triglyceride, polyurethane crosspolymer-1, allantoin, chlorhexidine digluconate, xanthan gum, Hamamelis virginiana (witch hazel) leaf extract.
- Hydrafacial Solution - containing propylene glycol, water, butylene glycol, pentylene glycol, 1,2-hexanediol, Salix alba (willow) bark extract, glycolic acid, salicylic acid, polysorbate 80, allantoin, dipotassium glycyrrhizate, potassium hydroxide, disodium EDTA, sodium hyaluronate, betaine salicylate, Centella asiatica extract, lactobionic acid, panthenol, Saussurea involucrata extract, Bambusa vulgaris water, ethylhexylglycerin, Aloe barbadensis leaf extract, propanediol, and glycerin.
- Duofilm (Stiefel) - 15 mL of cutaneous solution contain 2.505 g of salicylic acid and 2.505 g of lactic acid, with excipients consisting of flexible collodion (containing pyroxylin, colophony, castor oil, ethyl alcohol, and ether).
- Clavusin (Meduan) – 100 g of cutaneous solution contain salicylic acid (19.30 g) and glacial acetic acid (19.30 g), with excipients including nitrocellulose adhesive (collodion), ethyl alcohol, and acetone.

Accurately weighed portions of each commercial formulation, corresponding to approximately 10 mg of salicylic acid, were transferred into 25 mL volumetric flasks. Samples were dissolved in a methanol:water mixture (1:1, v/v), sonicated for 5 minutes to ensure complete dissolution, and then brought to volume with the same solvent. The resulting solutions were centrifuged at 5000 rpm for 10 minutes, and the clear supernatants were subsequently filtered through 0.45 µm PTFE membrane filters prior to CE analysis.

Samples were analyzed within 24 h of preparation to prevent degradation or precipitation.

Results

Preliminary analysis

Salicylic acid is a weak aromatic acid with a pKa value of approximately 2.97, determined by the carboxyl group (-COOH). The phenolic group (-OH) has a much higher pKa (13.6), remaining protonated in the pH range used in CE, so it does not directly influence the electrophoretic mobility [14]. At acidic pH of the BGE, salicylic acid is predominantly found in the protonated form, which results in a low electrophoretic mobility. With increasing pH,

deprotonation of the carboxyl group leads to the formation of the salicylate anion, which becomes the main migrating species in the electric field. At pH values higher than 5, the electrophoretic mobility increases significantly, and the analytical signal becomes more stable and reproducible.

In the preliminary stage, different buffer systems (phosphate, borate and phosphate-borate mixtures), as well as various concentrations of the BGE, were evaluated to establish appropriate conditions for the separation of salicylic acid. Several pH values in the range of 5.0-9.5 were tested, and the influence of ionic strength on migration behavior was monitored.

Preliminary electropherograms revealed that salicylic acid exhibits sharp and symmetrical peaks in alkaline BGEs, with better migration time stability at pH values above 7.0. At lower pH values (< 6.5) peak distortions and reduced reproducibility were observed.

Separation under MEKC conditions was also tested, using SDS as an additive in the BGE. However, it was observed that the presence of micelles did not bring significant improvements in terms of peak shape and reproducibility; in addition, it led to a slight increase in migration times. Therefore, the final method chosen for the determination was classical CZE.

The introduction of methanol as an organic modifier (5–20%, v/v) had a negative influence on the analysis: a reduction in signal intensity and a broadening of the peak were observed, due to the decrease in the conductivity of the BGE and the increase in the viscosity. Consequently, the optimal analysis conditions were obtained in the absence of organic modifiers, using an aqueous BGE with alkaline pH.

Among the buffer systems tested, the borate BGE offered the best reproducibility of migration times and a superior peak shape, being chosen as the BGE for the analysis of salicylic acid in pharmaceutical and cosmetic preparations.

Method optimization

BGE concentration was evaluated in the range of 20-50 mM, finding that at higher concentrations (35–40 mM) there was a strong increase in the generated current and a slight increase in Joule heating with peak broadening; consequently, the concentration of 25 mM was chosen as the optimal value.

The applied voltage range was evaluated in the range of +15-+30 kV, noting that higher values reduce migration times, but above 25 kV determine the tendency for the peak to broaden through Joule heating, which is why +20 kV was chosen as the optimal value. The generated current was approximately 40-45 μA, without excessive Joule heating.

For the capillary temperature, the range of 17-25 °C was evaluated, finding that lower values improve efficiency but prolong migration times, while above 25 °C variations occur; therefore, the temperature of 20 °C was chosen.

For hydrodynamic injection, the range of 20-50 mbar was evaluated, with short injection times of 1–3 s to avoid overloading, noting that increasing the injected volume leads to peak broadening and higher values of RSD for the area; consequently, the condition of 50 mbar for 1 sec. was maintained with a short and reproducible time.

For the quantification of salicylic acid, the wavelength of 300 nm was used, corresponding to the specific maximum absorption, ensuring better specificity in the presence of excipients in pharmaceutical and cosmetic preparations.

Figure 2 presents an example of a typical electropherogram obtained with optimized analytical conditions.

Analytical performance verification

The optimized CZE method for the determination of salicylic acid was validated according to the ICH Q2(R2) guideline, by evaluating the following parameters: specificity, linearity, accuracy, precision, sensitivity and robustness.

The method was found to be specific for salicylic acid, with no interference observed from excipients present in

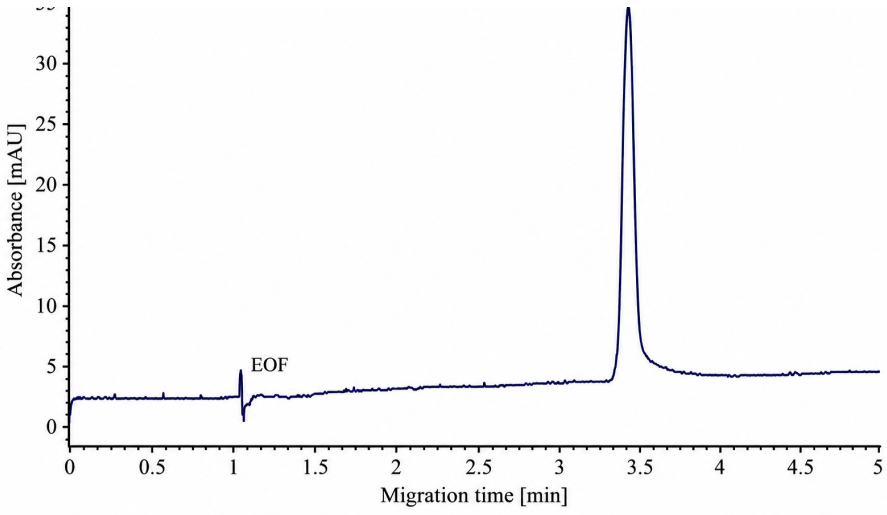

Figure 2. Salicylic acid determination by CZE (electrophoretic conditions: 25 mM sodium tetraborate BGE, pH 9.30, voltage + 20 kV, temperature 20 ºC, hydrodynamic injection 50 mbar/1 sec., UV detection at 300 nm, analyte concentration: 0.5 mg/mL)

pharmaceutical or cosmetic preparations on the migration time of the analyte. Control (placebo) electropherograms confirmed the absence of co-migrating peaks at 300 nm. Peak purity evaluated by DAD analysis confirmed the absence of co-migrating compounds.

Calibration curves were constructed in the concentration range 0.03–1.00 mg/mL. A good linear correlation was obtained, with correlation coefficients (R^2) of 0.994, demonstrating linearity of the method. Peak area values used for calibration were expressed in normalized detector response units generated by the ChemStation software.

Accuracy was assessed by adding known amounts of standard salicylic acid to pre-analyzed pharmaceutical/cosmetic matrix at three concentration levels (0.05, 0.15, 0.5 mg/mL). The mean recoveries ranged from 98.5–101.2%, confirming the accuracy of the method.

Repeatability (intra-day precision) was determined by injecting salicylic acid standard solution at three different concentrations (0.05, 0.15, 0.5 mg/mL) six replicate injections on the same day (n = 6), while intermediate precision (inter-day precision) was determined by injecting samples of the same concentration levels six times on three consecutive days (n = 18). Relative standard deviations (RSDs) (%) were calculated for the migration time and peak area. All RSD values were below 1% for peak area and below 0.5% for migration time.

The limit of detection (LOD) and limit of quantification (LOQ) were calculated as 3.3σ/s and 10σ/s, respectively, where σ is the standard deviation of the intercept and s the slope of the calibration curve, were 0.01 mg/mL and 0.03 mg/mL for salicylic acid, respectively, under the optimized conditions. The LOQ concentration level (0.03 mg/mL) was experimentally verified with acceptable precision and signal-to-noise ratio.

Validation data are presented in Table I.

The robustness of the method was further assessed using a Plackett–Burman design. Deliberate small variations in key analytical parameters (BGE concentration ±2 mM, pH ±0.5 units, applied voltage ±1 kV, and temperature ±1 °C) did not significantly affect migration times or peak areas, with RSD values remaining below 2%, confirming the robustness of the method. 12 experiments were performed in factorial combinations and 3 additional rounds at the central point (25 mM BGE, pH 9.3, 20 kV, 20 °C), resulting in a total of 15 experiments. The observed variations in migration time and peak area remained within acceptable analytical limits, with RSD values below 2%, confirming the practical robustness of the method. Robustness verification data are presented in Table II.

System suitability parameters, assessed before each day, included reproducibility of migration times (RSD < 2%), peak symmetry (0.9–1.2), and number of theoretical plates (N > 100,000). All values were within the established acceptance criteria.

Table I. – Analytical performance of the optimized method

Intra-day precision (n = 6)		
Concentration (mg/mL)	RSD (%) migration time	RSD (%) peak area
0.05	0.03	0.26
0.15	0.03	0.22
0.5	0.02	0.25
Inter-day precision (n = 18)		
Concentration (mg/mL)	RSD (%) migration time	RSD (%) peak area
0.05	0.26	0.89
0.15	0.25	0.85
0.5	0.19	0.77
Accuracy		
Concentration (mg/mL)		Recovery (%)
0.05		98.5
0.15		100.6
0.5		101.2
Linearity		
Regression equation (0.03 - 1 mg/mL)		y = 68.5x + 1.12
Correlation coefficient		0.994
LOD (mg/mL)		0.01
LOQ (mg/mL)		0.03

Standard and sample solutions remained stable for at least 24 h at room temperature, with no significant changes in migration time or peak area.

Salicylic acid determination in different matrices

The optimized CE method was successfully applied for the quantitative determination of salicylic acid in pharmaceutical and cosmetic formulations, differing in composition, viscosity and acidity. The products analyzed included chemical peels, cosmetic concentrates and collodion-type skin solutions, with a declared salicylic acid content ranging from 2-20%. Despite the diversity of excipients (alcohols, glycols, fatty acids, resins and polymers), the electropherograms obtained under optimal conditions (25 mM sodium tetraborate, pH 9.30, +20 kV, 20 °C, UV detection 300 nm), presented no co-migrating peaks or interferences from excipients.

The results showed good agreement with the declared

Table II. – Plackett-Burman DoE matrix used to evaluate the robustness of the salicylic acid determination by CE

Run	BGE concentration [mM]	pH	Voltage [kV]	Temperature [°C]	Migration time [min]	Peak area [mAU s]
1	25.00	9.30	20.00	20.00	3.45	35.00
2	27.00	9.80	21.00	19.00	3.38	34.70
3	27.00	8.80	19.00	19.00	3.56	34.50
4	23.00	8.80	19.00	21.00	3.50	35.20
5	23.00	9.80	19.00	21.00	3.40	35.15
6	23.00	8.80	21.00	19.00	3.48	34.85
7	27.00	8.80	21.00	21.00	3.46	35.02
8	27.00	9.80	19.00	19.00	3.44	34.80
9	25.00	9.30	20.00	20.00	3.45	35.04
10	27.00	9.80	19.00	21.00	3.41	35.30
11	25.00	9.30	20.00	20.00	3.46	34.98
12	23.00	8.80	19.00	19.00	3.53	34.62
13	27.00	8.80	21.00	19.00	3.49	34.64
14	23.00	9.80	21.00	19.00	3.34	34.90
15	23.00	9.80	21.00	21.00	3.32	35.35

values of the analyzed products. The determined concentrations of salicylic acid in Purifying Peel (Toskani), Radiance Peel (Toskani) and Salicylic Peel (Toskani) ranged between 95.2–102.6% of the declared content, values considered acceptable for complex cosmetic products that may present slight formulation variations. For Clarity Concentrate (Dr. Belter) and Hydrafacial Solution, the measured concentrations were consistent with the expected range, confirming the method's applicability to viscous cosmetic matrices. For the pharmaceutical preparations Duofilm (Stiefel) and Clavusin (Meduan) the recoveries were between 98.1–101.5%, demonstrating the precision and accuracy of the method in well-defined matrices.

Matrix effects were minimal due to the use of methanol:water mixture (1:1, v/v) as extraction solvent and the high selectivity of detection at 300 nm. RSD values for migration time and peak area remained below 2% in all cases, confirming the good repeatability of the determinations.

The quantitative results obtained for the different formulations are summarized in Table III. The results obtained confirm the applicability of the developed CE method for routine quality control of pharmaceutical and cosmetic products containing salicylic acid.

Conclusion

The study demonstrated that the developed and validated CE method is a simple, rapid and reproducible method for the determination of salicylic acid in pharmaceutical and cosmetic preparations. The use of a sodium tetraborate BGE at pH 9.30 ensured an efficient separation with short migration times and good peak shape. Under the optimized conditions, salicylic acid migrated at approximately 3.45 min, with a generated current of approximately 45 μA and theoretical plate numbers exceeding 1.1×10^5. The analytical parameters validated according to the ICH Q2(R2) guideline confirmed the specificity, linearity (0.03–1.00 mg/mL, R^2 0.994), accuracy (recoveries between 98.5–101.2%) and precision of the method (RSD < 2%), as well as the detection limit (LOD 0.01 mg/mL, LOQ 0.03 mg/mL). Robustness tests revealed that deliberate variations in experimental conditions do not significantly affect analytical performance.

The method was successfully applied for the quantitative analysis of commercial formulations containing salicylic acid, including cosmetic products such as Purifying Peel, Radiance Peel, Salicylic Peel, Clarity Concentrate and Hydrafacial Solution, and pharmaceutical preparations such as Duofilm and Clavusin. The determined concentrations ranged from 95.2-102.6% of the declared values for the cosmetic products and from 98.8-101.5% for the pharmaceutical solutions, all within the accepted limits for

Table III. – Determination of salicylic acid in different pharmaceutical and cosmetic matrices

Product	Type of formulation	Declared salicylic acid content	Determined salicylic acid content	Recovery (%)	RSD (%)
Purifying Peel (Toskani)	Cosmetic chemical peel	2.0 (%)	1.91 ± 0.05 %	95.5	1.3
Radiance Peel (Toskani)	Cosmetic chemical peel	3.0 (%)	3.08 ± 0.09 %	102.6	1.5
Salicylic Peel (Toskani)	Cosmetic chemical peel	10.0 (%)	9.75 ± 0.18 %	97.5	1.6
Clarity Concentrate (Dr. Belter)	Cosmetic concentrate	not specified	0.98 ± 0.03 %	-	1.2
Hydrafacial Solution	Cosmetic exfoliating solution	not specified	1.85 ± 0.06 %	-	1.5
Duofilm (Stiefel)	Pharmaceutical cutaneous solution	16.7 (mg/mL)	16.5 ± 0.2 mg/mL	98.8	0.9
Clavusin (Meduan)	Pharmaceutical cutaneous solution	19.3 (mg/mL)	19.6 ± 0.3 mg/mL	101.5	1.1

* Values are expressed as mean ± SD (n = 3). Assay values were calculated relative to the manufacturer-declared salicylic acid content. For products with unspecified salicylic acid concentrations, only externally calibrated quantitative determination was performed.

quality control.

Compared with previously reported CE methods employing MEKC systems, CD additives, organic modifiers, or preconcentration procedures, the proposed method provides a simpler aqueous CZE approach with reduced reagent consumption and straightforward sample preparation, while maintaining adequate sensitivity and reproducibility. Although more sensitive CE methods have been reported the sensitivity achieved in the present study is fully adequate for routine quality control of pharmaceutical and cosmetic formulations containing salicylic acid at percentage levels.

The method was developed specifically for salicylic acid determination and was not intended for simultaneous multi-analyte analysis

Due to the low reagent consumption and the absence of the need for additional treatment steps, the method proves suitable for routine quality control of products containing salicylic acid. In this context, CE is a practical and sustainable alternative to conventional chromatographic methods, contributing to increasing the efficiency and safety of analyses in the pharmaceutical and cosmetic fields.

Authors' contributions

ȘEM (Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Project administration; Resources; Validation; Visualization; Writing – original draft; Writing – review & editing), GH (Conceptualization; Formal analysis; Investigation; Methodology; Supervision; Writing – original draft; Writing – review & editing), EM (Conceptualization; Formal analysis; Methodology; Resources; Visualization; Writing – review & editing),

Conflict of interest

Nothing to declare.

Funding

No external funding was received.

References

1. Nordström FL, Rasmuson ÅC. Solubility and melting properties of salicylic acid. J Chem Eng Data. 2006;51(5):1668–71.
2. Randjelović P, Veljković S, Stojiljković N, Sokolović D, Ilić I, Laketić D, et al. The beneficial biological properties of salicylic acid. Acta Fac Med Naiss. 2015;32(4):259–65.
3. Arif T. Salicylic acid as a peeling agent: a comprehensive review. Clin Cosmet Investig Dermatol. 2015;8:455–61.
4. Wiśniewska J, Klasik-Ciszewska S, Duda-Grychtoł K. Salicylic acid and its use in cosmetology. Aesthetic Cosmetol Med. 2023;12(3):91–5.
5. Merinville E, Laloeuf A, Moran G, Jalby O, Rawlings AV. Exfoliation for sensitive skin with neutralized salicylic acid? Int J Cosmet Sci. 2009;31(3):243–4.
6. Řemínek R, Foret F. Capillary electrophoretic methods for quality control analyses of pharmaceuticals: a review. Electrophoresis. 2021;42(1–2):19–37.
7. Kończyk J, Myga-Nowak M, Michalski R, Janoszka K. Electromigration techniques in the analysis of selected cosmetic ingredients: a review. Molecules. 2025;30(1):161.
8. Gomez MR, Olsina RA, Martí nez LD, Silva MF. Simultaneous determination of chloramphenicol, salicylic acid and resorcinol by capillary zone electrophoresis and its application to pharmaceutical dosage forms. Talanta. 2003;61(2):233–8.
9. Liu PY, Lin YH, Feng CH, Chen YL. Determination of hydroxy acids in cosmetics by chemometric experimental design and cyclodextrin-modified capillary electrophoresis. Electrophoresis. 2012;33(19–20):3079–86.
10. Wang P, Ding X, Li Y, Ang U. Simultaneous determination of eleven preservatives in cosmetics by micellar electrokinetic chromatography. J AOAC Int. 2012;95(4):1069–73.
11. Chen YL, Jiang SJ, Feng CH, Wang SW, Lin YH, Liu PY. Application of central composite design for the determination of exfoliating agents in cosmetics by capillary electrophoresis with electroosmotic flow modulation. Anal Lett. 2014;47(10):1670–82.
12. Jin W, Wang WY, Zhang YL, Yang YJ, Chu QC, Ye JN. Determination of phenolic whitening agents in cosmetics by micellar electrokinetic capillary chromatography with amperometric detection. Chin Chem Lett. 2013;24(7):636–8.
13. Xue Y, Chen N, Luo C, Wang X, Sun C. Simultaneous determination of seven preservatives in cosmetics by dispersive liquid–liquid microextraction coupled with high performance capillary electrophoresis. Anal Methods. 2013;5(9):2391–7.
14. Balakrishna M, Neeraja R, Kumar JS, Ramanaiah M. An electrometric method for the determination of impact of DMSO-water mixtures on pKa values of salicylic acid derivatives. Int J Appl Pharm. 2023;15(6):309–14.