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Review Article

Comparative Assessment of Transdermal Permeability of Cosmetic Products

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Abstract

The paper presents an experimental method for quantifying the transdermal permeability of cosmetic compositions by incorporating a fluorescent probe – acridone-acetic acid at a concentration of 100 μg/mL – followed by analysis of the extracted acridone-acetic acid in skin samples using HPLC with fluorescence detection. The proposed method was used to investigate the transdermal permeability of individual cosmetic compositions prepared by a standard method and using transdermal permeability enhancement technologies based on the formation of supramolecular complexes.

Keywords: Transdermal Permeability; Acridone Acetic Acid

Introduction

Currently, assessing transdermal permeability is a relevant task for modern medicine and cosmetology. While there is a significant number of scientific publications on transdermal drug delivery, transdermal delivery and permeability of cosmetic compositions in cosmetology have been practically unstudied [1-5]. This is mainly because most cosmetic compositions are multi-component systems containing different classes of organic and inorganic compounds. Research on transdermal permeability for individual components is possible, but these are also rare reports. There are no methods for integral assessment of the transdermal permeability of cosmetic compositions. Nevertheless, this task is quite relevant for modern cosmetology, as the main focus in the cosmetic industry is on creating molecular and biotechnological platforms that can specifically deliver various bioactive components into the deep layers of the skin. One such technological platform is the creation of cosmetic compositions based on supramolecular complexes with bionavigational properties. Currently, supramolecular complexes with bionavigational properties are mainly used as cosmetic drones for the targeted delivery of biologically active compounds to specific skin structures. One such modern means of targeted intradermal delivery is Antiaging Dron X50. The idea behind Antiaging Dron X50 is based on encapsulating active ingredients in an inert polymer and binding specific peptides to its outer surface [15].

The aim of this study is a comparative quantitative assessment of the transdermal permeability of cosmetic products.

Materials and Methods

The study used ASR line mice with an average body weight of 24 g.

Before the study, the mice were shaved on their backs. 100 µL of the test cosmetic product containing a fluorescent probe (acridone acetic acid) at a concentration of 100 µg/mL was evenly applied to the skin of the back and rubbed in until completely absorbed. After 3 minutes (Group 1) and 10 minutes (Group 2), the mice were euthanized by an overdose of ether anesthesia. The area of the back skin where the test cosmetic was applied was thoroughly wiped sequentially with a cotton swab moistened with 70% ethanol and a cotton swab moistened with distilled water. Then, 3 full-thickness skin flaps were excised from the backs of the mice, weighed, and placed in Eppendorf tubes containing buffer solution (0.1 M Tris-phosphate buffer, pH 7.4, with the addition of 0.05% sodium lauryl sulfate) at a ratio of 1 ml per 50 mg of skin flap weight for 30 minutes at 20°C to extract the fluorescent probe. The skin flap was then removed and the solution was centrifuged at 12000 rpm in an Eppendorf centrifuge for 10 minutes, followed by quantification of the extracted fluorescent probe using reverse-phase HPLC. The control was an aqueous solution of acridone-acetic acid with a concentration of 100 µg/ml applied to the skin on the backs of mice according to the method described above. Preliminary studies to refine the method for determining transdermal permeability showed that applying a standard moisturizing face cream containing a fluorescent probe at a concentration of 100 µg/mL and applying an aqueous solution of the fluorescent probe are identical. Therefore, we used the application of an aqueous solution of the fluorescent probe at a concentration of 100 µg/mL to the skin as a control for calculating the transdermal permeability of the tested cosmetic products.

HPLC equipment and conditions

Shimadzu LC-20 chromatographic complex (Japan). Eluent: 0.1 M Tris-phosphate buffer with pH 7.4 and the addition of 0.05% sodium lauryl sulfate, eluent flow rate 1 ml/min, pressure 7.4 MPa. All samples for HPLC were centrifuged before analysis using an Eppendorf centrifuge at 12,000 rpm for 5 minutes. BioSep-SEC-S 3000 Phenomenex (USA) size exclusion chromatography column, 75 x 7.80 mm. Acridone acetic acid (Figure 1) was used as a fluorescent probe, which is amphiphilic and dissolves well in both hydrophilic and hydrophobic components of cosmetic creams. Additionally, acridone acetic acid, due to its carboxyl group, is capable of forming ionic clusters with cosmetic substances that have positively charged ionic groups, and due to its carbonyl group, it is capable of interacting with cosmetic substances that contain primary amino groups (amino acids, peptides, proteins, etc.). Thus, when using acridone acetic acid as a fluorescent probe, the transdermal permeability of almost all known cosmetic substances can be assessed, both in single-product formulations and as part of complex cosmetic compositions.

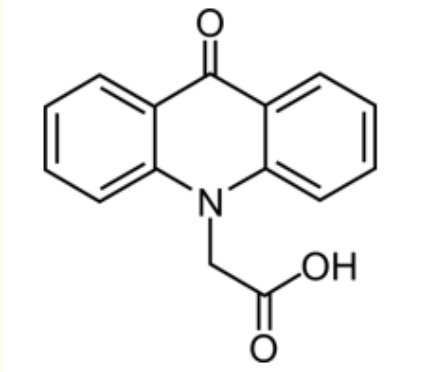

Figure 1: Acridone-acetic acid.

A fluorometric detector RF-20A (Shimadzu, Japan), 1 channel, Ch1 – excitation wavelength 390 nm, emission wavelength 455 nm, 2 channel, Ch2 – excitation wavelength 360 nm, emission wavelength 400 nm, was used as part of the HPLC system for detecting acridone acetic acid in extracts from the skin of experimental animals after the application of fluorescently labeled cosmetic compositions. The elution time of the main fraction of acridone acetic acid on chromatograms is 9.1 ± 0.3 min. For the quantitative analysis of the amount of acridone acetic acid extracted from the skin, data from channel 1 (Ch1) were used, as it has the highest sensitivity.

Tested cosmetic compositions

- Standard face moisturizer. Состав: aqua, lactobacillus ferment, hydrogenated polydecene, ceteth-20, propanediol, glycerin, c12-15 alkyl benzoate, bis-peg-18 methyl ether dimethyl silane, cyclopentasiloxane, glyceryl stearate, tetrahexyldecyl ascorbate, prunus amygdalus dulcis oil, ammonium acryloyldimethyltaurate/vp copolymer, 1,2-hexanediol, alcohol, alpha-arbutin, calcium chloride, calcium sulfate, carbomer, centella asiatica extract, ceramide

ap, ceramide eop, ceramide np, cetearyl alcohol, cholesterol, dimethyl isosorbide, disodium edta, ethylhexylglycerin, hydroxypinacolone retinoate, methylsilanol mannuronate, niacinamide, parfum, phenoxyethanol, phosphatidylcholine, phytosphingosine, polysorbate 20, rosa canina fruit oil, sodium chloride, sodium cholate, sodium hyaluronate, sodium hydroxide, sodium lauroyl lactylate, sorbic acid, tocopheryl acetate, xanthan gum.

- Anti-acne mask-concentrate "Bioakneroll". Состав: Lactobacillus Rye Ferment, Cellulose Gum, Carrageenan, Ceratonia Siliqua Gum, Sucrose, Sodium Benzoate, Potassium Sorbate
- Face Booster Concentrate "Bioakneroll Postbiotics". Состав: Aqua(Water), Lactobacillus Ferment Lysate, Bifida Ferment Lysate, Propionibacterium Ferment Lysate, Pentylene Glycol, Sodium Acrylates Copolymer, Lecithin, Phenoxyethanol, Cellulose Gum, Carrageenan, Ceratonia Siliqua Gum, Sucrose, Ethylhexylglycerin, Potassium Sorbate, Sodium Benzoate.
- Anti-aging cream for the skin around the eyes «Anti-Age Revitalizing Eye Countur Cream». Состав: Aqua, Butyrospermum Parkii (Shea Butter) Oil, Caprylic/Capric Triglyceride, Erythritol, Glycerin, Butylene Glycol, Sodium Acrylates Copolymer, Candida Bombicola/Glucose/Methyl Rapeseedate Ferment, Persea Gratissima (Avocado) Oil, Oryza Saava (Rice) Germ Oil, Saccharomyces/Xylinum/Black Tea Ferment, Lecithin, Tocopheryl Acetate, Polianthes Tuberosa Callus Extract, Betaine, Phenoxyethanol, Plukenetia Volubilis Seed Oil, Gardenia Jasminoides Fruit Extract, Schizandra Chinensis Fruit Extract, Hydrolyzed Rhodophyceae Extract, Polyglyceryl-10 Laurate, Glucosyl Ceramide, Biosaccharide Gum-1, Curcuma Longa (Turmeric) Root Extract, Lithospermum Erythrorhizon Root Extract, Polysorbat 20, Poria Cocos Sclerotium Extract, Tripeptide-1, Hexapeptide-9, Dipeptide-2, Acetyl Tetrapeptide-5, Phospholipids, Cholesterol, Palmitoyl Tripeptide-5, Palmitoyl Pentapeptide-4, Palmitoyl Tetrapeptide-7, Acetyl Hexapeptide-8, Pentapeptide-3, Dipropylene Glycol, Lactic Acid/ Glycolic Acid Copolymer, Polyvinyl Alcohol, Copper Heptapeptide-14 Pantothenate, Heptapeptide-15 Palmitate, Ethylhexylglycerin, Hydroxyethylcellulose, Xanthan Gum, Caprylyl Glycol, Parfum (Fragrance), Tocopherol, Glycine Soja Oil, Glyceryl Caprylate, Phenylpropanol, Citric Acid.

Results

The research results are presented in Figures 2-3 and Tables 1-3.

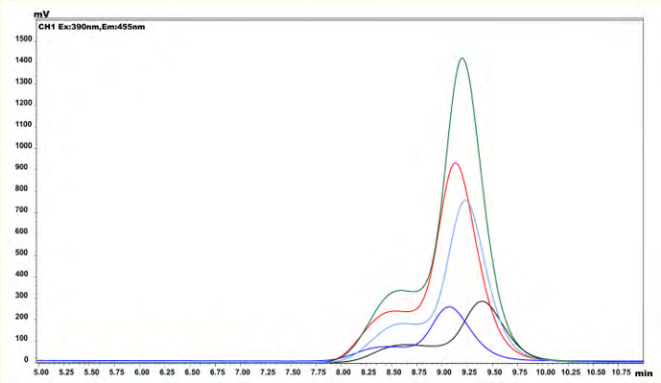

Figure 2: HPLC of acridoneacetic acid extracted from the skin. 3 minutes of exposure of cosmetic compositions on the skin.

1- - Acridone acetic acid solution in 0.1 M Tris-phosphate buffer pH 7.4.

2 - - Standard moisturizing cream, acridone acetic acid 100 mcg/ml.

3 - - "Bioakneroll" anti-acne mask-concentrate with acridone acetic acid 100 mcg/ml.

4 - - "Bioakneroll Postbiotics" face booster concentrate with acridone acetic acid 100 mcg/ml.

5 - - "Anti-Age Revitalizing Eye Contour Cream" rejuvenating eye cream with acridone acetic acid 100 mcg/ml.

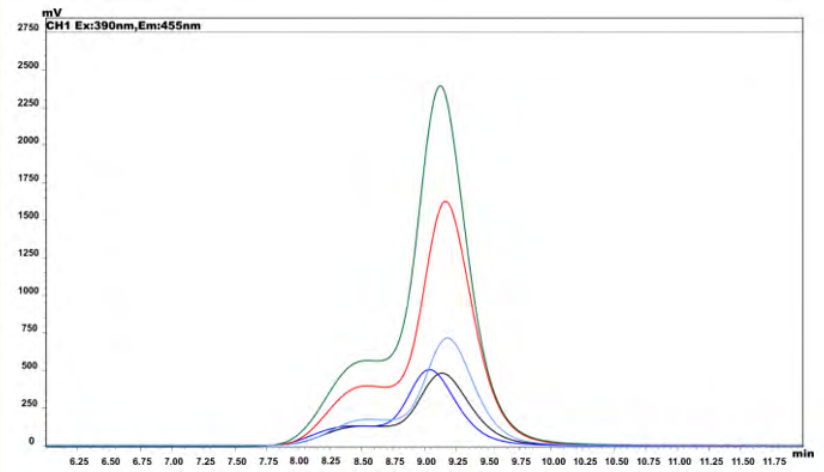

Figure 3: HPLC of acridone acetic acid extracted from the skin. 10 minutes of exposure of cosmetic compositions on the skin.

1- - Acridone acetic acid solution in 0.1 M Tris-phosphate buffer pH 7.4.

2 - - Standard moisturizing cream, acridone acetic acid 100 mcg/ml.

3 - - "Bioakneroll" anti-acne mask-concentrate with acridone acetic acid 100 mcg/ml.

4 - - "Bioakneroll Postbiotics" face booster concentrate with acridone acetic acid 100 mcg/ml.

5 - - "Anti-Age Revitalizing Eye Contour Cream" rejuvenating eye cream with acridone acetic acid 100 mcg/ml.

Exposure, min	**Control, Acridoneacetic Acid Solution 100 µg/mL**	**Experiment, Anti-Acne Mask-Concentrate "Bioakneroll" with Acridonacetic Acid 100 µg/ml, % increase in transdermal permeability**
	Peak Area of Extracted Acridonacetic Acid, M ± SE	
3	10008000 ± 174193 (100%)	39030900 ± 383626 (390%)
10	13778100 ± 2005360 (100%)	45415800 ± 7452780 (330%)

Table 1: The area of the HPLC peaks of acridone acetic acid extracted from the skin after topical exposure to the anti-acne concentrate mask "Bioakneroll," containing 100 mcg/mL of acridone acetic acid.

Exposure min	**Control, Acridoneacetic Acid Solution 100 µg/mL**	**Experiment, Bioakneroll Postbiotics Facial Booster Concentrate with Acridonacetic Acid 100 µg/ml, % increase in transdermal permeability**
	Peak area of extracted acridoleacetic acid, M ± SE	
3	10008000 ± 174193 (100%)	24996900 ± 881652 (250%)
10	13778100 ± 2005360 (100%)	24566000 ± 3642836 (180%)

Table 2: Area of HPLC peaks of acridonacetic acid extracted from the skin after dermal exposure to Bioakneroll Postbiotics facial booster concentrate containing acridonacetic acid 100 µg/ml.

Exposure, min	Control, Acridoneacetic Acid Solution 100 µg/mL	Experiment, Anti-Age Revitalizing Ye Countur Cream with Acridonacetic Acid 100 µg/ml, % increase in transdermal permeability
	Peak Area of Extracted Acridonacetic Acid, M ± SE	
3	10008000 ± 174193 (100%)	49441100 ± 8001416 (490%)
10	13778100 ± 2005360 (100%)	74693500 ± 9210670 (540%)

Table 3: Area of HPLC peaks of acridoneacetic acid extracted from the skin after skin exposure to Anti-Age Revitalizing Ye Countur Cream containing acridoneacetic acid 100 µg/ml.

Discussion

As can be seen from the results presented, the acridone acetic acid solution has low transdermal permeability. A standard facial moisturizer also has low transdermal permeability. The amount of acridone-2-acetic acid extracted from the skin after applying a standard moisturizing cream containing 100 mcg/mL of acridone-2-acetic acid to the skin and exposing it for 10 minutes is practically the same as the control after applying an acridone-2-acetic acid solution to the skin. Cosmetic compositions "Bioakneroll" anti-acne mask-concentrate and "Bioakneroll Postbiotics" face booster-concentrate have higher transdermal permeability. The amount of acridone-acetic acid extracted from the skin after applying these cosmetic compositions containing acridone-acetic acid at a concentration of 100 mcg/mL is significantly higher than in the control after applying a solution of acridone-acetic acid at an equivalent concentration. Moreover, the values of acridone acetic acid extracted from the skin are higher when applying the fluorescently labeled cosmetic composition anti-acne mask-concentrate "Bioakneroll" (390 and 330%) than when applying the fluorescently labeled cosmetic composition facial booster-concentrate "Bioakneroll Postbiotics" (250 and 180%). The highest transdermal permeability was shown by the rejuvenating eye cream "Anti-Age Revitalizing Eye Contour Cream" (490 and 540%). We believe that the high transdermal permeability of Bioakneroll cosmetic compositions is linked to the supramolecular complex formation technology and the composition, which, thru a specially selected algorithm for introducing cosmetic components into the final cosmetic composition, forms multilayered 3D complexes of biologically active substances with bionavigational properties [16]. The "Anti-Age Revitalizing Eye Contour Cream" also contains cosmetic drones in the form of peptide structures with high transdermal permeability and vector delivery [15].

Conclusion

The method of incorporating the fluorescent probe acridone acetic acid into cosmetic compositions can be used for an integral assessment of the transdermal permeability of cosmetic compositions and for the search for the most effective delivery agents for various biologically active substances into the skin.

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