WORLD JOURNAL OF PHARMACEUTICAL RESEARCH
Coden USA: WJPRAP Impact Factor 8.63
Volume 15, Issue 19, 1228-1234. Review Article ISSN 2277–7105

PREPARATION AND CHARACTERIZATION OF A PIOGLITAZONE HYDROCHLORIDE TOPICAL ANTI-AGING COSMECEUTICAL CREAM

Swarnali Das Paul[1], Ankita Damahe[1*]

Department of Pharmaceutics, Shri Shankaracharya College of Pharmaceutical Sciences, Shri Shankaracharya Professional University, Bhilai, Chhattisgarh - 490020, India.

Article Received on 21 Aug. 2026,
Article Revised on 11 Sept. 2026,
Article Published on 01 Oct. 2026

https://doi.org/10.5281/zenodo.24274436

***Corresponding Author**

Ankita Damahe

Department of Pharmaceutics, Shri Shankaracharya College of Pharmaceutical Sciences, Shri Shankaracharya Professional University, Bhilai, Chhattisgarh – 490020, India.

How to cite this Article: Swarnali Das Paul[1], Ankita Damahe[1*] (2026). Preparation And Characterization Of A Pioglitazone Hydrochloride Topical Anti-Aging Cosmeceutical Cream. World Journal of Pharmaceutical Research, 15(19), 1228–1234
This work is licensed under Creative Commons Attribution 4.0 International license.

ABSTRACT

Ultraviolet B (UVB)-induced skin damage is associated with oxidative stress, altered skin architecture and changes in extracellular-matrix organization. Topical formulations containing anti-aging activity may help limit these changes. Objective is to develop and characterize a pioglitazone hydrochloride (PGZ)-containing topical cream using a structured cream-base.

KEYWORDS: Pioglitazone hydrochloride; Topical cream; Cosmeceutical; UVB; Oxidative stress; Skin aging; Formulation optimization.

1. INTRODUCTION

Skin aging reflects the combined effects of intrinsic biological processes and extrinsic exposures, particularly ultraviolet radiation. Photoaging may present with roughness, dryness, laxity, wrinkles and changes in pigmentation, while chronic UV exposure can alter epidermal and dermal structure. UVB exposure contributes to reactive oxygen species generation and oxidative injury, which can disturb endogenous antioxidant defenses and promote lipid peroxidation. Such biochemical changes may occur alongside tissue thickening, inflammatory changes and remodeling of dermal connective tissue. Topical cosmeceutical systems offer a practical means of delivering active ingredients to the skin while also providing emolliency and supporting the skin surface. Cream performance

depends on the composition and proportions of the oil phase, structuring agents and aqueous phase, which influence consistency, spreadability, pH, release and user acceptability. Systematic design-of-experiments approaches can help screen formulation variables and select a base with appropriate physical properties. Skin is the largest organ of the human body and serves as a protective barrier against environmental pollutants, ultraviolet (UV) radiation, microorganisms, and chemical irritants. In addition to its protective functions, the skin contributes to thermoregulation, sensory perception, immune defence, and maintenance of body fluid balance. With increasing age, the skin undergoes progressive structural, biochemical, and physiological changes that affect its appearance, elasticity, hydration, and barrier function. Skin aging is a complex biological process influenced by intrinsic factors, including genetic predisposition, hormonal changes, and cellular senescence, as well as extrinsic factors such as UV radiation, air pollution, smoking, and lifestyle-related oxidative stress. These processes contribute to wrinkles, uneven pigmentation, reduced elasticity, dryness, and alterations in skin texture. Consequently, the development of topical formulations capable of supporting skin integrity and addressing the underlying mechanisms of skin aging has become an important area of pharmaceutical and cosmeceutical research.[1,2] Intrinsic skin aging occurs naturally over time and is associated with reduced cellular turnover, diminished fibroblast activity, altered extracellular matrix synwork, and gradual impairment of the skin barrier. In contrast, extrinsic aging, particularly photoaging, results primarily from chronic exposure to environmental stressors, especially ultraviolet A (UVA) and ultraviolet B (UVB) radiation. UVA penetrates deeply into the dermis and promotes oxidative damage, whereas UVB predominantly affects the epidermis and contributes to direct DNA injury and inflammatory responses. Both forms of radiation can stimulate the production of reactive oxygen species (ROS), activate inflammatory signalling pathways, and increase the expression of matrix metalloproteinases (MMPs).

Skin aging is a complex biological process characterized by oxidative stress, reduced fibroblast activity, decreased collagen synthesis, and increased degradation of extracellular matrix (ECM) components, particularly collagen and elastin. These alterations contribute to loss of skin firmness, reduced elasticity, wrinkle formation, and impaired skin integrity. Oxidative stress further accelerates cellular senescence and inflammatory responses, leading to progressive deterioration of dermal structure.[3–5] Conventional anti-aging strategies include moisturizers, sunscreens, retinoids, antioxidants, and peptides. Although these approaches offer benefits in improving skin hydration, barrier function, collagen synthesis,

and protection against oxidative damage, their effectiveness may be influenced by formulation characteristics, skin penetration, stability, and tolerability. Consequently, research has increasingly focused on alternative bioactive compounds and novel topical formulations with potential antioxidant, anti-inflammatory, and skin-protective properties.[6–8] In this context, cosmeceuticals have emerged as promising formulations incorporating biologically active ingredients intended to improve skin appearance and function. Their development requires systematic assessment of physicochemical properties, stability, skin compatibility, and relevant biological activities to establish their potential efficacy and safety. Pioglitazone hydrochloride, through its interaction with peroxisome proliferator-activated receptor (PPAR) signalling, represents an investigational candidate for exploring novel topical approaches to skin aging. Therefore, evaluating its potential in a suitable topical formulation may provide insights into alternative strategies for maintaining skin health and addressing age-associated changes.[9,10] Pioglitazone hydrochloride is a synthetic thiazolidinedione derivative primarily used in the management of type 2 diabetes mellitus. Its pharmacological activity is mediated through the activation of peroxisome proliferator-activated receptor gamma (PPARγ), a nuclear receptor involved in regulating glucose and lipid metabolism, cellular differentiation, and inflammatory responses. The presence of functional PPARγ signalling in skin cells has generated interest in exploring its potential dermatological applications beyond its established metabolic effects.[11] PPARγ plays an important role in maintaining skin homeostasis by regulating keratinocyte differentiation, epidermal lipid metabolism, and inflammatory responses. It may influence the expression of structural proteins, including involucrin, loricrin, and filaggrin, as well as the formation of the epidermal lipid barrier. Furthermore, PPARγ-mediated signalling has been investigated for its potential involvement in controlling oxidative stress and inflammatory processes, which are associated with extracellular matrix degradation and age-related skin deterioration.[12,13] Considering these biological functions, pioglitazone hydrochloride represents an investigational candidate for topical cosmeceutical formulation development. Its proposed application is based on the hypothesis that local PPARγ modulation may influence epidermal barrier integrity, skin hydration, and inflammatory responses. However, its potential anti-aging benefits, topical effectiveness, skin compatibility, and systemic absorption require systematic experimental evaluation before any therapeutic or cosmetic claims can be established.

The development of topical pioglitazone hydrochloride requires careful evaluation of its skin compatibility and safety, as its established oral use does not necessarily confirm the suitability of repeated topical application. Topical drug delivery offers advantages for localized treatment; however, drug release, skin penetration, and permeation are influenced by the physicochemical properties of the drug, formulation composition, and the barrier function of the stratum corneum. Therefore, systematic formulation development and characterization are essential to establish the pharmaceutical quality and potential dermatological applicability of the preparation.[14,15] Based on the biological relevance of PPARγ signalling in epidermal homeostasis, lipid metabolism, and inflammatory regulation, the present study aimed to develop and characterize a pioglitazone hydrochloride-loaded topical cream for exploratory evaluation of its potential anti-aging applications. The formulation was designed using stearic acid, shea butter, avocado oil, and geranium essential oil as selected components of the cream base. Pioglitazone hydrochloride was incorporated at three different concentrations (1.0%, 1.5%, and 2.0%) to prepare formulations CB5E4C1, CB5E4C2, and CB5E4C3, respectively. The developed formulations were subjected to physicochemical characterization and stability-related evaluation to assess their suitability for further investigation. The findings are expected to provide preliminary evidence supporting the development of topical pioglitazone hydrochloride formulations and guide future studies on their skin compatibility, drug release, penetration, and biological activity.

2. MATERIALS AND METHODS

Formulation of cream with essential oil

Cream bases were prepared using stearic acid (8.5 g), shea butter (8.5g), and avocado oil (11.5 mL). Citric acid and distilled water were included as described in the work. The cream was prepared by a fusion method: the aqueous phase was heated, the oil/wax components were melted separately, and the phases were combined under homogenization at approximately 1500–1700 rpm for 15 min, followed by cooling. The base was combined with geranium essential oil 1.5% in the screening formulations. Geranium oil at 1.5% was used for the final drug-loaded at 2.0% PGZ as CB5E1 with the geranium oil and base ingredients held constant.

Table 1: Drug loaded formulations.

S. No.	Ingredients	CB5E1
1.	Drug	2.00%
2.	Geranium Essential Oil	1.50%

3.	Stearic Acid	8.5 g
4.	Shea Butter	8.5 g
5.	Avocado Oil	11.5 ml

Characterization of Prepared Cream Formulation

pH Determination

The pH of each cream formulation was measured using a calibrated digital pH meter. Measurements were performed in triplicate, and results were expressed as mean values.

Spreadability

Approximately 350 mg of cream was placed between two glass plates (10 × 5 cm). The upper plate was dropped from a height of 5 cm, and the diameter of the spread cream was measured after 1 min. The test was performed in triplicate.

Viscosity

The viscosity of the cream was measured using a Brookfield CAP 2000+ viscometer at 50 rpm. Results were recorded in centipoise (cP), and measurements were performed in triplicate.

Zeta Potential

The zeta potential of the dispersed formulation was determined using a Malvern instrument to assess the surface charge and potential colloidal stability of the dispersed particles.

Physicochemical Characterization of the Cream Formulations

The physicochemical evaluation demonstrated differences in pH, spreadability, and viscosity of prepared cream formulation CB5E1. These properties are important quality attributes because they influence application characteristics, patient acceptability, drug distribution, and the physical performance of topical preparations. The pH values ranged as 6.67 ± 0.01 for CB5E1, indicating that the formulation were mildly acidic to near-neutral. Although these values were slightly above the commonly reported skin-surface pH range of approximately 4.5–6.5, they were relatively close to the upper end of that range. Therefore, the pH results suggest preliminary compatibility with topical application, but they do not independently establish skin safety or suitability for long-term use. Spreadability increased progressively as 4.9 ± 0.12 cm for CB5E1. The higher spreadability of indicated that it could be distributed more readily over the skin under the specified test conditions. Adequate spreadability is particularly important for topical anti-aging formulations because it facilitates uniform

application over the treated area and may improve user acceptability. The viscosity values found as 4513.3 cps for CB5E1. The higher viscosity of CB5E1 suggested a comparatively thicker consistency, which may help the formulation remain at the application site. Nevertheless, viscosity alone cannot establish physical stability or prolonged skin residence, particularly because cream systems often exhibit non-Newtonian flow behaviour. Among the tested formulations, CB5E1 exhibited the highest pH, spreadability, and viscosity. Its combination of improved spreadability and comparatively high viscosity suggested a favourable balance between ease of application and consistency. These characteristics supported its selection as the optimized formulation for subsequent investigations.

3. CONCLUSION

The present study successfully explored the development and preliminary physicochemical characterization of a pioglitazone hydrochloride-loaded topical cream for potential cosmeceutical and anti-aging applications. The formulation was designed based on the biological relevance of PPARγ signaling in epidermal homeostasis, lipid metabolism, and inflammatory regulation. A cream base containing stearic acid, shea butter, and avocado oil was developed using the fusion method, with geranium essential oil incorporated as an additional formulation component. Among the prepared formulations, CB5E1, containing 2.0% pioglitazone hydrochloride and 1.5% geranium essential oil, demonstrated favourable physicochemical characteristics, including a pH of 6.67 ± 0.01, spreadability of 4.9 ± 0.12 cm, and viscosity of 4513.3 cP. These findings indicated a satisfactory balance between consistency and ease of application, supporting its selection as the optimized formulation for further investigation. Overall, the study provides a preliminary foundation for the development of pioglitazone hydrochloride-based topical cosmeceutical preparations. However, further investigations involving drug release, skin permeation, stability, dermal irritation, and relevant antioxidant, anti-inflammatory, and anti-aging activities are necessary to establish its safety, efficacy, and potential dermatological applicability.

4. REFERENCES

1. Fisher GJ, Kang S, Varani J, Bata-Csorgo Z, Wan Y, Datta S, et al. Mechanisms of photoaging and chronological skin aging. Arch Dermatol, 2002; 138(11): 1462–70. doi:10.1001/archderm.138.11.1462.
2. Rittié L, Fisher GJ. UV-light-induced signal cascades and skin aging. Ageing Res Rev, 2002; 1(4): 705–20. doi:10.1016/S1568-1637(02)00024-7.

3. Fisher GJ. The pathophysiology of photoaging of the skin. Cutis, 2005; 75(2 Suppl): 5–8.
4. Quan T, Qin Z, Xia W, Shao Y, Voorhees JJ, Fisher GJ. Matrix-degrading metalloproteinases in photoaging. J Investig Dermatol Symp Proc, 2009; 14(1): 20–4. doi:10.1038/jidsymp.2009.8.
5. Fisher GJ, Wang ZQ, Datta SC, Varani J, Kang S, Voorhees JJ. Pathophysiology of premature skin aging induced by ultraviolet light. N Engl J Med, 1997; 337(20): 1419–28. doi:10.1056/NEJM199711133372003.
6. Mukherjee S, Date A, Patravale V, Korting HC, Roeder A, Weindl G. Retinoids in the treatment of skin aging: an overview of clinical efficacy and safety. Clin Interv Aging, 2006; 1(4): 327–48. doi:10.2147/ciia.2006.1.4.327.
7. Pullar JM, Carr AC, Vissers MCM. The roles of vitamin C in skin health. Nutrients, 2017; 9(8): 866. doi:10.3390/nu9080866.
8. Rawlings AV, Harding CR. Moisturization and skin barrier function. Dermatol Ther, 2004; 17 Suppl 1: 43–8.
9. Draelos ZD. The cosmeceutical realm. Clin Dermatol, 2008; 26(6): 627–32.
10. Barel AO, Paye M, Maibach HI, editors. Handbook of cosmetic science and technology. 4th ed. Boca Raton: CRC Press; 2014.
11. Ahmadian M, Suh JM, Hah N, Liddle C, Atkins AR, Downes M, et al. PPARγ signaling and metabolism: the good, the bad and the future. Nat Med, 2013; 19(5): 557–66. doi:10.1038/nm.3159.
12. Schmuth M, Jiang YJ, Dubrac S, Elias PM, Feingold KR. Thematic review series: skin lipids. Peroxisome proliferator-activated receptors and liver X receptors in epidermal biology. J Lipid Res, 2008; 49(3): 499–509. doi:10.1194/jlr.R700017-JLR200.
13. Ramot Y, Mastrofrancesco A, Herczeg-Lisztes E, Biro T, Ay E, Julia M, et al. The role of PPARγ-mediated signalling in skin biology and pathology: new targets and opportunities for clinical dermatology. Exp Dermatol, 2015; 24(4): 245–51. doi:10.1111/exd.12647.
14. Ottaviani M, et al. New insights into the role of PPARγ in skin physiopathology. Int J Mol Sci, 2024; 25. doi:10.3390/ijms25137300.
15. Schmuth M, Haqq CM, Cairns WJ, Holder JC, Dorsam S, Chang S, et al. Peroxisome proliferator-activated receptors and liver X receptors in epidermal biology. J Lipid Res, 2008; 49(3): 499–509. doi:10.1194/jlr.R700017-JLR200.