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FORMULATION AND EVALUATION OF TOPICAL SKIN HYDRATION CREAM USING HYALURONIC ACID

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ABSTRACT

The present study aims to formulate and evaluate a skin hydration cream incorporating hyaluronic acid as a key active ingredient. Hyaluronic acid, a naturally occurring biopolymer, is known for its exceptional ability to retain moisture and enhance skin elasticity. The formulation was developed using an oil-in-water (O/W) emulsion base containing suitable excipients such as emulsifiers, humectants, emollients, and preservatives. Different formulations were prepared and evaluated for physicochemical properties including pH, viscosity, spreadability, homogeneity, appearance, and stability. The optimized formulation demonstrated desirable texture, good spreadability, non-greasy feel, and effective absorption upon topical application. Stability studies indicated no significant changes in color, odor, or consistency over the test period. Evaluation of the moisturizing efficacy revealed that the cream significantly improved skin hydration levels compared with the control. The study concludes that hyaluronic acid-based cream is a promising formulation for enhancing skin moisture retention and maintaining healthy, supple skin.

INTRODUCTION

A drug delivery system (DDS) is a formulation or device designed to transport a therapeutic substance into the body in a controlled, targeted, and efficient manner. The primary goal of DDS is to optimize the safety and efficacy of drugs by regulating the rate, timing, and site of release. Conventional dosage forms often suffer from limitations such as poor solubility, rapid metabolism, systemic toxicity, and frequent dosing requirements, which can lead to reduced therapeutic effectiveness and patient non-compliance. To overcome these drawbacks, advanced drug delivery systems have been developed to ensure sustained, controlled, and site-specific release of active pharmaceutical ingredients (APIs).

Modern DDS have evolved significantly with advancements in polymer science, nanotechnology, biomedical engineering, and materials chemistry. These interdisciplinary innovations have led to the development of biodegradable polymers, nanoparticles, liposomes, transdermal systems, and implantable devices capable of enhancing drug stability and bioavailability. The integration of such systems has revolutionized the management of complex diseases, particularly in areas such as cancer, autoimmune disorders, and genetic deficiencies.

Drug delivery systems can be broadly classified into conventional, controlled, sustained, delayed, and targeted types, each designed to achieve specific therapeutic objectives. Among the most recent developments are nanotechnology-based carriers, stimuli-responsive systems, and gene and RNA delivery platforms, which enable precise and efficient transport of drugs across biological barriers. Additionally, 3D-printed and mucoadhesive drug delivery systems have introduced new opportunities for personalized and patient-centered treatment strategies.

Despite these advances, DDS development faces challenges including regulatory hurdles, formulation instability, scalability issues, and inter-individual variability in skin or tissue response. However, the future of drug delivery is promising, with ongoing research focused on intelligent, AI-assisted, and patient-specific systems that combine biotechnology, materials science, and digital monitoring. Such smart therapeutic platforms are expected to redefine precision medicine and enhance clinical outcomes through real-time, adaptive drug delivery.

The topical and transdermal drug delivery systems (TDDS) represent an important subset of modern DDS, offering non-invasive administration routes with localized or systemic therapeutic effects. The skin, being the largest organ of the body, serves as both a protective

barrier and a potential portal for drug transport. TDDS bypasses first-pass metabolism, improves patient compliance, and allows controlled release over extended periods. The understanding of skin structure, permeation pathways, and formulation design is therefore crucial for optimizing transdermal therapy. In recent years, innovations in nanotechnology, polymeric films, and penetration enhancers have further expanded the potential of topical delivery in both pharmaceutical and cosmetic applications.

Drug and Excipient Profile

Hyaluronic acid as the principal active pharmaceutical ingredient (API), selected for its superior moisturizing, anti-inflammatory, and wound-healing properties. Hyaluronic acid, a naturally occurring glycosaminoglycan, plays a vital role in maintaining skin hydration and elasticity by binding water molecules and stimulating collagen synthesis. Its biocompatibility and non-irritant nature make it ideal for dermatological and cosmetic formulations.

The formulation incorporated several excipients to enhance texture, stability, and therapeutic performance. Beeswax acted as a natural emollient and emulsifying agent, providing structural integrity and moisture retention. Mineral oil and paraffin wax functioned as occlusive moisturizers, reducing transepidermal water loss and improving skin softness. Cetyl alcohol served as a co-emulsifier and stabilizer, improving cream consistency and spreadability. Borax (sodium borate) was used as a buffering and emulsifying agent to maintain pH balance and formulation stability. Methylparaben served as an antimicrobial preservative to prevent microbial contamination and extend product shelf life.

METHODOLOGY

Glycerin and Hyaluronic acid as active pharmaceutical ingredients (APIs). These agents were selected for their proven moisturizing and skin-regenerative properties. The formulation also incorporated beeswax, mineral oil, paraffin wax, cetyl alcohol, borax, and purified water as excipients, serving as emollients, emulsifiers, stabilizers, and solvents to ensure the formation of a smooth, stable, and effective cream base.

The cream was prepared using the emulsion technique, wherein the oil and aqueous phases were prepared separately and heated to 70–75°C. The aqueous phase containing glycerin, hyaluronic acid, and borax solution was gradually added to the molten oil phase under continuous mechanical stirring at 1000–1500 rpm for 10–15 minutes to form a uniform emulsion. The formulation was then cooled slowly with gentle stirring to prevent air

entrapment and phase separation. The resulting cream was packed in clean, sterilized containers and stored at room temperature for further analysis.

Comprehensive pre-formulation and evaluation studies were carried out to assess the physicochemical and performance characteristics of the prepared formulations. These included determination of organoleptic properties, melting point, solubility, UV spectrophotometric analysis, and FTIR spectral studies for drug-excipient compatibility. Particle size and surface morphology were evaluated using Scanning Electron Microscopy (SEM), while zeta potential measurements were conducted to determine the stability of the dispersed system.

Physicochemical parameters such as pH, viscosity, spreadability, extrudability, homogeneity, saponification value, acid value, and drug content uniformity were evaluated to ensure quality and consistency. In vitro diffusion studies were performed using an egg membrane model to assess the drug release profile, and drug release kinetics were analyzed using zero-order, first-order, and Higuchi models to elucidate the mechanism of release.

Furthermore, the antimicrobial activity of the optimized formulation was assessed by the agar well diffusion method against Staphylococcus aureus (Gram-positive) and Escherichia coli (Gram-negative) to evaluate its efficacy against common skin pathogens. Finally, stability studies were performed following ICH guidelines under accelerated conditions (40°C ± 2°C / 75% RH ± 5% RH) for three months. Samples were periodically evaluated for changes in pH, viscosity, and appearance to confirm the formulation's stability.

RESULT AND DISCUSSION

Hyaluronic acid-based skin hydration cream was systematically evaluated for its physicochemical and functional characteristics. The organoleptic and solubility analyses confirmed that hyaluronic acid was a white to off-white, odorless crystalline powder, freely soluble in water, methanol, and ethanol, indicating suitability for topical use. Drug–excipient compatibility studies using ATR-FTIR spectra (Fig. 10.1–10.8) revealed that all characteristic peaks of hyaluronic acid remained unchanged, confirming no chemical interaction with excipients.

The UV-visible spectrophotometric analysis (Fig. 10.9–10.10) showed a linear calibration curve (R^2 = 0.995), confirming the accuracy of the quantitative method. Evaluation of six

formulations (F1–F6) demonstrated that formulation F5 exhibited an optimal pH of 5.3, viscosity of 6890 cps, excellent spreadability (13.80 g·cm/sec), and extrudability (32.05 g/cm²), all within acceptable limits for topical applications. No irritancy was observed during skin patch testing, confirming the formulation's dermatological safety showed an average particle size of 96.5 nm and a zeta potential of –56.8 mV, indicating strong electrostatic stability and uniform dispersion. The in vitro drug diffusion profile (Fig. 10.12) demonstrated sustained drug release, with formulation F5 achieving a maximum cumulative release of 92.88% at 240 minutes. This finding was further supported by ANOVA analysis, which confirmed statistically significant differences ($p < 0.05$) between formulations and time intervals.

Showed that formulation F5 best fit the Zero-order ($R^2 = 0.991$) and Higuchi models ($R^2 = 0.981$), indicating diffusion-controlled, constant drug release. The Korsmeyer–Peppas model ($n = 0.872$) suggested an anomalous non-Fickian diffusion mechanism. SEM images (Fig. 10.18) confirmed a smooth, homogenous surface morphology with evenly distributed microstructures, indicating excellent physical stability.

The antimicrobial activity graphs (Figs. 10.19–10.20) *demonstrated that formulation F5 exhibited strong inhibition zones against Staphylococcus aureus (25 mm) and Escherichia coli (19 mm) in a concentration-dependent manner, comparable to the standard drug. Stability studies (Table 10.16)* over three months under ICH conditions (40 °C ± 2 °C / 75% ± 5% RH) showed no significant changes in color, pH, viscosity, or spreadability, confirming long-term stability.

Overall, the results confirm that formulation F5 possesses optimal physicochemical, antimicrobial, and release characteristics, making it a stable, safe, and effective topical cream for skin hydration and scar management.

SUMMARY AND CONCLUSION

Hyaluronic acid-based topical cream formulated for enhanced skin hydration and scar management. Hyaluronic acid, selected as the active ingredient, demonstrated excellent solubility, compatibility, and stability with other excipients. The optimized formulation (F5) showed favorable physicochemical characteristics with a pH of 5.3, viscosity of 6890 cps, spreadability of 13.80 g·cm/sec, and extrudability of 32.05 g/cm², all of which are ideal for

topical applications. No irritation was observed during dermatological testing, confirming its skin safety and suitability for regular use.

The particle size (96.5 nm) and zeta potential (–56.8 mV) results indicated nanoscale dispersion and excellent electrostatic stability, which enhance drug penetration and sustained action on the skin. In-vitro diffusion studies demonstrated a maximum cumulative release of 92.88% within four hours, following Zero-order kinetics ($R^2 = 0.991$) and Higuchi diffusion model ($R^2 = 0.981$), suggesting a steady and controlled release mechanism.

The antimicrobial evaluation revealed strong dose-dependent activity against Staphylococcus aureus (25 mm) and Escherichia coli (19 mm), confirming its dual moisturizing and antibacterial potential. SEM imaging confirmed a smooth, homogeneous structure with evenly distributed microparticles, ensuring stability and uniformity. Stability studies, conducted for three months under ICH accelerated conditions (40 ± 2 °C / 75 ± 5% RH), showed no significant variation in physical appearance, pH, or viscosity, indicating excellent formulation stability.

In conclusion, the Hyaluronic acid cream (F5) demonstrated optimal physicochemical, microbiological, and performance characteristics. It provides sustained hydration, antibacterial protection, and long-term stability, making it a promising candidate for dermatological and cosmeceutical applications. The formulation's proven efficacy, safety, and scalability suggest strong potential for further clinical evaluation and commercial development.

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