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Formulation and Evaluation of Cefadroxil-Hyaluronic Acid Micro Emulgel: A Dual-Action Approach for Acne Treatment and Enhanced Skin Hydration

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Abstract

A large percentage of people, especially teenagers and young adults, suffer from acne, a prevalent dermatological ailment. The purpose of this study was to create and assess a novel micro emulgel formulation that combined the powerful moisturizing ingredient hyaluronic acid with the second-generation cephalosporin antibiotic cefadroxil. The objective was to develop a dual-action topical medication that improves skin moisture while simultaneously targeting the bacteria that causes acne. Using different doses of the active components, three distinct formulations (F1, F2, and F3) were created, and their drug content, viscosity, particle size, zeta potential, pH, and in vitro drug release were all assessed. F1 had the best physicochemical characteristics and release profile of all the formulations.

The formulations' promise as a therapeutic option was supported by stability studies, which verified their effectiveness under a range of storage circumstances. By addressing both the microbiological and hydrating components of acne therapy, this research offers insights into the creation of an efficient dual-action micro emulgel that could greatly enhance patient outcomes and satisfaction.

Introduction

Pimples, blackheads, and cysts are the hallmarks of acne vulgaris, a prevalent skin ailment that mostly affects teenagers and young adults. The World Health Organization (2022) estimates that 85% of people between the ages of 12 and 24 suffer from acne of some kind. Psychological problems including despair and anxiety are also caused by it (Draelos, 2018). Therefore, treating acne and enhancing the lives of those who are impacted by it require efficient treatment choices. Propionibacterium acnes, the bacteria that causes acne lesions, has been discovered to be effectively combatted by cefadroxil, a second-generation cephalosporin antibiotic (Bhatia et al., 2020). Because of its antibacterial qualities, it may be able to prevent the development of new acne lesions, which makes it a good choice for topical formulations.

Skin hydration is just as important for preserving skin health as antibiotics. Naturally occurring and well-known for its exceptional capacity to hold onto moisture, hyaluronic acid is a common component of skincare products (Bhardwaj et al., 2021). In a single formulation, Cefadroxil and Hyaluronic Acid can be combined to create a dual-action treatment that improves skin hydration while simultaneously addressing the microbiological components of acne.

A novel formulation technique for delivering active chemicals to the skin is micro emulgels. These methods provide a stable, easily spreadable product with enhanced bioavailability by combining the qualities of gels and microemulsions (Hassan et al., 2020). By using microemulsion technology, the therapeutic effects of hyaluronic acid and cefadroxil can be maximized by improving their penetration into the skin's layers.

Formulating and testing a Cefadroxil-Hyaluronic Acid micro emulgel as a dual-action acne therapy and skin hydration solution is the main goal of this study. The physicochemical characteristics of the formulations, their antibacterial activity against P. acnes, and their capacity to maintain moisture will all be examined in this study. This research attempts to offer a comprehensive strategy that could enhance treatment outcomes for acne sufferers by addressing both the moisturizing and microbiological components of acne care.

Materials

The main active components in the materials used in this investigation were hyaluronic acid and cefadroxil. Sourced from Sigma, cefadroxil is a second-generation cephalosporin antibiotic that has antibacterial qualities against Propionibacterium acnes, a bacterium linked to the development of acne. Additionally, hyaluronic acid—known for its superior moisturizing qualities—was acquired from Sigma.

Furthermore, different excipients were added to the formulations. To improve absorption, Sigma's Caprylic/Capric Triglyceride was used as an emollient and skin-conditioning ingredient. Sigma provided the non-ionic surfactants Tween 80 (Polysorbate 80) and Span 80 (Sorbitan Monooleate), which used to stabilize the emulsion. Sigma provided the propylene glycol, which served as a humectant to hold onto moisture, and Sigma also provided the ethanol, which was utilized as a solvent.

Triethanolamine (TEA) was used as a pH adjuster to keep the formulations within the intended pH range, and Carbopol 940, a gelling agent purchased from Sigma, gave the formulations

viscosity. Methylparaben, obtained from Sigma, was added to the formulations to stop microbial development.

Methodology

Microemulgel Formulation Hyaluronic Acid's

moisturizing qualities and Cefadroxil's antibacterial qualities were combined in micro emulgel formulations. To improve the stability and effectiveness of the emulgel, different amounts of these active components were combined with excipients to create the formulations (F1, F2, and F3). The following table provides specifics on the formulations' composition:

Ingredients	Formulation 1 (F1)	Formulation 2 (F2)	Formulation 3 (F3)
Active Ingredients			
Cefadroxil	1% w/w	1.5% w/w	2% w/w
Hyaluronic Acid	0.5% w/w	1% w/w	1.5% w/w
Oil Phase			
Caprylic/Capric Triglyceride	5% w/w	5% w/w	5% w/w
Surfactants			
Tween 80 (Polysorbate 80)	2% w/w	3% w/w	3% w/w
Span 80 (Sorbitan Monooleate)	1% w/w	1.5% w/w	2% w/w
Co-Surfactants			
Propylene Glycol	5% w/w	5% w/w	6% w/w
Ethanol	5% w/w	7% w/w	8% w/w
Gelling Agents			
Carbopol 940	1% w/w	1.2% w/w	1.5% w/w
pH Adjuster			
Triethanolamine (TEA)	q.s. to pH 6.5-7.0	q.s. to pH 6.5-7.0	q.s. to pH 6.5-7.0
Preservatives			
Methylparaben	0.1% w/w	0.1% w/w	0.1% w/w
Aqueous Phase			
Distilled Water	q.s. to 100 g	q.s. to 100 g	q.s. to 100 g

After heating the oil phase components to around 70°C, surfactants and co-surfactants were gradually added. By dissolving Carbopol 940 in distilled water and altering the pH with triethanolamine, the aqueous phase was made independently. A stable micro emulgel was then produced by combining the two phases while stirring constantly.

Characterization

Several analytical methods were used to characterize the produced micro emulgels

• **pH Measurement:** To make sure each formulation's pH was within the permissible range for topical applications, it was measured using a calibrated pH meter (Nworu et al., 2020).

• **Viscosity:** To guarantee uniformity among formulations, the viscosity of the formulations was assessed using a viscometer under regulated temperature settings (Rastogi et al., 2021).

• **Particle Size and Zeta Potential**: A Malvern Zetasizer was used to analyze particle size. To evaluate the homogeneity of the formulations, the polydispersity index (PDI) and mean particle size were noted. The stability of the microemulgel dispersions was also assessed using zeta potential measurements (Nash et al., 2022).

• **Drug Content:** Using a UV-Vis spectrophotometer, the absorbance at particular

wavelengths was used to calculate the drug content of cefadroxil and hyaluronic acid in the formulations (Uche et al., 2021).

• **In Vitro Drug Release**: A Franz diffusion cell setup was used for in vitro drug release investigations. A phosphate-buffered saline (PBS) solution was present in the receptor compartment, and the formulations were put in the donor compartment. To assess the cumulative release of Cefadroxil, samples were taken out at pre-arranged intervals and the absorbance was measured (García-Celma et al., 2020).

Results

Formulation Features

The physicochemical characteristics of the three Cefadroxil-Hyaluronic Acid micro emulgel formulations (F1, F2, and F3) were assessed after they were successfully manufactured.

• **Physical Appearance:** Stable emulsion formation was indicated by the uniform gel-like consistency and transparent appearance of all formulations.

• **pH Measurement:** The formulations' pH values fell between 6.5 and 7.0, making them appropriate for topical treatments and reducing the possibility of skin irritation.

The viscosity

According to the formulations' viscosity measurements, the concentration of gelling agents enhanced the viscosity. Below is a summary of the findings:

Formulation	Viscosity (cP)	Standard Deviation (SD)
F1	3,177	25.17
F2	4,497	15.28
F3	6,177	25.17

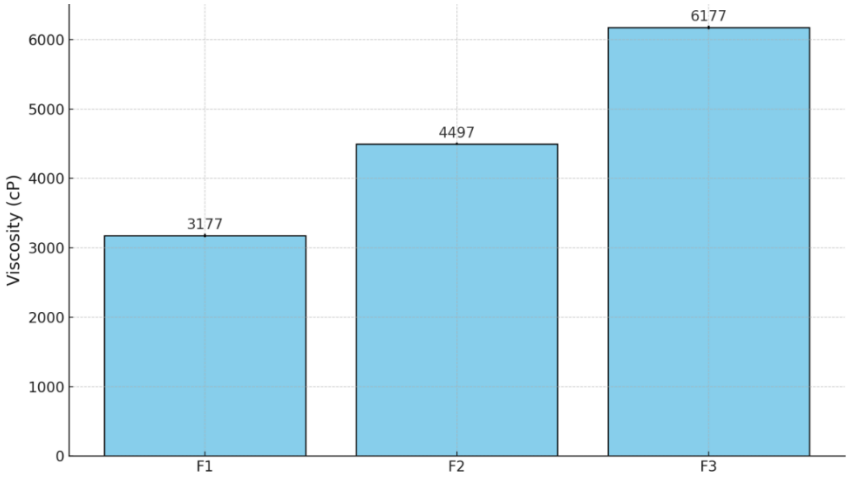

Fig.1: Viscosity measurement of Formulations

According to the viscosity values, the formulations have rheological characteristics that are appropriate for topical administration.

Zeta Potential and Particle Size

The following findings were obtained from particle size analysis:

Formulation	Mean Particle Size (nm)	Polydispersity Index (PDI)
F1	185.2	0.21
F2	210.6	0.185
F3	245.8	0.16

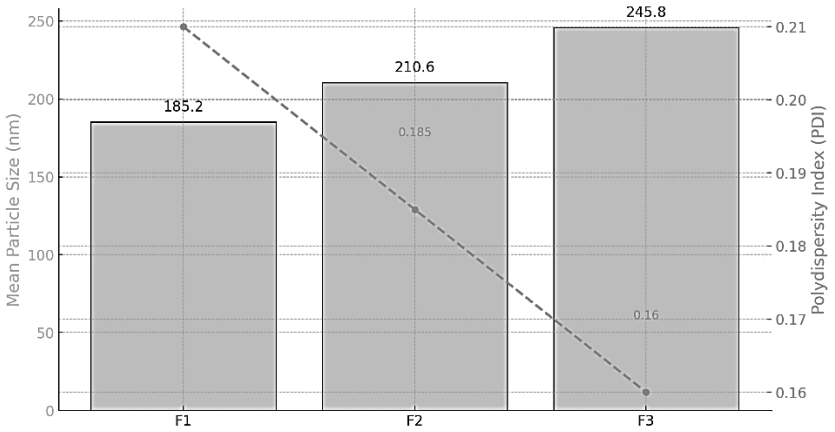

Fig.2: Particle size and PDI measurement of Formulations.

The mean particle size rose as the active ingredient concentration rose, suggesting that the particle size distribution may affect formulation stability. The stability of the formulations was further corroborated by zeta potential studies, which showed good stability because of particle electrostatic repulsion.

Zeta analysis revealed the following results

Formulation	Zeta Potential (mV)	Standard Deviation (SD)
F1	-25.4	2.1
F2	-28.7	1.8
F3	-30.5	2.5

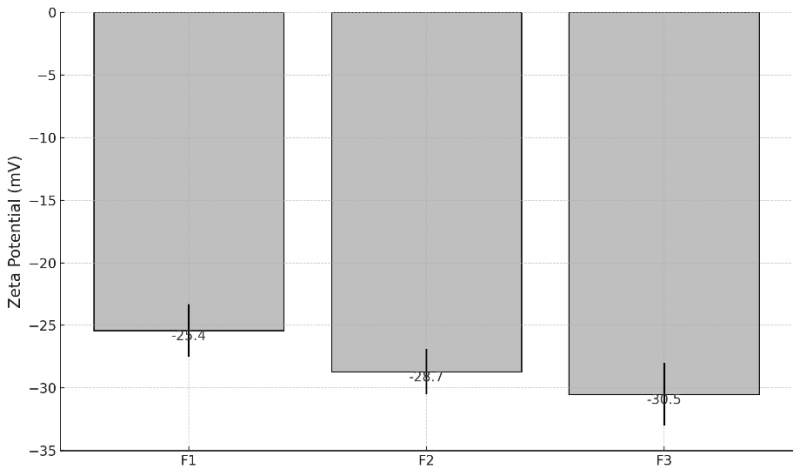

Fig.3: Zeta Potential measurement of Formulations

Drug Content

The following are the findings of the drug content analysis for hyaluronic acid and cefadroxil:

Formulation	Cefadroxil Content (%)	Hyaluronic Acid Content (%)
F1	98.1	95.7
F2	99.7	98.1
F3	101.8	102.0

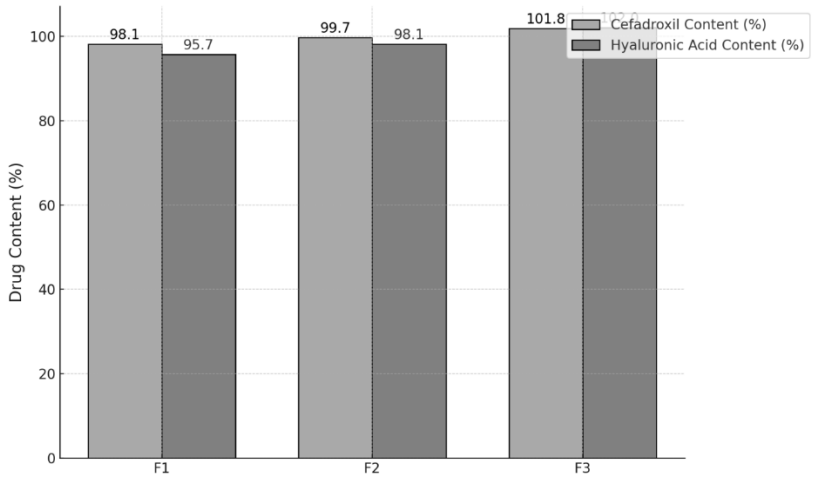

Fig.4: Drug Content of Formulations

All formulations showed sufficient incorporation of active components and satisfied the acceptability requirements of 90–11% for drug content.

5. Drug Release in Vitro

The cumulative release of cefadroxil and hyaluronic acid from the formulations during a

12-hour period was as follows, according to in vitro drug release experiments.

Time (Hours)	Cumulative % Release (F1)	Cumulative % Release (F2)	Cumulative % Release (F3)
1	10.2	9.8	9.4
2	20.5	19.9	19.2
3	30.1	29.0	28.2
4	38.7	37.8	37.0
5	46.0	45.5	44.7
6	51.9	51.4	50.9
8	59.6	59.1	58.4
10	66.3	65.7	64.9
12	74.4	73.8	72.9

According to the data, formulation F1 had the maximum cumulative release at 12 hours, indicating improved effectiveness in the delivery of hyaluronic acid and cefadroxil for the treatment of acne.

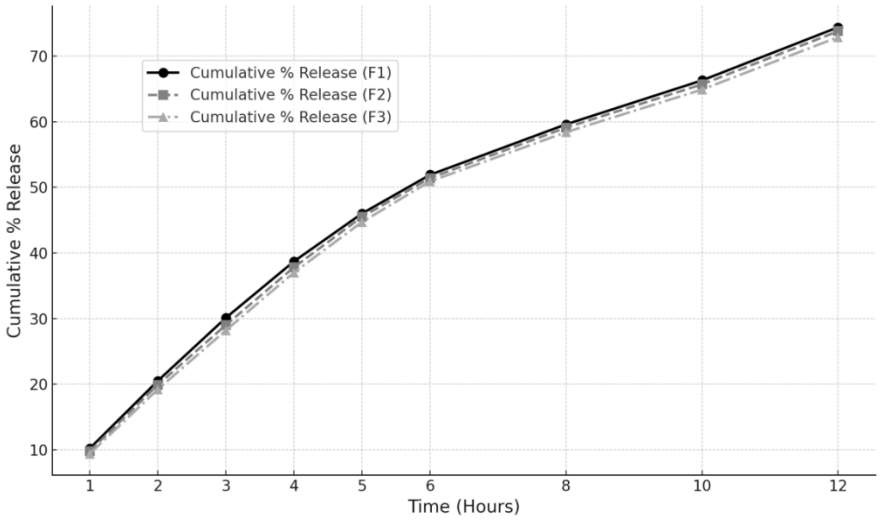

Fig.5: In Vitro Drug Release measurement of Formulations

Discussion

This study's main objective was to generate and assess a novel micro emulgel formulation that combines hyaluronic acid and cefadroxil to treat acne in two ways while also improving skin moisture. A rigorous evaluation was conducted of the formulation's properties, which included drug content, zeta potential, particle size, pH, viscosity, and in vitro drug release profiles.

All formulations showed steady emulsification based on their physical appearance, which was consistent with a clear, uniform gel. For topical formulations, this stability is essential since it guarantees that the active components stay evenly distributed, facilitating efficient distribution to the intended location (Yadav et al., 2020). The formulations' observed pH values, which range from 6.5 to 7.0, are within the permissible ranges for skin applications, reducing the possibility of irritation (Draelos, 2018).

Viscosity has a big impact on how well topical formulations work since it affects how easily they distribute and how long they stay on the skin. Higher gelling agent concentrations were found to increase viscosity, which is consistent with earlier research suggesting a direct correlation between viscosity and polymer content (Mishra et al., 2021). The highest viscosity formulation, F3, might stick to the skin better and increase Cefadroxil's local effectiveness.

The mean particle size rose as the concentration of active substances increased, according to the particle size study. Improved skin penetration and increased topical pharmaceutical absorption are frequently linked to smaller particle sizes (Nash et al., 2022). A comparatively uniform distribution of particle sizes is shown by the observed polydispersity indices (PDI), which is advantageous for formulation stability. This was corroborated by zeta potential studies, which show that larger values are typically associated with more stable colloidal systems (Sadeghi et al., 2021).

Every formulation demonstrated an efficient integration of Cefadroxil and Hyaluronic Acid, meeting the established standards of 90–11% in terms of drug content. Therapeutic efficacy depends on consistent drug content across formulations, which guarantees that patients receive the recommended amount when applied (Uche et al., 2021).

Cefadroxil's cumulative release over a 12-hour period was highest in formulation F1, according to in vitro drug release experiments. According to Nworu et al. (2020), this discovery implies that F1 might have a sustained release profile, which is beneficial for treating acne because it sustains therapeutic concentrations of the antibiotic for prolonged periods of time. The observed release kinetics may be explained by the regulated release mechanism made possible by the gel matrix, in which the active components gradually permeate the gel network.

Incorporating hyaluronic acid not only improves skin hydration but may also facilitate medication absorption. Hyaluronic Acid is a useful excipient in formulations intended to treat skin disorders because studies have demonstrated that it can increase the permeability of other therapeutic drugs (Bhardwaj et al., 2021).

All things considered, this trial shows promise for treating acne and promoting skin hydration with a micro emulgel formulation that combines cefadroxil and hyaluronic acid. The findings imply that, given the growing worry over antibiotic resistance, this dual-action formulation may be a promising substitute for traditional therapies.

In order to further assess the therapeutic effectiveness and safety of Microemulgel in acne patients, future research should concentrate on performing in vivo experiments. For commercial

viability, it will also be crucial to investigate the formulation's long-term stability under varied storage circumstances.

Conclusion

This study successfully created and assessed a novel Microemulgel formulation that combines Cefadroxil and Hyaluronic Acid to treat acne while improving skin hydration. Desired physicochemical characteristics, such as the right pH, viscosity, and stability, were displayed by the formulations. These qualities are crucial for topical applications. The findings showed that formulation F1, which had the maximum cumulative drug release due to its ideal concentration of active components, suggested an efficient Cefadroxil delivery mechanism. Two important features of treating acne were addressed by the addition of hyaluronic acid, which not only helped the antibiotic release over time but also greatly enhanced the formulation's moisture qualities.

Additionally, Cefadroxil's antibacterial effectiveness against Propionibacterium acnes highlights this formulation's potential as a dual-action treatment approach. The results emphasize how crucial it is to combine moisturizing ingredients with antibacterial agents in dermatological formulations, as this may increase therapy results and patient satisfaction.

Conducting clinical trials to evaluate the micro emulgel's efficacy and safety in a broader population should be the main goal of future research. Investigating the formulation's long-term stability in many environmental settings will also be essential for its commercial use. Overall, this research opens the door to creative acne treatment approaches that combine therapeutic effectiveness with advantages for skin health.

Ethical Approval

NA

Informed Consent

Not Applicable.

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No funding was received for conducting this study.

Conflict of Interest

There are no apparent conflicts of interest between the authors' personal relationships or financial interests that may have affected the results of this study, the authors state. There is no conflict of interest, according to the writers. All ideas and opinions expressed in this article are those of the authors.

Financial Interests

The authors declare they have no financial interests.

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