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Original Article

Development and Assessment of Aceclofenac Gel-Based Topical Formula

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ABSTRACT

Emulgel is an advanced drug delivery system that combines emulsion and gel for controlled topical release. Incorporating emulsion into a gel base enhances stability. Aceclofenac, a non-steroidal anti-inflammatory drug, is widely used for rheumatoid arthritis and osteoarthritis. This study aimed to develop and assess an aceclofenac emulgel to improve skin penetration compared to existing formulations. Five gelling agents—Carbopol 934, HPMC, Na CMC, and sodium alginate—were used. Drug release was tested via dialysis membrane, with all formulations exhibiting good physical properties. Among them, Carbopol 934 demonstrated the highest drug release efficiency.

Keywords: Aceclofenac, Topical Drug Delivery System, Emulgel, Carbopol 934, Hydroxyl Propyl Methyl Cellulose, Sodium Carboxyl Methyl Cellulose, Sodium Alginate

INTRODUCTION

Over the past several decades, various drug administration methods have been utilized to treat illnesses, including oral, sublingual, rectal, and parenteral routes. However, topical drug delivery systems have emerged as a valuable alternative, particularly in cases where conventional administration methods prove ineffective or for treating localized skin conditions such as fungal infections [1]. The application of drugs directly to the skin allows for a more targeted therapeutic approach in managing dermatological disorders [2]. Topical drug delivery has gained widespread acceptance due to its ability to circumvent several drawbacks associated with oral administration. These include first-pass metabolism, gastrointestinal irritation, and enzymatic degradation, which often reduce the bioavailability of orally administered drugs. Studies indicate that only 25-45% of an orally ingested drug effectively reaches systemic circulation due to presystemic metabolism. To overcome these limitations, gel-based formulations have been explored as an effective alternative for topical drug application [3]. This delivery method involves applying a drug-containing formulation directly to the skin to treat specific dermatological conditions. A variety of dermatological products exist, differing in formulation and consistency, ranging from liquids to powders. However, semisolid preparations, including ointments, creams, pastes, and gels, are the most commonly used. Among these, topical gel formulations offer significant advantages as they provide an efficient drug delivery system while being less greasy and easily washable from the skin, enhancing patient compliance and therapeutic effectiveness [4]. The percutaneous absorption of drugs from topical formulations is a complex process that involves the release of the drug from its formulation and its subsequent penetration through the skin to reach the intended target tissues. The efficiency of this process is influenced by several factors, primarily the physicochemical characteristics of both the drug and the vehicle used in the formulation. The ability of a drug to permeate through the skin depends on its solubility, molecular size, and partition coefficient, along with the formulation's composition and interaction with the skin barrier [5]. To enhance drug permeation through the skin, various strategies have been explored, including the selection of an appropriate formulation vehicle and the use of chemical penetration enhancers. These approaches help to optimize drug delivery by modifying the interaction between the formulation and the skin layers. Effective topical drug application requires a

Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

clear understanding of the factors influencing percutaneous absorption to ensure optimal therapeutic effects [6]. Molecules can penetrate the skin through three primary pathways: direct diffusion across the intact stratum corneum, entry through sweat glands, or passage via sebaceous follicles. Among these, the stratum corneum serves as the principal barrier to drug absorption, covering more than 99% of the total skin surface available for percutaneous penetration [7]. The movement of a drug through the stratum corneum is considered the rate-limiting step in the absorption process.Percutaneous drug absorption follows several key steps. Initially, a concentration gradient is established, which acts as the driving force for drug movement across the skin. Following this, the drug is released from the formulation, a process influenced by its penetration coefficient. Finally, the drug diffuses through the different layers of the skin, governed by its diffusion coefficient [8]. For a drug to be effectively delivered through the skin, it must possess certain preferred characteristics. These include a relatively low molecular weight (typically under 600 Daltons), adequate solubility in both aqueous and lipid environments, and a high partition coefficient that facilitates its movement from the formulation into the skin. By optimizing these properties, topical drug formulations can enhance drug penetration, ensuring better therapeutic efficacy and improved patient outcomes [9,10]. Gels represent a more recent advancement in pharmaceutical dosage forms, characterized by the entrapment of substantial amounts of aqueous or hydroalcoholic liquid within a structured network of colloidal solid particles. These semi-solid formulations have gained popularity due to their superior drug delivery properties. Compared to traditional topical preparations such as ointments and creams, gels typically facilitate a more rapid release of the active pharmaceutical ingredient, leading to enhanced therapeutic effects. Despite their advantages, conventional topical dosage forms present certain limitations [11]. One of the primary challenges associated with these formulations is the difficulty in achieving efficient drug diffusion and absorption. Hydrophobic drugs often struggle to diffuse adequately within the gel matrix, while hydrophilic drugs face barriers in permeating through the outermost skin layer, the stratum corneum. This layer serves as a critical protective barrier but also limits the extent of drug penetration, reducing the overall bioavailability of the applied medication.To address these challenges and improve the efficiency of topical drug delivery, emulgels have been developed as an innovative solution[12]. Emulgels combine the properties of both emulsions and gels, thereby enhancing drug permeation and absorption. This hybrid formulation not only stabilizes hydrophobic drugs within a gel matrix but also facilitates better skin penetration, ensuring a more effective and targeted therapeutic outcome. By leveraging the advantages of both gel-based and emulsion-based systems, emulgels offer a promising approach for optimizing topical drug delivery [13].

Topical Drug Delivery System: An Overview

Topical drug delivery involves the administration of medications directly to the skin or mucous membranes to achieve localized therapeutic effects. These formulations are designed to either act on the surface of the skin or penetrate deeper to exert their intended pharmacological action. Topical drug delivery is classified into two primary categories:

1. **External Topical Applications** – These include formulations such as creams, gels, lotions, sprays, and ointments that are applied directly to the outer layers of the skin. They are primarily used to treat dermatological conditions by covering and protecting the affected area [14].
2. **Internal Topical Applications** – These refer to drug formulations administered to mucous membranes for localized effects. Such formulations are applied to oral, vaginal, or rectal tissues to treat conditions affecting these specific regions [15].

Factors Influencing Topical Absorption of Drugs

The effectiveness of a topical drug depends on several physiological and physicochemical factors that impact absorption through the skin:

Physiological Factors:

- **Lipid Content:** The presence of lipids in the skin barrier influences the penetration of drugs, particularly lipophilic substances.
- **Skin Thickness:** Drug absorption varies based on the thickness of the epidermis, with thinner regions facilitating greater penetration.
- **Density of Hair Follicles:** Hair follicles serve as an additional pathway for drug absorption, enhancing the overall permeability.
- **Density of Sweat Glands:** Sweat gland openings can contribute to drug diffusion into the skin.

- **Skin pH:** The natural acidic pH of the skin affects drug stability and absorption.
- **Blood Flow:** Increased blood circulation enhances drug uptake and distribution.
- **Hydration of the Skin:** Moisturized skin has improved permeability compared to dry skin, which acts as a stronger barrier.
- **Inflammation of the Skin:** Inflamed or damaged skin may have increased permeability, allowing for greater drug absorption [16,17].

Physicochemical Factors:

- **Partition Coefficient:** The balance between lipophilicity and hydrophilicity of a drug determines its ability to penetrate the skin barrier.
- **Molecular Weight:** Smaller molecules (typically less than 400 Daltons) penetrate the skin more efficiently.
- **Degree of Ionization:** Unionized drugs exhibit better absorption as they can pass through lipid membranes more easily.
- **Effect of Vehicles:** The choice of formulation vehicle influences drug release, solubility, and penetration into the skin [18].

Advantages of Topical Drug Delivery Systems

- **Bypassing First-Pass Metabolism:** Topical applications avoid hepatic metabolism, ensuring higher drug availability at the site of action.
- **Reduced Gastrointestinal Side Effects:** Since the drug is not ingested, issues like gastric irritation or enzymatic degradation in the digestive system are avoided.
- **Targeted Drug Delivery:** Topical formulations provide localized treatment, minimizing systemic side effects.
- **Improved Patient Compliance:** Non-invasive application methods make topical treatments user-friendly and convenient.
- **Self-Medication Feasibility:** Patients can easily apply topical drugs without medical supervision, promoting better adherence to treatment regimens.
- **Effective for Drugs with Short Half-Life:** Topical systems provide sustained drug release, extending the therapeutic effect of drugs with rapid metabolism.
- **Flexible Termination of Treatment:** Medication can be easily discontinued by removing the formulation from the skin if adverse reactions occur [19].

Disadvantages of Topical Drug Delivery Systems

- **Skin Irritation and Contact Dermatitis:** Some drugs may cause localized irritation, redness, or itching upon application.
- **Risk of Allergic Reactions:** Certain active ingredients or excipients in topical formulations may trigger hypersensitivity responses in some individuals.
- **Limited Permeability for Some Drugs:** Large or highly hydrophilic drug molecules may struggle to penetrate the skin effectively.
- **Challenges with Large Particle Size Drugs:** Medications containing large molecules may have difficulty being absorbed through the skin, limiting their effectiveness [20].

Physiology of the Skin

The skin serves as the primary interface between the body and the external environment, and many topical preparations are designed for application to this organ. The skin of an average adult human covers a surface area of approximately 2 square meters and accounts for about one-third of the total blood circulation within the body. On average, the skin contains between 40 and 70 hair follicles and 200 to 300 sweat glands per square centimeter [21]. The pH of the skin typically ranges from 4 to 5.6, influenced by factors such as sweat production and the secretion of fatty acids from sebum. The skin is anatomically divided into four distinct layers of tissue:

1. **Non-Viable Epidermis**
2. **Viable Epidermis**
3. **Viable Dermis**
4. **Subcutaneous Connective Tissue**

A. Non-Viable Epidermis

The outermost layer of the skin, known as the **stratum corneum**, acts as the primary physical barrier to most substances that come into contact with the skin. This layer typically consists of 10 to 20 cellular layers across most of the body's surface. Each cell in the stratum corneum is a flattened, plate-like structure, measuring approximately 34-44 micrometers in length, 25-36 micrometers in width, and 0.5 to 0.20 micrometers in thickness, with a surface area ranging from 750 to 1200 micrometers. These cells are stacked together in a brick-like fashion, tightly adhering to one another. The stratum corneum is composed of approximately 5-15% lipids, including phospholipids, glycosphingolipids, cholesterol

sulfate, and neutral lipids, as well as 75-85% proteins, primarily keratin [22].

B. Viable Epidermis

Located beneath the non-viable epidermis, the **viable epidermis** occupies a position between the stratum corneum and the dermis. This layer typically measures between 50 and 100 micrometers in thickness. The cells within the viable epidermis share physiological and biochemical characteristics with other living tissues. The cells are interconnected by structures known as tonofibrils. The density of this layer is similar to that of water, and the water content of the viable epidermis is approximately 90% [23].

C. Viable Dermis

Below the viable epidermis lies the **dermis**, a structurally complex layer that plays a critical role in supporting and nourishing the skin. It is composed of a network of fibrous connective tissue and is sparsely populated by cells, making it quite distinct from other tissues in the body. The dermis generally ranges in thickness from 2000 to 3000 micrometers and is composed of a loose connective tissue matrix, rich in fibrous proteins, which is embedded in an amorphous ground substance [24].

D. Subcutaneous Connective Tissue

The **subcutaneous tissue**, or **hypodermis**, is not classified as a true component of the skin but plays a vital role in supporting the dermis and epidermis. This layer consists of loose connective tissue that is rich in fibrous elements and contains blood vessels, lymphatic vessels, sweat gland ducts, and sensory nerves. Though the hypodermis is involved in the absorption of substances that penetrate the skin, it is not generally considered the primary site of drug absorption. Most substances that penetrate the skin enter the circulatory system before reaching the hypodermis. However, the fatty tissue in the subcutaneous layer may serve as a depot for certain drugs, allowing for their slow release into the body [25]. This intricate organization of the skin allows it to function as a dynamic barrier, while also facilitating the absorption of certain substances, making it a critical component in drug delivery systems [26].

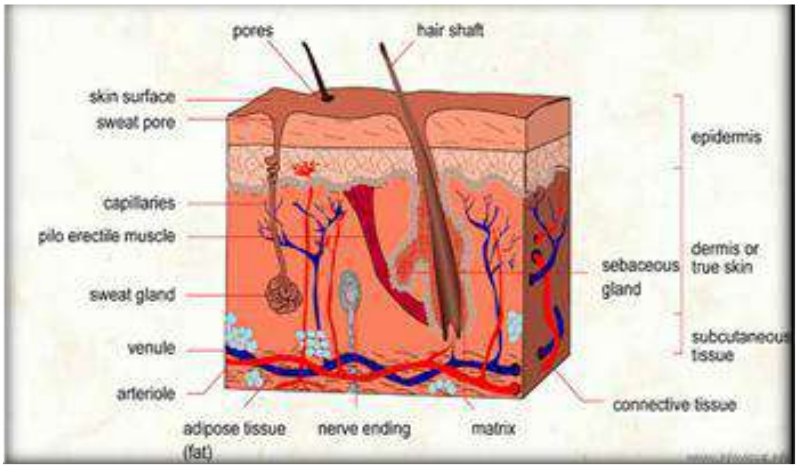

Fig.1. Cross Section of Skin

Transdermal Drug Delivery- The epidermis represents the outermost layer of the skin, composed of stratified, keratinized squamous epithelium that exhibits varying thickness depending on the anatomical region. This layer is most prominent in areas that require greater durability, such as the palms and soles, and contains abundant elastic fibers to provide resilience and flexibility. The skin functions as an effective waterproof barrier, safeguarding the deeper, more fragile underlying structures from external harm.Beneath the epidermis, a rich network of blood vessels is distributed, with particular importance placed on the continuous venous plexus. This plexus receives blood flow from the capillaries of the skin, providing essential circulation. In highly exposed regions, such as the hands, feet, and ears, the plexus is further supplied by blood directly from small arteries through specialized, highly muscular arteriovenous anastomoses, which regulate blood flow to these areas based on thermal and other physiological demands. One distinctive feature of dermatological pharmacology is the skin's direct accessibility as a target organ for both diagnostic and therapeutic interventions. The skin serves as a dynamic two-way barrier, meticulously regulating the absorption and loss of water and electrolytes. This protective function plays a critical role in maintaining homeostasis while also providing an avenue for the

transdermal delivery of various substances, including drugs [27].

MATERIALS AND INSTRUMENTS: -

All the chemicals used in the study were procured from standard source, standard instruments were used and established protocols were followed to conduct the experiments.

Chemicals:

Aceclofenac	-
Carbopol 934	Himedia laborites pvt. Ltd
Sodium alginate	Himedia laborites pvt. Ltd
Sodium CMC	Himedia laboratories pvt. ltd, mumbai
HPMCK 100	Himedia laborites pvt. Ltd
HPMCK 200	Himedia laborites pvt. Ltd
Light liquid paraffin	Finer chemical, ahmedabad
Tween 80	Hi media laboratories pvt. ltd., mumbai
Span 80	Siscore search laboratories pvt.ltd. ,maharashtra
Propylene glycol	Himedia laborites pvt. Ltd
Ethanol, methy paraben	Emplura, mumbai

Instruments:

UVSpectrophotometer	Shimadzu, UV-1800, Malaysia
FTIR	Bruker
Deepfreezer	Elanpro
Optical microscope	Samsung
Hot plate	Relitech
Magnetic stirer	Remi
pH meter	Alpha-60

Glass ware apparatus:

Beaker	Borosil
Conical flask	Borosil
Round bottom flask	Borosil
Pipette	Borosil
Glass rod	Borosil
Measuring cylinder	Borosil
Test tube	Borosil
Petri dish	Borosil

FORMULATION: -

Preparation of Emulsion:

Preparation of Aqueous Phase: The aqueous phase for the emulsion was formulated by dissolving Tween 80 in purified water.

Preparation of Oil Phase: Methyl Paraben and Propyl Paraben were dissolved in propylene glycol, while the active pharmaceutical ingredient was dissolved in ethanol. Both the oil and aqueous phases were then combined by mixing the respective solutions together. Prior to combining, both phases were heated separately to 75°C. Once the temperatures were achieved, the oil phase was gradually added to the aqueous phase with continuous stirring, allowing the mixture to cool to room temperature gradually[28].

Preparation of Gel:

The gel base was created by dispersing varying concentrations of polymers into distilled water. This process was carried out with constant stirring at a moderate speed using a mechanical shaker. To ensure stability and proper consistency, the pH of all formulations was adjusted to a value between 6 and 6.5 using triethanolamine (TEA)[29].

Preparation of Emulgel:

Finally, the prepared emulsion was gently mixed with the gel base to create the emulgel, using careful stirring to ensure a homogeneous blend, as illustrated in the procedure.

INGREDIENTS %W/W	C1	C2	C3	N1	N2	N3	S1	S2	S3	H1	H2	H3	h1	h2	h3
Drug	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Carbopol 934	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-
Na.cmc	-	-	-	5	5	5	-	-	-	-	-	-	-	-	-
Na.alginate		-	-	-	-	-	8	8	8	-	-	-	-	-	-
HPMCK100	-	-	-	-	-	-	-	-	-	3	3	3	-	-	-
HPMCK200	-	-	-	-	-	-	-	-	-	-	-	-	3	3	3
Liquid paraffin	5	7.5	5	5	7.5	5	5	7.5	5	5	7.5	5	5	7.5	5
Tween 80	1	2.5	3.5	1	2.5	3.5	1	2.5	3.5	1	2.5	3.5	1	2.5	3.5
Propylene glycol	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Ethanol	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Methyl Paraben	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Propyl Paraben	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Water	Q.S	Q.S	Q.S	Q.S	Q.S	Q.S	Q.S	Q.S	Q.S	Q.S	Q.S	Q.S	Q.S	Q.S	Q.S

Standard Graph Of Aceclofenac In pH 7.4 Buffer

A precise quantity of 100 mg of aceclofenac was weighed and dissolved in 10 mL of 0.1 N NaOH, after which the volume was adjusted to 100 mL to prepare the primary stock solution. This solution contained 1 mg/mL of the drug, as depicted in Fig. 2. From this primary stock, 10 mL was transferred and diluted to a final volume of 100 mL using 0.1 N sodium hydroxide, resulting in the secondary stock solution, which had a concentration of 100 µg/mL of aceclofenac. Following this, 1 mL of the secondary stock solution was further diluted to 10 mL, yielding a concentration of 10 µg/mL. Subsequently, the UV absorbance of these dilutions was measured using a UV spectrophotometer, with the 0.1 N sodium hydroxide solution used as the blank, over the wavelength range of 200–400 nm. The λmax (maximum absorbance wavelength) of aceclofenac was determined to be 273 nm. The absorbance values of the various concentrations were recorded, and a calibration curve was constructed by plotting the absorbance on the y-axis and the concentration on the x-axis.

Standard Graph Of Aceclofenac In PH 7.4 Phosphate Buffer-

S.NO	CONCENTRATION(µg/ml)	ABSORBANCE
1	5	0.092
2	10	0.218
3	15	0.347
4	20	0.458
5	25	0.609
6	30	0.732
7	35	0.868

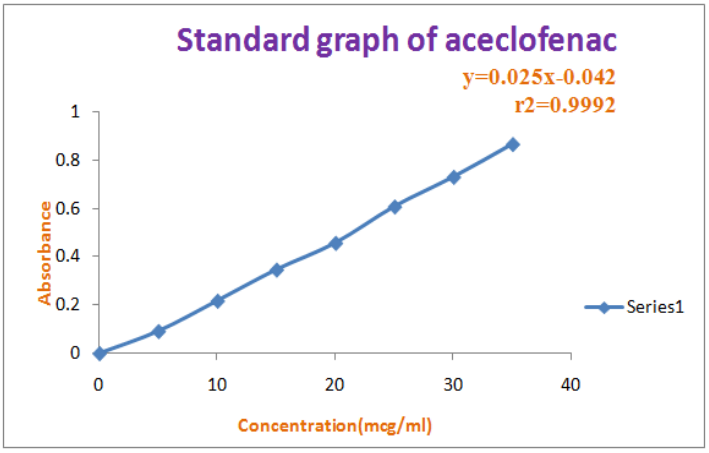

Fig.2. Standard graph of Aceclofenac in pH7.4 buffer

Evaluation Of Aceclofenac Emulgel:-

Physical-Examination:

The prepared emulgel formulations were visually examined for various physical attributes, including color, homogeneity, consistency, presence of any grittiness, and potential phase separation.

pH-Measurement:

The pH of the emulgel formulations was determined using a digital pH meter. A sample of 1 gram of the emulgel was dissolved in 100 mL of distilled water and allowed to stand for 2 hours. The pH of each formulation was measured in triplicate, and the average value was calculated to ensure accuracy.

Swelling-Index:

The swelling index of the prepared topical emulgel was determined by taking 1 gram of the emulgel and placing it on a porous aluminum foil. This was then placed in a separate 50 mL beaker containing 10 mL of 0.1 N NaOH. The samples were removed from the beakers at different time intervals, allowed to dry briefly, and then reweighed. The swelling index was calculated using the following formula: Swelling Index (SW) (%) = $[(Wt - W_0) / W_0] \times 100$ Where W_0 is the original weight of the emulgel at zero time and Wt is the weight of the swollen emulgel at the given time. This index reflects the equilibrium percent swelling of the emulgel.

DrugContent-Determination:

To determine the drug content, 1 gram of aceclofenac topical emulgel was accurately weighed and dissolved in 100 mL of 0.1 N NaOH. The solution was placed in a volumetric flask for 2 hours and shaken thoroughly to ensure proper mixing. Afterward, the solution was filtered through filter paper. The absorbance of the filtrate was measured spectrophotometrically at a wavelength of 375 nm, after appropriate dilution. The drug content was then calculated using the formula: **Drug Content** = (Concentration × Dilution Factor × Volume Taken) × Conversion Factor. Here, Wt represents the weight of the swollen emulgel.

InVitro Drug Release Study:

The in vitro drug release of the emulgel was evaluated using a modified diffusion cell equipped with a dialysis membrane. Prior to use, the membrane was soaked in phosphate buffer solution (PBS) at pH 7.4 for a duration of 9 to 12 hours. It was then securely clamped to one end of the hollow glass tube of the dialysis cell. A 300 mg sample of the emulgel was evenly applied to the surface of the dialysis membrane. The receptor compartment of the setup was filled with 100 mL of phosphate buffer solution at pH 7.4, which served as the dissolution medium, as illustrated [30].. The entire assembly was placed on a magnetic stirrer, where the solution in the receptor compartment was continuously stirred by a magnetic bead. The temperature of the system was carefully regulated at 37 ± 0.5°C. At predetermined intervals, 10 mL samples were withdrawn from the receptor compartment and replaced with an equivalent volume of fresh dissolution medium to maintain the system's volume. The withdrawn samples were then analyzed spectrophoto-metrically at a wavelength of 273 nm. The cumulative percentage of drug released was calculated based on the absorbance values obtained from the analysis.

Fig.3. In Vitro drug release

RESULTS AND DISCUSSIONS: -

Standard Graph Of Aceclofenac In Phosphate Buffer pH 7.4-

S.NO	CONCENTRATION(µg/ml)	ABSORBANCE
1	5	0.092
2	10	0.218
3	15	0.347
4	20	0.458
5	25	0.609
6	30	0.732
7	35	0.868

Physical-Examination:

The prepared aceclofenac emulgel formulations were examined for their visual characteristics. When assessed for color and appearance, the emulgel prepared with Carbopol 934 was found to be transparent. The formulations containing HPMC K100 and HPMC K200, as well as sodium carboxymethyl cellulose (Na.CMC), exhibited a white, viscous consistency. The emulgel made with sodium alginate appeared as a brownish, gummy substance. All formulations presented a creamy consistency, with a smooth, homogeneous texture and a glossy finish. The detailed observations and findings have been discussed further.

S.no	Formulation	Color	Phase separation	Grittiness	Homogeneity	Consistency
1	C1	white	None	-	+++	+++
2	C2	white	None	-	+++	+++
3	C3	white	None	-	+++	+++
4	N1	white	None	-	+++	+++
5	N2	white	None	-	+++	+++
6	N3	white	None	-	+++	+++
7	S1	Brownish gummy	None	-	+++	+++
8	S2	Brownish gummy	None	-	+++	+++
9	S3	Brownish gummy	None	-	+++	+++
10	H1	White	None	-	+++	+++
11	H2	White	None	-	+++	+++
12	H3	White	None	-	+++	+++
13	h1	White	None	-	+++	+++
14	h2	White	None	-	+++	+++
15	h3	White	None	-	+++	+++

pH-Measurement:

The pH values of all the prepared formulations were found to be between 5 and 6.8. This range is deemed appropriate and ensures that the formulations are unlikely to cause irritation when applied to the skin, as it falls within the acceptable pH level for topical use.

S.NO	FORMULATION	pH
1	C1	6.67
2	C2	6.20
3	C3	6.39
4	N1	5.98
5	N2	6.29
6	N3	6.30
7	S1	6.69
8	S2	6.55
9	S3	6.43
10	H1	6.60
11	H2	6.00
12	H3	6.53
13	h1	6.72
14	h2	6.00
15	h3	6.32

CONCLUSION:

The primary objective of this study was to enhance the penetration of aceclofenac into the skin. The research aimed to formulate and evaluate an emulgel of aceclofenac for topical application. In the future, topical drug delivery systems are expected to be widely utilized to improve patient compliance due to their convenience and effectiveness. The emulgels in this study were formulated using light liquid paraffin as the oil phase, Tween 80 as the emulsifier, and propylene glycol as a penetration enhancer. Based on the results, the aceclofenac emulgel formulations prepared with various gelling agents such as Carbopol 934, sodium carboxymethyl cellulose (Na CMC), sodium alginate, HPMC K100, and HPMC K200 exhibited acceptable physical properties and satisfactory drug release profiles. In vitro drug release studies were conducted over a period of 6 hours for all formulations. Among the formulations, the emulgel formulation C3, which contained 100 grams of Carbopol 934, demonstrated the best drug release performance, achieving a drug content of 90%. Furthermore, formulation C3 showed superior stability compared to the other formulations. Given its higher drug release rate, formulation C3 was selected as the optimized formulation. The emulgel technique, which has emerged as a novel approach in topical drug delivery, shows great promise, especially for hydrophobic drugs like aceclofenac, making it a potentially highly effective delivery system

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