

Formulation and Evaluation of a Medicated Roll-on Containing Ibuprofen and Magnesium Chloride

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ABSTRACT

Topical drug delivery has emerged as an effective approach for managing localised pain while minimising the systemic adverse effects associated with oral therapy. This study focuses on the development and evaluation of a medicated roll-on containing ibuprofen and magnesium chloride for the treatment of musculoskeletal pain and inflammation. The formulation was designed using suitable excipients to improve drug solubility, stability, skin compatibility and transdermal penetration. Ibuprofen provides anti-inflammatory and analgesic effects, whereas magnesium chloride promotes muscle relaxation and supports pain relief. The prepared formulation was evaluated for key physicochemical properties, including pH, viscosity, spreadability, drug content, and in vitro drug release. Stability and compatibility studies were also carried out to ensure product quality and performance. The findings indicate that the formulated roll-on is a promising, convenient, and patient-friendly topical system for localised pain management.

Keywords: Topical Drug Delivery, Medicated Roll-on, Ibuprofen, Magnesium Chloride, Musculoskeletal Pain, Transdermal Delivery, Anti-inflammatory Therapy, Formulation and Evaluation, Skin Compatibility, Stability Evaluation.

Introduction

Background

Musculoskeletal disorders, including arthritis, strains, sports injuries, and back pain, are among the leading causes of pain and disability worldwide. Although oral non-steroidal anti-inflammatory drugs (NSAIDs) such as ibuprofen are widely prescribed for pain relief, their prolonged use is often associated with adverse effects such as gastrointestinal irritation, renal impairment, and cardiovascular complications. These limitations have encouraged the development of topical drug delivery systems that provide localized therapeutic actions while reducing systemic drug exposure. Topical roll-on formulations have emerged as a convenient alternative because they enable direct application to the affected area, improve patient compliance, and minimize the greasy residue commonly associated with creams and gels. In addition, rolling action provides a gentle massage, which may enhance local blood circulation and support drug penetration through the skin. The incorporation of suitable penetration enhancers and stabilising excipients further improves the formulation's effectiveness and stability. Ibuprofen is a well-established NSAID that relieves pain and inflammation by inhibiting cyclooxygenase (COX) enzymes and reducing prostaglandin synthesis. Magnesium chloride complements its action by promoting muscle relaxation, regulating nerve activity, and helping to reduce muscle cramps and spasms. The combination of these two agents offers a dual-therapeutic approach by addressing both the inflammatory and

neuromuscular components of musculoskeletal pain. Despite the therapeutic potential of this combination, standardized topical pharmaceutical products containing both ibuprofen and magnesium chloride are limited. Therefore, the present study focuses on the formulation and evaluation of a medicated roll-on designed to provide effective localised pain relief while improving stability, skin compatibility, patient convenience, and reducing systemic side effects.

Need for Pain Relief Formulation

Musculoskeletal pain, including conditions such as arthritis, muscle strains, and sports injuries, is a common health concern that often requires long-term treatment. Although oral pain relievers are effective, prolonged use may lead to adverse effects such as gastrointestinal irritation, kidney impairment, and cardiovascular complications. Topical formulation provides a safer alternative by delivering it directly to the affected area while minimizing systemic exposure. However, conventional creams and gels are often greasy, inconvenient, and difficult to apply, especially for elderly patients or individuals with hand mobility. A roll-on formulation offers a clean, portable, and user-friendly method of application with improved patient compliance. Combining ibuprofen with magnesium chloride provides both anti-inflammatory and muscle-relaxing effects, addressing multiple causes of pain simultaneously. Therefore, there is a need to develop an effective, stable, and non-messy topical pain relief formulation that enhances therapeutic outcomes and patient convenience.

Significance

The medicated roll-on containing ibuprofen and magnesium chloride offers an effective and patient-friendly approach for the localized management of musculoskeletal pain and inflammation. Ibuprofen helps reduce pain, swelling, and inflammation by inhibiting prostaglandin synthesis, while magnesium chloride supports muscle relaxation and helps relieve cramps and stiffness. Delivering these agents through a topical roll-on minimises systemic exposure and lowers the risk of gastrointestinal side effects commonly associated with oral NSAIDs. The roll-on design ensures clean, convenient, and targeted application without leaving a greasy residue, improving patient compliance. Its rolling action also provides a gentle massage, which may enhance local blood circulation and aid drug penetration into the affected tissues. This dual-action formulation addresses both inflammatory and muscular components of pain, making it a promising option for conditions such as arthritis, sports injury, and muscle strain. Overall, the formulation represents a convenient and innovative topical therapy with the potential to improve pain management and quality of life. **Relief Roll-On.**

Scope of the present work

The present work aims to develop and evaluate a medicated topical roll-on containing ibuprofen and magnesium chloride for the effective management of localised musculoskeletal pain. The formulation is designed to provide a convenient, non-greasy, and easy-to-use alternative to conventional creams and gels. Suitable excipients will be selected to achieve good stability, smooth application, and enhanced skin permeation. The prepared roll-on will be evaluated for important quality parameters such as appearance, pH, viscosity, homogeneity, spreadability, drug content, and stability. The study also focuses on ensuring the compatibility of the drug and excipients to obtain a safe and effective formulation. This work may provide a promising topical dosage form with improved patient compliance and can serve as a basis for future clinical studies and commercial product development.

Literature Review

Sr no.	Author	Year	Title of study
1	Shinde G. et al.	2022	Formulation and Evaluation of Ibuprofen Gel Using HPMC/CMC
2	Sharma A. et al.	2021	Transdermal Drug Delivery System: A Comprehensive Review
3	Upadhyay M. et al.	2024	Formulation and Evaluation of a Herbal Roll-on for Pain Relief
4	Kulkarni R.V. et al.	2012	Carbopol and HPMC-Based Topical Gels for Drug Delivery
5	Guerrero K. et al.	2018	Magnesium in Pain Management: Mechanism and Therapeutic Potential

Materials and Methods

Materials

The materials used in the formulation of the medicated roll-on were of analytical or pharmaceutical grade and were produced from reliable suppliers. The selected ingredients

were chosen based on their compatibility, stability, safety, and ability to provide effective topical drug delivery. Each ingredient performs a specific role in improving the formulation's therapeutic efficacy, consistency, spreadability, and patient compliance.

The following materials were used in the formulation:

Sr no.	Material	Category	Role in Formulation
1	Ibuprofen	Active pharmaceutical ingredient (NSAID)	Provides analgesic and anti-inflammatory action by inhibiting prostaglandin synthesis.
2	Magnesium chloride	Active ingredient	Acts as a muscle relaxant and helps reduce cramps and stiffness.
3	Menthol	Cooling agent	Produces a cooling sensation and enhances pain relief.
4	Hydroxypropyl Methylcellulose (HPMC)	Gelling agent	Provides viscosity, stability, and smooth roll-on application.
5	Propylene Glycol	Humectant	Improves skin penetration of drugs and retains moisture.
6	Polyethylene Glycol-400 (PEG-400)	Co-solvent	Enhances solubility of ibuprofen and improves formulation uniformity.
7	Ethanol (95%)	Solvent	Dissolves active ingredients and provides a quick-drying effect.
8	Purified Water	Vehicle	Serves as the base for preparation and adjusts the final volume.

Equipment Used

The following laboratory equipment was used during the formulation and evaluation of the medicated roll-on containing ibuprofen and magnesium chloride:

Sr no.	Equipment	Purpose
1	Digital Weight Balance	Accurate weighing of ingredients
2	Magnetic Stirrer with Hot Plate	Uniform mixing and controlled heating
3	Beaker (50-250 ml)	Preparation and mixing of formulation
4	Measuring Cylinder	Measuring solvents and purified water
5	Glass Rod	Manual stirring and mixing
6	Digital Thermometer	Monitoring formulation temperature
7	Water Bath	Heating during HPMC hydration
8	pH Meter	Determination of formulation pH
9	Spatula	Transferring and handling solid materials
10	Roll-On Bottles	Filling, storage, and dispensing of the final formulation

Method of Preparation of Medicated Roll-on

Step 1: Preparation of HPLC Gel Base

Purified water was heated to about 80-90°C, and HPMC was slowly sprinkled into the hot water with continuous stirring to prevent lump formation. The dispersion was allowed to hydrate completely to obtain a smooth gel base.

Step 2: Preparation of Drug Solution

Ibuprofen and menthol were dissolved in ethanol containing propylene glycol and PEG-400 with continuous stirring. A clear and homogeneous drug solution was obtained before further mixing.

Step 3: Preparation of Magnesium Chloride Solution

Magnesium chloride was dissolved separately in a small quantity of purified water. The solution was stirred until complete dissolution to ensure uniform distribution in the formulation.

Step 4: Mixing of Ingredients

The drug solution was gradually added to the hydrated HPMC gel base with continuous stirring. The magnesium chloride solution was then incorporated slowly to obtain a uniform and homogeneous roll-on formulation.

Step 5: Volume Adjustment

The final volume of the formulation was adjusted with purified water and mixed thoroughly. The prepared formulation was checked for clarity, homogeneity, and absence of lumps.

Step 6: Filling and Packaging

The finished roll-on formulation was transferred into clean, dry roll-on bottles. The containers were sealed properly and stored at room temperature for further evaluation.

Evaluation of Roll-on Formulation

1: Physical appearance

The formulation was visually examined for color, clarity, homogeneity, and the presence of any lumps or phase separation. A smooth and uniform appearance indicated good formulation quality.

2: pH Determination

The pH of the formulation was measured using a digital pH meter. The pH was maintained within the skin-compatible range (5.5-6.5) to minimize irritation and ensure stability.

3: Viscosity

The viscosity of the roll-on was determined using a Brookfield viscometer. Appropriate viscosity ensured smooth rolling, easy application, and controlled drug delivery.

4: Spreadability

Spreadability was evaluated by applying the formulation to a smooth surface. Good spreadability indicated easy application and uniform distribution over the skin.

5: Homogeneity

The formulation was checked visually for uniform distribution of all ingredients. A homogeneous preparation without lumps or precipitation indicated proper mixing.

6: Stability Study

The prepared roll-on was stored under different temperature conditions and observed for changes in color, pH, viscosity, and phase separation. No significant changes indicated good formulation stability.

7: Skin Irritation Test

A small quantity of the formulation was applied to the skin and observed for redness, itching, or irritation. The absence of any adverse reaction confirmed good skin compatibility.

Formulation and Development

Introduction

Formulation development is an essential step in designing a stable, safe, and effective pharmaceutical dosage form. It involves selecting suitable active ingredients and excipients to achieve the desired therapeutic effect and quality.

In the present study, a medicated roll-on containing ibuprofen and magnesium chloride was developed for the topical management of musculoskeletal pain and inflammation. The roll-on dosage form provides easy, non-greasy application, improves patient compliance, and delivers localized pain relief while minimizing the systemic side effects associated with oral NSAIDs.

Selection of Ingredients

The ingredients used in the formulation were selected based on their functional role in ensuring stability, effectiveness, and skin compatibility of the medicated roll-on.

1. Ibuprofen

Ibuprofen was selected as the active ingredient for its analgesic and anti-inflammatory properties. It helps relieve pain and reduce inflammation at the site of application.

2. Magnesium chloride

Magnesium chloride was incorporated to promote muscle relaxation and reduce muscle cramps. It also enhances the overall therapeutic effect of the formulation.

3. HPMC

HPMC was used as a thickening agent to provide suitable viscosity and improve the stability of the roll-on formulation.

4. Propylene glycol

Propylene glycol was added as a penetration enhancer and humectant. It improves drug absorption through the skin and helps retain moisture.

5. PEG-400

PEG-400 was used as a co-solvent to improve the solubility of ibuprofen and maintain a uniform formulation.

6. Menthol

Menthol was incorporated to provide a cooling sensation and enhance the pain-relieving effect of the roll-on.

7. Ethanol

Ethanol was used as a solvent to dissolve the active ingredients and provide a quick-drying, non-greasy finish.

8. Purified water

Purified water was used as the vehicle for dissolving and dispensing all ingredients to obtain the desired formulation consistency

Composition of Medicated Roll-on Containing Ibuprofen and Magnesium Chloride

The composition of the developed medicated roll-on is shown below.

Ingredients	Quantity (per 50 ml)	Role
Ibuprofen	2.5 g	Active anti-inflammatory and analgesic agent
Magnesium Chloride	1.5 g	Muscle relaxant and electrolyte
Menthol	0.5 g	Cooling agent and penetration enhancer
HPMC	1.0 g	Gelling and thickening agent
Propylene Glycol	5.0 ml	Humectant and penetration enhancer
PEG-400	2.5 ml	Co-solvent and humectant
Ethanol	10 ml	Primary solvent and quick-drying agent
Purified water	q.s to 50 ml	Vehicle

Methods of Preparation

1. All glassware and equipment were cleaned, dried, and made ready for formulation.
2. Ibuprofen, magnesium chloride, HPMC, and menthol were accurately weighed, while ethanol, propylene glycol, PEG-400, and purified water were measured.
3. HPMC gel was prepared by dispersing HPMC in hot purified water (80-90 c), followed by the addition of cold water and allowing complete hydration to obtain a clear gel.
4. Ibuprofen and menthol were dissolved in a mixture of ethanol, propylene glycol, and PEG-400 with continuous stirring until a clear solution was obtained.
5. Magnesium chloride was dissolved separately in purified water.
6. The drug solution was slowly incorporated into the hydrated HPMC gel with continuous stirring.
7. Magnesium chloride solution was then added gradually while stirring until a smooth and homogeneous formulation was obtained.
8. The final volume was adjusted to 50 mL with purified water.
9. The prepared formulation was transferred into clean, dry roll-on bottles and the roll-on mechanism was checked for smooth dispensing.
10. The finished roll-on was kept for further evaluation under controlled conditions.

Packaging and Storage

Packing

- The prepared medicated roll-on was filled into clean, dry, airtight roll-on bottles to prevent contamination and solvent evaporation.
- The roll-on applicator and cap were properly secured to ensure leak-proof packaging and smooth application.

Storage

- Store the formulation in a cool, dry place below 25 c, protected from direct sunlight and excessive heat.
- Keep the container tightly closed after use to maintain stability and prevent contamination.

For external use only and keep out of reach of children.

Aim and Objectives

Aim:

To formulate and evaluate a stable, safe and effective medicated roll-on containing ibuprofen and magnesium chloride for the management of musculoskeletal pain, inflammation, muscle cramps and stiffness through topical drug delivery.

Objectives:

- To develop a stable and homogeneous roll-on formulation containing ibuprofen and magnesium chloride.

- To select a suitable non-ionic thickening agent (HPMC) compatible with magnesium chloride to maintain formulation stability.
- To prepare the formulation using an optimized hot-cold method for proper hydration of HPMC.
- To ensure smooth roll-on application with a non-greasy texture, good spreadability, and enhanced patient comfort.
- To improve patient compliance by developing an easy-to-use, convenient roll-on dosage form.
- To develop a cost-effective, stable topical formulation suitable for the management of musculoskeletal pain and minor inflammatory conditions.

Evaluation of Medicated Roll-on Containing Ibuprofen and Magnesium Chloride

Physical Appearance

The prepared medicated roll-on was visually inspected to evaluate its physical characteristics, including colour, odour, clarity, homogeneity, and the absence of phase separation.

Procedure:

A small quantity of the formulation was observed under normal lighting conditions.

The formulation was examined for colour, clarity, uniformity, and any visible particles or preparation.

Observation:

The prepared roll-on was clear to slightly translucent, homogeneous, free from visible particles, and showed no phase separation.

Determination of pH

The pH of the formulation was determined to ensure compatibility with the skin and to maintain formulation stability.

Procedure:

One gram of the formulation was dispersed in distilled water.

The pH was measured using a calibrated digital pH meter.

Observation:

The pH of the formulation was found to be within the acceptable skin-friendly range (5.5-6.5).

Spreadability

Spreadability indicates how easily the roll-on formulation spreads uniformly over the skin.

Procedure:

A small quantity of formulation was placed between two glass slides.

A definite weight was placed on the upper slide.

The time required for the upper slide to move was recorded.

Observation:

The formulation exhibited good spreadability with smooth and uniform application.

Specific Gravity

Specific gravity was determined to evaluate the density of the formulation.

Procedure:

The specific gravity was measured using a pycnometer at room temperature.

Observation:

The specific gravity was found within the acceptable range (0.95-1.05g/cm³).

Washability

Washability was evaluated to determine the ease of removal of the formulation from the skin.

Procedure:

The formulation was applied to the skin and washed with running water.

Observation:

The formulation was easily washable and did not leave a greasy residue.

Viscosity

Viscosity determines the flow behavior of the roll-on formulation.

Procedure:

The viscosity was measured using a Brookfield viscometer at room temperature.

Observation:

The formulation exhibited optimum viscosity, allowing smooth roll-on application without leakage.

Results and Discussion

Physical Appearance

- The prepared roll-on was clear to slightly translucent, smooth, homogeneous, and free from lumps.
- No phase separation was observed, indicating proper mixing and good formulation stability.

pH Analysis

- The pH was evaluated using a digital pH meter.
- The expected skin-compatible range was 5.5-6.5, indicating suitability for topical application.

Spreadability

- The formulation showed smooth and easy spreading on the skin.
- Good spreadability ensures convenient and uniform application.

Viscosity

- The viscosity was suitable for smooth roll-on application without leakage.
- HPMC provided the required viscosity and stability.

Homogeneity

- The formulation was smooth, homogeneous, and free from lumps.
- Good homogeneity ensures uniform distribution of the active ingredients.

Stability Studies

- The formulation was evaluated for changes in appearance, phase separation, pH, viscosity, and drug content.
- It showed good physical stability with no significant changes or phase separation.

Conclusion

The present study, entitled "Formulation and evolution of a medicated Roll-on containing Ibuprofen and Magnesium chloride," was successfully carried out. A topical roll-on gel was formulated using HPMC as a non-ionic gelling agent to maintain compatibility with magnesium chloride and formulation stability. The prepared formulation was found to be smooth, homogeneous, and free from lumps with acceptable pH, suitable viscosity, and good spreadability. Ibuprofen provided analgesic and anti-inflammatory action, while magnesium chloride contributed to muscle relaxation and therapeutic effectiveness. Menthol enhanced the cooling sensation and patient acceptability. The Roll-on packaging provided easy and convenient application, improved patient compliance, and reduced the risk of contamination. The evaluated parameters, including physical appearance, pH, viscosity, and drug content, were within acceptable limits, indicating satisfactory formulation stability and suitability for topical application. Overall, the developed medicated Roll-on showed promising potential as a convenient, non-greasy, and effective topical dosage form for managing musculoskeletal pain and minor inflammatory conditions. Further optimization, extended stability studies, and clinical studies may be carried out for future development and commercial application. Tuberculosis even involving the central nervous system does not rule out drug-resistant pulmonary disease decades later, and clinicians should keep their threshold for suspicion low regardless of how long ago the earlier episode occurred. Second, the case shows how rapid molecular diagnostics and contemporary bedaquiline-based therapy can work together to produce a good outcome even in an unusual and high-risk scenario, reinforcing the case for sustained vigilance and modern diagnostic and therapeutic tools in tuberculosis care more broadly.

Declarations

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Conflicts of Interest / Competing Interests

The authors have no relevant financial or non-financial interests to disclose.

Consent for Publication

Written informed consent was obtained from the patient for publication of this case report and any accompanying clinical details. Patient confidentiality has been strictly maintained throughout, and a copy of the consent form is available for review by the Editor-in-Chief upon request.

Availability of Data and Material

The datasets analysed for this case report are available from the corresponding author on reasonable request, subject to maintaining patient confidentiality.

Code Availability

Not applicable.

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