INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES
[ISSN: 0975-4725; CODEN(USA): IJPS00]
Journal Homepage: https://www.ijpsjournal.com

OPEN ACCESS

Review Paper

Recent Advances in Herbal Film-Forming Sprays for Topical Drug Delivery: A Comprehensive Review

Narmada Suroshe*, Dr. A. Mahale

Sudhakarrao Naik Institute of Pharmacy Pusad, Yavatmal , Maharashtra, India.

ARTICLE INFO

Published: 07 Aug 2026
Keywords:
Film-forming spray, topical drug delivery, herbal formulations, film forming polymer, wound healing
DOI:
10.5281/zenodo.21837856

ABSTRACT

Topical drug delivery systems have gained considerable attention due to their ability to provide localized therapeutic effects, improved patient compliance, and reduced systemic side effects. Among the various topical dosage forms, film-forming sprays have emerged as a promising and innovative approach for delivering therapeutic agents to the skin. These systems are applied as liquid formulations that rapidly transform into thin, transparent, and adherent films upon solvent evaporation. Film-forming sprays offer several advantages over conventional formulations such as creams, ointments, and gels, including ease of application, prolonged residence time, enhanced drug retention, and improved patient acceptability.In recent years, there has been growing interest in the incorporation of herbal bioactive compounds into film-forming spray systems owing to their diverse pharmacological activities, biocompatibility, and favorable safety profiles. Medicinal plants such as Tinospora cordifolia and Tridax procumbens possess significant antimicrobial, anti-inflammatory, antioxidant, and wound-healing properties, making them attractive candidates for topical therapeutic applications. The effectiveness of film-forming sprays is largely influenced by the selection of suitable polymers, plasticizers, solvents, and other formulation components that determine film characteristics and drug-release behavior.This review provides a comprehensive overview of topical drug delivery and film-forming spray technology, including formulation principles, mechanisms of film formation, polymers used in film-forming systems, evaluation parameters, and recent technological advancements. Particular emphasis is placed on the therapeutic potential of herbal agents and their application in film-forming sprays. Furthermore, current challenges, future perspectives, and opportunities for the development of advanced herbal film-forming spray systems are discussed. The review highlights the potential of herbal film-forming sprays as effective and patient-friendly alternatives for topical drug delivery

***Corresponding Author:** Narmada Suroshe
Address: *M. Pharm, Department of Industrial Pharmacy, Sudhakarrao Naik Institute of Pharmacy Pusad, Yavatmal ,Maharashtra, India.*
Email ✉: narmadasuroshe2000@gmail.com

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.

INTRODUCTION

The skin is the largest organ of the human body and serves as a protective barrier against physical, chemical, and microbial insults. In addition to its protective function, the skin plays a crucial role in thermoregulation, sensory perception, and immune defense. The increasing prevalence of skin disorders, wound infections, and inflammatory conditions has led to the development of various topical drug delivery systems designed to provide localized therapeutic effects while minimizing systemic exposure.

Topical drug delivery offers several advantages over conventional oral and parenteral routes, including avoidance of first-pass metabolism, reduced systemic adverse effects, improved patient compliance, and direct delivery of therapeutic agents to the site of action. Conventional topical dosage forms such as creams, ointments, lotions, and gels have been extensively utilized for the treatment of dermatological conditions. However, these formulations often suffer from limitations such as poor retention at the application site, greasiness, frequent reapplication, and inadequate patient acceptance.To overcome these limitations, innovative drug delivery approaches have been explored, among which film-forming systems (FFS) have attracted significant attention. Film-forming systems are non-solid formulations that transform into thin, flexible, and transparent films upon application to the skin and subsequent evaporation of volatile components. These systems create a protective film that enhances drug residence time, improves skin contact, and enables controlled release of active ingredients. Film-forming sprays represent an advanced category of film-forming systems that combine ease of application with improved therapeutic performance.In recent years, there has been increasing interest in the use of herbal medicines for topical drug delivery. Herbal products are widely recognized for their therapeutic efficacy, biocompatibility, safety, and minimal adverse effects. Numerous medicinal plants possess antimicrobial, anti-inflammatory, antioxidant, and wound-healing properties that make them suitable candidates for incorporation into topical formulations. Among these, Tinospora cordifolia and Tridax procumbens have received considerable scientific attention due to their diverse pharmacological activities and traditional medicinal applications.[1,3]

2. SKIN PHYSIOLOGY AND MECHANISM OF SPRAY

The skin is the largest organ of the human body, accounting for approximately 15–20% of total body weight. It serves as a dynamic barrier that protects the body from environmental hazards, pathogenic microorganisms, ultraviolet radiation, and excessive water loss. The skin also plays important roles in thermoregulation, sensation, immune response, and maintenance of physiological homeostasis.Structurally, the skin is composed of three major layers: the epidermis, dermis, and hypodermis (subcutaneous tissue). Each layer possesses distinct anatomical and functional characteristics that influence the penetration and effectiveness of topically applied therapeutic agents.

Wound care remains a major clinical challenge, especially in chronic and drug-resistant wounds requiring prolonged treatment. Conventional topical formulations often have limitations such as poor retention, uneven drug distribution, and low patient compliance. Film-forming sprays have emerged as an advanced alternative due to their ease of application, sustained drug release, and protective barrier properties. Recent advancements in Film forming sprays include smart polymers, pH-responsive systems, and

nanoparticle-based carriers to improve wound healing and antimicrobial effectiveness.[4,5]

2.1 Concept and Mechanism of Film-Forming Sprays

The concept of film-forming sprays is based on the conversion of a liquid formulation into a solid polymeric film after application. The formulation typically contains film-forming polymers, solvents, plasticizers, and active pharmaceutical ingredients.

The mechanism of film formation involves the following steps:

- Spraying of the liquid formulation onto the skin.
- Uniform spreading of the formulation over the application site.
- Rapid evaporation of volatile solvents.
- Polymer chain aggregation and coalescence.
- Formation of a continuous, flexible film.

A film-forming spray is a topical drug delivery system in which a liquid formulation containing polymers and active ingredients is sprayed onto the skin or wound surface. Upon application, the volatile solvent evaporates and forms a thin, transparent film that adheres to the skin. The formed film acts as a polymeric matrix and provides sustained release of the incorporated drug.Compared to conventional ointments, gels, and patches, FFS offers uniform drug distribution, better access to irregular wound surfaces, adjustable drug dosage, and improved patient compliance. The thin, non-sticky film enhances comfort, maintains wound moisture balance, and reduces the risk of irritation or infection. Due to these advantages, film-forming sprays are considered a promising approach for next-generation wound care systems.[6,7]

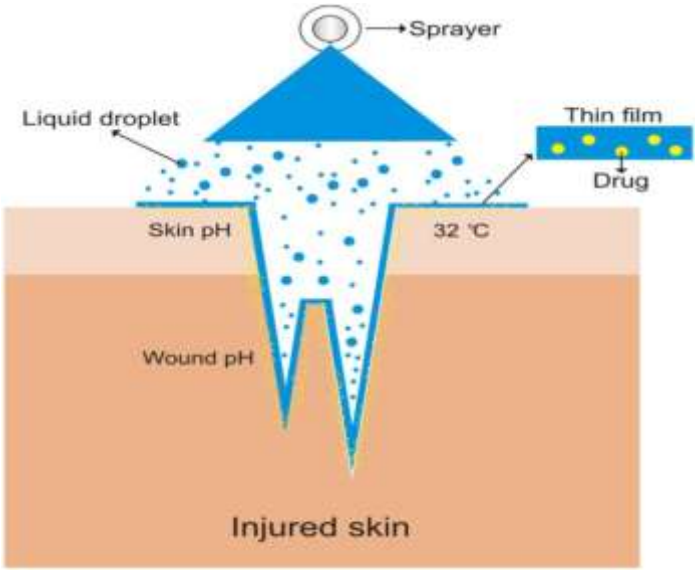

Figure no.1 Mechanism of fim forming spray

2.1 Routes of Drug Penetration Through Skin

Topically applied drugs can penetrate the skin through three primary pathways:

Intercellular Route – Drug molecules diffuse through the lipid matrix surrounding corneocytes.

Transcellular Route – Drug molecules pass directly through corneocytes and intracellular components.

Transappendageal Route – Drug molecules penetrate through hair follicles, sebaceous glands, and sweat glands.[8,9]

Among these pathways, the intercellular route is considered the predominant pathway for most topically administered drugs. Most drugs diffuse through the lipid matrix surrounding corneocytes to reach viable skin layers. The pilosebaceous route also contributes to drug delivery. The main barrier to penetration is the stratum corneum, the outermost layer of the epidermis, which controls the rate of drug absorption. Topical formulations such as creams and gels are commonly used to deliver therapeutic agents locally. [10,11]

3.FILM-FORMING SPRAYS

Film-forming sprays are advanced topical drug delivery systems that combine the advantages of spray technology with the benefits of film-forming formulations. These systems are applied as liquid preparations using a spray device and rapidly transform into thin, transparent, and flexible films upon evaporation of volatile solvents. The formed film adheres to the skin surface and serves as a reservoir for the controlled release of active ingredients.

Film-forming sprays have emerged as promising alternatives to conventional topical dosage forms such as creams, ointments, gels, and lotions due to their ease of application, enhanced patient compliance, and improved therapeutic performance. Their ability to form a protective film over the affected area makes them particularly useful in wound healing, antimicrobial therapy, and dermatological treatments.[12,13]

3.1 Components of Film-Forming Sprays

3.1.1 Polymers

Polymers play a critical role in determining film properties such as flexibility, adhesion, mechanical strength, and drug-release behavior. Film-forming polymers are the essential components of film-forming spray formulations because they are responsible for converting the liquid formulation into a thin, continuous, and flexible film after application. The polymer solution undergoes solvent evaporation, resulting in polymer chain entanglement and formation of a stable film layer on the skin surface. The selection of polymer greatly influences important characteristics of the formulation, including film flexibility, adhesion, mechanical strength, drying time, drug diffusion, and stability.

An ideal film-forming polymer should possess good film-forming ability, compatibility with active pharmaceutical ingredients, sufficient flexibility, skin adhesion, and ability to produce a uniform film without causing irritation. Both synthetic and natural polymers are used in film-forming spray systems depending on the required therapeutic application.[14,15]

Commonly used polymers include:

Eudragit RS100, Eudragit RL100, Ethyl cellulose, Hydroxypropyl methylcellulose (HPMC),

Polyvinyl pyrrolidone (PVP), Chitosan,Sodium alginate

Comparison of common polymers used in film forming sprays

Polymer	Types	Film forming ability	Drug Release	Major Advantages
Eudragit RS100	Synthetic	Excellent	Sustained	Good adhesion
Eudragit RL100	Synthetic	Excellent	Faster than RS100	Higher permeability
Ethyl cellulose	Synthetic	Excellent	Sustained	Good mechanical strength

HPMC	Semi-Synthetic	Good	Moderate	Hydrophilic,safe
PVP	Synthetic	Good	Rapid	Excellent adhesion
Chitosan	Natural	Good	Controlled	Antimicrobial activity
Sodium alginate	Natural	Good	Controlled	Moisture retention

3.1.2 Solvents

Solvents dissolve formulation components and facilitate sprayability. Following application, solvents evaporate and allow film formation. Solvents are important components of film-forming spray formulations as they act as a medium for dissolving polymers, active ingredients, and other formulation components. The selection of an appropriate solvent system influences important formulation characteristics such as viscosity, sprayability, drying time, film formation, and stability.An ideal solvent for film-forming sprays should have good polymer solubilizing capacity, rapid evaporation ability, safety for topical application, and compatibility with the active ingredient. During application, the solvent evaporates from the sprayed formulation, allowing the dissolved polymer chains to come closer and form a continuous film layer on the skin surface.

Different types of solvents are used in film-forming sprays, including organic solvents, aqueous solvents, and mixed solvent systems. Organic solvents are commonly selected because of their ability to dissolve hydrophobic polymers and promote rapid drying.[16]

Common solvents include:

Ethanol,Acetone, Isopropyl alcohol, Ethyl acetate, Purified water

The solvent system significantly influences drying time and film appearance.

3.1.3 Plasticizers

Plasticizers improve film elasticity and prevent cracking. Plasticizers are important formulation components that improve the flexibility, elasticity, and mechanical properties of the polymeric film formed after application. They are low molecular weight substances that interact with polymer chains and reduce intermolecular forces, resulting in increased mobility and flexibility of the film.In film-forming spray formulations, plasticizers help to prevent brittleness, cracking, and peeling of the formed film. They improve film durability and provide better adhesion to the skin surface, which can enhance the residence time of the formulation and support effective drug release.

An ideal plasticizer should be compatible with the selected polymer, stable, non-toxic, and capable of producing a flexible film without affecting the therapeutic activity of the active ingredient. The type and concentration of plasticizer significantly influence film characteristics such as tensile strength, flexibility, drying behavior, and drug diffusion.[17]

Examples include:

Polyethylene glycol, Propylene glycol, Glycerin, Triethyl citrate

3.2 Advantages of Film-Forming Sprays

Film-forming sprays offer numerous advantages over traditional topical formulations:[18,19]

1. Non-contact and hygienic application.
2. Uniform distribution over the skin surface.
3. Rapid drying after application.

4. Formation of transparent and aesthetically acceptable films.
5. Enhanced adhesion and prolonged residence time.
6. Controlled and sustained drug release.
7. Improved patient compliance.
8. Reduced risk of contamination.
9. Better protection of wounds and damaged skin.
10. Convenient application to large or difficult-to-reach areas.

3.3 Limitations of Film-Forming Sprays

Despite their advantages, certain challenges remain associated with film-forming spray systems:[20]

1. Possible skin irritation caused by organic solvents.
2. Film brittleness at inappropriate polymer concentrations.
3. Stability issues during long-term storage.
4. Variability in spray pattern and droplet size.
5. Potential incompatibility between polymers and active ingredients.
6. Appropriate formulation optimization is essential to minimize these limitations.

3.4 Applications of Film-Forming Sprays

Film-forming sprays have been explored for a variety of therapeutic applications, including:

- **Wound Healing**-The protective film maintains a moist environment, prevents microbial contamination, and promotes tissue regeneration.
- **Antimicrobial Therapy**-Incorporation of antimicrobial agents helps control bacterial and fungal infections while maintaining prolonged contact with the affected area.
- **Anti-inflammatory Therapy**-Film-forming sprays can provide sustained delivery of anti-inflammatory agents to reduce redness, swelling, and irritation.
- **Pain Management**-Topical analgesics incorporated into film-forming sprays may provide localized and prolonged pain relief.
- **Cosmetic and Dermatological Applications-**These systems are increasingly utilized in cosmetic formulations due to their ease of use and superior aesthetic properties.[21,22]

4. EVALUATION PARAMETERS OF FILM-FORMING SPRAYS

1.Physical Appearance

Physical appearance is one of the preliminary evaluation parameters. The formulation should be visually inspected for: color, clarity, homogeneity, presence of particulate matter, phase separationAn ideal film-forming spray should be clear, uniform, and free from visible impurities.[23]

2.pH Determination

The pH of the formulation is measured using a calibrated digital pH meter to ensures compatibility with skin pH,minimizes irritation and discomfort,maintains formulation stabilitythe pH of topical formulations is generally maintained within a range suitable for skin application.[23]

3.Viscosity Measurement

Viscosity is an important parameter affecting sprayability and film formation. It is commonly determined using a Brookfield viscometer it influences spray pattern,affects droplet formation,determines ease of application,impacts film uniformity an optimum viscosity is necessary to ensure proper atomization and distribution of the formulation.[23]

4.Drying Time

Drying time refers to the period required for complete solvent evaporation and film formation

following application.it influences patient convenience,affects treatment compliance,determines onset of film formation,rapid drying is generally preferred for topical film-forming sprays.[23]

5.Film Thickness

Film thickness is measured after complete film formation using a micrometer or digital thickness gauge it influences drug release,affects mechanical strength,determines film flexibility,impacts patient comfort ,uniform film thickness contributes to reproducible therapeutic performance.[24]

6.Folding Endurance

Folding endurance is used to evaluate the flexibility and mechanical strength of the formed film.The film is repeatedly folded at the same location until it breaks.It indicates film flexibility,assesses mechanical durability,predicts resistance to crackingfilms with high folding endurance are considered more suitable for topical applications.[24]

7.In Vitro Drug Release Studies

In vitro drug release studies are performed to evaluate the release behavior of active constituents from the film matrix.[25]

Objectives

Determine release profile, Assess controlled-release characteristics, Compare different formulations, Drug release studies are commonly conducted using diffusion cells and suitable receptor media.

8.Skin Permeation Studies

Skin permeation studies evaluate the ability of active ingredients to penetrate the skin barrier.

Importance

Predicts therapeutic effectiveness, Assesses penetration efficiency, Supports formulation optimization These studies are often performed using animal or synthetic membranes[25].

9.Antimicrobial Activity

Antimicrobial evaluation is particularly important for herbal film-forming sprays intended for wound healing and infection management. Common Test Organisms like Escherichia coli, Staphylococcus aureus, Pseudomonas aeruginosa, Aspergillus niger Methods used are Agar well diffusion method, Disc diffusion method, Determination of zone of inhibition. The results provide evidence of the formulation's ability to inhibit microbial growth.[26]

10. Spray Pattern Evaluation

Spray angle:

The solution (d) was sprayed horizontally onto a white sheet that was held 10 cm distant. On the paper, the circumference of the circle was measured three times from various perspectives. The diameter is used to calculate the radius (r). The spray angle (θ) can be obtained using formula. [27]

Spray angle (θ) = tan -1 (L/r)

Where, L = distance between sheet and spray nozzle.

R = radius of spray region

10.1 Spray pattern:

By passing the spray through the TS onto white paper, the spray pattern was evaluated. To aid in visibility, 1% methyl orange was dissolved in each formulation. At a distance of 2.5 to 3.0 cm from the plate, the paper was clipped to the ship and sprayed with the mixture. The diameters of the spots created by spray testing were measured and

observed. Each reading was averaged after this was done three times1. [27]

10.2 Average weight per dose:

The containers' initial weight was noted. The containers were weighed once again after five successive deliveries were sprayed and foamed. The average weight per dose was calculated by dividing the difference between the containers' original and final weights by the number of deliveries.[27]

Average weight per dose (W)=Initial weight(W0)-Final weight(W1) /Number of deliveries.

11.Stability Studies

Stability studies are conducted to assess the physical, chemical, and microbiological stability of the formulation during storage. Parameters Monitored are appearance, pH, viscosity ,drug content, film-forming ability ,antimicrobial activity Stability evaluation helps determine shelf life and storage conditions.[28]

5. RECENT ADVANCES IN HERBAL FILM-FORMING SPRAY TECHNOLOGY

The field of topical drug delivery has witnessed significant advancements in recent years, driven by the growing demand for effective, patient-friendly, and non-invasive therapeutic systems. Among various innovative approaches, herbal film-forming spray technology has emerged as a promising platform for the delivery of bioactive compounds to the skin. Continuous developments in polymer science, nanotechnology, formulation design, and herbal drug standardization have considerably improved the performance and therapeutic potential of film-forming spray systems.

Recent research has focused on enhancing drug stability, improving skin permeation, achieving controlled release, and maximizing therapeutic efficacy while maintaining patient comfort and safety.[29]

5.1 Advancement in Film-Forming Polymers

The development of novel polymers has significantly improved the quality and functionality of film-forming sprays.

Recent trends include:

1. **Use of advanced acrylic polymers** Acrylic-based polymers, including methacrylate derivatives, have gained importance in film-forming spray formulations due to their excellent film-forming ability, mechanical strength, and drug release-modifying properties. Polymers such as Eudragit grades are widely investigated for developing stable films with controlled release characteristics.
2. **Development of biodegradable polymers** Biodegradable polymers are receiving attention because of their biocompatibility, safety, and reduced environmental impact. Natural polymers such as chitosan and sodium alginate are being explored for topical applications due to their film-forming ability and biological advantages.
3. **Combination of synthetic and natural polymers** Polymer combinations are increasingly used to obtain improved formulation properties. Synthetic polymers provide strength, stability, and controlled release, whereas natural polymers may contribute bioadhesion, flexibility, and biocompatibility. Such combinations allow optimization of film properties according to therapeutic requirements.
4. **Improved flexibility and adhesion characteristics** New polymer systems are designed to produce films with better flexibility and adhesion to the skin surface. Improved flexibility prevents cracking or peeling of the film, while enhanced adhesion

helps maintain prolonged contact with the application site.

5. **Enhanced controlled-release properties** Advances in polymer technology have enabled better control over drug diffusion from the formed film. Modified polymer systems can regulate the release rate of active compounds, providing prolonged therapeutic action and reducing the frequency of application.

Overall, advancements in film-forming polymers have contributed to the development of more efficient topical delivery systems. The use of optimized polymers and polymer combinations improves film integrity, stability, drug release behavior, and patient acceptability, making film-forming sprays a promising approach for advanced drug delivery.[30]

5.2 Nano-Based Herbal Film-Forming Systems

Nanotechnology has gained significant attention in pharmaceutical and biomedical fields due to its ability to improve the delivery of therapeutic agents, especially those with poor solubility, stability, or bioavailability. Integration of nanotechnology with herbal film-forming spray systems provides a promising approach for enhancing the performance of plant-based topical formulations.In nano-based herbal film-forming systems, nanoparticles are incorporated into a polymeric film-forming matrix to improve the delivery of bioactive phytoconstituents. The nanosized carriers provide a larger surface area, which may enhance solubility, stability, and interaction with the skin surface. After application, the formulation forms a thin polymeric film that maintains prolonged contact with the skin and facilitates controlled release of herbal constituents. The incorporation of nanoparticles into film-forming sprays offers several advantages:

Improved Solubility: Nanocarrier systems can enhance the solubility of poorly water-soluble herbal compounds by increasing their dispersion and surface area, which may improve their availability at the application site.

Enhanced Skin Penetration: Nanoparticles can improve the interaction between active compounds and the skin barrier, supporting better localization and delivery of herbal constituents.

Increased Bioavailability: Protection of active phytoconstituents within nanoparticles can reduce degradation and improve the effective concentration of therapeutic compounds.

Improved Formulation Stability: Nanoparticles can protect sensitive herbal components from environmental factors such as oxidation and degradation, thereby improving formulation stability.[31,32]

5.3 Polymeric Nanoparticles

Polymeric nanoparticles are widely investigated as drug delivery carriers because of their biocompatibility, controlled release capability, and ability to protect active ingredients. These systems can encapsulate herbal extracts or isolated phytoconstituents and provide improved retention at the application site.When incorporated into film-forming sprays, polymeric nanoparticles can work together with film-forming polymers to create an efficient delivery platform. The polymeric film provides prolonged contact with the skin, while nanoparticles contribute to enhanced protection, controlled release, and improved therapeutic performance of herbal compounds.

Common polymeric materials used for nanoparticle development include biodegradable and biocompatible polymers that allow safe application on the skin. These systems are particularly beneficial for herbal formulations where maintaining stability and activity of natural compounds is challenging.[33]

5.4 Herbal Extract Standardization

Standardization of herbal extracts is an essential step in developing effective herbal film-forming spray systems. Plant extracts contain multiple phytoconstituents, and their concentration may vary depending on factors such as plant source, extraction method, and storage conditions.Proper standardization ensures consistent quality, reproducible therapeutic activity, and better formulation performance. Identification and estimation of important bioactive markers help in maintaining batch-to-batch consistency and improving the reliability of herbal-based delivery systems.

Incorporation of standardized herbal extracts into advanced film-forming spray platforms provides a potential strategy for developing stable, effective, and patient-friendly topical formulations with improved therapeutic benefits.[34]

5.5 Controlled-Release Film Technology

Controlled-release systems represent a significant advancement in film-forming spray formulations. Controlled release film technology is an advanced drug delivery approach designed to regulate the release of active pharmaceutical ingredients over an extended period of time. In film-forming spray systems, this technology involves the formation of a polymeric film layer on the skin surface that acts as a reservoir for the incorporated drug or herbal constituents.After application, the solvent evaporates and the polymer chains form a continuous film. The active compounds are gradually released from this polymeric matrix through diffusion and polymer-related mechanisms, providing sustained drug delivery at the targeted site. This controlled release behavior helps maintain therapeutic concentration for a longer duration and may reduce the requirement for frequent application

The release characteristics of controlled release films mainly depend on various formulation factors such as polymer type, polymer concentration, drug-polymer interaction, film thickness, solvent system, and presence of plasticizers. Polymers such as Ethyl cellulose and Eudragit RS 100 are commonly explored for modifying drug diffusion and achieving prolonged release profiles.[35,36]

Advantages include:

1.Sustained therapeutic activity

2.Reduced frequency of administration

3.Improved patient adherence

4.Better maintenance of drug concentration at the target site

5.Controlled-release films are particularly beneficial for chronic wounds and long-term dermatological conditions.

5.6 Advancement in Spray Delivery Devices

The performance of film-forming sprays is greatly influenced by the design of spray delivery devices. The performance and effectiveness of film-forming spray systems are not only dependent on formulation components but also on the design and efficiency of the spray delivery device. Advanced spray technologies have been developed to improve application accuracy, uniformity, and patient convenience.

Modern spray delivery devices are designed to provide controlled deposition of the formulation on the skin surface, ensuring proper coverage and consistent film formation. Improvement in spray mechanism helps in producing fine and uniform droplets, which promotes even distribution of the formulation and better contact with the application site.

Recent improvements include:

- **Metered-dose spray systems** Metered-dose spray devices are designed to deliver a specific quantity of formulation with each actuation. This helps in maintaining dose accuracy and reducing variation during application, which is important for reproducible therapeutic effects.

- **Improved atomization mechanisms** Advanced atomization technologies improve the conversion of liquid formulation into fine droplets. Proper atomization supports uniform spreading of the formulation and assists in the formation of a continuous and smooth film after solvent evaporation.
- **Uniform droplet distribution** Uniform droplet size and distribution are important factors affecting film quality. Improved spray devices help achieve consistent coverage of the application area, preventing uneven film formation and variation in drug delivery.
- **Enhanced dose accuracy** Accurate delivery of the formulation ensures that the required amount of active ingredient reaches the target site. This improves formulation performance, reliability, and patient compliance.[37]

5.7 Challenges Associated with Recent Technologies

Despite significant advancements, several challenges remain:

- Standardization of herbal extracts
- Regulatory requirements
- Scale-up and commercialization
- Stability of phytoconstituents
- Cost of advanced technologies

Addressing these challenges is essential for the successful translation of research findings into commercial products.[38,39]

5.8 Marketed product of film forming spray [40]

Product	Drug	Company	Formulation type
Lamisil Once®	Terbinafine hydrochloride	Novartis Consumer Health, Australasia, Pty	Film forming solution
Axiron®	Testosterone	Lilly USA,LLC	Film forming spray
Phama Dur®Technology	Hydroquinone	Polytherapeutics,Inc	Filmforming emulsion-gel
Durapeel Technology	Ropivacane	Crescita therapeutics,Inc	Film forming gel

CONCLUSION AND FUTURE PERSPECTIVES

Film-forming spray technology represents a promising advancement in topical drug delivery by combining the advantages of conventional formulations with improved application convenience and therapeutic performance. The ability of these systems to form a uniform polymeric film after application provides prolonged contact with the skin, controlled release of active compounds, and enhanced patient acceptability.The selection of suitable polymers, solvents, and plasticizers plays a crucial role in determining the quality and efficiency of film-forming sprays. Polymers such as Ethyl cellulose and Eudragit RS 100 provide desirable characteristics including film integrity, flexibility, adhesion, and release modification, making them valuable materials for advanced topical formulations. The integration of herbal extracts with film-forming spray technology offers a novel approach for delivering bioactive phytoconstituents with improved stability and localized therapeutic action. Herbal-based systems containing plant-derived compounds have the potential to provide antioxidant, antimicrobial, anti-inflammatory, and wound-healing benefits

while overcoming limitations associated with conventional herbal preparations.

Recent developments such as nano-based delivery systems, controlled-release films, and advanced spray devices have further improved the effectiveness and reliability of film-forming spray formulations. However, challenges related to herbal extract standardization, formulation optimization, stability, and regulatory requirements still need to be addressed.

Overall, herbal film-forming spray systems represent a significant area of research with potential applications in wound management and dermatological therapies. Further studies focusing on polymer optimization, characterization, and clinical evaluation may support the development of safe, effective, and patient-friendly topical delivery platforms. The future of herbal film-forming spray technology appears highly promising due to continuous advancements in pharmaceutical formulation and drug delivery approaches. Future research may focus on the development of multifunctional film-forming sprays with enhanced therapeutic activity, improved stability, and targeted delivery properties. The incorporation of nanotechnology, smart polymers, and advanced biomaterials may further improve drug penetration, controlled release, and treatment outcomes.Standardization of herbal extracts, identification of active phytoconstituents, and improvement in formulation reproducibility will be important areas for future development. Advanced evaluation techniques and clinical studies are required to establish the safety, efficacy, and long-term performance of these systems.With increasing demand for convenient, non-invasive, and patient-friendly therapies, herbal film-forming sprays have the potential to become an important platform in wound care, dermatological treatments, and localized drug delivery. Future innovations may lead to more effective, stable, and commercially viable formulations that bridge the gap between traditional herbal medicine and modern pharmaceutical technology.

REFERENCES

1. Prausnitz MR, Langer R. Transdermal drug delivery. Nature Biotechnology. 2008;26:1261-1268.
2. Brown MB, Martin GP, Jones SA, Akomeah FK. Dermal and transdermal drug delivery systems: current and future prospects. Drug Delivery. 2006;13:175-187.
3. Barry BW. Novel mechanisms and devices to enable successful transdermal drug delivery. European Journal of Pharmaceutical Sciences. 2001;14:101-114.
4. Bouwstra JA, Ponec M. The skin barrier in healthy and diseased state. Biochimica et Biophysica Acta. 2006;1758:2080-2095.
5. Menon GK. New insights into skin structure. Microscopy Research and Technique. 2002;59:168-179.
6. Williams AC, Barry BW. Penetration enhancers. Advanced Drug Delivery Reviews. 2012;64:128-137.
7. Scheuplein RJ, Blank IH. Permeability of the skin. Physiological Reviews. 1971;51:702-747.
8. Kathe K, Kathpalia H. Film forming systems for topical and transdermal drug delivery. Asian Journal of Pharmaceutical Sciences. 2017;12(6):487-497.
9. Goh CF, Lane ME. Formulation and evaluation of film-forming systems for topical drug delivery. International Journal of Pharmaceutics. 2014;473:1-8.
10. Perioli L, Ambrogi V, Rubini D, Giovagnoli S. Novel film-forming systems for topical drug delivery. Journal of Controlled Release. 2012;161:1-7.
11. Karki S, Kim H, Na SJ, Shin D, Jo K, Lee J. Thin films as an emerging platform for drug

delivery. Asian Journal of Pharmaceutical Sciences. 2016;11:559-574.
12. Felton LA. Mechanisms of polymeric film formation. International Journal of Pharmaceutics. 2013;457:423-431.
13. McGinity JW, Felton LA. Aqueous Polymeric Coatings for Pharmaceutical Dosage Forms. 3rd ed. CRC Press.
14. Thakral S, Thakral NK. Eudragit: A technology evaluation. Expert Opinion on Drug Delivery. 2013;10(1):131-149.
15. Rowe RC, Sheskey PJ, Quinn ME. Handbook of Pharmaceutical Excipients. 8th ed. Pharmaceutical Press.
16. Ahmed TA, Aljaeid BM. Chitosan based drug delivery systems: applications and perspectives. Journal of Drug Delivery Science and Technology. 2016.
17. Lee KY, Mooney DJ. Alginate: properties and biomedical applications. Progress in Polymer Science. 2012;37:106-126.
18. Aulton ME, Taylor K. Aulton's Pharmaceutics: The Design and Manufacture of Medicines. Elsevier.
19. Wypych G. Handbook of Plasticizers. ChemTec Publishing.
20. Banker GS, Rhodes CT. Modern Pharmaceutics. Marcel Dekker.
21. Gupta P, Garg S. Recent advances in semisolid dosage forms for dermatological applications. Pharmaceutical Technology. 2002.
22. Boateng JS, Matthews KH, Stevens HNE, Eccleston GM. Wound healing dressings and drug delivery systems. Journal of Pharmaceutical Sciences. 2008;97:2892-2923.
23. Dhivya S, Padma VV, Santhini E. Wound dressings – a review. BioMedicine. 2015.
24. Allen LV. The Art, Science, and Technology of Pharmaceutical Compounding.
25. Lachman L, Lieberman HA, Kanig JL. The Theory and Practice of Industrial Pharmacy.
26. Syed A, Benit N, Alyousef AA. In-vitro antibacterial, antioxidant potentials and cytotoxic activity of the leaves of Tridax procumbens. Saudi Journal of Biological Sciences. 2020;27(2):757–761.
27. Franz TJ. Percutaneous absorption. Journal of Investigative Dermatology. 1975.
28. Balouiri M, Sadiki M, Ibnsouda SK. Methods for antimicrobial activity evaluation. Journal of Pharmaceutical Analysis. 2016.
29. World Health Organization. Quality Control Methods for Herbal Materials. Geneva: WHO; 2011.
30. Kumari A, Yadav SK, Yadav SC. Biodegradable polymeric nanoparticles based drug delivery systems. Colloids and Surfaces B: Biointerfaces. 2010;75:1-18.
31. Choudhury H, Pandey M, Hua CK, et al. Recent advances in nanotechnology based drug delivery systems. International Journal of Pharmaceutics. 2018;548:71-95.
32. Pardeike J, Hommoss A, Müller RH. Lipid nanoparticles as a promising delivery system for topical applications. International Journal of Pharmaceutics. 2009;366:170-184.
33. Siepmann J, Peppas NA. Modeling of drug release from delivery systems. Advanced Drug Delivery Reviews. 2012.
34. Langer R. Drug delivery and targeting. Nature. 1998.
35. Park JH, Allen MG, Prausnitz MR. Biodegradable polymer microneedles for controlled drug delivery. Pharmaceutical Research. 2006.
36. Batiha GES, Beshbishy AM, Tayebwa E, et al. Tinospora cordifolia: Traditional uses, phytochemistry and pharmacological activities. Biomedicine & Pharmacotherapy. 2020;131:110723.

37. Sonchhoya A, et al. Pharmacological and therapeutic potential of Tridax procumbens: A review. Journal of Pharmacognosy and Phytochemistry. 2018;7(2):1-6.
38. Rawlings AV, Harding CR. Moisturization and skin barrier function. Dermatologic Therapy. 2004;17:43-48.
39. Lane ME. Skin penetration enhancers. International Journal of Pharmaceutics. 2013;447:12-21.
40. Patange R, Wakade R. Review On Film Forming Spray for Topical Drug Delivery. International Journal of Pharmaceutical Sciences. Volume 03, Issue 07, Article ID: IJPS/250307377.

HOW TO CITE: Narmada Suroshe, Dr. A. Mahale, Recent Advances in Herbal Film-Forming Sprays for Topical Drug Delivery: A Comprehensive Review, Int. J. of Pharm. Sci., 2026, Vol 4, Issue 8, 1248-1261, https://doi.org/10.5281/zenodo.21837856