IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

# Spray Bandages in Modern Wound Care: A Comprehensive Review of Synthetic and Herbal Film-Forming Systems

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***Abstract:*** Spray bandages can be regarded as a future-oriented wound management technique, which provides immediate non-contact wound cover by creating a thin, flexible, and breathable layer of polymeric film when solvent vapor is present. Compared to traditional wound dressing methods like gauze or adhesive strips, spray bandages are able to shape greatly to irregular wound surfaces, which minimizes pain on application and removal, has lower chances of contamination and decreases the number of changing bands. These qualities lead to better patient adherence and positive healing results. The strategies that are used to formulate spray bandages (such as the choice of an appropriate film-forming polymer, solvent systems, plasticizers, and integration of therapeutic agents) are critically important in determining the performance of such products. All these factors determine the integrity, permeability, mechanical strength and drug-release behavior of a film, which finally determines clinical efficacy. Although their benefits are encouraging, their introduction is restricted by their drawbacks like stability of formulation, regulatory restrictions and limited drug-loading capacity. There exist new avenues of research such as nanotechnology-based delivery systems and responsive wound dressings which provide a potential answer to such constraints. On the whole, spray bandages have high potential as the next generation wound care systems and it is hoped that technology will continue to be enhanced that will increase their clinical applicability.

***Key words:*** Spray bandage; Advanced wound care; Polymeric wound dressings; Drug delivery systems

## I. INTRODUCTION

Effective wound care remains a significant clinical challenge, requiring simultaneous control of infection, maintenance of optimal moisture balance, minimization of pain, and promotion of efficient tissue repair while ensuring patient comfort and adherence. Traditional dressings, such as gauze, adhesive bandages and plain pads, may require regular replacement, may have difficulty complying with shapes of irregular wounds, and may stick to the Malling tissue during their removal resulting in pain and secondary injury [1,2,15]. In response to these obvious constraints, film forming topical systems, commonly known as spray or liquid bandages, have become very popular. These are the non-contact techniques used in modern times with the purpose of protection of a superficial wound and a localized treatment. Spray bandages are in the form of liquid or aerosol. They readily change wherever they are, to a continuous, pliant breathable film. This film heals the wound and allows delivery of active compounds to be in a controlled and localized fashion.

Spray bandage formulations belong to the category of film-forming systems, where a combination of polymer matrix that can form a film, volatile solvents, diverse plasticizers as well as therapeutic agents are brought together, including, but not limited to, antiseptics, antibiotics, growth factors, or phytochemicals. When solvents are applied, they dry up fast. It is a layer of polymer which is sprayed onto Figure 8 on the skin. The layer forms a microbial shield and maintains the wound damp in order to restore skin cells. In contrast to the old-fashioned ready-made dressings, spray bandages do not present any problem with fitting into the irregularities of the body fingers, joints, and even complicated postoperative surgical wounds [3,10,14]

The past five years reflect the drastic changes in technologies. To ensure that materials are more body friendly and decompose naturally, researchers are now working with biopolymers, such as chitosan and cellulose derivatives. There are also nanoscale antimicrobial agents that prevent infections such as silver or graphene composites. The herbal and natural substances come together to apply their healing and anti-inflammatory powers [3,4,5]. Such initiatives address the most important clinical requirements. They reduced the risk of infection among outpatients. They provide therapeutic effect anti-microbial, anti-inflammatory or pro regenerative to the wound with no effects on the entire body.

Among the film sprays are the Chitosan-based ones. It is unique due to its natural antimicrobial properties, blood-clotting properties, and film-forming properties. The preclinical and formulation research supports the notion that water-soluble chitosan sprays are promising and effective to deliver growth factors or antimicrobials in the forms of films that self-adhere and speed up wound healing in animal trials [6,7]. Complex areas of optimization are utilized, such as design of experiments. The techniques optimize drying speed, spraying quality and film strength to clinical application. [6,7,9]

Herbal spray bandages are increasing as well as synthetic and biopolymer work. Plant extracts are also used in making film systems like *Centella asiatica*, *Curcuma longa*, the source of curcumin, and *Syzygium cumini*. They also seek to capitalize on collagen boosting, anti-oxidant and anti-inflammatory action. These have the ability to accelerate re-epithelialization and reduce the extent of scarring. The more recent studies use phytochemicals in conjunction with nanocarriers or polymer matrices. This strategy effectively overcomes key limitations associated with botanical therapeutics, including poor aqueous solubility and variable drug release, while maintaining an excellent safety profile.

People want liquid bandages. The demand to find instant waterproof protective coverage which carries painlessness and is not associated with major wounds and sports injuries is proven by the market uptake. Evidential promises, such as commercial offerings such as over-the-counter liquid bandage sprays, can easily display the actual promise of FFS technology. The product landscape of spray bandages is rapidly evolving, driven by patented academic and industrial research incorporating advanced antibacterial nanoparticles, bioactive peptides, and controlled-release antimicrobial agents. These innovations extend beyond simple antimicrobial protection, aiming to actively promote wound healing through enhanced bioactivity and sustained therapeutic action. Although significant progress has been made, challenges persist in formulation development and regulatory standardization. The stability of active compounds, particularly herbal extracts, remains a major concern due to their susceptibility to degradation. Additionally, certain solvents used in spray formulations may cause skin irritation. Furthermore, current spray bandage systems often demonstrate limited effectiveness in managing wounds with heavy exudate. Maintenance of film thickness and stability of mechanical strength in dissimilar application strategies is the eternal issue in recent studies. We should have more improved methods of gauging spray capacity, dry up time, adhesions, strengths, permeability and the level of actual usefulness of these products. These issues can only be solved to achieve strong clinical use and approval. [12,16]

The technology is changing to extremely useful, smart spray bandages. This entails the movies reacting to stimuli, integrated monitors indicating infection or pH changes, and nanotech releasing bioactive in the long run. Numerous recent publications and patents present prototypes. They combine antimicrobial nanoparticles or intelligent polymers to enhance the protection and treatment of improved and extended duration. Such developments are in the hopes of treating not only a small scrape. They might assist in diabetic foot ulcers, burns and post-surgical involvement. There is a need to conduct stronger human trials. Finally, commercial interest, as well as the needs of the population in health terms, is aligned towards the healthy expansion of liquid bandage tech. This trend is supported by more outpatient care, sports medicine and cosmetic procedures. According to market reports, liquid bandages have great prospects of growth in a year that should prompt more research and clinical trials. New technology should be associated with safety, compliance, and evident patient outcomes. Only at this point will a wide adoption be realized. Altogether, quick advances in science of spray bandages continue to be reported in the recent literature published between 2021 and 2025. It involves polymer options, process modifications, and inclusion of antimicrobials, growth factors and herbals. However, there are still thorny problems formulation, evaluation and market introduction. These advances are gathered together in this review. It weighs the arguments of synthetic and herbal spray bandage. It includes tactics of formulation, their application, available products, regulations, and research directions in the future. The objective is current and clear resource. It can be used by researchers and formulators. They would like to take spray bandage tech out of labs and to the patient [11,16]

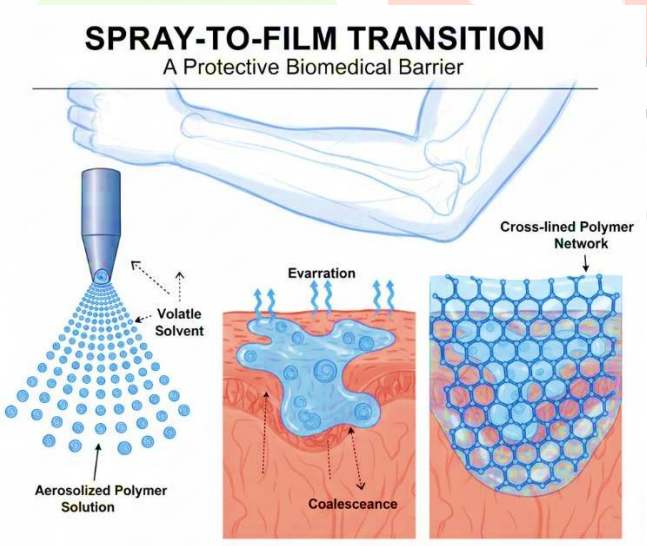


**Figure 1: Spray Bandage formation**

## II. TYPES OF SPRAY BANDAGES

**2.Based on polymer origin**

**2.1 Artificial, Polymer based spray bandages.**

Synthetic spray bandages are carefully crafted with the help of advanced film forming polymers such as polyvinylpyrrolidone (PVP), special polyurethanes, multiple polymethacrylates as well as some silicones, which give the bandage the required strength, essential elasticity, water resistant properties, and essential skin sticking properties. Solvent vanishes quickly. Quick formation of films creates a protective layer against the invasion of microbes and environmental contamination. These artificial systems are widely used in commercial products but they are mainly appreciated because of their high stability nature and stability. They fix minor cuts. Specific utility is applied to minor cuts, to different abrasions and to post-procedural wound management. Issues are connected with solvent induced skin irritation and a high lack of intrinsic biological activity, which causes serious limitations that are still unresolved in present application.

**2.2 Spray Bandages based on natural and biopolymers.**

Other biopolymers include chitosan, alginate, gelatin and cellulose derivatives which are used as natural polymer spray bandages; all of these polymers are biodegradable, biocompatible and often antimicrobial or hemostatic in nature. Qualities are strong. Spray films made of chitosan showed superior wound contraction, reduction of infection, and epithelialization in preclinical trials. Results are promising. The purpose of biopolymer systems has a significant benefit in chronic wounds and sensitive skin application, which is mainly explained by the fact that bio-polymer systems have significantly lower toxicity profile in comparison to synthetic polymer systems.

**3. The Therapeutic Functions are use-purposes.**

**3.1 Barrier-Type Spray Bandages**

Barrier-type spray bandages are mainly non-pharmacological, non-epidermal barriers on the skin, which include vital roles like preventing the entry of pathogens, dampening the loss of moisture through the damaged tissues as well as protecting the lesions against mechanical damages. This protection is inert. These preparations do not contain active therapeutic molecules but rather their protective effect on a wound is solely based on the creation of a polymer film over the area of interest.

**3.2 Drug-Loaded Spray Bandages**

The current spray bandage systems use a range of active agents including antibiotics, antiseptics, anesthetics and growth factors that are administered onto the wound directly. This limits the exposure of the system. These bandages have incorporated the use of mupirocin, silver nanoparticles and epidermal growth factor to enhance positive antimicrobial and regeneration effects.[8,11,12,13]

**4.Depending on the Source of Active Ingredients.**

**4.1 Spray Bandages made of synthetic drugs.**

The chemical solutions under consideration, which are based on the use of such compounds like chlorhexidine, povidone-iodine, or lidocaine created by means of synthesis, help to reduce localized infections significantly and professionally deal with acute pain. Their impact is direct. Persistent usage usually provokes irritation of tissues; this negative outcome is particularly mentioned.

**4.2. Herbal-Based Spray Bandages**

Herbal spray bandages are based on known extracts of plants known to exhibit good wound healing properties, with particular references to Centella asiatica, Curcuma longa, Aloe vera, as well as *Syzygium cumini* in its composition. These compounds work. They have a strong anti-inflammatory effect, great antioxidant effects, and direct stimulation of collagen production, which together hastens wound closure and enhances the overall patient safety results. Such spray applications of herbs attract a lot of attention as a sustainable and safer alternative. The issue of stability is not resolved. There are challenges of standardization.

**5.Based on Formulation Design Spray**

Bandages are differentiated in two design paradigms that include aerosolized propellant-based ones and entirely propellant-free pump-based ones that are becoming more popular because of severe environmental effects and impending government regulation of such chemicals. Synthetic Spray Bandage Spray bandages are synthetic compounds and belong to an old and commercially successful group of film forming wound dressings in existence today. They have major roles in covering wounds very fast, protecting against physical damage, and delivering therapeutic agents to their target, all of which is made possible by synthetic polymers with fully characterized characteristics. The consistent performance of materials, the ease of scalability of production, and the existence of well-defined regulatory channels all put such products in the role of the cornerstone of the commercial spray bandage industry in a large portion. A critical base. Such synthetic systems are normally made in the form of liquid or aerosol film forming solutions in which polymers are dissolved using volatile organic solvents, which allows an easy method of application. On the skin surface, the solvent rapidly evaporates leaving a thin continuous polymeric film that sticks directly to the skin surface and directly to the wound bed. This film creates a physical barrier and provides protection against microorganisms, mechanical stress, and prevents water loss at the site of injury, and at the same time has high oxygen permeability, which is a mandatory condition to the wound healing processes. Polymers in Use in Synthetic Spray Bandages. Synthetic polymers can be used in many instances. These include polyvinylpyrrolidone (PVP), polyurethane, polymethacrylates which include Eudragit ® and contain a large amount of polyvinyl alcohol, and silicone-based materials. PVP is widely used due to its good film forming characteristics, natural transparency and affinity to the skin. Polyurethanes are also incredibly elastic and strong and durable and thus these materials are very suitable to be incorporated in joint specific formulations and designs of mobile skin areas as a finding supported by. They perform. The use of silicone-based polymers is highly considered as a result of their inherent hydrophobicity and their high level of resistance to water, which also means that they can be used to offer long lasting protection such that they can effectively last even when in a continuous exposure to wet or humid environment. This is crucial. Polymethacrylates enable the control of film permeability and mechanical strength to the minute by careful copolymer design, which is essential in the design of sophisticated systems of controlled drug release [14].

**Solvency Systems and Formulation Design.**

The evolving of synthetic spray bandages can also not be carried out without volatile solvents, including ethanol, isopropyl alcohol, acetone, or complex mixtures of both that are necessary to reach immediate evaporation of the solution and provide an adherent film once applied. These solutions irritate. The pain is short lived but remarkably acute when they touch damaged skin particularly open wounds. Addition of plasticizing agents such as propylene glycol, polyethylene glycol or triethyl citrate is done intentionally; it makes the film more flexible and, at the same time, less brittle in nature. These formulations are provided in two major ways; aerosol systems which require propellants, or mechanical pump spray. Increasing environmental needs and stringent regulatory guidelines are now supportive to one. Pump designs lead.

**Synthetic Spray Bandages Loaded with Drugs.**

Inclusion of active pharmaceutical agents is a major milestone in the process of synthetic spray bandage. Antibiotic (mupirocin), antiseptic (chlorhexidine), local anesthetic (lidocaine), as well as other antimicrobial nanoparticles were successfully incorporated into synthetic polymer matrices. This research design is effective. These drug-impregnated systems enable local therapy to be administered at the wound site where the drug is directly delivered to the wound site, minimizing the exposure of the systemic environment, and increasing the effect of the therapy. Research exhibits a long-term drug release pattern of these polymeric films, which enhances antimicrobial activity more significantly and reduce the dose frequency.[11,15]

## III. Clinical Applications

Synthetic spray bandages are mainly applicable when treating superficial epidermal wounds; this consists of cuts, abrasions, minor burns, surgical operation, and post-surgical skin complications. The open wound allows constant visual evaluation of the wound area. Water resistance is able to deal with patient compliance to daily tasks eliminating the need to change dressing frequently. It proves effective.

These bandages are extensively used in the sports medicine departments and outpatient clinics. They are preferred because they are easy to use and apply. These dressings are not effective in deep, high discharging wounds, or infected wounds.

## IV. Advantages and Limitations

The main benefits of synthetic spray bandages include reproducible performance, mechanical strength intrinsic, shelf life and the capacity to manufacture such products on large scale, all of which are crucially enabled by established regulatory pathways of synthetic polymers that effectively enable accelerated commercialization. There are issues. One of the major problems is the irritation of solvents, which is accompanied by the biological inactivity of solvents and a large number of environmental problems directly connected with the use of solvents. The process of regeneration of tissues is not natural. Such artificial films require the incorporation of bioactive substances that will actively stimulate any type of tissue repair or development. Regardless of these disadvantages, synthetic spray bandages still survive to be the cornerstone of the modern liquid bandage technology as well as being reliable wound protectors, they can also be used in a remarkably versatile way as platforms to bring groundbreaking innovations in drug delivery. [2,11]

## V. Herbal Spray Bandage

A recent, sharp increase in interest in the use of herbal spray bandages in wound care is now witnessed due to the growing trend in the demand to develop natural, biocompatible, and highly multifunctional therapeutic systems. This is not the case with synthetic equivalents. Herbal bandages on purpose contain bioactive compounds that are obtained through the look directly in plants; these confer antimicrobial, anti-inflammatory, antioxidant, and tissue-restoring effects. Protective measures of physical wounds also take place. The idea of herbal spray bandages is generally viewed as the progressive film forming construction, being designed with highly complex relations between herbal extracts that are carefully standardized with either natural or semi-synthetic polymers. The process is precise. When used, these special formulae produce an overall protective coating on the whole wound area, and at the same time, provide essential phytoconstituents that actively enhance and support endogenous tissue repair processes.

**Herbal Actives found in Spray Bandages.**

Some of herbal ingredients that are commonly incorporated into treatment regimens would be *Centella asiatica*, *Aloe vera*, *Curcuma longa* (curcumin), *Azadirachta indica* (neem), and *Syzygium cumini*, each with vast listings of their ability to assist in wound healing procedures. These botanical extracts have a lot of potential. To name but a few, *centella asiatica* stimulates collagen production and angiogenesis with vigor, and *Aloe vera* has been known to guarantee the dedication of the epithelialization process and the maintenance of tissue moisture. Curcumin demonstrates significant anti-inflammatory and antioxidant properties but poses considerable problems with formulation due to its very low solubility and the general stability of the compound. This is remedied by new developments. Modern formulation approaches, now incorporate polymer matrices and improved nanocarriers to significantly increase its systemic bioavailability in the current spray bandage applications.

**Film-Forming Matrices and Polymers.**

Herbal spray bandages commonly use natural polymers, namely chitosan, alginate, gelatin and a number of derivatives of cellulose, which have been selected due to their natural properties such as being biodegradable, non-toxic and, in many cases, native wound healing or antimicrobial. They perform well. Chitosan is especially beneficial in promoting haemostasis and hindering bacterial growth and thus it is a perfect ingredient in the development of advanced herbal wound dressings. Synergy results. The combination of these herbal actives with biopolymers brings about compound effects, enhancing the physical defense and the vital biological response at the wound location.

**Mechanism of Action**

The therapeutic action of herbal spray bandages is a composite effect; the first action is to put in place a polymeric film to provide a physical blockade which in turn prevents microbial invasion and precludes epidermal dehydration. This layer protects. The release of herbal bioactives occurs then, as a result, through the same film, namely, targeting inflammatory pathways, stimulating fibroblast activity, promoting collagen integration, and ultimately speeding up the full wound healing. This action is profound. It is an amalgamation of both defensive and active regenerative properties and this is what actually makes herbal spray bandages superior to older, less efficient synthetic approaches that act primarily as passive, superficial barriers to environmental ingress. [11,14,16]

**The benefits of Herbal Spray Bandages.**

The herbal spray bandages offer high levels of improvement in the biocompatibility, a considerably reduced chance of toxicity and major increase in overall curative effect in wound healing. Patients prefer them. The inherent feature of herbal systems is that they lower the reliance on classical antibiotics, which directly addresses topical issues in the world about the emergence of antimicrobial resistance. [6,7,10,14]

**Challenges and Limitations**

Herbal spray bandages have potential but have significant challenges. Poor phytoconstituent stability, intrinsic variability in plant composition, and chronic regulatory approval challenges make formulation processes more challenging as well as regulation approval in the end. The consistency of batches is problematic. The issue of the long-term stability of products is particularly challenging. Extensive clinical evidence on their effectiveness in the treatment of chronic wounds still remains very scarce and requires further in vivo and large-scale clinical investigations. [11,14,16]

## VI. Formulation strategies

The creation of spray bandages in the form of film-forming systems (FFS) requires a delicate balance between a number of key parameters, namely a high degree of sprayability, rapid formation of the film in-situ, a high level of mechanical strength, innate biocompatibility, and in case desired a tightly controlled release of the active pharmaceutical agents incorporated. It's a delicate interplay. Components to such systems are the underlying polymer meshwork with its own plasticizer or solvent complex; an active constituent, in the case of bioactivity, included; the application system, a pump or an aerosol dispenser; and any additional nanocarriers or particulate additives, added to provide bioactivity or mechanical support. [1,8]

1.Polymer selection. Polymers dictate mechanics of the film, adhesion, permeability and biocompatibility. Synthetic polymers (PVP, polymethacrylates, polyurethanes, silicones) provide reproducible mechanical strength, elasticity and water resistance which are envisionable in longterm wear on mobile body locations. Biopolymers (chitosan, alginate, gelatin and cellulose derivatives) have the ability to biodegrade, show inherent bioactivity (e.g., antimicrobial and haemostatic capabilities of chitosan), as well as excellent skin compatibility, and are appealing to sensitive or chronic wound indications. Selection is determined by target indication (superficial dry wound vs exuding wound), desired residence time, as well as the necessity of release of actives in the film).

2.Plasticizer system and solvent system. Solvents that are volatile (ethanol, isopropanol, acetone mixtures, etc.) allow rapid drying and quick forming the film, yet the mentioned solvents may lead to stinging or dehydrating consequences in delicate tissue. Contemporary preparations tend to minimize the strength of the solvent. There are others that incorporate low stinging hypoallergenic mixtures, which are used on sensitive skin. Plasticizers such as propylene glycol, PEG and triethyl citrate reduce film brittleness. This increases flexibility especially around joints. A balance between these solvent and plasticizer components determines the drying time, tack and the tensile qualities of the ultimate film.

3.Rheology and sprayability. To get homogenous surface deposition, the base formulation must be dispersible into a steady and monitored range of droplet size per application. The physical pattern of the spray is controlled by viscosity modifiers such as cellulose ethers or selected low molecular weight polymers together with surfactants as well as eliminate the possible obstructions of nozzles. Experiment design techniques, Box Behnken, or other factorial schemes, offer powerful procedures to optimize factors, like drying rates, sprayability of materials used, and the general film thickness, without compromising inherent therapeutic efficacy. This method is critical.

4. Response system (pump vs aerosol). The emerging trend of pump spray applications in the market is also observed due to the ability to bypass complicated environmental and government requirements of propellants which resides in the fact that it has a distinct upward trend in the market in terms of adoption. This trend indicates the wider industry pressures[42].Even though aerosol and proprietary propellants offer extraordinary fine atomization of certain product types, they will always have heavy headwaters as a result of the changing regulations and the pressing imperatives of sustainability. Safe packaging is completely essential regarding contamination prevention.

5. Additives & functionals. Complicated material systems, by incorporation of components such as antimicrobial nanoparticles, in particular AgNPs, or even reinforcing nanosheets as graphene oxide, or even by the incorporation of pH indicators and stimuli-responsive polymers are developed to offer a spectrum of superior functionality, such as intense antibacterial activity, important mechanical receptiveness, and intensive infection-detecting abilities. This increases the utility of materials. Although application of useful natural extracts, such as curcumin, Centella asiatica or aloe, are promising, such molecules require special stabilizing technologies such as nanoencapsulation or inclusion in cyclodextrins to overcome their low solubility nature and counter strong oxidation deterioration. Stabilization is essential.

6. Quality attributes & testing. Various critical quality attributes are essential to optimal product performance such as drying time, accurate film thickness and penetration, tensile strength and suitable elongation, resistance to water, effective oxygen and water vapor permeability, consistent adhesion to wet and dry skin, consistent drug content and confirmed in-vitro owing to in-vivo release and subsequent efficacy. These are crucial. Such protocols of standardized and reproducible characterization continue to be in active development throughout the field.

**Mechanism of action**

Spray bandages operate under the interacting actions of physical barrier effects, and biochemical regulation of wound healing in drug-loaded systems or bioactive systems.

1.Resistance to fatality and development of a film. Volatile solvent evaporation results in a thin polymeric film which sticks to the skin/wound surface after spraying. This film is physical in the sense that it prevents access of environmental microbes and particulates, mechanical damage of friction, and contamination of the wound. The fact that many films are transparent allows visual inspection of wound without removal.

2.Modulation of microenvironment (moist wound healing). The resulting created film cuts down undue trans-epidermal water loss and is permeable to gases (oxygen) thus maintaining a moist microenvironment that is favorable towards keratinocyte migration and re-epithelialization. Gas and vapour permeability should be appropriate: excessively closed films can occurred to maceration, and excessively permeable ones can lead to dryness of the wound bed. The choice of polymer and porosity of the films thus determine the kinetics of healing.

3.Localized administration of therapy. Polymer matrix is used in drug-loaded spray bandages and serves as a local release depot of the active agent. Diffusion through the polymer matrix, polymer erosion (in the case of biodegradable matrices) or, release mediated by nanoparticles are all release mechanisms. Local delivery limits the systemic exposure and focuses the treatment on the wound (e.g. mupirocin as a topical agent, antiseptic silver nanoparticles).

4.Active biological modulation (of herbal/biopolymer systems). Chitosan (biopolymers), curcumin and Centella asiatica extracts (herbal actives) regulate inflammation, oxidative stress and collagen production, as well as create inherent antimicrobial and haemostatic action. Together with appropriate carriers, these actives amplify wound healing (inflammation resolving) to granulation to re-epithelialization phases to go beyond the passive barrier effect.

5. Advanced functionalities. New systems also include stimuli-responsive polymers (pH, protease, ROS sensors), colorimetric warning systems of infection, or antimicrobial nanocomposites to deliver a smart response -e.g. release is more in an infected or

inflamed environment. These systems strive to extend utility to chronic wounds and diabetic foot ulcers and surgery-site management (most on preclinical/ prototype level). Sold products (table format). The following is a brief table of some typical commercial liquid bandage / spray bandage products (OTC consumer and medical), product manufacturers and product characteristics. These are examples of mainstream positioning of products (barrier vs. antiseptic vs. hypoallergenic). [11,14]

**Table 1: Marketed Products:**

| Product (example) | Manufacturer / Brand | Type / Matrix | Key features & intended use |
|---|---|---|---|
| Nexcare No-Sting Liquid Bandage (spray) | 3M (Nexcare) | Synthetic film-forming spray | Alcohol-free, nosting, fast-drying, waterproof protective film for minor cuts/abrasions; suitable for infants >2 months. |
| New-Skin Liquid Bandage (spray & liquid) | New-Skin Products | Synthetic/antiseptic liquid bandage | Antiseptic claims, waterproof, flexible film; botanicals variant available (aloe, chamomile). |
| Band-Aid Single-Step Liquid Bandage (premoistened applicator) | Kenvue / BandAid | Liquid adhesive film | No-sting, singlestep protection for small cuts & cracks; convenient applicator format. |
| (Research prototypes) MUP-FFS (mupirocin in chitosan/α-cellulose) | Academic/Industry prototypes | Biopolymer film-forming spray with antibiotic | Designed for localized mupirocin delivery; demonstrates improved wound closure and antimicrobial efficacy in preclinical work. |
| AgNP–GO liquid bandage (prototype) | Academic prototypes | Nanocomposite (AgNPs + graphene oxide) | Antibacterial nanocomposite films with enhanced antimicrobial potency preclinical stage. |

## VII. Future potential and Perspectives

Continued advances in extraction standardization are being made, as well as considerable advances in the practices of nanoencapsulation and polymer engineering have been made, which will be all the more critical in order to overcome and eliminate many of the current limitations in the development and delivery of therapeutic products. Enter herbal spray bandages. The fact that these new systems can combine sustainable production, patient safety, and strong therapeutic activity is what makes them the promising choices as the next-generation wound care solutions. [11,16 ]

1.Restricted exudate management & deep-wound appropriateness. Spray bandages develop layers that are thin with low absorbent capabilities, which limit them to shallow, low-exudate injuries. In the case of moderately to heavily exuding wounds, standard absorptive dressings or hydrocolloids are still the best choices.

2.Patient tolerability Solvent irritation. Solvents used in the volatile solvents that must be used in case of quick drying may cause sting or irritation of the sensitive skin and inflamed wounds, so the optimization of the formulations and the system of hypoallergenic solvents is needed in order to decrease the adverse effects.

3.Bioactives Standardization and stability. Herbal extracts are problematic in variability and oxidative degradation, and strict standardization (nanoencapsulation, cyclodextrins) is needed to be accepted by the regulations.

4.Repeatability and film monotony. Having uniform thickness of the film, uniformity of drug content and coverage in different techniques of application has been a manufacturing and usereducation challenge.

5.Smart films Multifunctional films. The incorporation of stimuli-responsive polymers, infection sensors and triggered release systems would make the spray bandages active wound-management devices as opposed to passive shields. Sensors Prototype AgNPGO and sensor enabled films give illustrated directions. Nanomaterials will need effective safety assessments in clinical translation.

6. Herbal actives facilitated by nanocarriers. Nanoencapsulation should be coupled with standardized phytoconstituents so that solubility/stability can be overcome, and predictable release can be performed, combining the advantages of naturalness with the strict pharmaceutical regulation.
7.Indication-specific and personalized systems. Barrier sprays Only barrier sprays, antiseptic sprays, analgesic sprays or regenerative sprays (loaded with growth factors) might be chosen based on the type of wound and comorbidity in the patient (ex: diabetic foot). The adoption will be pushing by regulatory, economic and real-world evidence.
8. Sustainability & propellant-free shipping. The future of the environmental issues and regulatory trends will support the use of pump systems and more environmentally friendly solvents, enhancing safety and reducing the impact on the life cycle of the devices.
9.Vigorous clinical testing and standardization. Additional randomized controlled trials comparing FFSs to conventional dressings in the outcome endpoints (healing time, infection rate, scarring, patient comfort) are necessary to change the paradigm of consumer OTC barrier products to accepted clinical therapeutics, and harmonized test methods of film properties are needed. [11,13,14]

## VIII. Conclusion

Spray bandages are innovative film-forming wound care systems that provide rapid protection, maintain a moist healing environment, and allow localized delivery of therapeutic agents. Compared to traditional dressings, they offer better conformity, patient comfort, and ease of application, especially for minor and superficial wounds. Synthetic polymer-based systems remain commercially dominant due to their stability, reproducibility, and scalability, though concerns such as solvent irritation and limited bioactivity persist. In contrast, biopolymer and herbal-based spray bandages offer improved biocompatibility and active wound-healing benefits but face challenges related to stability, standardization, and regulatory approval. Overall, spray bandage technology is evolving toward smarter, bioactive, and more sustainable systems. However, further formulation optimization, standardized evaluation methods, and strong clinical evidence are essential for broader clinical adoption.

### IX. Acknowledgment

The authors would like to thank the School of Pharmaceutical Sciences, Vels Institute of Science, Technology and Advanced Studies, Chennai for their technical support.

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