TRANSDERMAL DELIVERY OF HERBAL MEDICINE BY NANO-FIBROUS LOADED COSMETIC FACE MASK: A PROMISING APPROACH FOR DELIVERY OF DRUGS

Abstract

To get beyond the drawbacks of conventional preparation, nano-fibres technology has been successfully used to create drug delivery systems. Its use has been expanded to numerous pharmaceutical disciplines, including injection preparation, oral preparation, and external preparation, and it has recently made an appearance in the field of cosmetics for use in the enhancement of attractiveness. The fact that nano-fibres may successfully boost the percutaneous penetration and significantly increase skin retention of active components in functional cosmetics accounts for the extensive influence of nano-fibres in the cosmetics sector. Nano-fibres, meantime, can successfully increase the water dispersion of insoluble active cosmetic compounds, improve the stability of efficacy components, and achieve the codelivery of several cosmetic active ingredients.

Keywords: Nano-fibres, Cosmetics, Skin penetration, Active cosmetic ingredients, Efficacy evaluation.

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I. INTRODUCTION

As in every industry, the cosmetics sector has undergone significant diversification in order to raise the standard of production and satisfy the demands of customers who value high-quality, well-groomed personal care items. Incorporating nanomaterials into the many different cosmetic goods has improved their potential [1], and they are frequently used in lipsticks [2], anti-aging creams [3, 4], hair products [5, 6], facial masks [7, 8], sunscreen creams and anti-hair-fall products. A new field in which great focus has been placed on creating facial masks or membranes that can release skincare ingredients is the cosmetic application of electrospun nanofibres [9, 10].

Utilizing polymer solutions such as cellulose acetate [11], chitosan [12,13], hyaluronic acid [14,15], as well as synthetic polymers, such as polyvinyl alcohol (PVA), polyvinyl pyrrolidone (PVP) [16], and polyethylene oxide (PEO) [17], electrospinning is a straightforward, inexpensive, and adaptable technique for obtaining nano-fibre. The capacity of the electrospinning technology to integrate any active compounds of interest while constructing the fibre mat is by far its greatest benefit. Additionally, electrospun fibre masks are effective at releasing active ingredients, don't need preservatives, and can even be packaged as dry sheets [18]. They must only be wetted when necessary in order for active chemicals to release [18] only when necessary must they be wetted in order for active chemicals to be released [19]. These have largely been targeted to release chemicals for skin healing [20], treatment [21], and cleansing due to their capacity to allow greater contact with the skin and aid in a deeper penetration of the active agent [22]. A drug's percutaneous absorption is a challenging process; the molecular size, hydrophile/lipophile balance, melting point, and water solubility all have an impact on the penetration rate. The majority of the time, a natural product ingredient is used in a therapeutic environment. In general, medicines that stimulate blood circulation (such borneol, lilac, and pepper [23]) and potent irritants make up transdermal natural product drugs (white mustard, ginger onion, garlic, leek). Transdermal delivery of these natural substances has a long history, and provides a well-researched example [24,25].

Due to the restrictions of social hygiene in ancient culture, medication powders or unprocessed plant extracts were used in formulations, such as topical powders, pastes, and pills. The dosage form for topical administration is a powder mixed with water, honey, wine, or vinegar. However, there are a number of drawbacks, including: poor adhesion and mess; it may have a high bacterial content and easily cause skin infection; it is difficult to preserve and just grows mould; the percutaneous penetration of the drug components is low; and it may also have a high bacterial content. Application in contemporary clinical practice is constrained by the difficulty of industrially producing numerous classic dosage forms or the difficulty of controlling their quality. Chinese medicines are nevertheless still commonly used in specific clinical situations due to their ease of acquisition and practicality of use.

Since ancient times, herbal medicines have been widely used throughout the region of the world. Herbal preparations are used in India's traditional medical systems, such as Siddha and Ayurveda [26]. Herbal medications currently have a dominant position in the pharmaceutical sector due to their well-known efficacy and extremely few adverse effects. In addition, compared to manufactured medications, herbal pharmaceuticals have a more balanced interest in creating nanoparticles [27]. Despite the fact that herbal medicines have powerful pharmacological effects against a wide range of diseases, they have only a modest impact on the human biological system because of their poorer kinetic performance, which includes low absorption, an inability to cross lipid membranes, large molecular weights, and poor absorption. These factors reduce the drugs' bioavailability and biological system-wide effectiveness [28].

In the field of cosmeceuticals, nanotechnology holds enormous promise for the manipulation of materials at the atomic level, providing new opportunities for the cosmetics sector. Nanocosmetics and nanocosmeceuticals, respectively, are products created by using various nanomaterials into the production of cosmetic and cosmeceutical goods. Among the benefits of cosmeceuticals based on nanotechnology are the extension of action, increased bioavailability, and enhanced aesthetic appeal of goods. These products differ from conventional cosmeceuticals in a number of ways, including their tiny size and high surface-to-volume ratio, which makes them useful adjuvants in cosmeceuticals. Additionally, adding nanoparticles to cosmetic formulations enhances their look, coverage, and skin-adherence without altering the cosmeceuticals' inherent qualities. Manufacturers of cosmetics use nanosized components to enhance a range of features, including UV protection, skin penetration, colour, scent release, finish quality, anti-aging impact, and a host of others. By regulating the transport of active components, causing site-specificity, promoting biocompatibility, or increasing the drug-loading capacity, they extend the duration of action. Because of all of these advantages, they are increasingly widely used by consumers, which calls for clinical research to address any safety issues. A lot of nano-cosmeceuticals have been used to create various anti-aging compositions. They are successfully promoted as skincare, hair, and nail care products among others, with the promise that doing so will boost their potency as cosmetics by stimulating their growth, safeguarding their structure, and enhancing moisture [29,30]. Although they offer many advantages, they also have drawbacks in terms of stability, scalability, toxicity, expense, etc. Furthermore, there is ongoing debate on the toxicity and safety profiles of nanomaterials. The biological interactions that nanoparticles can have with their milieu are enhanced by their small size, increased surface area, and positive surface charge. However, through various delivery methods, they exhibit dose-dependent toxicity.

It is widely known that the dosage has a greater impact on an active ingredient's bioavailability than the active moiety's physicochemical characteristics [31]. As a result, in the context of beauty products, a major worry about the development of nanoformulations is that they might increase the concentration of active substances that reach the blood and affect toxicity [32].

II. METHODS OF PRODUCTION OF NANO-FIBERS

1. **Self‑assembly method:** In this approach, atomic/molecular aggregates spontaneously organise into a structurally defined nanofibrous structure. This process produces nano-fibers with a size range of up to 100 nm. This technique takes longer to produce nano-fibers and is consequently less frequently used. However, self-assembled nano-fibers can closely resemble natural materials like chitin (polysaccharide), which has been investigated in tissue engineering [33].

2. **Phase‑separation method:** This technique involves lyophilizing a polymeric mixture to create a nano-fibrous mat. The nano-fibers produced using this process range in size from 50 to 500 nm, although they are shorter in length and need a lot of time [34].

3. **Melt‑blown technology:** The melt blown process involves extruding a polymer mixture via a tiny hole, then passing it through a heated air stream at a high velocity. The size of the nano-fibers made with this technique ranges from 150 to 1000 nm [35].

4. **Electrospinning:** The method used most frequently to create nano-fibers is electrospinning. The size range of the fibres produced by the electrospinning process can range from nanometer to micrometre. It is regarded as a low-cost and scalable method for producing nano-fibers [36]. The 'nanospider' method of modified electrospinning also yields nano-fibers. This method produces nonwoven nano-fibers with diameters ranging from 50 to 300 nm [37].

   Transdermal medication administration, enzyme immobilisation, wound dressing, and tissue engineering are just a few of the biomedical engineering applications that nano-fibrous nonwovens are being investigated in depth for [38]. When using electrospinning, polymeric melt or solution must first be prepared, and then once it has been extruded from a nozzle syringe or pipette, an electric charge must be applied to it [39]. Finally, the produced nano-fibers are deposited on the aluminium wall as a result of electrostatic attraction between the polymer and wall (caused by the existence of opposite charges on both) [40].

III. METHODOLOGIES OF DRUG LOADING IN NANO-FIBERS

The following sections cover various methods of drug loading into nano - fibers:

1. **Co‒electrospinning:** This method simply entails combining the medication and polymeric solution before starting the electrospinning process. Co-electrospinning is a form of electrospinning that involves electrospinning a homogenous solution of a medicament and a polymer in a single solvent [41]. The nano-fibrous network exhibits good loading efficacy and homogenous drug distribution when using this approach [42]. The physicochemical characteristics of the polymer employed, followed by the interaction of polymers with drug molecules, determine the loading efficiency of nano-fibers created using this technique[43]. The distribution of drug molecules within nano-fibers and their shape may have an impact on the kinetics of release [44]. Due to their full breakdown in the aqueous phase, many natural polymers like gelatin, collagen, and chitosan are employed to create nano-fibers that are loaded with hydrophilic medicines [45]. The cross-linking process causes the nano-fibers made using this technology to collapse, which causes issues with the electrospinning procedure. Using synthetic hydrophilic polymers like PEO (Polyethylene oxide) in addition can help solve this issue. This may be caused by the lower viscosity of the solution. A burst release effect may also result from the creation of nano-fibers using this technique[46]. Immobilisation of pharmacological molecules on nano-fiber surfaces Following the surface immobilisation method, numerous therapeutic drug molecules can be loaded in nano-fibers via a variety of physical and chemical methods. Electrostatic, hydrogen-bonding, and weak van der Waals interactions are a few of the factors that might result in physical immobility

[47]. Chemical immobilisation entails directly attaching drug molecules to the surface of nano-fibers by functionalizing them with different groups, such as thiol, carboxyl, hydroxyl, and amine [48]. Due to the excessive use of organic solvents and high voltage, the surface immobilisation method does not lead to drug molecule denaturation as was seen in the case of the co-electrospinning method [49].

2. **Co‑axial electrospinning:** The co-electrospinning technique may encounter issues if the medicinal molecules and the polymer are incompatible. As a result, a novel technology known as "co-axial electrospinning" is employed to load various drug types with disparate levels of solubility in polymers [50]. The use of a spinneret needle with an inner and an outer nozzle arranged concentrically allows for co-axial electrospinning. To handle sheath solution and core solution, there are two separate chambers available. From the co-axial cone, the final solution is expelled [51] Using this method, two non-miscible polymers with therapeutic compounds in both the core and sheath can be electrospun [52]. Due to the presence of a stagnant sheath, electrospinning using this method has a high drug loading capacity and prevents initial burst release [53]. An aqueous solution of a protein or medicinal substance is emulsified with a lipophilic polymeric solution in emulsion electrospinning [54]. Additionally, upon the completion of the electrospinning process, the drug-loaded phase is distributed throughout the nanofibers. This approach completely depends on the ratio of hydrophilic to lipophilic solution utilised for the drug molecule dispersion within the nanofiber [55]. This method can be used to dissolve polymers and therapeutic substances in appropriate solvents. The medicinal substance is just little exposed to an organic solvent in this approach [56]. The employment of several hydrophilic drug and lipophilic polymer combinations is permitted by the emulsion electrospinning technique [57]. Due to their great sensitivity, the interfacial tension and intense shearing forces that exist between the two phases of an emulsion can destroy proteinaceous drug molecules [58]. This electrospinning technique's usage of ultrasonication approach has been shown to harm drug molecules, decreasing the effectiveness of the resulting nano-fiber [59].

IV. THE TYPES OF DERMAL/TRANSDERMAL DRUG DELIVERY NANO-FIBRES IN COSMETICS

Nanocrystals, lipid nanoparticles, lipid liquid crystals, microemulsions /nanoemulsions, liposomes, lipid nanoparticles, polymer nanocarriers, and inorganic nanocarriers are some of the dermal/transdermal drug delivery nanocarriers utilised in cosmetics. The major property of nanofibres is their particle size, which provides a significant material foundation for their unique biological activities. In contrast to the size of nanomaterials defined in the field of materials science (0.1 100 nm), extensive research has shown that when the particle size of the nanofibres is between 10 and 1000 nm, the efficacy components are noticeably different from the traditional preparations in terms of physical and chemical properties, pharmacokinetics, and pharmacodynamics.

1. **The routes of dermal/transdermal drug delivery nano-fibres:** According to the available research,[60] there are three basic ways that nano-fibres can promote the percutaneous absorption of efficacy components:

- The nano-fibres deliver cosmetic efficacy components to surrounding tissues by penetrating through skin appendages like hair follicles and sebaceous glands.
- Interactions between nanocarriers and the stratum corneum of the skin can increase the permeability of efficacy components.
- The deformable nanocarriers in intact form penetrate the living cell layer of the skin by the intercellular route of the stratum corneum.

V. APPLICATION AND EFFICACY EVALUATIONOF ACTIVE COSMETIC INGREDIENT NANOFIBRES

1. Skin moisturizing efficacy components nano-fibres: Dysfunction of the epidermal barrier is linked to skin issues and diseases. Skin can lose a lot of water due to epidermal barrier failure, resulting in dry, sensitive, itchy, and chapped skin. According to studies, skin moisturising nanocarriers may effectively raise epidermal moisture content and restore skin barrier function, which not only treats skin issues but also has a preventive and therapeutic effect on chronic skin conditions like eczema, atopic dermatitis, and psoriasis. [61–63]

2. Components of freckle-removing efficacy nano-fibres: Tyrosinase is a crucial enzyme in a sequence of oxidation events that lead to the creation of melanin. In order to create a whitening and freckle-removing effect, whitening and freckle-removing effectiveness components in cosmetics nowadays mostly work by inhibiting melanocyte proliferation, tyrosinase activity, and other associated rapid-limiting enzyme activity. However, when using these efficacy components, there are typically the following issues: As a result of the skin barrier and the poor solubility and stability of the efficacy components, as well as their ease of degradation and discoloration when exposed to light and heat.

A novel whitening agent called phenylethyl resorcinol has been used in cosmetic products as a whitening and brightening ingredient because of its ability to block tyrosinase activity. [64] Phenylethyl resorcinol can be used, however its poor water solubility and light instability restrict its use. Kim et al.[65]used the hot-melted ultrasonic technique to create nanostructured lipid carriers that were loaded with phenylethyl resorcinol. Phenylethyl resorcinol was incorporated into nanostructured lipid carriers, which resulted in exceptional physico-chemical stability, photo stability, and a sustained release.

3. Nano-fibres as anti-aging efficacy components: The buildup of too many extra oxygen-free radicals in the human body is linked to skin ageing. Preventing illnesses and delaying the ageing process of the skin can be accomplished by promptly scavenging excess oxygen-free radicals. The anti-aging ingredients that are frequently found in cosmetics can currently effectively remove oxygen-free radicals, but there are some issues with their practical application, such as poor stability, low bioavailability, the decomposition of these ingredients in the presence of light, heat, and oxygen, and difficulties with transdermal absorption. These issues may now be resolved thanks to the development of nanocarriers with anti-aging effectiveness components. Natural active substances having antioxidant and free radical-scavenging characteristics, like polyphenols, flavonoids, and carotenoids, are frequently employed in cosmetic efficacy components due to their safety.

4. **Nano-fibres with anti-acne efficacy components:** A common and persistent inflammatory dermatosis of the pilosebaceous units is acne vulgaris (also known as acne).[66]. The hyperactivity of the sebaceous gland, follicular epidermal hyperproliferation, and inflammation of the pilosebaceous units brought on by pathogens like Cutibacterium acnes are the fundamental reasons of acne development (C. acnes). [67] The physical and chemical characteristics of drugs, such as skin irritation and low permeability, limited their applications even though topical therapy is generally regarded as the first line of treatment for mild to moderate acne. This created a significant opportunity for nanocarrier technology in the development of novel, low-dose, and efficient treatment systems to manage acne disease. [68]

VI. FUTURE ASPECTS AND CHALLENGES OF NANO-FIBRES

Numerous applications in healthcare and biomedical engineering, including wound dressing, medication delivery, tissue engineering, and regenerative medicine, have made extensive use of nanofibers.Due to their distinct structural architecture and physicochemical characteristics, they are particularly useful for biological sensing and the delivery of medicinal agents. For instance, the interconnected nanofiber networks with high micropore densities can imitate the native topographical features of ECM found in vivo. Because of this, they are ideal as scaffolds for cell development and proliferation, which encourages their use in tissue engineering and wound dressing. Furthermore, nanofibrous networks' high porosity and huge specific surface area make them very desirable for immobilising a variety of biomolecules and active species. As a result, nanofibers with high molecular loading capacities are attractive for use in biological sensing and medication delivery. The practical uses of nanofibers in healthcare and biomedical engineering still face difficulties despite these intriguing characteristics. The size, orientation, arrangement, and porosity of nanofibers and their network structures, for instance, need to be carefully controlled and optimised in order to further increase the applicability of nanofibers for bioapplications. These characteristics have a significant impact on a number of biological processes that occur in the presence of nanofibers, including biomolecule adsorption, cell adhesion, and cell proliferation. Academic research and studies on one-dimensional nanofibers are developing quite quickly. There is no indication that the rate at which new synthesis methods and uses for nanofibers are disclosed in the literature will slow down. However, there are still a number of obstacles that need to be addressed and overcome before commercial and industrial uses of nanofiber synthesis may be realised. These obstacles are not little, but they are also not insurmountable. First and foremost, it is crucial to create new techniques for synthesising nanofibers that can combine the best aspects of all existing and future approaches to generate high-quality nanofibers quickly enough for industrial use. One-dimensional nanofiber investigations and academic study are progressing swiftly. There is no sign that the pace of novel nanofiber production techniques and applications being published in the literature will slow down. Before commercial and industrial uses of nanofiber manufacturing can be realised, however, a number of challenges must be addressed and surmounted. These challenges are not insignificant, but neither are they insurmountable. In order to produce high-quality nanofibers quickly enough for commercial usage, it is essential to first develop novel procedures for synthesising nanofibers that may incorporate the best features of all current and future methods.

VII. CONCLUSION

In addition to increasing the stability and solubility of functional cosmetics, nanocarrier technology.In order for the active cosmetic ingredients to reach the target site of the skin and perform the tasks of sustained release, regulated release, and long-term release, they must first overcome the barrier effect of the cuticle. This overcomes a variety of skin disorders and skin diseases. The creation and preparation of nanocarriers is more difficult compared to normal cosmetic preparations. Surface charge, internal structure, interaction with efficacy components, stability, and skin permeability of the nanocarriers are all influenced by the characteristics, dose, and percentage of each component in the formulation as well as the production procedure.Many issues in the still need to be resolved.

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