World Journal of Biology Pharmacy and Health Sciences
eISSN: 2582-5542
Cross Ref DOI: 10.30574/wjbphs
Journal homepage: https://wjbphs.com/

(REVIEW ARTICLE)

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Current review on nail drug delivery system and their future perspectives

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World Journal of Biology Pharmacy and Health Sciences, 2024, 19(01), 337–349

Publication history: Received on 12 June 2024; revised on 22 July 2024; accepted on 24 July 2024

Article DOI: https://doi.org/10.30574/wjbphs.2024.19.1.0444

Abstract

Human nails are not only beautiful and protective, but they may also be utilized as a vehicle for drug delivery, particularly in the treatment of nail disorders such as psoriasis and onychomycosis. Even though nails develop at a somewhat moderate rate, their highly keratinized structure presents unique opportunities and challenges for medication penetration. Achieving therapeutic doses might be difficult even with topical pharmaceutical delivery, which offers advantages like non-invasiveness and customized effect. Many physical and chemical methods, such as acid etching and permeation enhancers, have been studied to improve drug penetration. It has recently been demonstrated that nail lacquers have potential for effectively delivering medication through the nails. Nail anatomy, common nail diseases, nail medication administration methods, and the advantages and disadvantages of nail lacquers are all covered in this overview. In addition, it discusses factors influencing drug diffusion through nails, draws comparisons between topical nail lacquers and oral antifungal medications, and looks at recent studies and patents on the topic. Future prospects for transungual medicine administration are promising, thanks to innovations such as photodynamic therapy and water-based lacquers. To fully realize the promise of this distribution method, more research is necessary.

Keywords: Onychomycosis; Psoriasis; Transungual; Nail lacquer; Keratinized

1. Introduction

Not only may human nails protect and adorn the structure of the hand, but they can also be specifically employed to carry medication for nail diseases like psoriasis and onychomycosis. The average growth rate of human nails is 3 mm each month, or 0.1 mm per day. Human nails grow continuously. Toenail development is slower than fingernail development. While fingernails can regenerate in 4-6 months, toenails typically do so in 8–12 months. Several research works have been carried out to demonstrate the physicochemical properties of nails or their behavior. The most visible part of the nail tool, the nail plate (0.25–0.6 mm), controls how much of the medication enters the nail.

It has tightly packed dead cells (0.01 mm thick) and is heavily keratinized. There are several sizes and forms available for the nail plates, such as ridged, smooth, hard, small, large, wide, and narrow. The unusual appearance of the nail plate could have taken away from the brightness. The In addition to the physical or chemical characteristics of the nail bed that lead to the ingrowth of various drugs in the nail, the nail plate also plays a role in the reduction of blood flow in the nail bed. Owing to the way this nail plate is arranged, the medication might only penetrate a portion of the topical formulation. This hinders the achievement of the therapeutic concentration in an efficient manner.

Nevertheless, the administration of topical medications is advantageous due to its non-invasive nature, capacity to precisely target the site of action, elimination of drug interactions and systemic adverse effects, and potential to reduce

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treatment costs all of which encourage patient compliance. Analyzing how efficiently medications penetrate nails is another really difficult task. To maximize the efficacy of topical therapy, ungual drug permeability must be raised. The nail plate must be physically or chemically damaged in order to achieve this. Alternatively, nail penetration might be enhanced by using a vehicle to generate the drug within and permit a high drug partition into the nail plate.

Examples of physical methods include acid etching, low-frequency ultrasound application, electric currents, laser ablation, manual and electrical nail absorption, and microporation. Chemicals include things like sulfites, thiols, water, urea, hydrogen peroxide, and enzymes.

A transungual drug administration approach is used to obtain the desired therapeutic absorption of the medication for treating the twenty to thirty percent of patients who suffer from nail disorders. Many diseases can affect a person's nails, such as psoriasis, paronychia, and infections caused by bacteria, viruses, or fungi. When oral medication is used for nail problems, there may be some systemic side effects and drug interactions as opposed to topical therapies. Recent advances in the topical delivery of medication include the use of antifungal nail lacquers and chemical treatments to alter the nail plate barrier. The goals of this review are to pinpoint problems with nail lacquer therapy for different nail disorders as well as issues with the administration of nail medications.

2. Anatomy of nail

Compared to other human bodily membranes, nails are entirely distinct in terms of composition and layout. Keratin molecules with numerous disulphide bonds and little amounts of complementary lipids make up nail plates. The nail plate is different from all other body membranes in that it "tends more like a hydrogel than lipophilic membrane" in terms of its barrier properties.The nail's root, cuticle, folds, nail plate, nail bed, nail hyponychium, paronychium, and lunula are among its constituent parts. The living skin, or eponychium, covers around 20% of the nail plate. The part of the nail skin that overlays the nail plate on its sides is also called the paronychium. The nail unit's most distal or outermost edge is called the hyponychium.

Keratin makes up the majority of the nail plate. The thickness and width of the nail plate are influenced by a number of factors, such as fingertip size, length, shape, and matrix thickness. The special protein keratin is responsible for producing the majority of the nail plate. The new nail plate presses on the old nail plate when the latter becomes translucent, compressed, and flat and the new plate cells are finished. The pinkish tissue area is the nail bed, and it supports the entire nail plate. The nail bed is composed of tissues from the deeper dermis and the surface epidermis. The microscopic longitudinal channels known as crests are where the dermis and epidermis layers meet. The lunula is moreover present in the human nail. This opaque, bluish-white substance at the base of the nail plate looks like a half-moon. The small finger lacks a lunula, while the thumb possesses the largest.

The nail matrix promotes nail growth because it generates the cells needed for nail growth. As long as it is nourished, the matrix can keep growing and remaining healthy. The epithelial layer lies beneath the nail root, and it is from this layer that the nail grows by changing the surface cells.Many factors influence how quickly nails develop, such as age, sex, weather, dominant hand, pregnancy, small wounds or nail biting, fever and psoriasis, malnourishment, and drug use.Many factors, such as the physicochemical properties of the drug molecule, formulation components, the presence of permeation enhancers, nail qualities, and interactions between the keratin network and the nail plate permeant, influence drug transit into the nail.Aqueous delivery is the main element influencing drug penetration.

3. Nail diseases and disorders

Numerous illnesses and genetic conditions, including congenital abnormalities, skin conditions affecting the nail bed, systemic diseases, decreased blood flow, local trauma, tumors of the nail fold or nail bed, infections of the nail fold or nail plate, and so forth, can be blamed for the unusual appearance of the nail.

3.1. Onychomycosis

This is a fungal infection caused by molds, yeasts, or dermatophytes that affects the nails of humans. Generally speaking, 10–40% of people have this illness. Fungal infections can cause nail thickness, discoloration, and splitting, which can aggravate and damage the nails. This infection affects the toenail more than the fingernail. Onychomycosis infections can be divided into the following classes based on the infection site:

- Distal and lateral subungual onychomycosis: he distal or lateral nail bed is eventually affected by the infection, which first affects the hyponychium. The ventral nail plate and proximal nail bed are the next areas the fungus attacks.
- Superficial white onychomycosis:- bacteria invading the nail plate and causing white, powdery patches to appear. The surface may crack when these dots combine to occupy the entire plate.
- Proximal subungual onychomycosis: Prior to affecting the newly formed nail plate, the fungal infection first affects the nail folds. This might cause a white discoloration in the vicinity of the lunula.
- Total dystrophic onychomycosis: Fungi affects the entire nail plate and nail bed.

3.2. Paronychia infections

This condition can be brought on by bacteria, fungi, or some viruses and causes inflammation in the proximal and lateral nail folds. It could be short-term or long-term in nature. If there is a tear or fracture in this seal, the bacteria can easily get in. An uncomfortable reaction to an alkali or environmental irritant might result in chronic paronychia(01). The swelling of the nail fold, which promotes the growth of common bacteria, makes the disease worse. An infection of the proximal, lateral, and toenail folds, encompassing the tissue bordering the nail's sides and base, is known as paronychia. This illness may develop on its own or as a result of trauma or manipulation. One of the most prevalent hand infections is paronychia.As show in figure 1.

Figure 1 Paronychia infections

3.3. Pseudomonas bacterial infection

This type of infection can impact the nail bed and plate, as well as natural and artificial nail plates(02). On the nail plate, iron compounds may cause a green discoloration.The same discolorations will result from bacteria that has gotten between the nail plate and the nail bed, and it may even push the nail plate away from the nail bed(03). The symptoms of green nail syndrome, also known as chromonychia, include onycholysis and a green-black staining of the nail bed. Chronic paronychia is frequently linked to this illness. The most often found bacterium in cultures from the impacted area is Pseudomonas aeruginosa. Even with the range of available treatments, nail extraction is still frequently required. A 35-year-old man showed up with onycholysis on his left thumbnail and a dark-greenish discoloration of the nail plate(04). As show in figure 2

Figure 2 Pseudomonas bacterial infection

3.4. Tinea Unguis, or ringworm

Characterized by thickening, distorting, and ultimately losing the nail plate, these nails have it. A thicker, malformed nail is the hallmark of this type of infection that affects the finger or toe nail. Toenails are more frequently affected by this illness than fingernails. Compared to young children, teenagers and adults experience it more frequently. As show in figure 3 (05).

Figure 3 Tinea Unguis, or ringworm

3.5. Onychatrophia

Degeneration can cause the nail plate to shrink, become less shiny, and sometimes even shed entirely. With nails, the same thing can occur(06). Nails can atrophy due to a variety of causes, including injury to the matrix (affecting only one nail) or a more serious health problem (affecting all 20 nails). Atrophied nails start to lose their youthful appearance, start to get smaller, and may even completely wither away(07). The nail, on the other hand, cannot regenerate its health and vitality like muscles can. Onychatrophia is the medical term for the irreversible atrophic nail disease(08). As show in figure 4 .

Figure 4 Onychatrophia

3.6. Onychorrhexis

These are the brittle nails that often peel, splinter, or have ridges running vertically through them(09). Strong solvents can be inherited or used at home or at work. Examples of such solvents are those found in household cleaning solutions. Even if the nail plate could rehydrate after paraffin or oil treatments(10). Onychorrhexis is usually considered a cosmetic issue and is not a cause for concern(11). However, occasionally, nails can become brittle and break easily, which can hurt and make certain tasks difficult(12). Additionally, onychorrhexis may indicate an underlying medical condition. As show in figure 5 .

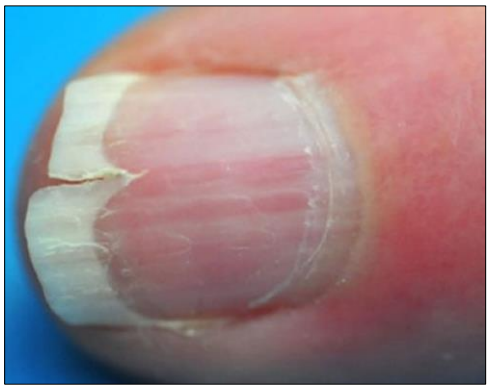

Figure 5 Onychorrhexis

3.7. Leuconychia

White dots or lines emerge on one or more nails, then spread out on their own. This disease may be genetic, however therapy is not required because the spots will vanish with the nail plate(13). White nails, or leukonychia, are typically not a cause for concern, but occasionally they can reveal serious systemic illnesses or congenital abnormalities(14). Anomalies of the nail bed or nail plate may be the cause of the white hue. Making a distinction between these two is crucial for categorizing and interpreting leukonychia(15). As show in figure 6 .

Figure 6 Leuconychia

3.8. Beau's Lines

The nail plate has linear depressions and darker cell lines running horizontally(16). Chemotherapy, injuries, illnesses, malnutrition, or any severe metabolic abnormality can cause these lines. One or more of your fingernails or toenails have horizontal ridges or dents called Beau's lines(17). They are an indication that your nail growth was disrupted by a disease, trauma, or skin ailment(18). If the underlying reason is addressed, smooth, fresh nails will regrow. As show in figure 7.

Figure 7 Beau's Lines

3.9. Koilonychias

Kokonychiasis is frequently caused by iron deficiency(19). Nails have higher ridges and are thin and concave. This disease commonly affects children as a result of nail biting, being in the cold, etc. The spooning of the nails where the lateral distal borders of the nail plate are lifted above a depressed center is called koilonychias(20). Under the nail's everted edges, peripheral hyperkeratosis may occasionally be seen. The colloquial name "spoon nails" comes from the fact that when koilonychia is viewed laterally, the nail plate resembles the bowl of a spoon(21).

3.10. Melanonychia

These are nail moles, which are vertical bands of pigmentation that are also called lesions or malignant melanoma. Usually, they start in the nail matrix(22). For people with dark complexions, black lines may be typical or even naturally occurring. Melanonychia is derived from the Greek words "Melas," which means "black" or "brown," and "Onyx," which means "nail." The nail plate becomes discolored, usually turning brown or black. Melanin is the pigment that is usually mentioned in these kinds of situations. It can affect one or more fingernails as well as toenails (23). As show in figure 8.

Figure 8 Melanonychia

3.11. Pterygium

Pterygium is a nail condition that typically affects the inner part of the nail plate and can be brought on by deep cuts or surgical treatments(24). The nail plate comes off as a result of pterygium scar tissue development. Cortisone is one treatment for the advancement of scar tissue(25). A split nail is the result of pterygium, an irreversible scarring of the nail matrix. Though it can also be the outcome of autoimmune bullous disorders like cicatricial pemphigoid, graft versus host disease, or aggressive inflammatory diseases involving the nail matrix such nail lichen planus, the deformity is most commonly post-traumatic(26). It is believed to be caused by damage to the nail matrix caused by lymphocytic inflammation. This damage sets off a fibrotic process that gradually merges the nail fold with the nail matrix and bed, destroying the nail plate(27).. As show in figure 9.

Figure 9 Pterygium

3.12. Psoriasis

One to three percent of people worldwide suffer from PSORIASIS, a scaly, inflammatory skin illness that is recurrent, remitting, and genetically influenced(28).. The diagnosis is based on clinical evidence, however a skin biopsy specimen's histologic analysis may be useful(29).. Physicians and other health care providers underestimate the social and economic consequences of psoriasis, a debilitating but seldom fatal condition(30).. The pathophysiology of psoriasis is

now better understood, and even individuals with severe cases are receiving better care because to recent pharmaceutical developments. Dry, pitted, and often crumbly nail beds, nail matrix, and nail folds can all result from this condition(31). The lunula becomes red, orange, or brown with red patches when the nail plate separates from the nail bed(32) . Though more widespread in North America and Europe, it affects about 1% to 3% of the population.

3.13. Hematoma

A hematoma causes trauma to the nail plate. It was the outcome of a sports-related nail injury. Bleeding in the nail bed may result from this trauma, which traps blood between the plate and the nail bed. This infection is indicative of a broken bone and can attract bacteria and fungi. Subungual hematomas are wounds to the nail bed when there is bleeding beneath the nail. Typically, patients report discomfort and nail discolouration(32). A direct hit or a crush injury to the distal phalanx—such as pinching a finger in a doorway—causes the damage. The nailbed is painfully compressed as blood seeps into the area.Avulsions of the nail or tip of the finger, as well as distal phalanx fractures, may also accompany the injury. As show in figure 10 .

Figure 10 Hematoma

4. Methodologies for nail drug delivery

Several techniques, including mechanical (nail abrasion and avulsion), chemical (permeation boosters), and physical (iontophoresis, micro-needles, etc.), can be used to achieve nail penetration.

4.1. Mechanical Approaches

Studies have looked into a variety of mechanical methods, including nail abrasion and nail avulsion, to enhance medication transungal administration and nail penetration.If there is a fungal infection in the nail, the abrasion procedure thins the nail plate and reduces fungal debris. Sanding the nail plate to reduce its thickness or eliminate it entirely is known as nail abrasion. The amount of sand paper used will depend on how severe it is. Sanding the nail edges is necessary, and this can be done with a high-speed hand piece. Dentist drills are used to create small holes and promote nail plate penetration.In contrast, a nail avulsion involves either partial or complete surgical removal of the damaged nail plate while under local anesthesia. Examples of keratolytic substances that can soften the nail plate in advance of an avulsion are salicylic acid and urea(33).

4.2. Chemical method

N-acetyl-l-cysteine and 2-mercaptoethanol together account for the diffusion of tolnaftate into the nails. N-acetyl-l-cysteine has also been shown to facilitate oxiconazole penetration. When keratolytic drugs like salicylic acid, urea, and papain are used, some antifungals including ketoconazole, miconazole, and itraconazole can penetrate more easily. Furthermore, ethanol, propylene glycol, isopropanol, and polyethylene glycol are examples of organic solvents that may be useful in improving the drug's penetration through the nail. When organic solvents come into direct contact with the nail plate during transungual drug transport, they can alter the hydration condition of the nail and cause barrier resistance in the nail(34).

4.3. Physical Methods

The tiny needles used in microneedle-based medicine delivery devices expose the pores in the stratum corneum and do not cause pain. An alternative method is the etching process, which entails exposing environmental agents to compounds that change surfaces, like phosphoric acid. This results in the production of many microsporocytes, a rise in surface area and wettability, and a decrease in contact angle. Microporosities can enhance the drug delivery system's interpenetration and bonding as well as facilitate the therapeutic substance's interdiffusion by offering an ideal surface for the bonding material. The iontophoresis method transfers chemicals across a membrane by means of an electric field. Using this procedure could lead to more medication being absorbed by the nails. Iontophoresis facilitates glimeofulvin's eight-fold distribution(35).

The carbon dioxide laser is another method that is used, however the outcomes are not entirely obvious. Thus far, two approaches have been discussed. In the first, the nail piece is extracted and treated with a laser set at 5000 W/cm2. Using this method, the deep tissue is immediately exposed to laser treatment. The second method is to penetrate the nail plate with a CO2 laser beam. A novel approach to hydration and occlusion is developed. Hydration procedures impact nail permeability by increasing the pore size of the nail matrix. Wet nails are more pliable and porous. As human skin gets more moisturized, its drug and water diffusivity improves. Electroporation is a high-tech physical treatment that uses an electric pulse with a voltage range of 100 to 1000 V/cm.Because of this, the lipid bilayers are disrupted and temporary water pores occur, allowing the solutes to pass through the nail(36).

5. Nail lacquers for the delivery of drug through nails

To protect and improve their fingernails or toenails, people use nail polish or varnish. Nail lacquer has been used as cosmetics to protect and enhance nails for a very long time. Modern beauty restoratives require the use of topical nail preparation treatments including lacquer, enamel, and varnish. It adds color and intensifies their brilliance while shielding the nail plate. In order to treat fungal nail diseases, it also produces high tissue concentration and active substances. The drug for male patients is colorless and non-glossy, but more importantly, it is composed of a film that permits it to go through nails. Because the drug is predicted to spread in the film before manufacture, the drug is carefully disseminated with polymer in the medication's polymer film, which might be thought of as a matrix type controlled release(37).

5.1. The way nail lacquer works

According to Fick's rule of diffusion, the disseminated drug acts over the plane surface of the unit area since it is soluble in the polymer film.

This action plan is determined by:

$$J=D\ dc/dx$$

where D is the drug's diffusion coefficient in the film and dc/dx is the drug's concentration gradient over the dx diffusion pathway.

With time, the thickness of the diffusion path rises. As the film surface next to the nail surface becomes more concentrated with the drug, the drug's absorption is improved by the increased concentration in the lacquer. Drugs based on nail lacquer are a unique formulation. A transparent, colorless liquid formulation including the antifungal amorolfine 5% , eudragit RL 100, glycerol triacetate, butyl acetate, ethyl acetate, and ethanol was first put up for sale in 1992. In 1999, the FDA approved nail lacquer, which is worn once a week or twice a week for up to six months on infected nail plates and nine to twelve months on toenails. Nail lacquer, a colorless, clear liquid containing an antifungal component, is applied topically to cure fungal infections and other ailments for up to 48 weeks. Every seven days, the nail lacquer is reapplied after the film has been cleaned with alcohol(38).

6. Merits of nail lacquer

- Removing nail polish by washing or massaging the nail is a challenging task.
- One coat of the lacquer is sufficient to give protection that lasts for a week.
- Diffusion rate and production can be maximized by choosing the right lacquer preparation.
- The formulation is as easy to use as an oral dosage form,
- Minimal or nonexistent adverse systemic effects

With regard to the pharmacokinetics of nails, less oral dosage actually reaches the nails. In this sense, localized therapy can aid in dosage reduction.

6.1. Demerits of nail lacquer

Side effect-related rashes, which typically manifest as erythema of the proximal nail fold. Nail issues are linked to shape change, inflammation, ingrown toenails, and discoloration, which is another negative effect of nail lacquer.

7. The components of nail lacquer

Solvents, resins that give the film a unique sheen and allow it to conform to the nail plate, and polymers that make films Both coloring and suspending agents are present in standard nail lacquer.

- FILM FORMERS: A variety of substances, such as nitrocellulose, cellulose acetate, ethyl cellulose, and other polymers, have been proposed for use as film formers in nail enamels.
- RESINS: Resins give the proper sheen and adhesion to transfers. The usual chairing of resins is to increase the opposite of moisture. They dissolve in heavier and solvent solutions.
- PLASTICIZERS: Plasticizers increase surface adhesion and flexibility. There are two varieties available: solvent-based and non-solvent. Generally, plasticizers can be added to nail lacquer at concentrations ranging from 25% to 50% of the film formation.
- SOLVENTS: A rapid rate of evaporation produces a consistent and transparent pot flow of enamel with each application, even though evaporation qualities are important for nail lacquer. Solvents are usually grouped according to their boiling points.
- PIGMENTS: Nail colors ought to have the same characteristics as makeup colors. It is common practice to employ pigments like titanium dioxide, red iron oxide, yellow iron oxide, etc.
- SUSPENDING AGENTS: Bentonite or colloidal clays are examples of suspending agents that can be used to stop insoluble pigments from settling. Together with nail preparation, a few methods are applied to maximize the drug's topical bioavailability through the nail.

8. Absorption via nail

The nail plate is approximately 100 times thicker than the stratum corneum, measuring between 0.25 and 0.6 mm. The nail plate's nature is more akin to a concentration than the strata. Hydrated nail plates behave like a hydrogel with higher ionic strength to the polar and semi-polar alcohols because hydration can change the hydrogel's actual pore size and, consequently, the transungual transport. Furthermore, keratin, which is mostly connected by disulphides, strengthens the nail initially. Short hydrophilic molecules can penetrate the nail more successfully. Because they are so lipophilic, many pharmaceutical compounds are unable to diffuse through the nail at therapeutic doses. Because of their stronger adherence, lipophilic vehicles like nail lacquer, in particular are more appropriate for topical treatment on the nail than aqueous systems. The nail plate penetrates with first order kinetics following a 400-hour lag time. Because of their high penetrability, the membranes primarily regulate the length of permeation, which is then managed by the matrix.

Table 1 Characterstics for satisfactory film of nail lacquer

• Uniform color
• Better shine
• Better wetting and flow properties to produce a homogeneous film formation.
• Sturdy adherence.
•Sufficient flexibility to avoid brittleness or cracking.
• A sturdy surface that prevents dents and knocks.
• One to two minutes is now the drying time.
•.It should be capable of handling the previously specified for a reasonable duration, around one week.

9. Topical nail lacquer versus oral anti fungal agent

Application of antifungal medications, like fluconazole or itraconazole, is done from the ventral to the dorsal side of the nail plate until the desired area is systemically reached. On the other hand, nail lacquer penetrates the thickness of the nail plate when applied to its dorsal side, reaching the nail bed's ventral side. By avoiding first-pass digestion, topical administration improves the drug's bioavailability at the intended site. Moreover, the topical method offers controlled and prolonged drug release via depot formation with no negative systemic effects.Because of this, topical therapy acts more quickly and has a higher bioavailability than oral medication. Transungual drug delivery is another word for topical medication delivery via the nail.

10. Affectors of drugs' diffusion through nails

- Physical and chemical characteristics of nails: Keratin protein is complexed to form nails. Through the nail development plane, transverse connections with keratin filaments take place. This type of structure gives the nail plate a toughness. Furthermore, many hydrogen and disulfide bonds that serve as electrostatic bridges connect keratin filaments to one another. These bonds are responsible for maintaining the reliability of the nail as a barrier. The thicker part of the nail, which provides more resistance to drug penetration, is composed of phospholipids, which communicate the flexibility of the nail. Lipids are responsible for the nail plate's hydrophilic properties. Thus, during permeability, hydrophobic substances go through a rate-limiting step. Water acts as a plasticizer, giving the nails elasticity and sensitivity.

10.1. The active ingredient's physical-chemical characteristics

- Solute molecular size: The nail plate acts as a molecular sieve because it is composed of a vast network of keratin strands connected by disulfide bonds. The distance between the strands must have a fixed maximum size. While larger molecules cannot pass through the nail plate's gaps, smaller molecules may with ease. The harder it is for a material to get through the keratin strands, the bigger the molecule. Thus, the drug's optimal particle size is important from a formulation standpoint.
- Hydrophilicity/Hydrophobicity: It was discovered that low molecular weight homologous alcohols can cross nail plates more easily than high molecular weight alcohols. The nail plate favorably increases the permeability of polar compounds over non-polar ones, as seen by the low rate of permeability of hydrophobic materials. Walters et al. came to the conclusion that the permeability coefficient dropped as the number of carbon atoms increased from one to eight based on permeation character investigations. Permeability increased when the chain length exceeded twelve carbon atoms.
- Ionization: The pH level of the mixture determines the ionic nature of mildly basic or acidic chemicals. Changes in the ambient pH have an impact on how compounds ionize as well as their hydrophilicity or hydrophobicity, which influences their solubility and permeability.

11. Future of transungual drug delivery system

The growing incidence of onychomycosis and the advancements in this system—discussed in the section on patent reviews—provide hope for the future for producers of lacquers containing antifungals. In an attempt to create a water-based lacquer, Luis N. et al.'s most recent work employed partly methylated b-cyclodextrin and in situ hydrogels to spread Ciclopirox and triamcinolone transungally. For in situ gelling, Pluronic F-127 poly-pseud-rotaxanes hydrogels were used. Their thermogelling properties enable localization in this system. St. An analysis of the flow of commercially available organic formulation with water-based lacquer was conducted. The results showed that the formulation of poly-pseudo-rotaxanes produced a higher amount of ciclopirox, indicating that it would be a promising candidate for further characterization. In a different study, Ryan F. D. et al. examined the application of photodynamic therapy (PDT), which is used to treat onychomycosis in cancer patients. This treatment method destroys cells by using visible light and a sensitizing drug. A successful attempt was made to produce bioadhesive patches containing 5-aminolevulinic acid (ALA), which showed good in vitro ALA penetration into human nails. As a result, the ALA-PDT system appears promising, and with further development, it may prove to be a practical substitute for the management of onychomycosis.

A rising body of research indicates that the science of ungual drug administration is still in its infancy, and additional work is needed to characterize novel delivery mechanisms, instruments, or penetration enhancers. In conclusion, we can state that in addition to offering protection and aesthetic appeal, the human nail serves as a vehicle for the administration of pharmaceuticals. Contemporary technology holds immense promise. Patch-based delivery,

penetration enhancers, and water-based lacquers are a few examples. But it's imperative to turn this potential into beneficial results. Additionally, research on using UV radiation and microneedles to increase transungual permeability is just being begun. As a result, the transungual drug delivery system demonstrates its immense potential and breadth, which may result in additional developments for this delivery system.

12. Conclusion

This page provides a detailed explanation of nail medication delivery techniques. Nail anatomy, frequent nail diseases, nail drug delivery methods, and the use of nail lacquers for medicine administration are among the topics covered. Using the information at hand, the following inference may be drawn: Human nails have a lot of promise for use as a drug delivery system because of the intricate structure of nails and the prevalence of nail diseases, particularly in the treatment of nail conditions like psoriasis and onychomycosis. The highly keratinized nail plate makes it challenging to attain therapeutic drug concentrations, despite the fact that administering medications topically has advantages such as concentrated action and less systemic adverse effects.

Many physical and chemical techniques, including permeation enhancers, acid etching, and cutting-edge methods such nail lacquers, have been studied to increase drug penetration via the nails. In particular, nail lacquers have proven to be a promising drug delivery system that can deliver both controlled release and prolonged drug activity through the nails. Despite recent advancements, more research is still required to fully realize the promise of transungual pharmaceutical administration. Recent developments like photodynamic therapy and water-based lacquers point to a promising future for translingual medication administration. Future studies will focus on concerns including curing nail diseases and enhancing medicine permeability.

In conclusion, the human nail holds great promise for drug delivery, but there is still much to learn about the science of nail medication administration. Future developments in this field could lead to better treatment outcomes for nail problems and more effective treatments.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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