A Mini Review on dutasteride

Aryan*,Satinder Kakar

Himachal Institute of Pharmacy,Paonta Sahib,H.P, India

**Correspondence*

Aryan

Himachal Institute of Pharmacy,Paonta Sahib,H.P, India

Abstract

Dihydrotestosterone (DHT) is the main hormone responsible for the gradual hair loss disorder known as androgenetic alopecia (AGA). Despite being a strong dual inhibitor of 5-alpha-reductase (5-AR), oral dutasteride's systemic use is restricted due to possible adverse effects like sexual dysfunction. The formulation and assessment of topical dutasteride are examined in this review, with an emphasis on cutting-edge delivery methods such as niosomal and nanoemul gels. We examine the medicine's chemical makeup, preparation techniques, and assessment metrics including drug release and particle size. The potential of topical dutasteride as a targeted, safer alternative for hair restoration is highlighted by discussing current research gaps and future treatment prospects

Keywords:dutasteride,alopecia

Introduction

Dutasteride, a synthetic 4 azasteroid, is a potent dual inhibitor of type I and type II 5 α reductase enzymes, thereby reducing DHT levels more effectively than finasteride[1]. Oral dutasteride has demonstrated significant clinical efficacy in AGA, but systemic administration is associated with adverse effects such as decreased libido, gynecomastia, and hormonal imbalance.These limitations have prompted the exploration of topical drug delivery systems (TDDS) as an alternative route.

Topical vesicular systems—liposomes, niosomes, transferosomes, and ethosomes—offer unique advantages for dermal and follicular drug delivery. They encapsulate lipophilic drugs like dutasteride within bilayered vesicles, enhance penetration through the stratum corneum, and preferentially accumulate in hair follicles due to their nano scale size.Transferosomes, with their ultra deformable bilayers, and ethosomes, enriched with ethanol, further improve penetration and follicular targeting. These systems not only provide controlled release but also minimize systemic absorption, thereby reducing adverse effects[2,3].

Chemical Nature of Dutasteride

Structure: A synthetic 4-azasteroid compound (C23H36N2O2) (PubChem, 2025)

Molecular Weight: 528.5 g/mol, which presents a challenge for traditional passive skin permeation (ChemicalBook CAS DataBase, n.d.)

Lipophilicity: It is highly lipophilic, making it virtually insoluble in water but soluble in ethanol, methanol, and various oils. (PubChem, 2025).

Classification: Classified under BCS Class II, characterized by low solubility and high permeability[4].

Method of Preparation for Topical Applications

A wide range of formulation approaches have been investigated for the topical delivery of dutasteride in androgenetic alopecia, reflecting the drug's high lipophilicity and poor water solubility. One promising strategy is the development of insitu emulgels, which combine the advantages of emulsions and gels to improve drug penetration, reduce systemic exposure, and enhance patient compliance. Radhakrishnan et al. reported that a dutasteride loaded insitu emulgel significantly improved skin penetration and reduced the required dosage, thereby minimizing adverse effects.

Another approach involves niosomal gels, where dutasteride is encapsulated in non ionic surfactant vesicles; these systems provide controlled release, improved stability, and enhanced follicular deposition compared to conventional gels.

Liposomes and transfersomes have also been widely studied, with demonstrating that dutasteride loaded liposomes and ultradeformable transfersomes achieved superior follicular targeting and deeper skin penetration, making them highly suitable for scalp application[5]

More recently, ethosomes, which are phospholipid vesicles containing high ethanol concentrations, have been developed to exploit ethanol's penetration enhancing properties; these formulations showed improved targeting of dutasteride to hair follicles and enhanced drug deposition in the dermis.

In addition, nanoemulgels have been designed to combine the benefits of nanoemulsions with gel matrices, offering improved scalp residence time, patient acceptability, and controlled release, while reducing systemic dihydrotestosterone (DHT) exposure.

Patented formulations have described liposomal systems with siliconic barrier forming components, which not only stabilize dutasteride but also improve follicular targeting and minimize crystallization risks.

Other adjunctive approaches include microneedling assisted delivery, which mechanically enhances follicular uptake of topical dutasteride (Yunbu, et al., 2024), and mesotherapy, involving intradermal microinjections for localized delivery, though this requires further validation for safety and efficacy.[6]Collectively, these formulation strategies highlight the versatility of vesicular and lipid based carriers in addressing the physicochemical challenges of dutasteride, while opening pathways for safer and more effective topical therapies in androgenetic alopecia.

Evaluation of Formulations

To ensure efficacy, the following parameters are rigorously tested:

In Vitro Release Studies

In vitro release testing is the first step in evaluating topical Dutasteride formulations. Franz diffusion cells are commonly employed to study drug release kinetics from gels, emulsions, and vesicular carriers. Niosomal gels demonstrated sustained release compared to conventional gels, indicating controlled diffusion through vesicular bilayers. Insitu emulgels showed enhanced release due to dual solubilization in oil and gel phases. Nanoemulgels provided prolonged release with reduced burst effect, aligning with controlled delivery goals[7].Mathematical models such as Higuchi and Korsmeyer–Peppas are applied to interpret release mechanisms.

Ex Vivo Skin Permeation and Follicular Deposition

Ex vivo permeation studies using human or porcine scalp skin are critical for assessing follicular targeting. Liposomes and transfersomes have been shown to deposit Dutasteride more effectively in hair follicles compared to simple solutions. Tape stripping and cyanoacrylate follicular biopsy techniques quantify drug levels in the stratum corneum and follicular infundibulum. Ethosomes, due to their ethanol content, demonstrated enhanced follicular penetration. Nanoemulgels also showed improved follicular deposition with reduced systemic absorption.

Physicochemical Characterization

Physicochemical evaluation ensures formulation stability and performance. Parameters include particle size distribution (dynamic light scattering), zeta potential (for colloidal stability), polydispersity index, morphology (TEM/SEM), and rheological behavior of gels. Niosomal gels exhibited particle sizes in the nanometer range with stable zeta potential. Transfersomes showed ultradeformability, enhancing penetration. Nanoemulgels demonstrated uniform droplet distribution and favorable viscosity for scalp application [8]

Stability Studies

Stability testing under ICH guidelines evaluates shelf life, crystallization tendencies, potency, and microbial safety. Dutasteride's lipophilicity and tendency to recrystallize necessitate stabilizers such as polymers and film formers. Niosomal gels retained potency and vesicle size stability under accelerated conditions (Victor & Mauro, 2021). Emulgels maintained viscosity and gelation properties over long term storage . Patented liposomal formulations with siliconic barrier components improved stability and minimized crystallization[9].

Clinical Evaluation

Clinical pilot trials assess efficacy, safety, and patient compliance. Endpoints include hair density, hair diameter, global photography scores, and patient satisfaction. A Springer pilot study reported improved hair density in AGA patients when Dutasteride gel was combined with iontophoresis and skin patting. Microneedling combined with topical Dutasteride enhanced follicular uptake and clinical outcomes. Mesotherapy with intradermal Dutasteride injections showed localized efficacy but requires further validation.

Safety and Irritation Testing

Safety evaluation includes skin irritation and sensitization assays (patch tests, HET CAM). Most vesicular and gel formulations demonstrated good tolerability, with reduced systemic exposure compared to oral Dutasteride (Yunbu, et al., 2024). Patient acceptability studies highlighted improved compliance with emulgel and nanoemulgel systems due to non greasy texture and ease of application (Mahipal Reddy, et al., 2023).

Dermal PK/PD and Systemic Exposure

Dermal pharmacokinetics/pharmacodynamics studies monitor systemic Dutasteride levels and DHT suppression. Nanoemulgels and transfersomes demonstrated reduced systemic absorption compared to oral administration, aligning with the goal of minimizing endocrine side effects[9]

Advantages and Disadvantages

Advantages:

Localized follicular action: Directly targets hair follicles where DHT causes miniaturization, improving efficacy at the site of action.

Reduced systemic exposure: Limits drug circulation in the bloodstream, lowering risks such as sexual dysfunction and hormonal imbalance seen with oral use.

Comparable or superior efficacy: Clinical studies suggest topical Dutasteride can achieve hair density improvements similar to or better than oral finasteride.

Controlled release formulations: Advanced carriers (nanoemulgels, niosomes, liposomes) allow sustained release and prolonged scalp residence time.

Improved patient compliance: Safer profile encourages long-term use, especially for cosmetic indications.

Combination therapy potential: Can be paired with minoxidil, microneedling, or mesotherapy to enhance follicular penetration and outcomes.

Reduced dosing frequency: Nanocrystalline suspensions and liposomal systems may allow once-weekly application, lowering treatment burden.

Better cosmetic acceptability: Non-greasy gels and emulgels improve ease of use compared to oral tablets.

Safety in long-term use: Early evidence suggests fewer systemic adverse effects, making it suitable for chronic therapy[9]

Personalized delivery options: Different formulations (solutions, gels, vesicular carriers) can be tailored to patient needs and scalp conditions[10]

Disadvantages:

Limited clinical evidence: Long term, large scale trials are still lacking to confirm safety and efficacy.

Variable absorption: Skin permeability differs among individuals, leading to inconsistent therapeutic outcomes.

Formulation challenges: Advanced carriers (liposomes, nanoemulgels, niosomes) are complex to prepare and may face stability issues. (ai, n.d.)

Local irritation risk: Some patients may experience scalp redness, dryness, or itching.

Regulatory limitations: Topical Dutasteride is not yet widely approved by major health authorities, restricting clinical use.[11]

Current Gaps

The absence of extensive, long-term clinical trials to determine the efficacy and safety profile of topical Dutasteride for androgenetic alopecia is the primary cause of the existing gaps in its development. Although preliminary research indicates potential, there is still a dearth of information regarding endocrine safety and systemic absorption over long-term use. Additionally, there is considerable individual variation in follicular deposition and skin penetration, which makes standardized dosing challenging. Furthermore, industrial production is hampered by the intricacy and scalability of advanced carriers like liposomes, niosomes, and nanoemulgels, and regulatory approval is still pending in the majority of locations. Lastly, there are few studies comparing oral finasteride and dutasteride, and patient adherence to topical regimens has not been thoroughly assessed, leaving crucial problems unresolved for clinical translation. The "ideal" concentration (0.01% vs 0.1%) and application frequency are not yet standardized.[12]

Future Aspects

Integration of adjunctive techniques such as microneedling and mesotherapy has emerged as a major research focus to enhance the depth of delivery and improve follicular targeting of topical dutasteride. These minimally invasive methods facilitate greater drug penetration into the dermis and hair follicle units, thereby augmenting the efficacy of conventional topical formulations. In parallel, the development of advanced carriers including nanocrystalline suspensions and targeted liposomal systems offers the potential for sustained drug release and controlled follicular deposition. Such innovations may significantly reduce the required frequency of application, with preliminary evidence suggesting that optimized formulations could maintain therapeutic levels with once-weekly administration. Collectively, these strategies highlight the evolving landscape of topical dutasteride delivery, where

integration of physical enhancement techniques and novel nanocarriers may provide superior clinical outcomes while improving patient compliance[13]

References

1. Seager H. Drug-delivery products and the Zydis fast-dissolving dosage form. J Pharm Pharmacol 1998; 50(4): 375-82.
2. M. Akbar, N. Panda, AV Reddy, "Formulation and Evaluation of Doxofylline Sublingual Tablets Using Sodium Starch Glycolate and Crosscarmellose Sodium as Superdisintegrant" Int. J. of Pharm. Res. & All. Sci. 2015; 4(2):90-100.
3. Niranjan Panda, Afshan Sultana, A Venkateswar Reddy, G. V. Subba Reddy, M.S.Ansari: Formulation Design and Study the effect of Polyplasdone-XL and AC-Di-Sol on Release Profile of Doxofylline Immediate Release Tablets. Int. J. Pharm. Sci. Rev. Res., 32(2), 2015: 67-76.
4. Deepika J, Mishra A. A review - Formulation and development of orodispersible tablet. Int J Pharm Erudition 2014;4(1):21-38.
5. Kalpesh G, Lalit K, Kori M, Sharma C, Nema R. Formulation and characterisation of fast dissolving tablet of Aceclofenac by sublimation method. International Journal of Pharmaceutical Science and Research.2011;3:19-22
6. Shirwaikar R., Shirwaikar A., Prabu L., Mahalaxmi R., Rajendran K., Kumar C. Studies of superdisintegrant properties of seed mucilage of Ocimumgratissimum. Indian Journal of Pharmaceutical Sciences. 2007; 69(6): 753-758.
7. Palkhede M., Amrutkar S., Erande K., Formulation, optimization and evaluation of fast disintegrating tablet of mebeverine HCl. Int J Pharm Pharm Sci. 2012; 4(4):121-125.
8. Valleri M, Mura P, Maestrelli F, Cirri M, Ballerini R. Development and evaluation of glyburide fast dissolving tablets using solid dispersion technique. Drug Dev Ind Pharm 2004; 30(5): 525-534.
9. Tanmoy G, Amitava G, and Devi P: A review on new generation orodispersible tablet and its future prospective. International Journal of Pharmacy and Pharmaceutical Sciences 2011; 3: 1-7.
10. Hirani JJ, Rathod DA, and Vadalia KR: Orally Disintegrating Tablets: A Review. Tropical Journal of Pharmaceutical Research 2008; 8(2): 161-172.
11. Arora P, Arora VS: Orodispersible tablets: A comprehensive review. International Journal of Research and Development in Pharmacy and Life Sciences 2013; 2: 270-284.
12. Rahul C, Zahra H, Farhan A, Alan MS, Afzal RM. The role of formulation excipients in the development of Lyophilised fast - disintegrating tablets. Eur. J. Pharm. Biopharm.2009;72:119-229.
13. Bangale GS, Yadav GJ, Shinde GV, and Stephen Rathinaraj B: New Generation of Orodispersible Tablets: Recent Advances and Future Prospects. International Journal of Pharmacy and Pharmaceutical Science Research 2011; 1(2): 52-62.

Source of Support: Nil
Conflict of Interest: Nil