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# The Potential of DMSO Applied to the Scalp for Improving Hair Health: A Comprehensive Scientific Review

Recent years have seen a surge of interest in the use of dimethyl sulfoxide (DMSO) as a topical agent for hair and scalp health, fueled both by anecdotal reports and a growing body of scientific inquiry. DMSO, known for its remarkable ability to penetrate biological membranes and act as a carrier for other substances, has long been used in medical and industrial contexts. Its application to the scalp, particularly for the purposes of improving hair health, is a relatively novel area of exploration. This report critically examines the available scientific evidence, underlying mechanisms, clinical observations, and safety considerations regarding the use of DMSO on the scalp for hair health. While some studies and case reports suggest potential benefits-ranging from improved delivery of hair growth agents, anti-inflammatory effects, and even direct impacts on hair structure-rigorous, large-scale clinical trials are notably lacking. This review synthesizes current knowledge, highlights key findings, and identifies critical gaps in the literature, offering a balanced perspective for clinicians, researchers, and individuals considering DMSO for hair health.

#### Introduction to DMSO and Its Relevance to Hair Health

Dimethyl sulfoxide (DMSO) is an organosulfur compound with the formula  $(CH_3)_2SO$ , first discovered in the late nineteenth century as a byproduct of wood pulp processing. Its unique chemical properties-particularly its ability to dissolve both polar and nonpolar compounds and to traverse biological membranes-have made it a subject of intense research in pharmacology and dermatology. DMSO is best known in medical circles for its use as a prescription medication for interstitial cystitis and as a topical analgesic and anti-inflammatory agent <sup>[1]</sup> <sup>[2]</sup>. However, its potential applications extend far beyond these uses, with growing interest in its role as a skin penetration enhancer and as a vehicle for drug delivery.

The relevance of DMSO to hair health primarily stems from three interrelated properties: its ability to enhance the percutaneous absorption of other compounds, its intrinsic anti-inflammatory and antioxidant activities, and its direct effects on keratin-the primary structural protein in hair <sup>[3]</sup> <sup>[2]</sup> <sup>[4]</sup>. These features have led to speculation and preliminary investigation into whether DMSO, applied to the scalp, might support hair growth, improve hair quality, or serve as an adjunct in the treatment of hair loss disorders such as androgenetic alopecia and alopecia areata.

Despite its promise, the use of DMSO in hair care remains controversial. The scientific literature is characterized by a paucity of large, controlled clinical trials, with much of the available evidence deriving from in vitro studies, animal models, case reports, and theoretical considerations. This review aims to provide a comprehensive, critical synthesis of the evidence,

exploring both the mechanistic underpinnings and the practical implications of DMSO application to the scalp.

# The Chemistry and Pharmacology of DMSO

## **Chemical Structure and Properties**

DMSO is a small, highly polar molecule with a distinctive sulfur-oxygen double bond. Its amphipathic nature allows it to interact with both hydrophilic and lipophilic substances, making it an exceptionally versatile solvent<sup>[1] [2]</sup>. This property is central to its role as a carrier for other molecules, enabling the dissolution and transport of a wide range of pharmacologically active agents through the skin.

# Pharmacokinetics and Skin Penetration

One of the defining features of DMSO is its ability to rapidly penetrate the stratum corneum, the outermost layer of the skin, and facilitate the transdermal delivery of co-administered substances<sup>[2] [4]</sup>. This has been demonstrated in both animal and human studies, where DMSO has been shown to increase the dermal absorption of drugs such as minoxidil and finasteride-two agents commonly used in the treatment of hair loss<sup>[5] [6] [4] [7]</sup>. The mechanism of this enhanced penetration involves the disruption of lipid bilayers in the stratum corneum, increased hydration of the skin, and possible alterations in protein conformation within the epidermis<sup>[3] [2]</sup>.

# **Intrinsic Biological Activities**

Beyond its role as a solvent and carrier, DMSO exhibits a range of intrinsic biological effects. It possesses anti-inflammatory, antioxidant, and analgesic properties, which have been harnessed in the treatment of conditions such as osteoarthritis and interstitial cystitis<sup>[1] [2]</sup>. The anti-inflammatory effects are thought to arise from the inhibition of prostaglandin synthesis and the scavenging of free radicals, while the analgesic effects may be related to modulation of peripheral nerve conduction.

# Safety Profile and Regulatory Status

DMSO is approved by the U.S. Food and Drug Administration (FDA) for specific medical uses, such as the treatment of interstitial cystitis, but its use in other contexts-including as a hair or scalp treatment-remains off-label<sup>[1]</sup>. Topical application of DMSO is generally considered safe when used appropriately, but side effects such as skin irritation, itching, and a characteristic garlic-like odor are not uncommon<sup>[1] [2]</sup>. Importantly, DMSO's potent ability to enhance the absorption of other substances raises concerns about the inadvertent systemic exposure to contaminants or co-administered agents<sup>[8]</sup>.

## Mechanisms by Which DMSO Might Influence Hair Health

#### Enhancement of Drug Delivery to Hair Follicles

Perhaps the most compelling rationale for using DMSO in hair care is its ability to enhance the delivery of active pharmaceutical ingredients to the hair follicles. The follicles are situated deep within the dermis, and the effectiveness of topical hair growth agents such as minoxidil and finasteride is often limited by poor skin penetration<sup>[5] [6] [4]</sup>. DMSO, by disrupting the lipid matrix of the stratum corneum and increasing skin permeability, can facilitate the transport of these agents to their target sites.

Several studies have explored this effect. For example, DMSO-modified liposomes loaded with finasteride demonstrated significantly greater follicular density and an improved anagen/telogen (A/T) ratio in a rat model of androgenic alopecia compared to finasteride liposomes without DMSO<sup>[5]</sup>. Similarly, DMSO has been shown to reduce the photodecomposition of minoxidil, potentially increasing its stability and effectiveness when applied topically<sup>[6]</sup>. These findings suggest that DMSO may serve as a valuable adjunct in the topical treatment of hair loss, not by directly stimulating hair growth, but by enhancing the delivery and efficacy of established hair growth agents.

## Anti-Inflammatory and Antioxidant Effects on the Scalp

Chronic inflammation of the scalp is implicated in several forms of hair loss, including androgenetic alopecia and alopecia areata. DMSO's anti-inflammatory properties, mediated by the inhibition of inflammatory mediators and the scavenging of reactive oxygen species, may help to mitigate scalp inflammation and create a more favorable environment for hair growth<sup>[1]</sup>  $^{[2] [4] [9]}$ . There is also evidence that DMSO can reduce the severity of dermatitis and other inflammatory scalp conditions, which are often associated with hair thinning and loss<sup>[4] [9]</sup>.

# Direct Effects on Hair Keratin and Structure

The structural integrity of hair is maintained by keratin, a protein characterized by extensive disulfide bonding. Studies investigating the interaction between DMSO and hair keratin have revealed that DMSO can induce both reversible and irreversible changes in hair structure, depending on concentration and exposure time<sup>[3]</sup>. At concentrations above 80%, DMSO promotes stress relaxation in hair fibers, decreases the modulus of elasticity, and facilitates disulfide bond interchange. These effects may influence the mechanical properties of hair, potentially making it softer or more pliable. However, the clinical significance of these changes for hair health and appearance remains unclear, and excessive use of high-concentration DMSO could theoretically compromise hair strength<sup>[3]</sup>.

# Potential for Promoting Hair Growth

Beyond its role as a carrier and anti-inflammatory agent, there is limited but intriguing evidence that DMSO may directly promote hair growth in certain contexts. A notable case report described a patient with amyloidosis who experienced regrowth and repigmentation of scalp hair following DMSO treatment <sup>[10]</sup>. While this observation is anecdotal and confounded by the

underlying disease process, it raises the possibility that DMSO may exert direct effects on hair follicle biology. Animal studies have yielded mixed results, with some suggesting a modest stimulatory effect of DMSO on hair growth, while others report no significant impact<sup>[11]</sup>. The mechanisms underlying any such effect are poorly understood and warrant further investigation.

#### **Review of Clinical and Preclinical Evidence**

#### **Case Reports and Human Observations**

The clinical literature on DMSO for hair health in humans is sparse, with most reports being anecdotal or limited to single cases. The most frequently cited example is the case of a 67-yearold male with amyloidosis who experienced regrowth and darkening of scalp and beard hair several months after initiating DMSO treatment<sup>[10]</sup>. While intriguing, this case cannot be generalized to the broader population, as the underlying disease and other treatments may have contributed to the observed effects.

Other reports have focused on the use of DMSO as a vehicle for delivering minoxidil or other agents in patients with alopecia areata and androgenetic alopecia<sup>[7]</sup>. In these cases, DMSO was chosen specifically for its penetration-enhancing properties, with the expectation that it would improve the efficacy of the active drug rather than exerting a direct effect on hair growth.

# **Animal Studies**

Preclinical studies in animal models provide additional insights into the potential effects of DMSO on hair growth and scalp health. In a rat model of testosterone-induced alopecia, DMSO-modified liposomes loaded with finasteride resulted in increased follicular density and a higher anagen/telogen ratio compared to controls<sup>[5]</sup>. These findings suggest that DMSO can enhance the delivery and effectiveness of finasteride, a drug that inhibits the conversion of testosterone to dihydrotestosterone (DHT), a key driver of androgenetic alopecia.

Other animal studies have examined the direct effects of DMSO on hair growth. In one experiment, guinea pigs treated with DMSO showed variable rates of hair regrowth, with no consistent pattern emerging <sup>[11]</sup>. These results highlight the need for more rigorous, controlled studies to determine whether DMSO has intrinsic hair growth-promoting properties.

#### In Vitro and Biochemical Studies

Laboratory studies have elucidated the biochemical interactions between DMSO and hair keratin. At high concentrations, DMSO induces stress relaxation in hair fibers, decreases the modulus of elasticity, and promotes disulfide bond interchange<sup>[3]</sup>. These effects are largely reversible at concentrations below 70%, but become more pronounced and potentially damaging at higher concentrations. The implications of these findings for hair health are uncertain, as the concentrations used in laboratory studies often exceed those employed in clinical or cosmetic applications.

# DMSO as a Penetration Enhancer for Hair Growth Agents

The most robust evidence supporting the use of DMSO in hair care pertains to its role as a penetration enhancer for topical hair growth agents. Several studies have demonstrated that DMSO can increase the dermal absorption and stability of minoxidil, finasteride, and other compounds commonly used to treat hair loss<sup>[5]</sup> <sup>[6]</sup> <sup>[4]</sup> <sup>[7]</sup>. In these studies, formulations containing DMSO resulted in greater follicular uptake, improved drug stability, and, in some cases, enhanced clinical efficacy compared to formulations without DMSO.

However, not all penetration enhancers are created equal. Comparative studies have found that certain fatty acid esters, such as methyl caprate, may be even more effective than DMSO at enhancing the penetration of minoxidil and other agents<sup>[12]</sup>. These findings underscore the importance of formulation optimization and the need for head-to-head trials to determine the most effective and safe penetration enhancers for hair care applications.

## **Theoretical and Anecdotal Perspectives**

#### Popular and Alternative Medicine Views

In the realm of alternative medicine and online forums, DMSO has gained a reputation as a "miracle" solvent capable of delivering a wide range of beneficial effects when applied to the scalp<sup>[4] [9] [8]</sup>. Proponents claim that DMSO can improve blood flow to the scalp, reduce inflammation, promote hair growth, and even reverse hair loss. These claims are often supported by anecdotal reports and testimonials, but lack rigorous scientific validation.

Some users advocate for the combination of DMSO with other hair growth agents, such as minoxidil, finasteride, or natural extracts, to enhance their efficacy<sup>[4] [9]</sup>. Others report using DMSO alone or in combination with moisturizing agents to improve hair texture and manage scalp conditions. While these practices are widespread, they are not without risk, as DMSO's potent penetration-enhancing properties can increase systemic exposure to both intended and unintended substances<sup>[8]</sup>.

# **Potential Risks and Safety Considerations**

The use of DMSO on the scalp is not without potential hazards. The most commonly reported side effects include skin irritation, itching, dryness, and a characteristic garlic-like odor on the breath and skin<sup>[1] [2] [9]</sup>. More concerning is the risk of systemic absorption of contaminants or co-administered agents, as DMSO can facilitate the entry of a wide range of molecules into the bloodstream<sup>[8]</sup>. This underscores the importance of using pharmaceutical-grade DMSO and exercising caution when combining it with other substances.

There have also been reports of allergic contact dermatitis in individuals using DMSO-containing formulations, particularly when combined with other agents such as minoxidil<sup>[7]</sup>. Patch testing and careful monitoring for adverse reactions are recommended for individuals considering DMSO-based scalp treatments.

#### **Comparative Analysis of DMSO and Other Penetration Enhancers**

#### Efficacy of DMSO Versus Other Enhancers

While DMSO is a well-established penetration enhancer, it is not unique in this regard. Other compounds, such as methyl nonanoate, methyl caprate, and Azone, have been shown to increase the dermal absorption of hair growth agents, sometimes to a greater extent than DMSO<sup>[12]</sup>. For example, methyl caprate at a 10% concentration was found to be more effective than DMSO at enhancing the penetration of minoxidil in both animal and human skin models<sup>[12]</sup>. These findings suggest that while DMSO is effective, it may not always be the optimal choice, and formulation-specific considerations are critical.

#### **Safety Profiles and Side Effects**

The safety profile of DMSO compares favorably to some other penetration enhancers, particularly in terms of skin irritation and photostability. DMSO has been shown to cause less photodecomposition of minoxidil compared to other enhancers, potentially improving the stability and shelf life of topical formulations<sup>[6]</sup>. However, its potent ability to facilitate systemic absorption of co-administered agents remains a concern, particularly when used in combination with drugs or in individuals with compromised skin barriers<sup>[8]</sup>.

#### **Regulatory and Practical Considerations**

Unlike many other penetration enhancers, DMSO is available over the counter in many jurisdictions, often in gel or liquid form<sup>[1]</sup>. This accessibility has contributed to its widespread use in alternative medicine and self-experimentation. However, the lack of standardized formulations, dosing guidelines, and regulatory oversight increases the risk of misuse and adverse effects. In contrast, other penetration enhancers are typically used in regulated pharmaceutical formulations, with established safety and efficacy profiles.

#### **Practical Application and Formulation Strategies**

#### **Recommended Concentrations and Application Methods**

The optimal concentration of DMSO for scalp application remains a subject of debate. Laboratory studies suggest that concentrations below 70% are largely reversible in their effects on hair keratin, while higher concentrations may induce more pronounced and potentially damaging changes<sup>[3]</sup>. Anecdotal reports and alternative medicine sources often recommend diluting DMSO with water or other agents to achieve concentrations in the range of 50-70% for scalp application<sup>[9]</sup>. It is generally advised to start with lower concentrations and gradually increase as tolerated, with close monitoring for adverse reactions.

#### **Combination with Hair Growth Agents**

The most promising application of DMSO in hair care is as a carrier for established hair growth agents such as minoxidil and finasteride<sup>[5] [6] [4] [7]</sup>. Formulations combining DMSO with these agents have demonstrated improved dermal absorption, increased follicular uptake, and, in some cases, enhanced clinical efficacy. However, the risk of increased systemic exposure and potential side effects must be carefully weighed, particularly in individuals with underlying medical conditions or those taking other medications.

# Moisturizing and Supportive Agents

Given the potential for DMSO to cause skin dryness and irritation, it is often combined with moisturizing agents such as aloe vera, glycerin, or natural oils to mitigate these effects<sup>[9]</sup>. These combinations may also enhance the cosmetic acceptability of DMSO-based formulations and improve user compliance.

# **Safety Precautions and Contraindications**

Individuals considering the use of DMSO on the scalp should be aware of several important safety considerations. Only pharmaceutical-grade DMSO should be used, as industrial-grade products may contain harmful contaminants<sup>[8]</sup>. A patch test is recommended prior to widespread application to assess for allergic or irritant reactions. DMSO should not be used on broken or inflamed skin, as this may increase the risk of systemic absorption and adverse effects. Pregnant or breastfeeding women, individuals with liver or kidney disease, and those taking multiple medications should consult a healthcare professional before using DMSO-containing products.

# Limitations of Current Evidence and Future Directions

# Gaps in the Scientific Literature

Despite the growing interest in DMSO for hair health, the scientific literature remains limited in several key respects. There are few large, randomized controlled trials evaluating the efficacy and safety of DMSO for hair growth or scalp health in humans. Most available evidence derives from in vitro studies, animal models, case reports, and anecdotal observations. The mechanisms by which DMSO might directly influence hair follicle biology are poorly understood, and the long-term safety of repeated scalp application has not been systematically studied.

# **Need for Rigorous Clinical Trials**

To establish the efficacy and safety of DMSO for hair health, well-designed clinical trials are urgently needed. Such studies should compare DMSO-containing formulations to standard treatments and placebo, assess both short- and long-term outcomes, and systematically monitor for adverse effects. Particular attention should be paid to the risk of systemic absorption of co-administered agents and the potential for allergic or irritant reactions.

#### **Mechanistic Studies**

Further research is needed to elucidate the mechanisms by which DMSO may influence hair follicle biology, keratin structure, and scalp inflammation. Studies employing advanced imaging, molecular biology, and proteomics techniques could shed light on the cellular and biochemical pathways involved.

#### Formulation Optimization

Given the availability of multiple penetration enhancers, comparative studies are warranted to determine the most effective and safe agents for delivering hair growth drugs to the follicles. Optimization of formulation parameters-including concentration, vehicle, and combination with moisturizing agents-will be critical to maximizing efficacy while minimizing side effects.

## Conclusion

The application of DMSO to the scalp for the purpose of improving hair health is a topic of considerable interest, driven by its unique chemical properties, potent penetration-enhancing effects, and anecdotal reports of benefit. The available scientific evidence suggests that DMSO can enhance the delivery and stability of established hair growth agents such as minoxidil and finasteride, potentially increasing their efficacy. Its intrinsic anti-inflammatory and antioxidant activities may also contribute to a healthier scalp environment, particularly in conditions characterized by chronic inflammation.

However, the direct effects of DMSO on hair growth and structure are less well established, with limited and conflicting evidence from case reports and animal studies. The risk of skin irritation, dryness, and systemic absorption of co-administered agents underscores the need for caution and professional guidance.

In summary, while DMSO holds promise as a component of topical hair care formulationsparticularly as a penetration enhancer for established hair growth agents-its use should be approached with caution pending further research. Individuals considering DMSO for hair health should consult a healthcare professional, use pharmaceutical-grade products, and be vigilant for potential side effects. Rigorous clinical trials and mechanistic studies are needed to fully elucidate the risks and benefits of DMSO in this context and to establish evidence-based guidelines for its use.

# **Synthesis of Findings and Recommendations**

The current body of evidence indicates that DMSO, when applied to the scalp, may improve the effectiveness of topical hair growth agents by enhancing their penetration to the hair follicles. Its anti-inflammatory properties may also support scalp health, potentially benefiting individuals with inflammatory scalp conditions. However, the direct impact of DMSO on hair growth and hair structure remains uncertain, with limited and conflicting evidence from clinical and preclinical studies.

Given the potential risks-particularly skin irritation and increased systemic absorption of coadministered agents-DMSO should be used with caution, preferably under the supervision of a healthcare professional. Only pharmaceutical-grade DMSO should be used, and individuals should perform a patch test prior to widespread application. Further research, including large-scale clinical trials and mechanistic studies, is needed to clarify the efficacy, safety, and optimal use of DMSO in hair care.

For now, DMSO may be considered as an adjunct to established hair growth agents in topical formulations, with the caveat that its use is off-label and not supported by robust clinical evidence. Individuals seeking to improve hair health should weigh the potential benefits against the risks and uncertainties, and prioritize evidence-based treatments pending further research in this promising but as yet unproven area.

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