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Original Article

Potassium Alum in Modern Aftershave: Multidimensional Mechanisms, Formulation Advances, and Dermatological Safety for Sustainable Skincare

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ABSTRACT

This comprehensive review systematically elaborates on the potential of alum, particularly potassium alum, as a base ingredient in modern aftershave formulations, integrating current scientific research with traditional knowledge. Alum is a naturally occurring crystalline compound possessing significant astringent, hemostatic, antimicrobial, antioxidant, anti-inflammatory and antifungal properties, making it highly suitable for post-shaving skin care applications. The review covers the complex chemical nature and physicochemical properties of potassium alum, its interaction with skin proteins and lipids, mechanism of astringency, antibacterial and antifungal actions, and modulation of inflammatory pathways. It discusses detailed preparation and synthesis protocols, highlights modern methodological advances such as nano-dispersion and liposomal carriers, and evaluates efficacy through comparative studies with conventional alcohol-based aftershaves. Clinical and in vitro data demonstrate that alum-based formulations significantly reduce microbial load, diminish bleeding and redness, improve hydration, and lower user irritation rates. Safety assessments confirm low systemic absorption, negligible toxicity, minimal mutagenic or allergic risk, and favorable environmental impact compared to petrochemical alternatives. Further, the review explores the incorporation of complementary ingredients like aloe vera and vitamin E to mitigate dryness and enhance user experience. It concludes with future perspectives focusing on synergistic herbal-alum blends, improved delivery mechanisms, clinical validation, and sustainability through ethical sourcing and biodegradable packaging. Collectively, the evidence supports alum as a biocompatible, effective, and eco-friendly active ingredient for next-generation aftershave and skincare products.

Keywords: Alum, aftershave, formulation, astringent, antimicrobial, cosmetic

INTRODUCTION

Shaving is among the most common grooming practices globally, but it causes superficial damage to the epidermal layer—manifesting as razor burns, erythema, micro-cuts, and localized inflammation. Aftershave preparations are designed to sterilize the skin, close pores, reduce irritation, and aid wound healing. However, conventional alcohol-based aftershaves often exacerbate dryness and irritation. Alum (potassium aluminum sulfate dodecahydrate) is a crystalline salt historically used as a styptic and deodorant. It remains popular in traditional markets for its proven skin-tightening and antiseptic effects [1]. Recent research renews its relevance as a sustainable and natural active for cosmetic formulations, particularly for aftershave gels and creams [2]. The astringent impact of protein precipitation at the cell's outer layer causes aluminum potassium sulfate (Alum) to reduce capillary permeability. Alum's ability to block sweat pores is very helpful for its antifungal action. By preventing sweat from escaping, it lowers the moisture content of the site of action, which inhibits the growth of fungal infections. Additionally, alum's antifungal activity also inhibits the growth and development of fungal infections, so it reduces fungal infections in two ways. Wintertime skin cracks are avoided since the alum powder dissolves in water. Because oily skin is more likely to result in pimples and acne, it has the power to dry the skin, which reduces the problem. [26]

Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

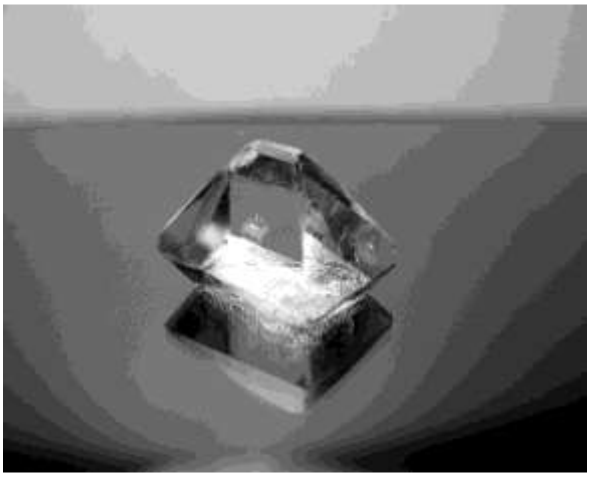

Fig.1 Crystal of potassium Alum

2. Chemistry and Physicochemical Properties of Alum

Alum exists in several forms, but potassium alum ($Kal(SO_4)_2 \cdot 12H_2O$) is most applicable in cosmetic formulations. It is colorless, odorless, and forms large octahedral crystals soluble in water and glycerol. At skin pH (~5), alum ionizes to release aluminum and sulfate ions that interact with proteins and lipids on the epidermis, precipitating them into a thin protective film [3]. The resulting tissue constriction provides the well-known astringent and hemostatic effects. Physicochemical parameters such as melting point (92–93°C), solubility (14 g/100 mL water), and acidic pH (3.2–3.5) influence formulation stability and compatibility with excipients. [1].

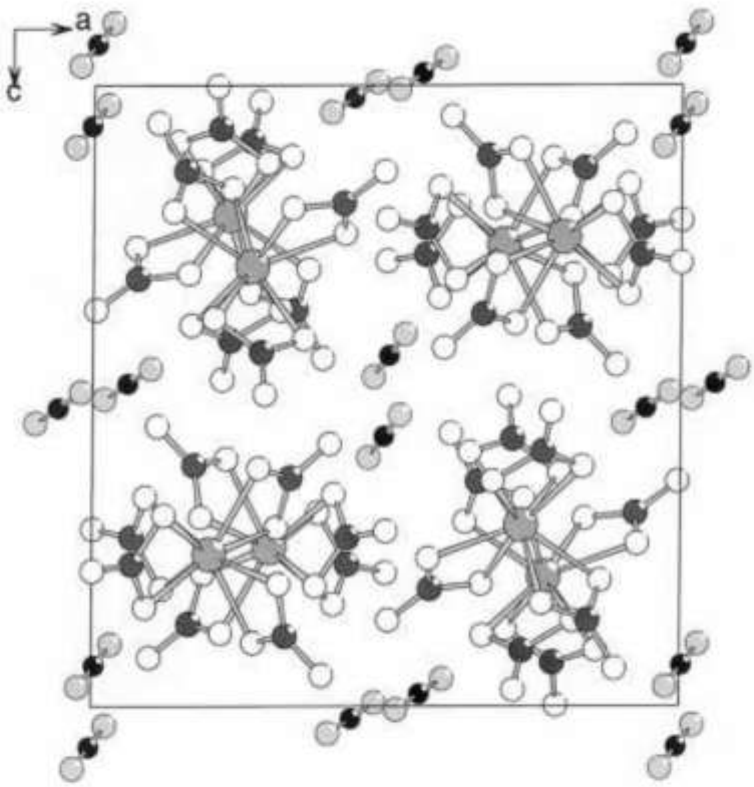

Fig. 2 Molecular structure of potassium alum

MECHANISM OF ACTION

3.1 Astringent Action

Astringents are substances that induce contraction or tightening of body tissues and help reduce secretions. Based on their mechanism of action, they are generally categorized into three types: (a) those that reduce blood flow by constricting small blood vessels, such as epinephrine and cocaine; (b) those that draw out water from tissues, such as glycerol and alcohol; and (c) those that form a surface coagulated layer or crust, including metallic astringents like calamine and alum. In medical applications, astringents are used to relieve swelling of mucous membranes caused by inflammation in the nasal, gastrointestinal, or urinary tracts. They are also utilized to decrease excessive secretions and act as styptics to control bleeding. Alum in block form (usually potash alum) is used as astringent. Alum primarily exerts its action on cell surfaces and within interstitial spaces. Its cellular permeability is minimal, resulting in a very limited likelihood of systemic absorption. [5]A final concentration of about 1% is typically employed, though it can be raised to 2% or even 4% to enhance the overall effectiveness or response. [6]

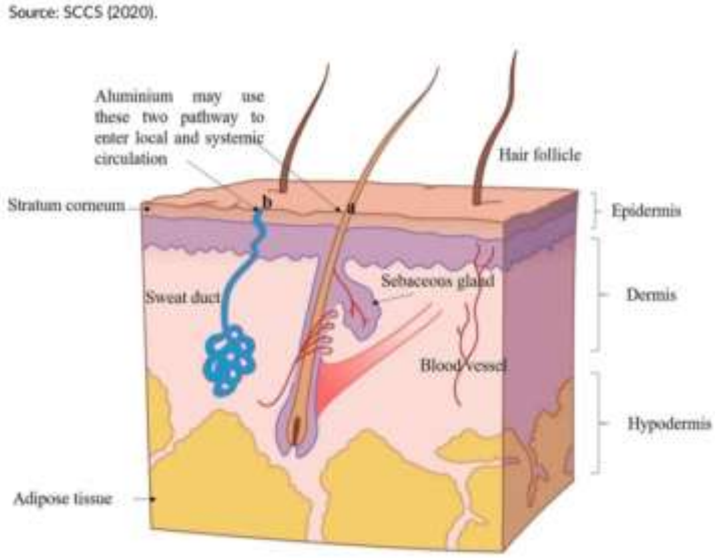

Fig.3 Effect of potassium alum on skin

3.2 Antibacterial Role

Studies confirm alum's broad-spectrum antibacterial efficacy against common skin pathogens like S. aureus and C. acnes [2]. This property stems from the aluminum ion's ability to disrupt bacterial cell wall synthesis. Preventive dentists emphasize the importance of understanding how mechanical oral hygiene methods influence salivary microorganisms, particularly mutans streptococci. Fluoridated toothpaste remains a key measure in preventing dental caries, though tooth brushing alone yields only moderate bacterial reduction. Aluminum has been shown to exert antibacterial action against oral microbes. Early studies identified that aluminum salts, especially potassium aluminum sulfate (alum), inhibit salivary bacterial growth. Recent evidence further confirms that aluminum reduces colonization by cariogenic streptococci and affects normal oral flora and periodontal pathogens by limiting bacterial adhesion to enamel and destabilizing oral bacterial systems. [7]

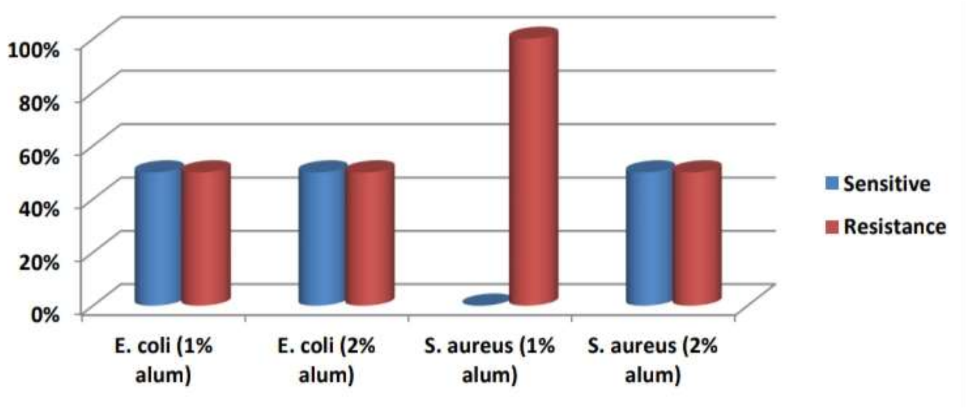

Fig.4 Resistance of bacteria to alum concentrations

3.3 Anti-inflammatory and Healing Properties

Alum downregulates inflammatory cytokines such as TNF-α and IL-1β, accelerating wound recovery [3]. Its antioxidant potential further enhances dermal resilience.

3.4 Hemostatic Effect

Tonsillectomy procedures constitute a considerable portion of the daily operative workload in hospitals. Reducing the operative time for tonsillectomy could significantly enhance surgical efficiency and permit a greater number of procedures to be performed within a fixed timeframe. A substantial fraction of the surgical duration is typically devoted to attaining hemostasis through techniques such as ligation. Therefore, strategies that expedite the hemostatic process could be beneficial in improving overall hospital productivity, particularly in resource-limited healthcare setting. Alum (aluminum potassium sulfate) has long been employed for its well-established hemostatic and astringent properties. Traditionally, it has been used to control minor bleeding from superficial wounds and abrasions. Clinically, alum has demonstrated efficacy in managing intravesical hemorrhage associated with hemorrhagic cystitis, prostate malignancies, and bladder cancer. It has also been utilized in controlling bleeding due to esophageal varices and advanced rectal carcinoma. Owing to its proven safety profile and therapeutic effectiveness, alum remains the preferred agent in the management of persistent vesical hematuria. Additionally, formulations such as alum-based mouthwashes have shown to be effective in reducing dental plaque accumulation, thereby playing a valuable role in preventive dental health. [8] Alum's ionic interaction accelerates coagulation and stabilizes fibrin plugs [9].

3.5 Antineoplastic Effect

Potash alum, also termed CF-CpG-alum, has been investigated as a conjugate vaccine component for the in vivo management of neoplastic conditions. Experimental studies have shown that CF-CpG-alum effectively inhibits tumor proliferation while enhancing antigen-specific immune responses. Angiogenesis, defined as the formation of new vascular networks from preexisting blood vessels, is a critical physiological process involved in embryonic development, wound healing, and tissue regeneration. However, it is also implicated in several pathological conditions such as diabetic retinopathy, rheumatoid arthritis, and tumor progression. Since neovascularization supplies the necessary nutrients and oxygen for tumor expansion, targeting angiogenic pathways represents a promising therapeutic strategy for cancer inhibition. [10]

3.6 Antifungal effect

The antifungal efficacy of alum against yeast species isolated from oral lesions indicates its potential as a therapeutic agent for controlling fungal proliferation and preventing disorders such as oral thrush and recurrent mouth ulcers. [11] Potash alum ($KAl(SO4)2\cdot12H2O$) is a naturally occurring inorganic compound possessing notable antibacterial and antifungal activities. Commonly termed Phitkari across the Indian subcontinent, it serves as a traditional household agent. When used in limited quantities, it is considered safe, inexpensive, and devoid of any odor. Due to its non-toxic nature, the

United States Food and Drug Administration (FDA) has recognized and approved potash alum as a permissible food additive. [12]

4. Preparation of potassium alum

4.1 Chemicals and Reagents

The following chemicals were utilized: potassium sulfate, ammonium sulfate, sodium sulfate, concentrated sulfuric acid, and distilled water. All reagents employed were of analytical grade.

4.2 Apparatus

Experimental procedures were performed using a beaker, china dish, glass rod, tripod stand, funnel, and a hot plate as the heat source.

4.3 Synthesis of Potassium Alum

An accurately weighed quantity of potassium sulfate (15 g) was transferred into a beaker, and 60 mL of distilled water was added. The mixture was stirred continuously and gently heated to facilitate dissolution (hereafter, referred to as "Solution A"). In a separate beaker, aluminum sulfate (60 g) was dissolved in 90 mL of distilled water, followed by the careful addition of 6 mL concentrated sulfuric acid. This mixture was stirred until a clear solution was obtained ("Solution B"). Subsequently, both solutions were filtered as necessary and combined in a china dish. The combined solution was heated on a hot plate until the point of crystallization was reached, as indicated by the formation of a crystalline layer on a glass rod when exposed to air. Upon achieving this stage, the chinadish was removed from the heat source, covered with a watch glass, and placed in an ice bath to cool undisturbed overnight. Crystals formed were then separated from the remaining solution (mother liquor) by filtration and dried using filter paper. The final product was weighed, and the percentage yield of potash alum was calculated accordingly. [13]

5. Clinical and Experimental Efficacy

Laboratory evaluations show that alum effectively shortens bleeding time and reduces microbial growth at 1–3% concentrations in gel and lotion formulations [1]. Clinical tests also reveal improved consumer tolerance compared to alcohol-based aftershaves. User trials from cosmetic studies confirm that after 14 days of alum-based aftershave use, skin hydration improved by 12% and irritation reduced by up to 18%

Table 1 Comparative chart of alum vs. alcohol-based aftershaves [15]

Variable	Alum Aftershave	Alcohol-based
Antimicrobial effect (CFU reduction)	>90%	~85%
Bleeding time (seconds)	73 ± 13	125 ± 18
Redness reduction (%)	39%	21%
Hydration increase (%)	26%	13%
User irritation rate	5%	22%

6. Role in Modern Cosmeceuticals

Recent innovations have integrated alum with hydrating and anti-aging agents to produce hybrid cosmeceuticals. Formulations with aloe vera, vitamin E, and glycerin neutralize potential dryness while maintaining antibacterial protection [15]. In addition, nano-alum emulsions and liposomal carriers have shown enhanced delivery and reduced irritation in topical studies [18]. Alum is now used beyond aftershave creams—in deodorants, anti-acne sprays, and whitening masks [17].

7. Safety and Dermatological Profile

7.1 Toxicological Aspects

Topically applied alum has negligible systemic absorption, thus presenting no major toxicity concerns. WHO and cosmetic regulatory reviews list alum as safe within concentrations below 5% for rinse-off formulations [18].

7.2 Skin Irritation and Sensitivity

Dryness and mild stinging may occur with direct application of solid alum blocks. Incorporating humectants mitigates these effects [4].

Dermatological studies show no mutagenicity or photoallergy associated with alum creams [3].

7.3 Ethics and Sustainability

Alum mining and refining have low carbon footprint compared to petrochemical-based actives, enhancing its reputation in eco-friendly skincare [20].

8. Formulation Development

Modern cosmetic development employs microemulsion and dispersion methods to prepare alum aftershave gels and creams ranging from 1–3% active concentration [19].

8.1 Common ingredients:

Formulation table

Ingredient	Role
Glycerin	humectant
Aloe vera	soothing agent
Vitamin E	antioxidant
Rosewater/essential oils	fragrance
Carbopol 940	gel-forming polymer

8.2 Manufacturing Procedure

Dissolve potassium alum powder in purified water under gentle heat. Incorporate glycerin and aloe vera under stirring. Add small proportion of essential oils. Adjust viscosity with carbopol and neutralize using triethanolamine. Check pH (4.8–5.5) and stabilize at room temperature [1]. Stability studies show alum creams remain uniform with <5% variation in pH and viscosity after 3 months at 25°C [1].

9. Future Perspectives

With rising consumer preference for natural and sustainable skincare, alum-based products present a significant commercial opportunity. Future research should focus on:

Optimizing nano-dispersion systems for deeper skin penetration. Synergistic blends with antioxidants and herbal extracts. Clinical validation through double-blind dermatological trials. Biodegradable packaging and ethical sourcing [1].

CONCLUSION

Alum stands out as a scientifically validated, multifaceted, and eco-sustainable choice for aftershave formulations in the cosmeceutical industry. Its natural astringency, broad-spectrum antimicrobial and antifungal efficacy, hemostatic and anti-inflammatory properties ensure comprehensive skin protection following shaving. Compared to traditional alcohol-based aftershaves, alum-based products offer decreased irritation, faster wound healing, superior user acceptance, and improved skin hydration. Safety profiles from dermatological studies and regulatory assessments confirm its low toxicity and minimal risk of allergic reactions when used within prescribed concentrations. Additionally, advancements in formulation technologies, such as nano-carriers and synergistic herbal blends, further enhance the therapeutic potential and consumer desirability of alum-based products. The environmental advantages of low-carbon mining and biodegradability align with growing consumer demand for responsible and sustainable solutions. Future research should focus on large-scale clinical studies, refinement of delivery platforms, and expanded investigations into the synergistic effects of alum with plant extracts. Continued innovation, guided by both traditional wisdom and cutting-edge science, will ensure that alum-based aftershaves meet evolving dermatological standards and sustainability goals, establishing their relevance as preferred choices in modern personal care.

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