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Advances in cosmetic science: A comprehensive review of lipstick formulation, ingredients, and emerging trends

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Summary

Lipsticks are among the most widely used cosmetic products, combining aesthetic appeal with essential functional performance. Effective lipstick manufacturing requires a precise balance of ingredients to achieve the desired colour, durability, texture, and user safety. This review outlines the fundamental principles of lipstick formulation, focusing on key components such as waxes, oils, pigments, colorants, emollients, and functional additives. These ingredients collectively influence important characteristics including hardness, melting behaviour, spreadability, gloss, and wear resistance. Safety and regulatory considerations are equally critical in cosmetic development. Strict quality control measures, systematic evaluation of ingredient safety, and cosmetovigilance practices in India play a major role in monitoring adverse reactions and ensuring consumer protection. Lipstick manufacturing also involves several evaluation parameters used to assess product quality, including melting point, breaking strength, ease of application, stability under varying conditions, and microbial safety. In addition, this review highlights emerging sustainability trends within the cosmetic industry, such as the adoption of ecofriendly raw materials, biodegradable formulations, and environmentally responsible packaging solutions. Despite ongoing advancements, challenges related to regulatory compliance, environmental impact, and ingredient safety remain significant. Future research and development efforts are expected to emphasize green chemistry approaches, safer alternative ingredients products.

Keywords

Lipstick formulation; Cosmetic science; Waxes and oils; Pigments and colorants; Quality evaluation; Safety and regulation; Cosmeto-vigilance; Sustainability; Green Chemistry; Cosmetic manufacturing

Introduction

Lipstick is one of the oldest and most popular cosmetic products which are used not only to add colour and enhance the appearance of the lips but also to keep them comfortable and protected [1].

The beauty and attractiveness of a person are enhanced as lipsticks colour the lips and protect them from the external surroundings. Currently lip care products not only focus on aesthetic appearance but also preferably have added medicinal value to the lip of consumers. This led to the emergence in the market of medicated lipsticks with active medicinal ingredients. The medicated lipsticks may provide protection against infections of bacteria due to the presence of an active medicinal ingredient in the formulation. This function adds on to the existing role of lipsticks, which provide moisture and emollient action to prevent cracking and chapping of the lips [2]. Recent progress in cosmetic science has led to the creation of

lipsticks that last longer, feel better, and are safer for consumers. As consumers become more aware, there is a growing interest in cruelty-free and vegan lipstick options that do not use animal products or harmful chemicals. [3].

In addition to looking good, safety checks are now essential in lipstick making, especially because of the chance of accidental swallowing while using it. As a result, regulatory bodies have set up strict rules to limit heavy metals and other harmful substances in lipstick to protect consumer health. [4].

History Of Lipsticks

The origins of lipstick can be traced back to prehistoric eras, during which early humans sought to improve their appearance by experimenting with natural materials. Historical records indicate that the practice of lip colouring began in ancient civilizations, with some of the earliest evidence discovered in Mesopotamia. These primitive cosmetic practices suggest that the desire for beautification was an integral part of human culture long before the advent of contemporary cosmetics.

As time progressed, the application of lipstick transformed across various cultures, mirroring the evolving cultural values and aesthetic tastes. The evolution of lip products persisted through different historical epochs, ultimately culminating in the creation of more sophisticated lipstick formulations in subsequent centuries. [5].

Lipstick formulation fundamentals

The process of creating lipstick is a specialized field within cosmetic science that involves mixing various types of ingredients to achieve the desired texture, colour, stability, and performance. A typical solid lipstick formulation includes a combination of waxes, oils, pigments, and emollients, each offering distinct functional properties to the final product. The quality of pigment dispersion in the wax-oil blend significantly influences the colour uniformity, strength, and visual attractiveness of the lipstick. Functional additives like antioxidants and preservatives may be incorporated to protect the formulation from oxidation and microbial contamination, thus enhancing shelf life and ensuring safety. Each lipstick formulation is usually optimized through repeated testing for melting point, hardness, texture, sensory feel, and colour performance to comply with safety regulations and meet consumer expectations. [6].

Oils and emollients like castor oil, coconut oil, and olive oil are added to improve spread-ability, moisture, and sensory experience while helping with pigment distribution. Natural oils and butters from plants not only enhance the feel but also offer extra skin conditioning benefits in herbal lipstick products.Reviews of herbal lipsticks emphasize the use of plant-based pigments, such as betalains and anthocyanins, which deliver colour along with antioxidant and skin-friendly properties. [7].

Advances in lipstick formulation technology

The formulation of modern lipstick has changed significantly, integrating improvements that boost not just colour and longevity but also provide functional advantages like hydration, antioxidant defence, and overall lip wellness, surpassing the typical cosmetic functions.[8]

A significant development is the use of natural bioactive ingredients and herbal extracts, which enhance skin conditioning, offer antioxidant benefits, and lessen the dependence on synthetic colorants in lipstick products. [9]

Current scientific formulation methods emphasize improving emollients, innovative wax mixtures, and natural oils to create the perfect texture, spread-ability, and stability, all while boosting the sensory qualities that today's consumers seek.[10]

Ingredient Type	**Function in Formulation**	**Examples / Notes**	**References**

Waxes	Provide structure, rigidity, and determine melting point; influence hardness and pay-off	Beeswax, Carnauba wax, Candelilla wax	[6]
Oils & Emollients	Improve spread-ability, moisture, sensory feel; aid in pigment dispersion	Castor oil, Coconut oil, Olive oil, Plant butters	[6][7]
Pigments & Colourants	Impart colour, opacity, and visual appeal; natural pigments may offer antioxidant benefits	Synthetic pigments, Plant-derived pigments like betalains, anthocyanins	[7]
Antioxidants	Protect oils and lipids from oxidation; enhance shelf life	Vitamin E (Tocopherol), natural extracts	[6]
Preservatives	Prevent microbial contamination and ensure product safety	Common cosmetic preservatives	[6]
Functional Additives	Enhance specific properties such as gloss, stability, and skin conditioning	Film-forming agents, UV filters, herbal extracts	[6][7]

Long Lasting and Transfer Resistant Systems.

Long-lasting and transfer-resistant lipstick formulas are made to form a strong film on the lips that sticks well and keeps its colour even when faced with activities like talking, eating, and drinking. Polymers and film-forming resins are key in ensuring the long-lasting hold of these products, as they create a semi-continuous layer that stays attached to the lip surface during everyday movements and contact.

In summary, today's long-lasting lipstick technologies depend on polymeric film-forming systems and carefully chosen ingredient interactions that ensure strong adhesion and less transfer, representing a major shift from traditional wax-based formulas to performance-driven cosmetic science. [11]

Natural and Herbal Lipstick Formulation

Natural lipsticks mainly consist of waxes, oils, and butters sourced from plants, including beeswax, carnauba wax, shea butter, and coconut oil. These ingredients contribute to the product's structure, emollience, and moisture retention, all while preserving appealing sensory characteristics. [6]

Nanotechnology in lipstick formulation

Nanotechnology involves manipulating materials at the nanoscale, specifically within the range of 1–100 nm. This manipulation leads to unique physicochemical properties that differ from those of bulk materials. [12]

In cosmetic science, nanotechnology is being used more and more to improve formulation stability, product performance, and sensory qualities. [13] Lipstick formulas now use nanotechnology to enhance pigment distribution, colour consistency, and stickiness to the lips [14] Nanoparticles like silica, titanium

dioxide, and zinc oxide are often added to lipsticks to boost opacity, shine, and feel. Silica nanoparticles are essential in lipstick recipes as they stop pigment clumping and allow for a smooth and even application [14].

Safety and regulatory consideration

In lipstick, safety checks are very important due to the risk of accidental oral exposure from licking, swallowing, and long contact with the lips. This way of exposure makes lipsticks different from other cosmetics and means that both skin and mouth toxicity need to be considered during safety evaluations [15].

Regulatory bodies stress that nanomaterials should not be considered safe just because their non-nano versions have been used in cosmetics before. In the European Union, cosmetics with nanomaterials are regulated by Regulation (EC) No. 1223/2009, which requires clear labelling of nanomaterials in the ingredient list with the term “(nano)”. This regulation also demands that manufacturers notify about nanomaterials through the Cosmetic Products Notification Portal (CPNP) at least six months before they are sold [16].

In the United States, cosmetics are regulated by the Food and Drug Administration (FDA), which assesses cosmetics that use nanotechnology under the current safety rules of the Federal Food, Drug, and Cosmetic Act. While nanomaterials do not need premarket approval for cosmetics, the FDA strongly advises manufacturers to perform extra safety tests when using nanoscale ingredients [17]

Evaluation parameters of lipstick formulation

Evaluating lipstick formulations is essential for maintaining product quality, stability, and consumer safety [18].

These evaluations include physical, mechanical, performance, and safety factors that affect usability and compliance with regulations [19].

Physical and Mechanical Parameters

The initial step in evaluation involves checking the appearance and surface features of the lipstick [20]. A visual inspection looks at uniformity, colour consistency, and surface flaws like cracks, air bubbles, or sweating [18]. Determining the melting point gives insights into thermal stability, ensuring the lipstick stays solid at room temperature [19]. Breaking point tests measure the force needed to break the lipstick, assessing its mechanical strength [20]. Hardness tests evaluate resistance to deformation, which affects how well the product spreads [18].

Performance Parameters

Spread-ability tests assess how smoothly the lipstick applies to the lips [19].
Pay-off tests measure how much product is transferred to the lips during application [20].
Smudge resistance tests check how well the lipstick stays in place when subjected to friction [18].
Longevity studies evaluate how long the colour and texture last while being worn [19].

Safety Parameters

pH testing ensures the lipstick matches the natural pH of the lips [20].
Irritation and safety tests identify any potential allergic or sensitizing reactions to the formulation [18]. Stability studies under various environmental conditions track changes in texture, colour, and smell over time [19].

Challenges and future directions in lipstick formulations

Finding a balance between long-lasting wear and comfort for lips is a major challenge in today's lipstick formulations. Translating lab formulations to large-scale production presents challenges in maintaining batch consistency, reproducibility, and controlling costs [21]. Highly

pigmented or long-lasting lipsticks can lead to dryness or friction, necessitating careful adjustment of wax-oil ratios and emollient systems [22]. Stability problems like phase separation, sweating, and cracking can happen at high temperatures, impacting product quality. Using nanotechnology-based pigments or delivery systems can enhance colour intensity and durability but also raises safety and regulatory issues [23].

Adding functional ingredients such as UV filters, antioxidants, and moisturizers can make it harder to ensure chemical compatibility and stability [24].

Different regulatory standards in global markets require careful adherence to ensure safety, labelling, and acceptable ingredients [25].

Conclusion

Lipstick is one of the most popular cosmetic products because it enhances appearance, provides comfort, and protects the lips [26]. Modern cosmetic science has evolved lipstick from basic pigment mixtures to advanced formulations that include moisturizing, antioxidant, and functional properties [27]
However, there are still challenges in formulation, such as finding the right wax-oil balance for texture and stability without losing effectiveness [28].

Recent developments in cosmetic science have greatly improved the effectiveness, safety, and sensory qualities of lipstick products.
New technologies in nanoscale delivery systems have enhanced pigment stability, moisturizing effectiveness, and the controlled release of bioactive ingredients, resulting in improved wear and greater consumer satisfaction.[29]

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