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Research on the Formulation Composition and Future Development Trends of Liquid Soap

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Abstract. Liquid soap has become an indispensable daily necessity, which is widely used in households, healthcare institutions, and public places due to its convenience, hygiene, and easy portability. The rationality of its formulation directly determines its cleaning performance, skin-friendliness, and stability, thus making it crucial to optimize the formulation and explore its development directions. This paper summarizes the components, types, and key influencing factors of liquid soap formulations, as well as their future development trends, by adopting the literature analysis method to systematically sort out and analyze relevant domestic and foreign studies. The results show that liquid soap formulations are mainly composed of surfactants, moisturizers, thickeners, and preservatives, and the proportion of each component directly affecting product quality. With the improvement of consumers' health awareness and environmental protection requirements, natural, green, and functional liquid soaps will become the mainstream of the market. Meanwhile, the optimization of formulation technology and the innovation of packaging forms will further promote the sustainable development of the liquid soap industry.

Keywords: liquid soap, formulation, surfactant, future development, green innovation

1. Introduction

In recent years, with the continuous improvement of people's living standards and hygiene consciousness, liquid soap has gradually replaced traditional bar soap and become a core product in daily cleaning and personal care. Relevant studies have laid a foundation for the research on liquid soap formulations and their development. Borković et al. [1] optimized liquid soap formulations by adjusting the concentrations of anionic and amphoteric surfactants and sodium chloride, confirming that the combination of two surfactants and appropriate NaCl addition can improve product performance. Widya Santi et al. [2] developed castor oil-based liquid soap with white tea extract, proving that natural plant ingredients can enhance the antibacterial properties and skin-friendliness of products. The research by IJETRM [3] systematically elaborated on the chemistry, formulation types, and application characteristics of liquid soap, pointing out the challenges in mildness and stability of current formulations. Existing research has made certain progress in formulation optimization, but there is still a lack of a systematic sorting of formulation components and in-depth discussion of future development trends. This paper adopts the literature analysis method, combs the

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composition and characteristics of existing liquid soap formulations, explores its future development direction, and provides theoretical support and practical reference for the research and development, production, and innovation of liquid soap products in related fields.

2. Existing liquid soap formulation analysis

Liquid soap formulations constitute a complex system composed of multiple components, each of which plays a unique role, and the rational ratio of components determines the comprehensive performance of the product. The core components of liquid soap mainly include surfactants, moisturizers, thickeners, preservatives, and other auxiliary components, and different types of liquid soaps have obvious differences in formulation composition and proportion.

Surfactants are the core functional components of liquid soap, accounting for 10% - 30% of the total formulation, and their main function is to reduce the surface tension of water, emulsify dirt, and achieve the cleaning effect [3]. According to their ionic charge properties, surfactants used in liquid soap can be divided into anionic, amphoteric, non-ionic, and cationic types, among which anionic and amphoteric surfactants are the most widely used. Anionic surfactants have strong decontamination and foaming properties, such as sodium lauryl ether sulfate (SLES) and potassium cocoate, which are often used as the main surfactants in liquid soap [4,5]. Amphoteric surfactants, such as cocamidopropyl betaine (CAPB) and cocamidopropylamine oxide, have good skin-friendliness and compatibility, which helps reduce the irritation of anionic surfactants and improve the foaming stability of the products [1,3]. Non-ionic surfactants, such as alkyl polyglucoside (APG), have mild performance and good environmental friendliness, and are often used in high-end and sensitive skin-friendly liquid soaps [3]. Cationic surfactants have antibacterial properties but poor compatibility with other surfactants, so they are only used in small amounts in antibacterial liquid soaps.

Moisturizers are important auxiliary components in liquid soap, accounting for 3% - 10% of the formulation, and they prevent the skin from drying after cleaning and maintain skin moisture [4]. Common moisturizers include glycerin, propylene glycol, sorbitol, and natural plant oils. Glycerin is the most widely used moisturizer, which is a natural by-product of saponification, can attract moisture from the air to the skin surface, and has good moisturizing effect [4,5]. Natural plant oils, such as sweet almond oil and castor oil, not only have moisturizing effects but also can enhance the skin-friendliness of liquid soap. For example, Lubrizol [5] added 40% sweet almond oil to liquid soap formulations to improve their moisturizing and emollient properties. Widya Santi et al [6]. used castor oil as the main raw material to prepare liquid soap, which made the skin smooth and tender after use.

Thickeners are used to adjust the viscosity of liquid soap, making it easy to apply and preventing leakage, accounting for 0.1% - 5% of the formulation [4]. Common thickeners include cellulose derivatives, acrylic acid polymers, and natural gums. Carbopol® aqua sf-2 polymer is a commonly used acrylic acid thickener, which can provide good viscosity and stabilize the formulation system (Lubrizol, n.d.). Sodium chloride can also be used as a thickener, and its addition amount directly affects the viscosity of liquid soap. Borković et al. [1] found that the viscosity of liquid soap increases with the increase of NaCl concentration within a certain range, but excessive addition will lead to stratification of the product. Xanthan gum and guar gum are natural thickeners, which are environmentally friendly and mild, and are widely used in green liquid soaps [4].

Preservatives are essential components in liquid soap, accounting for 0.1% - 1% of the formulation, which can prevent the growth of bacteria, fungi, and other microorganisms in the product, extend the shelf life of the product [3]. Common preservatives include phenoxyethanol,

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ethylhexyl glycerin, parabens, and benzalkonium chloride. Euxyl® PE 9010, a compound preservative composed of ethylhexyl glycerin and phenoxyethanol, has good preservative effect and low irritation, and is often used in liquid soap formulations [5]. With the improvement of consumers' health awareness, the use of natural preservatives, such as tea tree oil and grapefruit seed extract, is gradually increasing, as they can reduce the potential harm of synthetic preservatives to the human body [6].

In addition to the above core components, liquid soap formulations also include auxiliary components such as fragrances, colorants, and pH adjusters. Fragrances can improve the user experience of the product, and common ones include natural essential oils and synthetic fragrances [5]. Colorants are used to adjust the appearance of liquid soap, but their use should comply with relevant national standards to ensure safety [4]. pH adjusters, such as sodium hydroxide and citric acid, are used to adjust the pH value of liquid soap to 5.5 - 9.5, which is consistent with the pH value of human skin and reduces skin irritation [1,5].

At present, the main types of liquid soaps on the market include daily cleaning liquid soap, antibacterial liquid soap, sensitive skin-friendly liquid soap, and natural organic liquid soap. Daily cleaning liquid soap focuses on decontamination and foaming properties, with simple formulation, mainly composed of anionic and amphoteric surfactants [3]. Antibacterial liquid soap adds antibacterial components, such as triclosan and chlorhexidine, or uses the antibacterial properties of cationic surfactants to inhibit the growth of microorganisms [6]. Sensitive skin-friendly liquid soap uses mild surfactants, such as APG, and adds a variety of moisturizers to reduce skin irritation [4]. Natural organic liquid soap uses natural plant raw materials, such as plant oils and plant extracts, without adding synthetic preservatives and colorants, which is environmentally friendly and healthy [7].

3. Future development direction

With the continuous improvement of consumers' health awareness and environmental protection requirements, as well as the rapid development of science and technology, the liquid soap industry will usher in a new development stage. Its future development will focus on naturalization, functionalization, environmental protection, and intelligence.

Naturalization of raw materials will become the mainstream trend. In recent years, consumers have paid increasingly attention to the safety and mildness of daily chemical products, and liquid soaps made from natural raw materials are favored by consumers [7]. In the future, the selection of raw materials for liquid soap formulations will gradually shift from synthetic raw materials to natural plant raw materials, such as plant oils, plant extracts, and natural surfactants. For example, castor oil, olive oil, and other plant oils can replace synthetic surfactants to prepare mild and moisturizing liquid soaps [4,6]. Plant extracts, such as white tea extract, aloe vera extract, and green tea extract, have antibacterial, anti-inflammatory, and moisturizing effects, and these can enhance the functional properties of liquid soap [6,7]. At the same time, the use of natural preservatives and fragrances will gradually increase, reducing the use of synthetic chemicals and improving the product safety.

Functionalization of products will be further enhanced. With the diversification of consumers' needs, liquid soap will no longer be limited to the basic cleaning function, and functional liquid soaps with multiple effects will become the focus of market competition [7]. Antibacterial liquid soap will be further optimized, and more safe and efficient antibacterial components will be used to improve the antibacterial effect and reduce the potential harm to the human body and the environment [8]. Sensitive skin-friendly liquid soap will be more targeted. Formulations will be

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personalized for different skin types, such as dry skin, oily skin, and sensitive skin, to develop personalized formulations [2]. In addition, functional liquid soaps with skin care, whitening, anti-aging, and other effects will gradually emerge, adding skin care components, such as hyaluronic acid and vitamin E, to achieve the integration of cleaning and skin care [7].

Environmental protection will become an important development direction. With the increasing emphasis on environmental protection globally, the liquid soap industry will pay more attention to environmental protection throughout the whole process of production, formulation, and packaging [7]. In terms of formulation, it will focus on the development of biodegradable liquid soaps, using biodegradable surfactants and auxiliary components to reduce environmental pollution [3]. In terms of production, green production technology will be adopted to reduce energy consumption and waste emissions. In terms of packaging, recyclable and degradable packaging materials will be used to replace traditional plastic packaging, reducing plastic pollution [7]. At the same time, refillable liquid soap will be further promoted, as this can reduce packaging waste and save resources.

The intelligent development will inject new vitality into the liquid soap industry. With the development of intelligent technology, intelligent liquid soap products will gradually enter the market [7]. For example, intelligent induction liquid soap dispensers can automatically sense and discharge liquid, avoiding manual contact and is more hygienic and convenient. Intelligent liquid soap with a formula adjustment function can adjust the concentration and components of the product according to the user's skin condition and usage environment, providing personalized services. In addition, the combination of the Internet of Things technology can realize the monitoring of the usage of liquid soap, reminding users to replenish supplies in time and improving the user experience.

In addition, the optimization of formulation technology will also promote the development of the liquid soap industry. In the future, with the in-depth research on liquid soap formulations, more scientific and reasonable formulation ratios will be explored, improving product performance and reducing production costs [1]. The application of new formulation technologies, such as microemulsion technology and nanotechnology, can improve the stability and efficacy of liquid soap, making the product more competitive in the market [3].

4. Conclusion

Liquid soap, as an indispensable daily necessity, has a wide range of applications and broad market prospects. This paper adopts the literature analysis method to systematically sort out and analyze the existing liquid soap formulations and future development directions. The research shows that the existing liquid soap formulations are mainly composed of surfactants, moisturizers, thickeners, preservatives, and other auxiliary components, and the type and proportion of each component directly affect product cleaning performance, skin-friendliness, and stability of the product. Surfactants are the core components, and the combination of anionic and amphoteric surfactants is the most common formulation mode. Moisturizers, thickeners, and preservatives play important roles in improving product quality and extending shelf life. At present, the main types of liquid soaps on the market include daily cleaning, antibacterial, sensitive skin-friendly, and natural organic types, which meet the diverse needs of consumers. The future development of liquid soap will focus on naturalization, functionalization, environmental protection, and intelligence. The naturalization of raw materials will improve product safety and mildness; the enhancement of functionalization will meet the personalized needs of consumers; environmental protection will conform to the global environmental protection trend; and intelligent development will inject new vitality into the industry.

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These development trends will promote the sustainable development of the liquid soap industry and bring new opportunities for the research and development and production of related products.

This paper has certain limitations. It only sorts out and analyzes existing literature, and lacks experimental verification of liquid soap formulations, and the discussion of future development trends is insufficiently in-depth. In the future, experimental research can be conducted to optimize formulation ratios through experiments, verify the performance of the formulation, and further explore the specific implementation paths of future development trends, such as the development and application of new natural raw materials and intelligent technologies, to provide more accurate and practical reference for the liquid soap industry.

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