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Research on the Working Mechanism of Skin Moisturizers

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Abstract. This article clarifies the operational mechanism of moisturizers on the stratum corneum of the skin, explains how they affect skin moisture content and barrier function, and provides a theoretical basis for formula design, offering more effective moisturizing solutions for people with damaged skin barriers, such as those with sensitive skin, dry skin, eczema, and aging skin. It also helps the public choose moisturizers suitable for their skin to maintain skin health. This article explores the principle of action of skin moisturizers and adopts a literature analysis method. This article shows that skin moisturizers can not only alleviate skin dryness but also maintain the integrity of the skin barrier and improve resistance to external factors, thereby protecting skin health. Through in-depth exploration of the mechanism of action of moisturizers, it can provide theoretical support for the scientific design of cosmetic formulas, the research and development and optimization of medical moisturizing products, and also provide a basis for the rational selection of moisturizing products.

Keywords: Moisturizers, humectants, emollients, occlusives, cosmetic formulation

1. Introduction

Moisturizers are the "water guardians" of the skin, dedicated to retaining moisture, preventing dryness and cracking, and maintaining softness and suppleness [1]. Meanwhile, moisturizers are also indispensable for maintaining skin health. As times change, people are becoming increasingly concerned about their appearance. Having smooth, delicate and healthy skin has become a pursuit for many. However, due to a lack of understanding of the ingredients and mechanisms of moisturizers, some people may even damage their skin by using inappropriate moisturizers. It is very important to understand one's own skin type and the essence of moisturizers. The three core functional components of moisturizers are humectants, emollients, and occlusives. This article will provide a detailed explanation of the mechanism of action for these three types of substances, so that more people can understand the underlying principles. This article employs the method of literature analysis. This research provides theoretical guidance and references for improving the formula of skin care products, making the applicable population of these products more extensive and helping to maintain the skin health of the general public.

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2. Humectants

Humectants are hygroscopic substances that attract and retain water molecules from the surrounding environment or from deeper layers of the skin [2]. Common humectants include glycerol, hyaluronic acid and polyols. Why can they absorb and retain moisture? This is because they all have hydrophilic groups such as hydroxyl or carboxyl groups. For example, polyhydric alcohols contain these groups which can form hydrogen bonds with water molecules. This hydrogen bonding allows humectants to bind water tightly, preventing its evaporation and maintaining skin hydration. In addition to hydrogen bonding, humectants create an osmotic gradient across the stratum corneum (SC). By increasing the solute concentration in the SC, humectants draw water from the viable epidermis and dermis upward into the SC, where it is needed to maintain hydration and barrier function. This osmotic effect is particularly important in dry environments where ambient humidity is low. Humectant also interact with the natural moisturizing factor (NMF) components of the SC, such as amino acids, pyrrolidone carboxylic acid (PCA), and urea. They enhance the water-holding capacity of the NMF and help to stabilize the SC lipid bilayer, which is critical for maintaining skin barrier integrity. Some humectants, such as glycerol, have been shown to upregulate the expression of aquaporin 3 (AQP3), a transmembrane protein that facilitates the transport of water and glycerol across cell membranes, further improving skin hydration [2].

For another example, hyaluronic acid is also a common substance with extremely strong water-absorbing capacity. It can absorb and retain over 1,000 times its own volume of water. This exceptional hygroscopicity arises from its unique chemical structure: a repeating disaccharide unit of glucuronic acid and N-acetylglucosamine, which contains numerous hydroxyl and carboxyl groups that form extensive hydrogen bonds with water molecules. Hyaluronic acid acts as a molecular sponge in the extracellular matrix (ECM) of the dermis, binding and immobilizing water to maintain dermal turgor and hydration. It also forms a viscoelastic gel network that fills the intercellular spaces of the stratum corneum, reducing transepidermal water loss (TEWL) and preserving the skin's barrier function. Unlike many humectants, hyaluronic acid does not draw water from deeper skin layers at the cost of overall hydration; instead, it stabilizes water content among skin layers, making it a superior moisturizing agent for both dry and aging skin [3].

Small-molecule humectants are more likely to penetrate into the stratum corneum and reach deeper skin layers, whereas large-molecule substances mainly act on the skin surface, forming a water-locking film.To achieve a balanced moisturizing effect, it is necessary to use the most appropriate concentration of moisture-absorbing agents. It is also important to avoid skin irritation or excessive water loss caused by reverse osmosis in extremely dry environments [2].

In the formulation of skin care products, the proportion of humectants needs to be adjusted flexibly according to the characteristics of the skin type. The main function of humectants is to draw moisture from the air or deeper skin layers to raise the water level in the outermost skin layer. However, excessively high concentrations may actually draw moisture away from the skin. Therefore, it must be controlled within a reasonable range. For oily and acne-prone skin, the focus should be on refreshing and hydrating, and the proportion of humectants is usually between 3% and 8%. Mild ingredients such as glycerin and panthenol should be selected to avoid excessive concentration that would increase the burden on the skin.For neutral and combination skin, the condition is stable, and the proportion of humectants can be set at 5% to 10%. This ensures adequate moisturizing effect without causing a sticky sensation on the skin, making it suitable for long-term daily use. For dry skin, which loses moisture quickly and has a dry stratum corneum, it requires a stronger ability to absorb and retain moisture. The proportion of humectants can be increased to 10% to 15%, combined with efficient ingredients such as hyaluronic acid and urea, to enhance the skin's

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moisture content. For sensitive skin and skin with damaged barriers, the principle is to be gentle and low in irritation. Humectant concentrations should be controlled between 4% and 12%. Priority should be given to using ingredients that are compatible with the skin. While providing hydration, they should also reduce irritation, helping to maintain the stability and comfort of the skin.

3. Emollients

Emollients are used to fill the gaps between keratinocytes, soften and smooth the skin. Their mechanism of action first involves barrier repair,which replenishes ceramides, cholesterol, and fatty acids to rebuild the "brick wall structure" of the stratum corneum. Then, it is about moisture retention, where humectants bind water and occlusives prevent evaporation, while emollients enhance the flexibility of the stratum corneum. Finally, they have antibacterial and anti-inflammatory effects, reducing pro-inflammatory factors in dry and irritated skin and inhibiting the growth of some pathogenic bacteria [4].

Emollients can regulate the organization of stratum corneum lipids at the molecular level, enhancing barrier function and water retention capacity by strengthening the intercellular lipid matrix [5].

In the formulation of skin care products, the proportion of emollients needs to be reasonably adjusted according to the characteristics of different skin types. The main factors to consider include the degree of skin dryness, sebum secretion, and barrier condition. For oily and acne-prone skin, the amount of emollients should not be excessive, with concentrations typically controlled between 2% and 6%. It is advisable to choose types with a light texture and good penetration properties to avoid excessive oiliness that may cause clogged pores. The key is to ensure the skin remains soft and smooth. Neutral and mixed skin types are relatively balanced, and the proportion of emollients can be moderate, ranging from 5% to 12%. This can not only improve skin roughness but also avoid a heavy feeling, providing a comfortable and natural sensation. For dry skin, due to the dryness and oil deficiency of the stratum corneum, peeling and roughness are likely to occur. The proportion of emollients can be increased to 12%–25%. By using ingredients with higher moisturizing properties, the gaps in the stratum corneum can be filled, making the skin soft and smooth. For sensitive skin and skin with damaged barriers, a gentle approach is preferred. The emollient content should be between 4% and 15%. It is advisable to choose emollients with high skin affinity and low irritation. This helps soothe the skin, alleviate dryness and tightness, and assist the skin in returning to a healthy state.

4. Occlusives

The occlusive is a moisture-retaining film on the skin surface. It is an oily and hydrophobic component that forms a continuous impermeable film that stops water from escaping the skin. Occlusive molecules self-assemble on the surface of the skin's stratum corneum through hydrophobic interactions and van der Waals forces, forming a continuous and dense hydrophobic film. This physically completely blocks the evaporation path of water through the skin, which is the core mechanism for achieving efficient water retention [6]. Among common occlusives, Vaseline has the strongest inhibitory effect on transepidermal water loss (TEWL), reducing it by 92% within 4 hours. At the same time, it can significantly increase the level of fibronectin, strengthening the skin barrier function at the molecular level [7]. The combined use of the sealant and the moisture-absorbing agent can produce a significant synergistic effect. The moisture-absorbing agent

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introduces moisture into the stratum corneum, while the sealant forms a hydrophobic film to prevent water evaporation, thus maintaining a more persistent and stable skin hydration state [8].

In the actual formulation design of skin care products, the addition ratio of the sealant needs to be adjusted based on the sebum production of the skin type and the health of the skin barrier. This is to ensure that the moisturizing effect is in harmony with the usage experience. Oily skin and acne-prone skin naturally have abundant sebum secretion, so they do not need excessive sealant components. Generally, their concentration can be controlled between 2% and 5%, and light, non-thickening raw materials such as squalane and silicone oil should be preferred to avoid clogged pores and acne.

Neutral skin and combination skin are relatively stable in their conditions. The proportion of the sealing agent can be moderately arranged between 5% and 10%. Combined with light oils and mild moisturizing ingredients, it can lock in moisture without causing a sticky sensation on the skin. Dry skin has poor self-moisturizing ability and loses moisture quickly. The proportion of the sealing agent can be increased to 10% to 25%. Using ingredients with strong sealing effects such as Vaseline and shea butter oil, a complete moisture-locking film can be formed.

For sensitive skin or skin with damaged barriers, the ratio should not be too high nor too low. Usually, it is between 3% and 12%. Choose mild and less irritating sealing ingredients to reduce water evaporation and assist the skin barrier in gradually recovering.

5. Conclusion

This research focused on the core components of moisturizers: the hygroscopic agent, the emollient, and the occlusive agent. It clarified the mechanism of action of these three components and the formulation ratios for different skin types, providing a theoretical basis for the scientific formulation design and skin type adaptation of skin care products. The hygroscopic agent combines water through hydrophilic groups and forms a gradient of water penetration for moisturizing. The emollient fills the keratin gaps and repairs the lipid structure to soften the skin. The occlusive agent physically locks in water through a hydrophobic membrane. The three components work together to raise the water level in the outermost skin layer and keep the skin barrier whole and strong， strengthen the skin's resistance to external stimuli, and protect skin health. This research provides a reference for the formulation optimization of moisturizing skin care products and the development of medical moisturizing products. It can also help the public choose moisturizing products based on their own skin types, and has practical application value for maintaining skin health.

This study also has some limitations. During the research process, no actual experiments were conducted; instead, conclusions were drawn through a literature review, which limits the study’s practicality. Moreover, this article does not cover everything. For instance, some less common ingredients in skin care products were not mentioned. This article only discusses some common ingredients. Therefore, in the next research and writing, I will be more rigorous and comprehensive.

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