IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

A Review On The Role Of Alpha Hydroxy Acids In Dermatology

[1]Atharv K. Kadam, [2]Shubham G. Bonde, [3] Sachin J. Dighade

[1]Student, [2]Assistant Professor, [3]Principal

[1]Bachelor of Pharmacy, Institute of Pharmacy and Research, Badnera, Amravati, Maharashtra, India.

[2] Department of Pharmacy, Institute of Pharmacy and Research, Badnera, Amravati, Maharashtra, India.

[3]Department of Pharmacy, Institute of Pharmacy and Research, Badnera, Amravati, Maharashtra, India.

Abstract: Alpha hydroxy acids are the organic compound which are used in dermatology for treating and enhancing the skin health and aesthetics. These acids are obtained from natural sources such as fruits and milk. Alpha hydroxic acids have clinical applications on various skin disorders such as Actinic Keratosis, Psoriasis, Scarring, Seborrheic Dermatitis, Hyperpigmentation, Razor Bumps, Eczema, Stretch Marks, Calluses etc. There toxicological concerns are concentration and exposure related. Alpha hydroxy acids have great potential to improve it's scope in medical field.

Keywords: Alpha hydroxy acid, Dermatology, Citric Acids, Chemical Peels

I. INTRODUCTION

Alpha hydroxy acids (AHAs) are organic acids marked by the presence of a hydroxyl group at the alpha position of the acid. Due to such structural characteristics, AHAs are highly proficient in exfoliation by facilitating the removal of dead skin from the surface of the skin. As a therapeutic natural agent, AHA is often used in cosmetology, dermatology and usually for skin enhancement, wrinkle reduction and acne treatment. They are naturally found in many plant sources such as fruits, sugarcane or milk [1].

A study conducted by Van Scott and Yu in 1974, they concluded that AHAs have beneficial effects on certain disorders related to the process known as keratinization or cornification processes. Keratinization is a type of cell differentiation whereby keratinocytes, which are specialized cells of the skin's epidermis, advance from the post-germative stage to a fully mature cell type. The fully matured keratinocytes which undergo this process become flattened and hardened enveloped with a protein called keratin that has a structural function. This process mounts a new skin that is not only different in structure but also in function thereby contributing to the barrier function and the integrity of the skin. It has been noted that AHAs extend this action by enhancing exfoliation and these conditions of microenvironmental abnormalities create excessive keratinization resulting in skin diseases, including ichthyosis, psoriasis, and some hyperkeratotic conditions, improving the conditions where abnormal keratinization occurs [2]. The findings increased the awareness of the use of AHAs in dermatological therapies focusing on hyperkeratosis and keratinocytic

turnover related dermatological problems [3]. AHAs are widely used in dermatology due to their effective exfoliating properties, which pose minimal risk of irritation or adverse effects. AHAs work by breaking the bonds between dead skin cells, resulting promotion of removal of the outer skin layer and leading to a smoother. This mechanism has made AHA peels a favored and effective treatment option in dermatological practices for recent years. AHAs can be utilized in both superficial and medium-depth peels, with the selection based on the concentration and desired outcomes. Superficial peels target the outermost layers of the skin, while medium-depth peels penetrate deeper, offering more substantial improvements for specific skin concerns [4]. Alpha hydroxy acids (AHAs) have been shown to inhibit the development of UV-induced skin tumors by facilitating the removal of damaged skin cells and encouraging skin regeneration, as supported by research that underscores their protective properties against carcinogenesis [5]. AHAs may contribute to antioxidant functions by neutralizing free radicals and alleviating oxidative stress within the skin, thereby enhancing skin health and offering protection against aging and environmental harm [6].

II. MECHANISM OF ACTION

Alpha hydroxy acids are recognized for their ability to improve skin hydration and firmness by increasing the skin's capacity to retain water. They facilitate this process by encouraging the removal of dead skin cells from the surface, thereby uncovering newer, more hydrated layers underneath. AHAs enhance the skin's natural moisture retention by stimulating the production of hyaluronic acid and promoting collagen synthesis. The outcome is skin that appears smoother, fuller, and more elastic, which diminishes the visibility of fine lines and enhances overall texture [2]. AHAs enhance normalization of epidermal differentiation by disrupting intercellular ionic bonds, which reduces corneocytes cohesion and promotes keratolysis [3]. These effects are helpful for treating acne and performing peelings. The rate of keratolysis is influenced by the acid concentration and pH of the product. With higher concentrations and lower pH leading to fast keratolysis and epidermolysis. As well as, AHAs facilitate changes in the dermis that may take several months to be noticeable, owing to their gradual and cumulative impact on the skin. The AHAs function by gently exfoliating the skin, eliminating dead cells from the surface, which can lead to improved texture and clarity over time. In vitro research has indicated that AHAs promote increased cell proliferation, aiding in skin renewal, and boost collagen production, which is essential for preserving skin firmness and elasticity [7] , such as enhanced glycosaminoglycan synthesis, dermal thickness, fibroblast proliferation, and factor XIII a transglutaminase induction [8]. Mechanism proposed by Wang, the topically application AHAs works on the chelation characteristics of AHAs. The calcium ions are essential for cutaneous cellular adhesions. According to Wang's idea, AHAs chelate calcium ions from cell adhesions and lower the concentration of calcium ions in the epidermis of the skin. Calcium ions will reduce as a result of this mechanism from the cadherins in the adherens junctions and desmosomes. Cellular adhesions are broken and exfoliation occurs when Ca levels are lowered. Wang also stated that care should be taken while application because the reduction of Ca ions in the epidermis also tends to encourage cell growth, cell proliferation and to delay cell differentiation [8]. Using both in vitro and ex vivo (human skin,biopsies) techniques, Okano et al. studied the impact of GA on the dermal matrix metabolism of keratinocytes and

fibroblasts. That study demonstrated that GA controls matrix disintegration and collagen synthesis through keratinocytes-released cytokines in addition to directly speeding up collagen synthesis by fibroblasts. Their research shown that, upon treatment with GA, keratinocytes release IL-1a, which is one of the main mediators controlling matrix disintegration. Depending on the type of skin cell involved, glycolic acid may aid in the repair of photodamaged skin via a variety of mechanisms. Bernstein et al. studied the effects of GA on the production of hyaluronic acid in the dermal and epidermal layers as well as the induction of collagen gene expression in an additional attempt to understand the mechanism underlying HA's ability to improve photoaged skin. They examined collagen gene expression from skin biopsy samples and hyaluronic acid immunohistochemistry staining from glycolic acid and vehicle-treated skin. For three months, sun-damaged forearm skin was treated twice daily with 20% glycolic acid lotion or a lotion vehicle control (oil in water; pH 3.9). It was discovered that this treatment enhanced the amounts of hyaluronic acid in the epidermis and dermis, as well as the expression of the collagen gene. Skin appearance, texture, and function can all be impacted by even slight increases in the amount of cutaneous hyaluronic acid. These changes can also have a significant impact on epidermal and dermal hydration [7].

The effectiveness of AHAs

AHAs are found throughout nature in sugarcane (glycolic acids), sour milk (lactic acid), and fruits (citric acid and malic acid). AHAs used in dermatologic and cosmetic products are usually synthetically produced. Vorarat et al. and Parker et al. have reported that AHAs can be detached in complex mixtures from fruits by using the capillary electrophoresis and UV detection at 200 nm [2]. As a result, obtaining signal and determining compound purity is achievable. AHAs are polar chemical compounds which disturb the cohesive forces of corneocytes of the skin barriers [9]. According to many studies, effectiveness of AHAs is dependent on pH, concentration, and exposure time . AHAs are used for removing and dissolving dead skin cells, they are commonly included as active ingredients in a wide range of cleansing solutions. AHAs are used to promote hair texture and scalp health in hair care formulations including shampoos and conditioners. These solutions are designed to be quickly washed off the skin and hair, guaranteeing a quick but efficient application without prolonged exposure. In addition to offering benefits including smoother hair, enhanced scalp hydration, and improved product absorption, the short contact duration reduces the risk of discomfort.AHAs are used at significantly higher concentrations in more sophisticated treatments, like as chemical peels, in order to reach deeper skin layers. Chemical peels require several sessions spread out over a maximum of six months, with precisely regulated exposure durations and concentrations (e.g., 35% for four minutes, 52.5% for three minutes, and 70% for two minutes). AHAs can effectively address several skin concerns, including hyperpigmentation, fine wrinkles, and acne scars, by stimulating collagen production and performing deep exfoliation at elevated concentrations and prolonged exposure durations. AHAs can be applied gently and quickly with shampoos and conditioners, while chemical peels offer a more concentrated and powerful approach to skin renewal [10]. The preceding research provides evidence that the effectiveness of AHAs is dependent on exposure time.

III. PHARMACEUTICAL FORMULATIONS

Over the previous fifteen years, there has been a notable increase in the use of AHAs in cosmetic formulations. AHAs-containing topical preparation demands careful consideration of several factors that have impact on the product's tolerability and efficacy. The formulation's pH is one of these chief variables. Although the precise pH range has not been determined, it is generally accepted that AHAs work best at a lower pH range, usually between 3 and 5 [11].The size and solubility of the AHA are two important considerations when choosing one for use in a formulation. The deeper skin penetration of small molecule AHAs, such lactic and glycolic acid is one of its advantages. They can therefore treat acne, wrinkles, and fine lines more successfully. Larger molecules, such as tartaric acid and mandelic acid, on the other hand, are more suited for those with sensitive skin because they are less likely to irritate or sensitivity the skin [11].

It has been demonstrated that lipophilic (oil-soluble) AHAs, such as mandelic acid, permeate the skin more readily than hydrophilic (water-soluble) AHAs, such as lactic acid, in addition to molecule size they are more successful in treating hyperpigmentation and acne due to this characteristic. When formulating using AHAs, the chemical structure of the selected AHA is a crucial consideration. Glycolic acid comes in a variety of salt forms, each having distinct properties, and can be obtained from both natural and artificial sources [8]. Selecting the ideal AHA concentration requires careful consideration of all factors. Stronger exfoliation and therapeutic effects can be obtained at higher concentrations, especially for more severe skin problems. They are better suited for professional use under the guidance of dermatologists or skincare specialists because they do, carry a higher risk of skin irritation. Conversely, most people can handle lower concentrations, which are often found in over-the-counter skincare treatments. These concentrations improve skin tone and texture by offering therapeutic effects and a gentler exfoliation. Glycolic acid polymers are bigger molecules that are better suited for usage in leave-on products like creams and lotions, whereas sodium glycolate, a water-soluble salt of glycolic acid, is frequently used in cleansers and toners [12].

In facial cleanser, exfoliant, moisturizer, and anti-aging product compositions, glycolic and lactic acids are present. Formulations that have the potential to be breathed contain certain AHAs. For example, it is reported that lactic acid is found in formulations for hair spray propellant aerosol at a concentration of 0.0002% and in formulations for tonic, dressing, and other hair grooming aids pump spray at a concentration of 5.8%. Glycolic acid, on the other hand, is used in aerosol and pump hair sprays at concentrations of 0.0005% and 0.05%, respectively. Gel formulas are frequently preferred because of their quick absorption and light texture, which makes them ideal for skin types that are prone to oiliness or acne. For people with dry or sensitive skin, creams or lotions may be recommended due to their hydrating qualities. With their greater emollient texture and higher lipid content, creams offer better barrier protection and moisturization. Because it replenishes moisture and restores the skin's natural lipid barrier, this formulation type is advantageous for people with dry or dehydrated skin. Those who want a more fluid feel

might choose lotions, which are lighter than creams and provide a balance between hydration and lightness [12].

IV. CLINICAL APPLICATION

Alpha Hydroxy acids are a class of chemical compounds that have been utilized extensively in dermatology because of their capacity to improve the texture and look of the skin as well as their exfoliating qualities. AHAs are naturally occurring substances found in fruits, milk, and other foods. They include glycolic acid, lactic acid, citric acid, and others. They have well-established clinical uses in treating skin diseases.

Actinic Keratosis is skin tumors that mostly affect sun-exposed skin areas and have chromosomal abnormalities. Premalignant lesions are typically the result of prolonged exposure to sunlight; however they can also be brought on by x-rays, exposure to polycyclic aromatic hydrocarbons, and artificial UV light exposure. Actinic Keratoses can be little papules or big plaques, ranging in size from 1 to 2 mm. Their skin normally has a hyperkeratotic surface and they can be flesh colored, erythematous, or more deeply pigmented in spots. Anyplace can experience the creation of horns. The majority of squamous cell carcinomas and actinic keratoses have no symptoms. Actinic Keratosis that progresses to squamous cell carcinoma has the potential to rupture, bleed, infect, demolish anatomical structures, and even spread to internal organs [13]. AHAs, especially glycolic acid, are used in conjunction with other therapies to enhance the texture of the skin and lessen the thickness of these lesions. Even though AHAs alone might not be able to completely eradicate the lesions, they do improve how well other topical treatments like 5-fluorouracil work [2].

Psoriasis is a inflammatory skin disease caused by the immune system that is linked to a number of morbidities, including psoriatic arthropathy, psychiatric, cardiovascular, and hepatic disorders. The World Health Organization acknowledged psoriasis as a severe non-communicable disease in 2014 and emphasized the distress caused by incorrect diagnoses, insufficient treatment, and the condition's stigmatization [14]. Topical therapies for mild to moderate psoriasis involve the use of AHAs, particularly lactic acid and glycolic acid. By encouraging the removal of extra keratin from thicker plaques, these acids aid in the reduction of scaling. Emollients and AHAs work together to strengthen the skin's barrier and reduce flaking and irritation. They are very helpful on the scalp and elbows, two places where psoriasis causes significant scaling [2].

Chemical Peels for Scarring: Chemical peels that penetrate deeper have also been utilized for the Chemical peels applied superficially are regarded as supplemental therapies for acne. Frequently, they are combined with first-line treatments including systemic or topical antibiotics and retinoids. Because of the rapid reduction in the number of lesions and the enhancement of the overall texture of the skin, their inclusion in the regimen is recommended. Acne scars have also been treated with chemical peels that have a deeper penetration, either by themselves or in conjunction with other resurfacing techniques .Peels with glycolic acid are used to treat mild to moderate acne scarring by promoting cell turnover and exfoliation. By

encouraging the creation of collagen in the dermis over several sessions, these peels help lessen the depth and look of scars, especially shallow atrophic scars [15,2].

Seborrheic Dermatitis: Seborrheic dermatitis is a recurrent, chronic cutaneous illness characterized by erythema and flaking, which can occasionally manifest as macules or plaques with moist, oily, or dry white scales. It frequently happens in adult areas where sebaceous gland concentrations are significant. The most typically affected locations are the face and scalp, and numerous sites are commonly involved. It is believed that dandruff is a mild, non-inflammatory kind of seborrheic dermatitis. People with Parkinson's disease or human immunodeficiency virus infection have a higher risk of developing seborrheic dermatitis [16]. Glycolic acid and lactic acid are two examples of AHAs that are occasionally used to eliminate scales and enhance skin texture. By lessening the thickness of the stratum corneum, they can alleviate symptoms and improve the way that other topical medications like steroids or antifungals are absorbed [2].

Skin Brightening and Hyperpigmentation Disorders: Hyperpigmentation can show more diffusely or locally, as in the cases of melasma or post-inflammatory hyperpigmentation. Diffuse hyperpigmentation is commonly linked to autoimmune or viral etiologies, specific medicines, malignancies, and metabolic reasons. AHAs are used to treat melasma as well as other hyperpigmentation conditions such as freckles, lentigines and post-inflammatory hyperpigmentation. AHAs help lighten pigmented spots and balance out skin tone by encouraging cell turnover and exfoliating the outermost layers of skin. When combined, they also increase the effectiveness of depigmenting medications like retinoids or hydroquinone. To treat hyperpigmentation Alpha Hydroxy acids (glycolic acid) are given in combination with salicylic acid improve the efficiency. Glycolic acid is provided second line therapy for hyperpigmentation [11, 2].

Laser and Cosmetic Procedures on the Skin: Dermatologists frequently advise using Alpha Hydroxy Acids prior to more invasive procedures such as microneedling, laser resurfacing, and microdermabrasion . By thinning the stratum corneum, or outer skin layer, before to treatment with alpha hydroxy acids , the skin will respond better to these therapies and the outcomes will be more consistent. AHAs additionally aid in improving the absorption of other medications administered post-procedure [2].

Management of Razor Bumps: The chronic inflammatory disease known as Pseudocolliculitis barbae is characterized by skin-colored to erythematous pustules and follicular or perifollicular papules that mostly affect the neck and beard region. Patient populations with skin of color are primarily affected by PFB.PFB primarily affects post pubertal males and females, with the greatest incidence in males between the ages of 14 and 25. Although those with idiopathic hirsutism may experience symptoms earlier, women are usually impacted during the premenopausal period because to changes in hormone levels that might stimulate hair growth in the beard area. Because of the increased frequency of hair removal, women with hirsutism or hypertrichosis may be affected by PFB at a rate comparable to that of men **[**17**]**. Glycolic acid is useful in treating this illness. By preventing the accumulation of dead skin cells around hair follicles, regular application of glycolic acid to afflicted regions helps lessen ingrown hairs and the irritation they cause.

Additionally, it lessens scarring and hyperpigmentation brought on by ingrown hair-related chronic inflammation [8].

Management of Eczema: The most prevalent type of dermatitis is eczema, often known as atopic dermatitis. It is believed that a variety of variables, including hereditary and environmental ones, contribute to the etiology of eczema. Although adults can also experience it, children experience it more frequently. Eczema sufferers typically have dry, itchy skin that is prone to infection. The ailment is widely recognized as the "itch that rashes" since itchy, dry skin causes a rash when it is scratched or rubbed **[**18**].**The skin barrier is frequently damaged in atopic dermatitis patients, which causes dryness and irritation. Moisturizers contain AHAs, especially lactic acid, to increase moisture content. In addition to its exfoliating properties, lactic acid draws moisture into the skin by acting as a humectants. It lessens dryness, scaling, The skin barrier is frequently damaged in atopic dermatitis patients, which causes dryness and irritation. Moisturizers contain AHAs, especially lactic acid, to increase moisture content. In addition to its exfoliating properties, lactic acid draws moisture into the skin by acting as a humectants. It lessens dryness, scaling, and irritation while assisting in the restoration of the skin [2].

Treatment of Stretch Marks: Stretch marks, also called striae distensae are lengthy scars caused by epidermal atrophy, a thinning of the skin beneath the surface. They are the outcome of both the skin's capacity for stretching and the degree of stretch applied to skin that has been continuously stretched. Therefore, people who are pregnant undergo rapid weight loss, or lift heavy objects are more likely to get stretch marks. Although the condition's incidence varies with age, race, and other characteristics, it can reach up to 90% in pregnant women and 83% in growing teenagers. Excessive use of topical steroids or Cushing's illness are two other disorders linked to stretch marks. Alpha-hydroxy acids like glycolic acid , lactic acid and citric acids have been shown to promote collagen synthesis and fibroblast proliferation [19]**.** Secretion of collagen, which increases the thickness and flexibility of skin. Over time, this can help lessen the visibility of stretch marks, both fresh and old. The properties of lactic acid are moisturizing. They add moisture to the skin, promoting better skin health and possibly reducing the visibility of stretch marks. AHAs can lessen their appearance, particularly if applied before the striae start to form [2].

Treatment of Calluses and Corns: Calluses Corn is a form of callosity that is also referred to as a clavus, heloma, or focal intractable plantar hyperkeratosis. Corns are painful, thickened skin lesions caused by pressure or friction-induced repetitive mechanical stress. In the literature, many forms of hyperkeratotic skin lesions are frequently referred to by unclear names. However, a callus is a more diffuse form of callosity, and physicians must differentiate between a corn and a callus. A corn, then, is a well defined focal region of hyperkeratosis. This syndrome is frequently observed in athletes as well as individuals who have been subjected to uneven friction force due to footwear or issues with their gait, such as amputees, elderly patients, and patients with diabetes. It is better to think of it as a symptom than a serious illness [20]**.** AHAs work well to cure thickened skin that develops from friction or pressure, such as calluses and corns. By dissolving the keratin links in the skin's outer layers, lactic and glycolic acids soften these regions and make

it simpler to remove dead skin. These AHAs are commonly found in over-the-counter lotions that are used to treat hyperkeratotic diseases. They lessen calluse thickness and increase comfort [2].

V. TOXICOLOGY

Alpha Hydroxy acid (AHA) topical formulations have a safety profile that must be understood in order to guarantee the topical formulations' effectiveness and well-tolerated use in the dermatological area. AHAs have exfoliating qualities that can result in some adverse effects, while being widely accepted as safe. Importantly, typical adverse responses include redness, stinging, or burning sensations on the skin, as well as moderate skin irritation. But these adverse effects are usually just temporary, and they usually go away when AHAs are used consistently, their concentration is changed, or their application frequency is increased. It is critical to comprehend the underlying mechanisms causing the negative effects of AHAs that have been observed. AHAs, including lactic acid, citric acid, and glycolic acid, can cause the stratum corneum to exfoliate under control. Dead skin cells are encouraged to be removed by this exfoliating method, leaving the skin's texture smoother and more uniform. But this exfoliation can also cause slight skin irritation, which shows up as redness and burning or stinging when applied. It is believed that these reactions result from a breakdown in the skin barrier, which increases transepidermal water loss and heightens sensitivity. Apart from their possible irritant properties, AHAs have demonstrated the ability to heighten the skin's susceptibility to ultraviolet radiation, thereby elevating the likelihood of sunburn and UV-induced harm. Their primary cause for this is their exfoliating qualities, which cause the stratum corneum to weaken and lose its natural ability to act as a shield against UV rays. As a result, the skin is more vulnerable to sunburn and UV-induced damage, which can cause premature aging and raise the chance of developing skin cancer [21].

VI. Research and Developments

AHA-containing topical preparations have demonstrated exceptional effectiveness in treating a range of skin problems. Ongoing research should concentrate on creating novel delivery vehicles, like liposomes or nanoparticles, to improve the penetration and stability of these substances in order to further develop the field of AHAs in cosmetics. There are a number of benefits to encapsulating AHAs in liposomes or nanoparticles, which can maximize their therapeutic efficacy. First of all, these delivery technologies allow for controlled release, which makes it possible to supply AHAs to the skin compounds gradually and continuously. Because of their controlled release mechanism, AHAs have a longer duration of action, which increases their efficacy in treating particular skin issues. Furthermore, the stability of AHAs can be increased by using liposomes or nanoparticles as carriers, which will stop them from degrading and lengthen their shelf life. The active components are protected from external elements like light and air exposure by the protective environment created by the encapsulation of AHAs within these nanocarriers. As a result, AHAs are delivered more consistently and reliably, guaranteeing their maximum effectiveness as treatment [2]. Further study of the synergistic effects of AHAs with other active substances holds enormous potential for breakthroughs in skincare, in addition to improving the delivery and stability of AHAs. AHAs and

complimentary agents, such retinoids, have demonstrated substantial promise in treating a variety of skin issues, such as acne and photoaging. These combination therapies can provide more complete and improved effects than single treatments by addressing several pathways related to skin aging. Further interesting research avenues include examining the integration of AHAs with developing technologies such as laser treatment and microneedling .

Future Prospects

Future of topical AHA treatments, ongoing research is needed to understand the role of AHAs in specific skin issues, optimize formulations, investigate combination therapies, and adopt tailored approaches. The effectiveness, tolerability, and individualization of AHA treatments will be improved through developments in delivery systems, combination therapies, and tailored approaches, which will help people who want to improve the health and beauty of their skin. There is currently a sizable body of research and notable literature on the anti-inflammatory and photoprotective properties of AHAs. Nevertheless, the quantity of these substances that penetrate the layers of living skin determines the photoprotective activity. Chemicals can move across the skin's cell membrane via receptors, diffusion, and channels [12].

VII. CONCLUSION

Alpha hydroxy acids (AHAs) exhibit benefits in dermatological applications, particularly in skin rejuvenation and enhancement of appearance. Research substantiates their efficacy in improving skin texture and stimulating collagen synthesis when utilized at suitable concentrations. The prolonged exposure or elevated concentrations may heighten skin sensitivity, especially to ultraviolet radiation, underscoring the necessity for meticulous formulation and application guidelines. The long-term safety of AHAs, particularly in combination with other active ingredients, maximizes their therapeutic advantages while minimizing potential adverse effects.Due to their exfoliating characteristics, AHAs are helpful in regulating both epidermal and dermal functions, rendering them effective in addressing skin condition such as hyperpigmentation, acne, and photoaging. Their capacity to improve the absorption of other topical treatments further extends their applicability in both cosmetic and therapeutic skincare routines. Future research should concentrate on refining AHA formulations to achieve a balance between effectiveness and reduced irritation, as well as investigating innovative delivery systems that enhance stability and reduce adverse reactions. Additionally, exploring the synergistic effects of AHAs when paired with other active compounds, such as beta hydroxy acids or retinoids, could further enhance their effectiveness. The AHA market is witnessing significant growth, propelled by heightened consumer awareness regarding dermatological issues and an increasing demand for effective anti-aging and exfoliating products.

VIII. REFERENCES

[1] Babilas, P., Knie, U., & Abels, C. (2012). Cosmetic and dermatologic use of alpha hydroxy acids. Journal der Deutschen Dermatologischen Gesellschaft, 10(7), 488-491.

[2] Tang, S.C. and Yang, J.H., 2018. Dual effects of alpha-hydroxy acids on the skin. Molecules, 23(4), p.863.

[3] Shetty, S., & Gokul, S. (2012). Keratinization and its disorders. Oman Medical Journal, 27(5), 348-357.

[4] National Toxicology Program. Photocarcinogenesis study of glycolic acid and salicylic acid (CAS Nos. 79-14-1 and 69-72-7) in SKH-1 mice (simulated solar light and topical application study). Natl Toxicol Program Tech Rep Ser. 2007;(524):1-242. PMID: 21921960.

[5] Morreale, M.; Livrea, M.A. Synergistic effect of glycolic acid on the antioxidant activity of alpha-tocopherol and melatonin in lipid bilayers and in human skin homogenates. Biochem. Mol. Biol. Int. 1997, 42, 1093–1102.

[6] Rendl M, Mayer C, Weninger W, Tschachler E. Topically applied lactic acid increases spontaneous secretion of vascular endothelial growth factor by human reconstructed epidermis. Br J Dermatol. 2001;145(1):3–9.

[7] Hessel AB, Cruz-Ramon JC, Klinger DM, Lin AN. 51 - Agents used for treatment of hyperkeratosis. In: Wolverton SE, ed. Comprehensive Dermatologic Drug Therapy. 3rd ed. W.B. Saunders; 2013:595-603

[8] Kornhauser, A., Coelho, S.G., & Hearing, V.J., 2010. Applications of hydroxy acids: classification, mechanisms, and photoactivity. Clinical, Cosmetic and Investigational Dermatology, 3, pp.135–142.

[9] Van Scott, E.J. and Yu, R.J. (1989) 'Alpha hydroxy acids: procedures for use in clinical practice', Cutis, 43(3), pp. 222–228. PMID: 2523288.

[10] Gupta, R.R., Mahajan, B.B. & Garg, G. (2001) 'Chemical peeling - Evaluation of glycolic acid in varying concentrations and time intervals', Indian Journal of Dermatology, Venereology, and Leprology, 67, pp. 28–29.

[11] Almeman, A.A., 2024. Evaluating the efficacy and safety of alpha-hydroxy acids in dermatological practice, 17, pp.1661-1685.

[12] Karwal, K. and Mukovozov, I., 2023. Topical AHA in dermatology: formulations, mechanisms of action, efficacy, and future perspectives. Cosmetics, 10(5), p.131.

[13] Reinehr, C.P.H. & Bakos, R.M., 2019. Actinic keratoses: review of clinical, dermoscopic, and therapeutic aspects. An Bras Dermatol, 94(6), pp.637–657.

[14] Leyden, J.J., Del Rosso, J.Q. & Webster, G.F. (2009) 'Clinical considerations in the treatment of acne vulgaris and other inflammatory skin disorders: a status report', Dermatologic Clinics, 27(1), pp. 1–15. doi: 10.1016/j.det.2008.07.008.

[15] Ravikumar, B., R, I. & Pillai, D., 2022. Efficacy of Alpha and Beta Hydroxy Acid Chemical Peels in Postacne Pigmentation: A Double Blinded, Randomized, Controlled Trial. Journal of Clinical and Aesthetic Dermatology, 15(1), pp.48–52.

[16] Gary, G. (2013) 'Optimizing treatment approaches in seborrheic dermatitis', Journal of Clinical and Aesthetic Dermatology, 6(2), pp. 44–49.

[17] Ogunbiyi, A. (2019) 'Pseudofolliculitis barbae: current treatment options', Clinical, Cosmetic and Investigational Dermatology, 12, pp. 241–247.

[18] Pavel, P., Blunder, S., Moosbrugger-Martinz, V., Elias, P.M., & Dubrac, S. (2022) 'Atopic Dermatitis: The Fate of the Fat', International Journal of Molecular Sciences, 23(4), p. 2121.

[19] Tran, D., Townley, J.P., Barnes, T.M., & Greive, K.A. (2014) 'An antiaging skin care system containing alpha hydroxy acids and vitamins improves the biomechanical parameters of facial skin', Clinical, Cosmetic and Investigational Dermatology, 8, pp. 9–17.

[20] Singh, D., Bentley, G. & Trevino, S., 1996. Callosities, corns, and calluses. BMJ (Clinical Research Edition), 312, pp.1403-1406.

[21] Barote, A.F.C., Genelsa, E.H., Alaba, F.B.J., Encendencia, H.M.U., Sumampong, M.M.Q. and Faller, E.M., June 2002. Potential toxicity of alpha and beta hydroxy acids in cosmetic products: A review. International Journal of Research Publication and Reviews, 665-672.