Revolutionizing Skincare: Dissociated Electrolysis and Hydroxy Carrier Solution Fusion for Hydrogen-Rich Liquid

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Abstract

This research introduces a revolutionary skincare solution by synergizing Dissociated Electrolysis Technology (DSET) with a specialized hydroxy (OH) Carrier Solution, resulting in the creation of Hydrogen-Rich Liquid (HRL). Through a meticulous process of extracting pure hydrogen from water and blending it with the OH Carrier Solution, a highly concentrated, pure, and stable hydrogen molecular liquid is achieved. This slow-releasing HRL proves to be exceptionally effective in skincare applications, demonstrating notable improvements in allergic skin conditions and atopic dermatitis. Our findings reveal a remarkable mean increase of 18.6% in skin tone brightness and a notable mean decrease of 28.4% in red spot count by day 7. The innovation offers a novel approach to skincare, harnessing the benefits of high hydrogen concentration for enhanced skin health and well-being.

Keywords: Hydrogen, Skin Care, Chronic Dermatitis, Acute Dermatitis

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改革護膚：分離電解和羥基載體溶液融合生成富氫液

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摘要

本研究介紹了一種革命性的護膚解決方案，透過將分離電解技術（Dissociated Electrolysis Technology，DSET）與專用羥基(OH) 載體溶液協同作用，創造了富氫液（Hydrogen-Rich Liquid，HRL）。藉由從水中提取純氫並將其與 OH 載體溶液混合，實現了高濃度、純淨且穩定的氫分子液體。這種緩慢釋放的 HRL 在護膚應用中表現出色，顯著改善了過敏性皮膚病和特應性皮炎等狀況。根據實驗結果顯示，使用 HRL 後的第七天，膚色亮度平均提升了 18%，而紅斑指數平均減少了 28%。這一創新為護膚提供了一種新穎的方法，充分利用高氫濃度的好處，提升皮膚健康和福祉。

關鍵字：氫、護膚、慢性皮膚炎症、急性皮膚炎症

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1. Introduction

In recent years, the skincare industry has undergone a transformative evolution with the integration of advanced technologies, giving rise to innovative solutions that transcend traditional approaches [1]. This research focuses on a groundbreaking skincare application that combines pure hydrogen extraction techniques with a specially formulated OH liquid, resulting in a versatile substance applicable not only in daily drinkable water but also in skincare [2]. Amid this progress, it is crucial to acknowledge past research on hydrogen and its diverse applications. Studies have revealed the potential benefits of hydrogen in mitigating oxidative stress, inflammation, and promoting overall skin health. The integration of hydrogen into skincare formulations has been explored for its antioxidant properties, suggesting promising outcomes for various skin conditions.

One of the key innovations lies in addressing the potential health risks associated with traditional hydrogen water machines that submerge the electrolytic module directly into the drinking water tank [3]. This research implements a separation strategy by distinctively isolating the electrolysis tank from the drinking water tank. This not only ensures the prevention of impurities, toxic substances, or heavy metals from contaminating the drinking water but also mitigates potential health hazards [4]. Furthermore, the technology employs a three-way pipeline system to collect pure hydrogen gas after electrolysis, which is then precisely mixed with the drinking water, ensuring the production of a highly pure hydrogen-rich liquid.

In addition to resolving contamination concerns, this research addresses the shortcomings of commercially available hydrogen water machines in terms of quantitatively producing hydrogen and establishing detection points for purity and volume confirmation. By adopting a constant current power supply mode, the technology maintains a consistent hydrogen production rate over time, preventing reductions in electrolysis current due to module aging [5]. Moreover, the hydrogen and oxygen separation method allow for the setting of detection points at the hydrogen production outlet, enabling precise measurement of volume and purity, thus ensuring quality control in mass production and regular maintenance [6]. This transformative approach positions the technology as a reliable and quantifiable solution in the burgeoning landscape of hydrogen skincare applications.

2. Research Purpose

In the expansive realm of skincare applications, various hydrogen extraction methods coexist, ranging from traditional techniques to cutting-edge technologies [7]. Traditional approaches, exemplified by direct electrolysis in general water, have been widely employed but are burdened with inherent drawbacks. The electrolysis process in water yields hydrogen with a modest purity of 70-80% [8], coupled with suboptimal efficiency, especially at low current density. This method introduces residues such as chlorine, hypochlorous acid, and ozone, raising concerns about potential health implications. Furthermore, the safety measures associated with these traditional methods are notably low, prompting a crucial shift toward advanced and secure technologies [9].

Another method, the chemical (Magnesium) approach, relies on the reaction between magnesium and water for hydrogen production [10]. While achieving a higher purity level ranging from 92-98%, this method encounters challenges due to an uneven reaction rate, generating residues like Magnesium Hydroxide. Safety measures associated with this method are only common, emphasizing the imperative need for advancements prioritizing efficiency, purity, and safety concurrently.

Addressing these challenges, our conceptual solution to the problem of producing high-purity hydrogen involves overcoming the difficulty of effectively storing hydrogen gas due to its small molecular weight. We propose a carrier that can attract hydrogen gas effectively, allowing it to stay for a short period before slowly releasing it through the OH carrier. This approach enables practical applications in skincare treatments, ensuring the hydrogen's optimal utilization. Importantly, this solution prevents direct use of the carrier solution when combined with hydrogen, as it could hinder hydrogen activity. These considerations pave the way for a transformative force in hydrogen-rich solutions for skincare and health, particularly in the innovative context of Dissociated Electrolysis Technology (DSET) and its exceptional purity, efficiency, and safety measures [11].

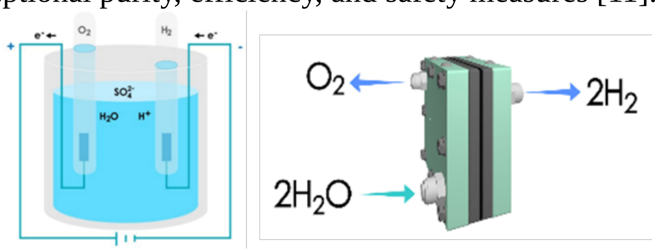


Figure 1. The left image illustrates the traditional direct electrolysis method, while the right image depicts a schematic diagram of the internal structure of DSET PET. The traditional schematic diagram precedes the introduction of the traditional electrolysis method.

3. Research Method

3.1. Designing the Technical Structure of Indirect Electrolysis

In designing the technical structure for indirect electrolysis, the process is meticulously crafted to optimize hydrogen extraction and produce a highly pure and stable hydrogen-rich liquid. Central to this approach is the deliberate separation of the electrolysis tank from the drinking water tank, a foundational step aimed at preventing impurities, toxic substances, or heavy metals from compromising the quality of the resulting solution. Integration of a three-way pipeline system serves as a dedicated conduit, ensuring the collection of pure hydrogen gas after the electrolysis process. This separated hydrogen is then intricately introduced into the drinking water tank, facilitating precise mixing with water. The strategic design not only minimizes contamination risks but also enhances the overall efficiency of hydrogen production.

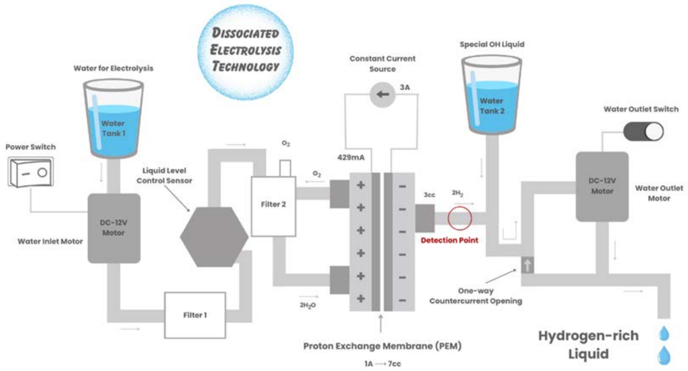


Figure 2. Conceptual diagram of indirect electrolysis and hydrogen mixing to create Hydrogen-rich liquid.

3.2. Preparation of the Composite Polymer Double Network Cross-Linked OH Carrier Solution

The OH Carrier Solution is crafted by blending natural polymer γ-Polyglutamic Acid (0.5%) and synthetic polymer Carbomer (0.1%) with EDTA-2Na (0.1%), Pentylene Glycol (3.5%), and pure water (95.8%). This blending process induces a double network cross-linking within the composite polymer. Subsequently, the OH Carrier Solution undergoes a high-pressure infusion of pure hydrogen molecules, resulting in the production of a hydrogen-rich aqueous solution.

The collaboration between natural and synthetic polymers generates a unique double-network cross-linked polymer composite with integrated characteristics. γ-Polyglutamic Acid, a natural polymer, showcases excellent hydrophilicity and an affinity for hydrogen molecules through its carboxyl group functional groups. Zanuy's research demonstrates that at pH 2.0, γ-Polyglutamic Acid assumes an undissociated α-helical free acid structure, transitioning to a linear polyanionic form as pH increases, eventually forming a 100% linear random coiled structure with strong hydrophilic properties beyond pH 5.5. This dynamic structure creates an intricate lattice-like internal network.

The inclusion of synthetic polymer Carbomer enhances the coating properties of the natural biopolymer, forming an outer network structure, as depicted in the accompanying figure. This novel OH Carrier Solution with double-grid cross-linked polymer composite efficiently encapsulates molecular hydrogen (H_2), facilitating its long-term and sustained release for optimized applications.

3.3. Human Trial Protocol for Assessing Hydrogen-Rich Liquid Effects on Skin

The experiment utilizes the VISIA imaging system to accurately measure skin color and the presence of red spots before and after the application of the Hydrogen-Rich Liquid. The research protocol is designed to span a duration of 7 days, allowing for comprehensive evaluation of Hydrogen-Rich Liquid's immediate effects on skin health. The experimental method involves recruiting a cohort of participants with varying degrees of skin tone unevenness and inflammation, including those diagnosed with rosacea. Baseline measurements of skin tone and the severity of red spots will be obtained using the VISIA imaging system prior to the commencement of the study. Participants will then be instructed to apply Hydrogen-Rich Liquid to their facial skin twice daily for the duration of 7 days, maintaining a consistent regimen.

Participants are provided with Hydrogen-Rich Liquid and instructed on its proper application technique. The formulated liquid is to be applied evenly to the entire face, avoiding contact with the eyes, twice daily-once in the morning and once in the evening. Measurements using the VISIA imaging system are scheduled at two intervals: day 0 (baseline), and day 7. During each visit, participants' skin is thoroughly analyzed using VISIA to assess changes in skin tone brightness and the presence of red spots. Additionally, participants are encouraged to report any subjective improvements or adverse reactions experienced during the study period.

A total of 32 participants are recruited for the study, with 21 participants included in the final data analysis. The data collected from instrumental analyses and human trials were subjected to comprehensive statistical analysis. This included comparing pre- and post-treatment measurements within the same participant group, as well as between the hydrogen-rich liquid-treated group and control groups. Statistical methods such as t-tests and ANOVA were utilized to determine the significance of any observed changes in skin parameters.

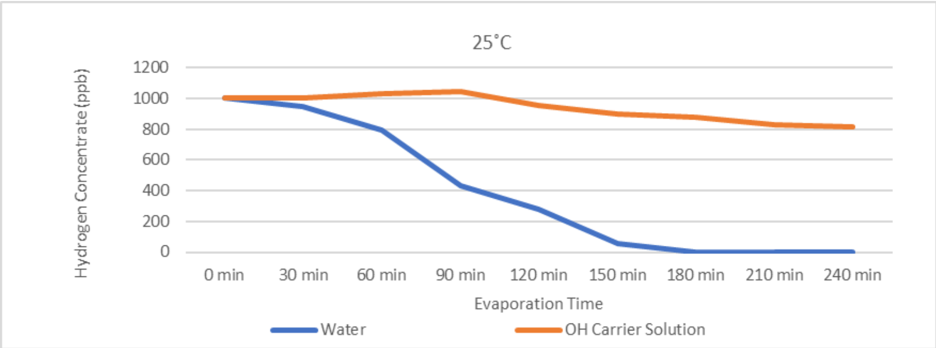
By integrating instrumental analysis with human trials, this methodology enabled a thorough evaluation of the effects of hydrogen-rich liquid on human skin, providing valuable insights into its potential therapeutic benefits for various skin conditions.

4. Experimental results

OH Carrier Solution plays a pivotal role in overcoming the inherent challenge of pure hydrogen's immediate disappearance and evaporation when mixed with water. In the context of the innovative skincare application explored in this research, the addition of OH Carrier Solution to the hydrogen-water mixture extends the longevity of hydrogen, surpassing four hours. This remarkable property is crucial for sustaining the therapeutic benefits of hydrogen in skincare, ensuring a protracted and consistent release of the gas.

Beyond its function as a hydrogen stabilizer, OH Carrier Solution contributes to the formulation's overall efficacy. By seamlessly integrating with the dissociated electrolysis technology (DSET), OH Carrier Solution facilitates the precise blending of pure hydrogen into the skincare solution, resulting in the creation of Hydrogen-Rich Liquid (HRL) characterized by exceptional purity and stability. This innovative liquid not only mitigates the challenges associated with hydrogen evaporation but also significantly enhances the overall effectiveness and stability of the skincare application [12].

(a)



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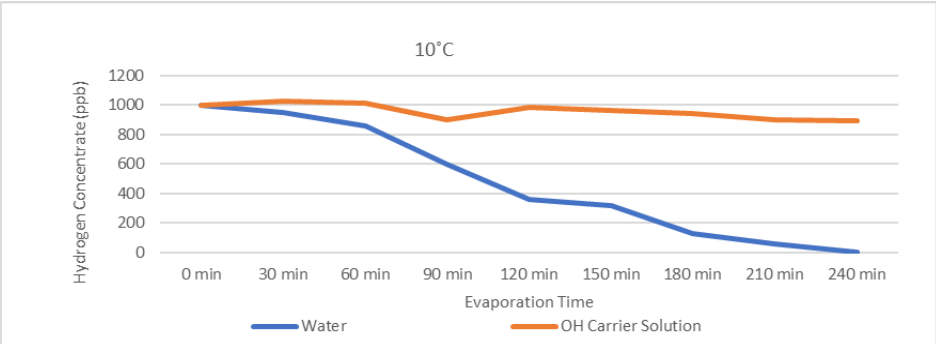

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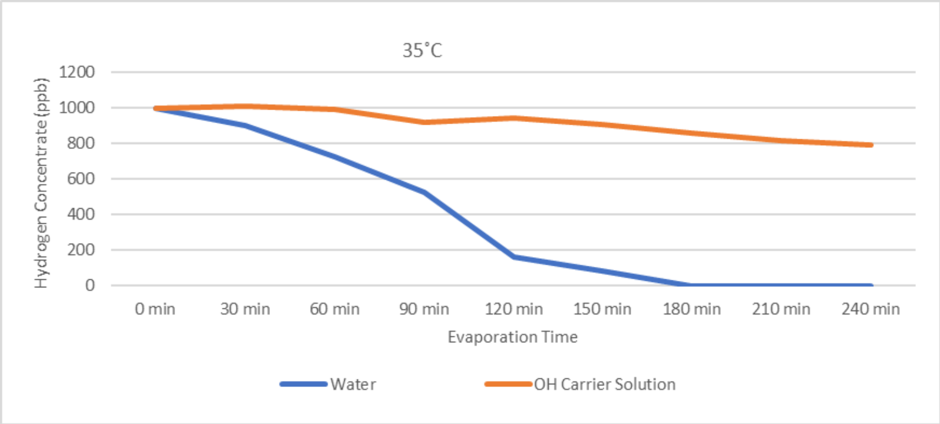

Figure 3. Using the hydrogen-rich detector ENH-2000, temperature-dependent assessments were conducted on hydrogen content in pure water and OH carrier solution. High-performance Liquid Chromatography (HPLC) revealed a remarkable hydrogen purity of 99.9995% (5N5), meeting FDA-designated medical-grade purity standards for hydrogen production. (a) OH Carrier Solution and water comparison at 10˚C every 30 minutes; (b) OH Carrier Solution and water comparison at 25˚C every 30 minutes; (a-c) OH Carrier Solution and water comparison at 35˚C every 30 minutes

These findings suggest that the OH Carrier Solution effectively mitigates the evaporation of hydrogen, thus contributing to enhanced stability compared to water. Specifically, the OH Carrier Solution exhibits a stability increase percentage of approximately 89% relative to water. This significant difference underscores the superior performance of the OH Carrier Solution in maintaining hydrogen stability over an extended period.

The meticulous mixing process ensures the harmonious integration of pure hydrogen, resulting in a highly concentrated, pure, and stable skincare solution that adheres to the medical-grade purity standard specified by the US FDA, reaching an exceptional purity level of 99.999% (5N5).

In the realm of skincare, the prolonged presence of hydrogen facilitated by OH Carrier Solution brings forth numerous benefits. The sustained release of hydrogen can contribute to improved skin hydration, reduced oxidative stress, and enhanced antioxidant effects, promoting overall skin health [13]. Additionally, the extended duration of hydrogen availability allows for a more prolonged interaction with the skin, potentially leading to enhanced therapeutic outcomes in addressing allergic skin conditions and atopic dermatitis [14]. The innovative combination of OH Carrier Solution and dissociated electrolysis technology opens new possibilities for skincare applications, promising sustained and heightened benefits for the skin.

4.2. Hydrogen-Rich Liquid Application to Skin Trial Results (in-vivo experiment)

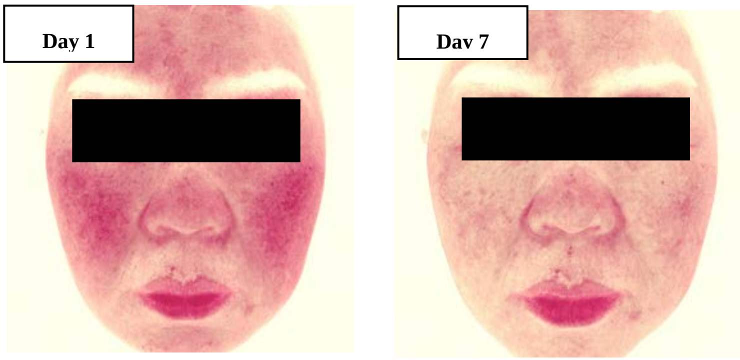

Figure 4. Hydrogen-Rich Liquid application for skin tone brightness. Notably, visible improvement in skin condition are discernible after 7 days, as confirmed by skin testing.

Table 1: Hydrogen-Rich Liquid for skin tone brightness from days 1 to 7

Day	**Hydrogen-Rich Liquid (Mean ± SEM)**	**Placebo (Mean ± SEM)**
1	1.3%% ± 0.2%	-1.4% ± 0.3%
2	2.6% ± 0.3%	-1.3% ± 0.2%
3	5.5% ± 0.4%	-1.2% ± 0.4%
4	6.1% ± 0.5%	-1.1% ± 0.5%
5	7.4% ± 0.4%	-1.0% ± 0.3%
6	14.0% ± 0.3%	-0.9% ± 0.4%
7	18.6% ± 0.2%	-0.3% ± 0.2%

*Values are presented as mean percentage change from initial condition ± standard error of the mean (SEM); n = 21/32, * indicates statistical significance with $p < 0.05$

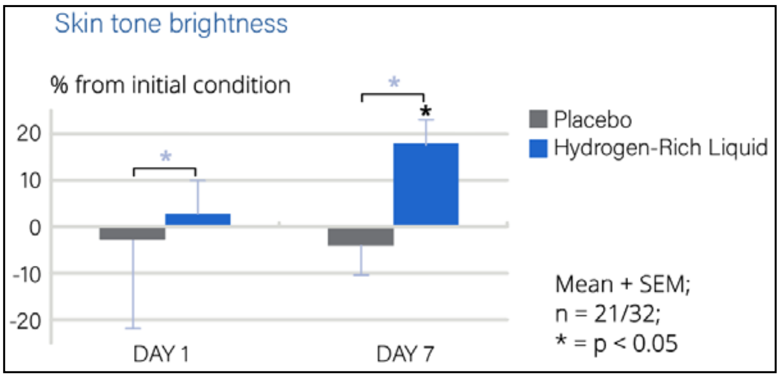

Figure 5. Hydrogen-Rich Liquid for skin tone brightness improvement chart

Table 2: Hydrogen-Rich Liquid red spots count relative to initial condition from days 1 to 7

Day	Hydrogen-Rich Liquid (Mean ± SEM)	Placebo (Mean ± SEM)
1	-0.9% ± 0.1%	0.2% ± 0.1%
2	-1.1% ± 0.2%	0.3% ± 0.2%
3	-1.4% ± 0.3%	0.5% ± 0.3%
4	-1.7% ± 0.4%	0.7% ± 0.4%
5	-8.2% ± 0.5%	1.2% ± 0.5%
6	-15.3% ± 0.6%	1.6% ± 0.6%
7	-28.4% ± 0.5%	16% ± 0.7%

*Values are presented as mean percentage change from initial condition ± standard error of the mean (SEM); n = 21/32, * indicates statistical significance with $p < 0.05$

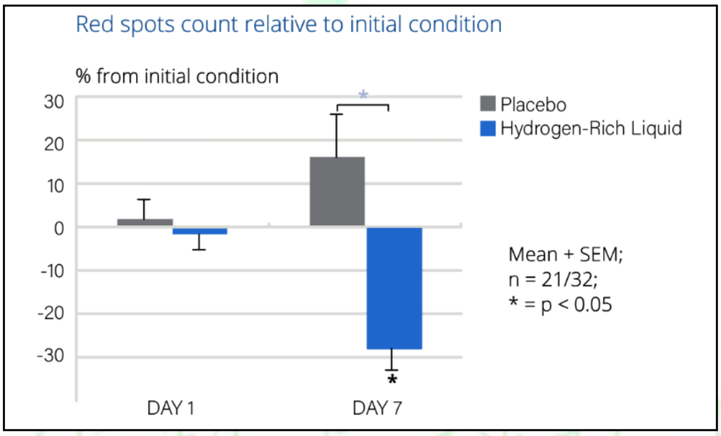

Figure 6. Hydrogen-Rich Liquid red spots count relative to initial condition

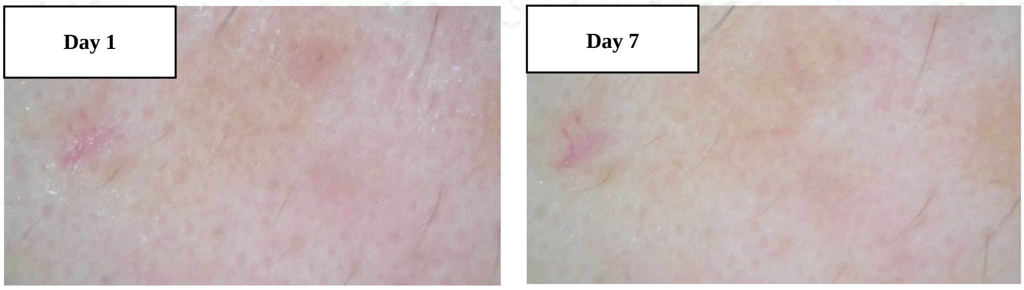

Figure 7. Hydrogen-Rich Liquid application for overall skin tone and spots. The primary outcomes include a brighter skin texture, along with reduced pore size and lighter spots following the treatment.

Throughout the duration of the study, participants using Hydrogen-Rich Liquid exhibited a consistent increase in skin tone brightness, with a mean increase of 1.3% on day 1, gradually reaching 18.6% on day 7. In contrast, those using the placebo experienced a decrease in skin tone brightness, ranging from -1.4% on day 1 to -0.3% on day 7. Regarding the reduction in red spot count relative to the initial condition, participants using Hydrogen-Rich Liquid demonstrated a noticeable improvement, with a mean reduction of -0.9% on day 1, further decreasing to -28.4% on day 7. Conversely, participants in the placebo group experienced an increase in red spot count relative to the initial condition, ranging from 0.2% on day 1 to 16% on day 7. Overall, these results indicate the significant effectiveness of Hydrogen-Rich Liquid in enhancing skin tone brightness and reducing red spot count, highlighting its potential as a beneficial skincare intervention.

Analysis of the collected data reveals promising findings regarding the efficacy of the Hydrogen-Rich Liquid in improving skin tone and reducing inflammation. Quantitative assessments demonstrate a statistically significant increase in skin tone brightness following the application of the formula, accompanied by a notable reduction in erythema severity. Individual case studies within the participant cohort highlight exceptional improvements observed in volunteers with rosacea symptoms, indicating Hydrogen-Rich Liquid’s potential as an effective intervention for specific skin concerns.

5. Conclusion

In the pursuit of innovative skincare solutions, this research has introduced a groundbreaking approach that leverages Dissociated Electrolysis Technology (DSET) in tandem with OH Carrier Solution, culminating in the development of Hydrogen-Rich Liquid (HRL). Its development, characterized by its exceptional purity, stability, and sustained release of hydrogen, represents a groundbreaking contribution to the field. The technology addresses inherent challenges associated with traditional hydrogen water extraction methods, providing a secure and quantifiable solution for mass production and regular maintenance.

OH Carrier Solution emerges as a pivotal element in enhancing the stability and efficacy of the skincare solution. By effectively countering the rapid disappearance and evaporation of pure hydrogen in water, OH Carrier Solution extends the duration of hydrogen presence to over four hours. This not only ensures the consistent delivery of therapeutic benefits but also opens avenues for prolonged interaction with the skin. The sustained release of hydrogen holds promising implications for skincare, offering benefits such as improved skin hydration, reduced oxidative stress, and enhanced antioxidant effects, contributing to overall skin health [15].

As the skincare industry continues to evolve, the integration of DSET and OH Carrier Solution sets a new standard, offering a reliable and innovative approach to harnessing the potential of hydrogen for skincare applications. This research opens avenues for further exploration and applications, marking a significant step toward a future where advanced technologies redefine the landscape of skincare solutions.

References

[1] Park S., Lee K. (2021) "Examining the Impact of E-Commerce Growth on the Spatial Distribution of Fashion and Beauty Stores in Seoul", Sustainability, 13(9), p. 5185.

[2] Mizuno K., Sasaki A.T., Ebisu K., Tajima K., Kajimoto O., Nojima J., Kuratsune H., Hori H., Watanabe Y. (2018) "Hydrogen-rich water for improvements of mood, anxiety, and autonomic nerve function in daily life", Med Gas Res., 7(4), p. 247-255.

[3] Hatae T., Miwa N. (2021) "Electrolytic hydrogen-generating bottle supplies drinking water with free/combined chlorine and ozone repressed within safety standard under hydrogen-rich conditions", Med Gas Res., 11(2), p. 61-65

[4] Tchounwou P.B., Yedjou C.G., Patlolla A.K., Sutton D.J. (2012) "Heavy metal toxicity and the environment", Exp Suppl., 101, p. 133-64.

[5] Fallah Vostakola M., Ozcan H., El-Emam R.S., Amini Horri B. (2023) "Recent Advances in High-Temperature Steam Electrolysis with Solid Oxide Electrolysers for Green Hydrogen Production. Energies. 2023; 16(8): p. 3327.

[6] Nnabuife S.G., Darko C.K., Obiako P.C., Kuang B., Sun X., Jenkins K. (2023) "A Comparative Analysis of Different Hydrogen Production Methods and Their Environmental Impact", Clean Technologies, 5(4), p. 1344-1380.

[7] Hassan Q., Azzawi I.D.J., Sameen A.Z., Salman H.M. (2023), "Hydrogen Fuel Cell Vehicles: Opportunities and Challenges", Sustainability, 15(15), p. 11501.

[8] Ahmad Kamaroddin M.F., Sabli N., Tuan Abdullah T.A., Siajam S.I., Abdullah L.C., Abdul Jalil A., Ahmad A. (2021) "Membrane-Based Electrolysis for Hydrogen Production: A Review", Membranes, 11(11), p. 810.

[9] Marouani I., Guesmi T., Alshammari B.M., Alqunun K., Alzamil A., Alturki M., Hadj Abdallah H. (2023) "Integration of Renewable-Energy-Based Green Hydrogen into the Energy Future", Processes, 11(9), p. 2685.

[10] Uda M., Okuyama H., Suzuki T.S., Sakka Y. (2012) "Hydrogen generation from water using Mg nanopowder produced by arc plasma method", Sci Technol Adv Mater., 13(2), p. 025009.

[11] Perović K., Morović S., Jukić A., Košutić K. (2023) "Alternative to Conventional Solutions in the Development of Membranes and Hydrogen Evolution Electrocatalysts for Application in Proton Exchange Membrane Water Electrolysis: A Review", Materials, 16(18), p. 6319.

[12] Ohsawa I., Ishikawa M., Takahashi K., Watanabe M., Nishimaki K., Yamagata K., Katsura K., Katayama Y., Asoh S., Ohta S. (2007) "Hydrogen acts as a therapeutic antioxidant by selectively reducing cytotoxic oxygen radicals", Nat Med., 13(6), p. 688-94.

[13] Li Y., Shen C., Zhou X., Zhang J., Lai X., Zhang Y. (2022) "Local Treatment of Hydrogen-Rich Saline Promotes Wound Healing In Vivo by Inhibiting Oxidative Stress via Nrf-2/HO-1 Pathway", Oxid Med Cell Longev., 2(8), p. 2949824.

[14] Purnamawati S., Indrastuti N., Danarti R., Saefudin T. (2017) "The Role of Moisturizers in Addressing Various Kinds of Dermatitis: A Review", Clin Med Res., 15(3-4), p. 75-87.

[15] Chilicka K., Rogowska A.M., Szyguła R. (2021) "Effects of Topical Hydrogen Purification on Skin Parameters and Acne Vulgaris in Adult Women", Healthcare (Basel), 9(2), p. 144.