

Research Article

Next-Generation Natural Sunscreen: A Six-Phase Homogenization Approach with Encapsulated Filters for Enhanced Photoprotection and Thermal Stability

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Abstract:

As concerns escalate regarding the dermatological safety and ecological impact of conventional sunscreens especially under intense UV radiation and high humidity in tropical regions like Malaysia there is a critical need for advanced, natural photoprotective solutions that deliver reliable efficacy without compromising environmental responsibility. This study presents a next-generation herbal–mineral sunscreen formulation employing a sophisticated six-phase homogenization process to achieve precise multi-phase microstructuring, which enhances stability, uniform dispersion, and sensorial performance of the active components. The formulation integrates bioactive botanical extracts, including α -Bisabolol and Roman Chamomile, with micronized Titanium Dioxide mineral filters to deliver broad-spectrum UV defence and excellent dermal compatibility. The formulation's performance and resilience were rigorously validated through multiple assessment protocols: SPF Testing to quantify sun protection efficacy; a proprietary ThermoShield Assay designed to simulate intense heat exposure and demonstrate enhanced thermal barrier properties; and UV Transmittance Card Evaluation to visually confirm UV blocking performance. Results demonstrated consistent photoprotection, rapid absorption, a non-greasy texture, and a transparent finish without white cast effectively overcoming key limitations of conventional formulations. By combining high-performance sun protection, potent botanical bioactivity, and an eco-conscious profile through a controlled multi-phase production approach, this innovation sets a new benchmark in natural photoprotection and addresses the unmet need for safe, multifunctional sun care tailored to demanding climatic environments.



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1. INTRODUCTION

The Sun has been the primary source of energy and life since the beginning of human history. Nevertheless, sunlight remains the predominant environmental source of ultraviolet (UV) radiation exposure consisting mostly of UVA (90–95%) and UVB (5–10%), as the ozone layer blocks UVC. UVA produces reactive oxygen species due to its strong penetration into the dermis, which indirectly disrupts DNA and causes tumor and skin aging. The epidermis absorbs the majority of UVB rays, which directly harm DNA through the formation of photoproducts such as cyclobutane dimers causing skin cancer and mutations (D'Orazio et al., 2013). The intensity of UV radiation exposure depends on

the amount of time spent outside and the use of sunblocks, sunscreens and UV protective clothing (Wilson et al., 2012).

Therefore, sunscreens are essential for protecting skin from harmful ultraviolet (UV) radiation (Young, 2023). However, conventional sunscreen formulation predominantly utilize synthetic UV filters that have been linked to both dermatological sensitivities and adverse environmental impacts, such as coral reef bleaching and aquatic toxicity (Pawlowski, and Petersen-Thiery, 2020). As awareness of these issues grows, there is increasing demand for safer, more effective, and environmentally friendly sun protection products. Traditional sunscreens that rely heavily on organic ultraviolet (UV) filters such as avobenzone and octocrylene are now under critical scrutiny due to their susceptibility to photodegradation, their tendency to generate reactive oxygen species (ROS), and their potential for systemic skin penetration (Dong et al., 2019). These shortcomings not only compromise the long-term efficacy and stability of sunscreen products but also raise concerns about adverse health and environmental impacts which have led to the exploration of a next-generation herbal-mineral sunscreen using a six-phase homogenization process and encapsulated UV filters to enhance performance and sustainability.

Research demonstrates that encapsulated filters primarily remain on the skin's surface, unlike their free counterparts, which tend to penetrate the stratum corneum (Cefali et al., 2017). Encapsulation technology significantly improves the photo-stability of UV filters, leading to maintained or enhanced SPF values and consistent broad-spectrum UV protection due to reduced degradation under UV exposure (Cozzi et al., 2018). It also allows for transparent, lightweight formulations with minimal whitening—making them suitable for all skin tones (Sharma et al., 2020). Alongside these advances, multi-phase formulation systems employing controlled, temperature-managed homogenization techniques show significant potential for improving product stability and performance. The six-phase homogenization approach is an advanced technique that enables the precise integration of hydrophilic and lipophilic phases under optimized shear and thermal conditions. The advanced homogenization approach enables the precise integration of hydrophilic and lipophilic phases under controlled shear and thermal conditions. This technique reduces droplet size, improves stability, and ensures uniform dispersion of components—ultimately enhancing the formulation's texture and improved aesthetic appeal for daily wear (Juttulapa et al., 2016).

Integrating encapsulated filters into a well-structured multi-phase system creates a thermostable emulsion. This emulsion effectively resists degradation and separation, even when exposed to the high temperatures and humidity characteristic of tropical climates like Malaysia. In addition, encapsulated physical filters like TiO₂ and ZnO not only scatter, reflect, and absorb harmful UV rays more efficiently, but they also exhibit significantly reduced photocatalytic activity. This preserves other formulation components and minimizes irritation risks (Thy et al., 2025).

The formulation was assessed through a series of validation tests, including SPF testing to quantify sun protection efficacy, a proprietary ThermoShield assay to visualize the sunscreen's ability to shield the skin from harmful UV radiation, UV transmittance card evaluation to visually confirm UV blocking capabilities, and a water resistance test to evaluate the sunscreen's ability to UV protection after water exposure, simulating real-world conditions such as swimming or sweating. Collectively, these analyses demonstrate the sunscreen's ability to deliver consistent photoprotection, enhanced thermal stability, rapid absorption, and a non-greasy, transparent finish, effectively addressing the shortcomings of traditional sunscreens.

This study investigates a next-generation herbal-mineral sunscreen developed using a six-phase homogenization process integrated with encapsulated mineral UV filters. The formulation combines

micronized titanium dioxide with botanical actives, such as α -Bisabolol and Roman Chamomile, known for their anti-inflammatory and skin-soothing properties. These natural ingredients complement the UV filtering system, enhancing dermal compatibility and reinforcing the formulation's eco-conscious profile.

2. METHODOLOGY

2.1 ThermoShield assay

The sunscreen's ability to shield the skin from harmful UV radiation was qualitatively illustrated using a flame-based visual demonstration, as shown in Figure 1. A standard single-tipped cotton bud was used as the substrate. One end was uniformly coated with a thin layer of the sunscreen, while an uncoated bud served as the control. Both samples were simultaneously exposed to a direct flame from a lighter for a standardized duration of approximately 10 seconds, and their combustion behavior was visually observed. A delay in ignition or absence of charring on the sunscreen-coated bud, compared to the untreated control, was interpreted as a symbolic representation of the formulation's protective barrier function. While flame exposure does not replicate the spectral characteristics of UV radiation, the test served as a compelling visual analogy for the sunscreen's photoprotective capabilities.

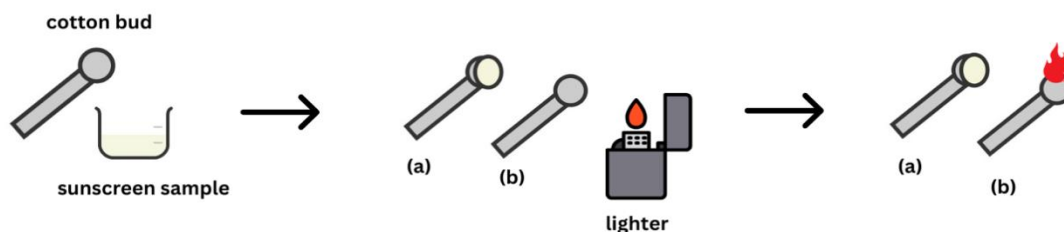


Figure 1: (a) Cotton bud tip coated with sunscreen formulation (b) untreated cotton bud tip (control). Both tips were simultaneously exposed to an open flame to assess differences in burn rate and charring.

2.2 UV Transmittance test

The photoprotective efficacy of the sunscreen formulations was assessed through a UV transmittance test, using UV-sensitive indicator cards, as a visual proxy for ultraviolet (UV) radiation exposure. A thin, uniform layer of the sunscreen sample was applied to the surface of one indicator card, while another card was left untreated to serve as a negative control. Both cards were simultaneously exposed to direct sunlight for a fixed duration of five minutes. After the exposure, the degree of color change on each card was recorded. Minimal or no color change on the sunscreen-treated card relative to the untreated control was interpreted as indicative of effective UV filtration or absorption by the formulation.

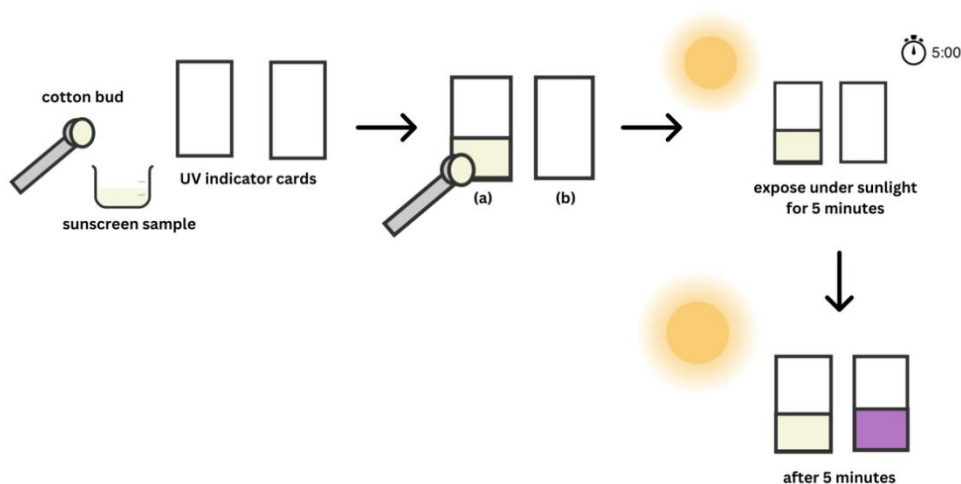


Figure 2: (a) UV-sensitive card treated with a uniform layer of sunscreen formulation (b) untreated UV-sensitive card (control). Both samples were exposed to direct sunlight for 5 minutes.

2.3 Water Resistance Test

The water resistance of the sunscreen formulation was evaluated using UV-sensitive indicator cards, as illustrated in Figure 3. A thin, uniform layer of the sunscreen sample was applied to the one of the UV indicator cards, while a second card was left untreated to serve as control. Both cards were then fully submerged in distilled water for 10 minutes to stimulate water exposure conditions. After removal from water, the cards were subsequently exposed to direct sunlight for about 5 minutes. The color response of each card was recorded post-exposure. The differences in color intensity between the treated and untreated cards were used to evaluate the extent to which the sunscreen retained its UV protection after immersion in water.

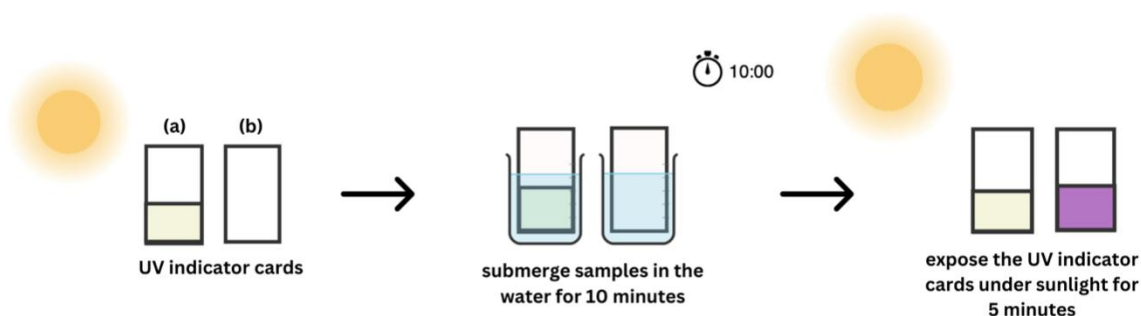


Figure 3: (a) card coated with sunscreen formulation (b) untreated control

2.4 Viscosity test

The viscosity of the sunscreen formulations was determined using a rotational viscometer. Prior to testing, the instrument was powered on, and the Spindle No. 3 was selected and carefully attached to the viscometer by lifting the coupling nut and twisting the spindle clockwise, ensuring the shaft was not bent during installation. The spindle was fully immersed in the sample, without touching the bottom of the container, by adjusting the spindle height using the rear knob. The viscosity of the formulation was measured at 30 rpm and 60 rpm to capture its flow behavior under low and moderate shear conditions, simulating product behavior both at rest and during application to the skin. These

speeds are commonly used in cosmetic testing to assess shear-thinning characteristics, which are critical for ensuring ease of spreadability while maintaining product stability. Spindle No. 3 was selected based on its suitability for medium to high viscosity emulsion typically found in sunscreens creams.



Figure 4: Rotational viscometer for viscosity measurement of the sunscreen formulations

2.5 pH measurement test

The pH of each sunscreen formulation was measured using a calibration digital pH meter following a dilution protocol. The sunscreen sample was accurately weighed into a beaker and diluted with distilled water. The mixture was stirred gently until a homogeneous suspension was achieved. Before measurement, the electrode was rinsed with RO water to eliminate any surface contaminants. The pH meter was powered on, and the electrode was immersed into the diluted sample until fully submerged. The reading was allowed to stabilize before being recorded. After use, the electrode was rinsed with RO water and stored in appropriate electrode storage solution.



Figure 5: The pH meter for pH measurements of the sunscreen formulation

2.6 SPF testing

The test formulation intended for sun protection was prepared under controlled laboratory conditions. A representative sample was selected, 42labelled appropriately, and securely packaged for analysis to ensure integrity during transit and handling. To determine the Sun Protection Factor (SPF) of the sample, the product was submitted to a third-party laboratory specializing in SPF evaluation.

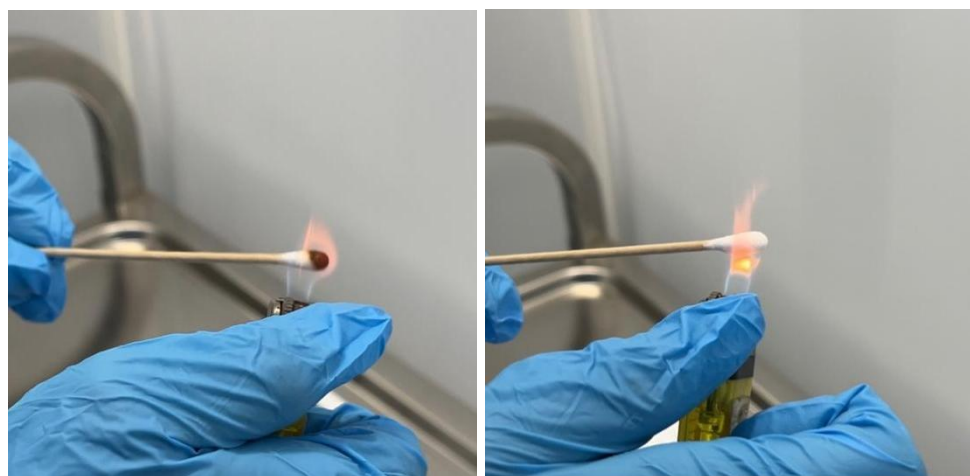
The testing was conducted using an SPF Analyzer, a non-invasive instrumental method designed for rapid and reliable SPF assessment.

3. FINDINGS

3.1 *ThermoShield assay*

The ThermoShield assay was conducted as a visual analytical method to illustrate the sunscreen's ability to shield the skin from harmful UV radiation. As shown in Figures 6 and 7, the untreated cotton bud ignited immediately and charred extensively, while the sunscreen-coated cotton bud showed no signs of burning or charring under identical exposure to an open flame. Although direct flame heat is not identical to sunlight in terms of spectral composition, this test served as a compelling visual demonstration of the sunscreen's protective capabilities. In this context, the absence of combustion illustrates how the formulation forms a robust barrier, capable of absorbing, reflecting, or diffusing high intensity energy, similarly to how it behaves under strong sun exposure.

This result reinforces the sunscreen's photoprotective strength, supporting its measured SPF value. The stability and effectiveness observed in this test are attributed to the six-phase homogenization process and the incorporation of encapsulated micronized titanium dioxide, which together help create a cohesive, heat-resilient film on the skin. Overall, the ThermoShield assay presents a compelling visual indication that the formulation can reliably protect skin from direct and prolonged UV exposure.



(a)

(b)

Figure 1: the cotton bud comparison during flame exposure: (a) the untreated cotton bud (b) the sunscreen-coated cotton bud

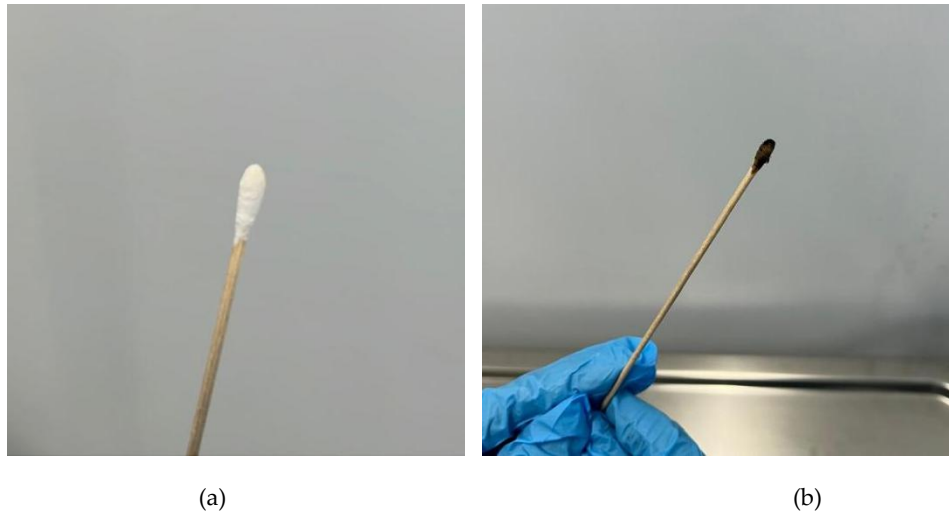


Figure 2: Cotton bud comparison after flame exposure: (a) the sunscreen-coated cotton bud (b) the untreated cotton bud (control)

3.2 UV Transmittance test

The photoprotective efficacy of the sunscreen was further confirmed by the UV transmittance test using UV-sensitive indicator cards. As shown in Figure 8, the untreated card underwent significant color change after 5 minutes of sun exposure, indicating high levels of UV penetration. In contrast, the sunscreen-coated card showed no color change, implying that the majority of UV radiation was effectively blocked or absorbed by the formulation.

This outcome validates the broad-spectrum UV filtering capabilities of the encapsulated micronized titanium dioxide. Encapsulation enhances particle dispersion and prevents agglomeration, which typically reduces UV scattering efficiency. Moreover, the botanical actives, such as Roman Chamomile and α -Bisabolol, may provide synergistic photoprotective effects, contributing to UV absorption while simultaneously soothing the skin and reducing inflammation. While UV indicator cards provide only a qualitative assessment rather than precise SPF values, they remain a valuable and accessible visual tool for demonstrating photoprotection. This immediate visual feedback is invaluable for educating consumers about the importance of consistent and thorough sunscreen application. (Aguilera et al., 2024).

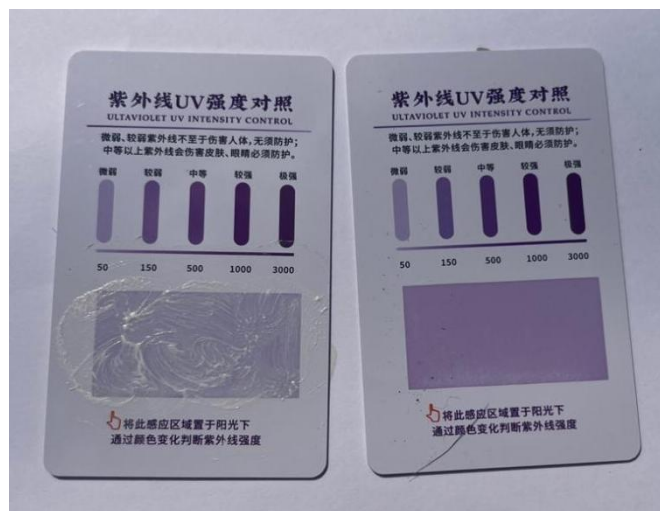


Figure 3: UV transmittance test: the sunscreen coated on UV indicator card (b) the untreated UV indicator card (right)

3.3 Water Resistance test

The formulation's resistance to water was assessed by immersing treated and untreated UV cards in distilled water for 10 minutes, followed by sunlight exposure. Figure 9 shows that the sunscreen-coated card retained a high level of UV protection post-immersion, with minimal to none color change compared to the control card. This result indicates excellent water resistance, a vital property for sunscreens used during swimming, sweating, or other outdoor activities. The cohesive film formed by the multi-phase system, coupled with the hydrophobic properties of the encapsulated mineral filters, likely contributes to the formulation's ability to maintain photoprotection after water exposure.

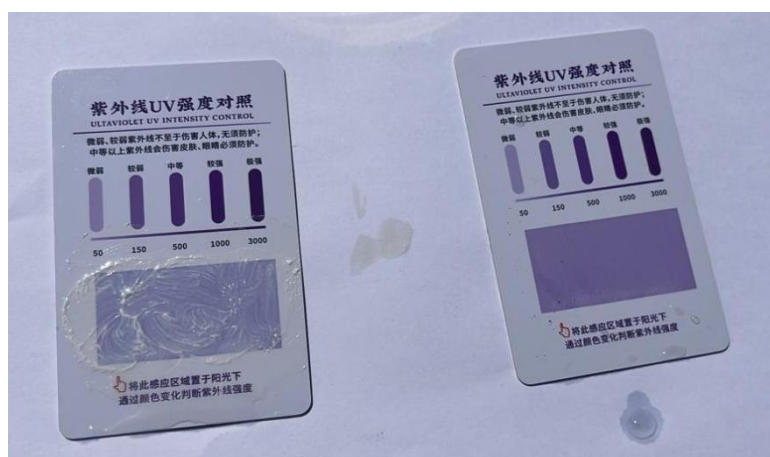


Figure 4: The UV indicator card with sunscreen-coated (left) and the untreated UV indicator card (right)

3.4 Viscosity test

Viscosity is a key parameter in topical formulations, influencing the product's texture and spreadability, which in turn affects the application and long-term stability (Simões et al., 2018). Viscosity measurements were conducted using a rotational viscometer at two speeds (30 and 60 rpm), as shown in Table 1. At 30 rpm, the formulation exhibited a viscosity of 62.5%, while at 60 rpm it was 42.43%, confirming shear-thinning behavior. These results indicate a decrease in viscosity as the rotational speed increases, which is characteristic of shear-thinning behavior, or also known as

pseudoplastic flow, which means that the formulation is thick when still, but becomes smooth and easy to spread when you apply it.

Based on the results, the higher viscosity at lower speed (62.5% at 30 rpm) shows that the formulation has a relatively thick consistency when undisturbed, which helps prevent the product from running off the skin or leaking during storage. While the lower viscosity at higher speed (42.43% at 60 rpm) demonstrates that the formulation becomes more fluid under stress, making it easier to spread evenly across the skin surface during application. This behavior indicates a formulation that maintains a desirable balance between structural integrity and ease of spreadability. This rheological profile is highly desirable for cosmetic and dermatological products as it provides good skin adherence, it ensures even distribution of active ingredients like titanium dioxide, and it enhances user comfort by enabling smooth and effortless application. It also supports formulation stability, as consistent and appropriate viscosity is a critical factor in ensuring physical stability. Adequate viscosity helps maintain uniform dispersion of active ingredients such as encapsulated micronized titanium dioxide, preventing them for settling (Yang, Corti, and Franses, 2015). Additionally, it contributes to emulsion stability by minimizing the risk of phase separation between oil and water phases. Therefore, stable viscosity over time reflects good internal cohesion of the product matrix, which is essential for long-term product performance and shelf stability.

In summary, the consistency observed across both rotational speeds suggest that the six-phase homogenization process successfully produced a stable emulsion system, with well-balanced oil and water phases, appropriate emulsifier concentration, and uniform particle dispersion.

Table 1: viscosity test results of Next-Generation Natural Sunscreen (NGNS-F1) Formulation

Rotor	Speed (rpm)	Result (%)			Average Results (%)
		1 st Reading	2 nd Reading	3 rd Reading	
3	30	62.1	62.9	62.5	62.5
	60	42.0	42.8	42.5	42.43

3.5 pH test

The pH of the sunscreen formulation, as recorded in Table 2, yielding a mean pH of 6.52. This value falls within the physiologically acceptable range for tropical skincare products and closely aligns with the skin’s natural pH, typically between 4.5 and 5.5 (Proksch, 2018). Maintaining a mildly acidic pH in sunscreens is important for preserving the skin's acid mantle and protective barrier, making them suitable for daily use, especially for individuals with sensitive or acne-prone skin. A pH close to the skin's natural pH ensures minimal disruption to the skin's natural defences (Lukić et al., 2021). The consistency of these readings indicates strong formulation stability, as significant pH drift is often a sign of ingredient degradation, microbial growth, or emulsion breakdown. Additionally, the inclusion of anti-inflammatory agents such as α -Bisabolol and Roman Chamomile enhances skin compatibility, particularly for sensitive skin types (Johnson et al., 2017). The stable pH also suggests that the six-phase homogenization process contributed to maintaining emulsion uniformity and preventing fluctuations over time. Overall, the pH findings support the sunscreen’s safety, dermal compatibility, and long-term usability of the sunscreen formulation for daily topical application.

Table 2: pH measurements of Next-Generation Natural Sunscreen (NGNS-F1) Formulation

Sample	pH Readings			Mean pH
	1 st Reading	2 nd Reading	3 rd Reading	
NGNS-F1	6.37	6.36	6.82	6.52

3.6 SPF test

The SPF testing, conducted by a certified third-party laboratory using a SPF Analyzer, resulting in a consistent SPF rating of 50, as illustrated in Table 2. This result places the product within the “very high protection” category, according to FDA standards, which define SPF 50 as blocking approximately 98% of UVB radiation. The SPF value validates the formulation’s effectiveness in providing robust UVB protection, which is critical for preventing sunburn and reducing the risk of skin cancer.

A key factor contributing to this high SPF performance is the encapsulation of titanium dioxide, a widely used physical UV filter. Encapsulation enhances particles dispersion within the formulation, increasing their surface area and optimizing their ability of the active ingredients to reflect and absorb UV radiation effectively (Jain, and Jain, 2010). This nanotechnology-based approach not only improves UV protection but also reduces potential skin irritation and enhances the cosmetic acceptability of the sunscreen by reducing the white cast commonly associated with mineral sunscreens. Moreover, the six-phase homogenization process employed during manufacturing ensures a uniform distribution of active ingredients, including titanium dioxide. This uniformity is essential for maintaining consistent coverage and preventing aggregation or uneven layering of particles, which can lead to inconsistent protection. Homogenization techniques are recognized in the cosmetic industry as critical for achieving stable, high-performance formulation. In this content, this advanced six-phase homogenization approach used here plays a central role in optimizing the bioavailability and skin coverage of the mineral filters, reducing gaps in protection and enhancing the overall photoprotective efficacy of the final product.

Table 3: SPF testing results of Next-Generation Natural Sunscreen (NGNS-F1) Formulation

TEST PARAMETER	METHOD USED	RESULT
Sun Protective Factor	SPF Analyzer	50

4. CONCLUSION

Humans remain at risk of serious health problems from prolonged exposure to UV rays, highlighting the urgent need for safer and effective sun protection solutions. Herein, we developed a next-generation herbal mineral sunscreen employing an advanced six-phase homogenization technique combined with encapsulated micronized titanium dioxide to deliver broad-spectrum UV protection with enhanced dermal compatibility. The sunscreen formulation exhibits strong photoprotective efficacy when exposed to direct sunlight, excellent water resistance and a steady rheological profile as demonstrated by the constant shear-thinning pattern. Furthermore, the near neutral pH indicates it is suitable for all skin types, minimizing the risk of irritation while high SPF value (SPF 50) validate its stability, safety, and efficacy for regular use in hot and humid climates. Although qualitative, the visual assessments highlight the formulation’s performance in terms of its ability to block UV radiation, resist heat exposure, and maintain a non-greasy appearance.

Acknowledgments: We would like to thank the laboratory responsible for conducting the SPF testing, microbiological analysis, and heavy metal screening. Their knowledge was invaluable in proving that our formulation is safe and effective. We also extend our sincere gratitude to the raw material suppliers for providing us with high-quality and premium-grade botanical and mineral ingredients, which contributed significantly to the success of this study.

References

- Aguilera, J., Cárdenas-González, D., Sánchez-Roldán, C., González, S., Bosch-García, R., Herrera-Ceballos, E., & De Gálvez, M. V. (2024). Qualitative and quantitative analysis of colorimetric response in different UV solar radiation level indicator bracelets based on photochromic substances. *Frontiers in Photobiology*, 2. <https://doi.org/10.3389/fphbi.2024.1281474>
- Cefali, L. C. et al. (2017). Development and evaluation of microencapsulated sunscreen. *Journal of Dispersion Science and Technology*, 39(8), 1149-1152. <https://doi.org/10.1080/01932691.2017.1385481>
- Cozzi, A. C., Perugini, P., & Gourion-Arsiquaud, S. (2018). Comparative behavior between sunscreens based on free or encapsulated UV filters in term of skin penetration, retention and photo-stability. *European Journal of Pharmaceutical Sciences*, 121, 309–318. <https://doi.org/10.1016/j.ejps.2018.06.001>
- D’Orazio, J., Jarrett, S., Amaro-Ortiz, A., & Scott, T. (2013). UV radiation and the skin. *International Journal of Molecular Sciences*, 14(6), 12222–12248. <https://doi.org/10.3390/ijms140612222>
- Dong, Y. et al. (2019). Perspectives on the Next Generation of Sunscreen: Safe, Broadband, and Long-Term Photostability. *ACS Materials Letters*, 1(3), 336-343. <https://doi.org/10.1021/acsmaterialslett.9b00203>
- Jain, S. K., and Jain, N. K. (2010). Multiparticulate carriers for sun-screening agents. *International Journal of Cosmetic Science*, 32(2), 89-98. <https://doi.org/10.1111/j.1468-2494.2010.00547.x>
- Johnson, W. et al. (2017). Safety Assessment of Anthemis nobilis–Derived Ingredients as Used in Cosmetics. *International Journal of Toxicology*, 36(1_suppl), 575-66S. <https://doi.org/10.1177/1091581817705620>
- Juttulapa, M., Piriya-prasarth, S., Takeuchi, H., & Sriamornsak, P. (2016). Effect of high-pressure homogenization on stability of emulsions containing zein and pectin. *Asian Journal of Pharmaceutical Sciences*, 12(1), 21–27. <https://doi.org/10.1016/j.ajps.2016.09.004>
- Lukić, M., Pantelić, I., & Savić, S. D. (2021). Towards optimal pH of the skin and topical formulations: from the current state of the art to tailored products. *Cosmetics*, 8(3), 69. <https://doi.org/10.3390/cosmetics8030069>
- Pawlowski, S., and Petersen-Thiery, M. (2020). Sustainable Sunscreens: A Challenge Between Performance, Animal Testing Ban, and Human and Environmental Safety. *The Handbook of Environmental Chemistry*, 185-207. https://doi.org/10.1007/698_2019_444
- Proksch, E. (2018). pH in nature, humans and skin. *The Journal of Dermatology*, 45(9), 1044-1052. <https://doi.org/10.1111/1346-8138.14489>
- Sharma, A., Kumar, A., Li, C., Sharma, R. K., & Swihart, M. T. (2020). Microencapsulated UV filter@ZIF-8 based sunscreens for broad spectrum UV protection. *RSC Advances*, 10(56), 34254–34260. <https://doi.org/10.1039/d0ra05828a>
- Simões, A., Veiga, F., Vitorino, C., & Figueiras, A. (2018). A tutorial for developing a topical cream formulation based on the quality by design approach. *Journal of Pharmaceutical Sciences*, 107(10), 2653–2662. <https://doi.org/10.1016/j.xphs.2018.06.010>
- Thy, L. T. M., Thanh, L. N. P., Dat, N. T., & Dat, N. M. (2025). Review on The Application of inorganic UV filters in Sunscreens: Mechanisms, Evaluation Methods, Toxicity, and Safety Enhancements. *Results in Surfaces and Interfaces*, 100580. <https://doi.org/10.1016/j.rsurfi.2025.100580>
- Wilson, B. D., Moon, S., & Armstrong, F. (2012). Comprehensive review of ultraviolet radiation and the current status on sunscreens. *PubMed*, 5(9), 18–23. <https://pubmed.ncbi.nlm.nih.gov/23050030>

Yang, Y., Corti, D. S., and Franses, E. I. (2015). Use of Close-Packed Vesicular Dispersions to Stabilize Colloidal Particle Dispersions against Sedimentation. *Langmuir*, 31(32), 8802-8808.

<https://doi.org/10.1021/acs.langmuir.5b02133>

Young, A. R. (2023). The adverse consequences of not using sunscreens. *International Journal of Cosmetic Science*, 45(S1), 11-19. <https://doi.org/10.1111/ics.12897>