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“Empowering PO: Synergistic mixture of diols and piroctone olamine for anti-dandruff application and beyond”

Steffen Nordziske*¹, Ewa Musiol-Kroll¹, Florian Genrich², Laura Meunier²

¹ Global Innovation Cosmetic Ingredients, Symrise AG, Holzminden, Germany

² Cosmetic Ingredients, Business Unit Microprotection, Symrise AG, Holzminden, Germany

1. Introduction

Dandruff, characterized by scaling and itching of the scalp, is a common dermatological condition affecting a substantial percentage of the adult population (Borda und Wikramanayake 2015). Beyond its physiological manifestations, dandruff can lead to social and psychological distress, highlighting the need for effective anti-dandruff strategies.

The pathophysiological understanding of dandruff is still incomplete. However, it was demonstrated that the imbalance of scalp microbiome leads to overgrowth and overrepresentation of *Malassezia* yeasts on scalp, triggering inflammatory and hyper-proliferative epidermal responses, which results in dandruff formation. In addition to *Malassezia*, a domination of the Genus *Staphylococcus* has been associated with dandruff and scalp (Xu et al. 2016; Saxena et al. 2018; Tao et al. 2021).

The evolving regulatory landscape, has created a growing demand for alternative anti-dandruff solutions that are both effective and compliant with regulatory requirements. This study aimed at the development of an adequate alternative, considering the important and highly fragile balance between efficacy and sustainability.

In our research, we assessed if we would be able to boost the anti-dandruff applicability of piroctone olamine with decylene glycol. Piroctone olamine (PO), a well-established anti-dandruff agent, exhibits broad-spectrum antifungal and antibacterial activity (Piérard-Franchimont et al. 2003; Piérard-Franchimont et al. 2002). Decylene glycol (DC), a multifunctional ingredient, might serves as a skin-conditioning agent, contributing to a healthier scalp. The combination of piroctone olamine and decylene glycol resulted in an optimized antimicrobial efficacy for dandruff control, serving as a further solution to replace zinc-pyritone.

2. Materials and Methods

In Vitro Antimicrobial Efficacy: Minimum Inhibitory Concentration (MIC) Assay

The antimicrobial efficacy of the blended DC and PO was assessed using Minimum Inhibitory Concentration (MIC) tests against a panel of *Malassezia* species, including *Malassezia furfur*, *Malassezia sympodialis*, *Malassezia globosa*, *Malassezia restricta*, and *Staphylococcus aureus*. Briefly, serial dilutions of blended DC and PO and individual components (piroctone olamine and decylene glycol) were prepared in culture media. The cultures were inoculated with standardized microbial suspensions, incubated under appropriate conditions, and the MIC was defined as the lowest concentration of the test substance that inhibited microbial growth after incubation.

In Vitro Antimicrobial Efficacy: Zone of Inhibition (ZOI) Assay

Zone of Inhibition (ZOI) tests were conducted to further evaluate the effect of the blended DC and PO against *Malassezia* species. *Malassezia* cultures were spread onto solid agar plates. The test substances (piroctone olamine and decylene glycol) or blends were pipetted onto sterile paper discs and placed on the agar surface. The plates were incubated under appropriate conditions. After incubation, the ZOI, representing the area of inhibited microbial growth surrounding the disc, was measured in millimeters.

3. Results

3.1. *In Vitro* Antimicrobial Efficacy

Key of this development was to combine the different strengths of two distinct ingredients to a modern, more sustainable solution. Therefore, the assessment of the efficacy was the first topic that was addressed. Testing many different compositions, we succeeded to find the optimal concentrations of all ingredients, reflecting both the strength of piroctone olamine and decylene glycol. The *in vitro* antimicrobial tests demonstrated that the resulting blend effectively inhibited the growth of all tested *Malassezia* species and *Staphylococcus aureus* (Table 1).

Table 1: Minimum Inhibitory Concentration (MIC) Values (ppm) for the final blend

	MIC in ppm				
	<i>S. aureus</i>	<i>M. sympodialis</i>	<i>M. furfur</i>	<i>M. furfur</i> (strain 2)	<i>M. restricta</i>
Crinipan® PO Plus	500	500	500	500	250

3.2. Synergistic Effect

To further underline the efficacy of the newly developed blend, we assessed the antimicrobial properties additionally in a zone of inhibition test. Congruent with the results from the MIC testing, ZOI data showed a higher efficacy of the blend than of piroctone olamine alone against *Malassezia* species, indicating a synergistic effect between piroctone olamine and decylene glycol even on this organism. As decylene glycol was originally selected based on its efficacy against *Staphylococcus* species, this result was unexpected, but highly appreciated.

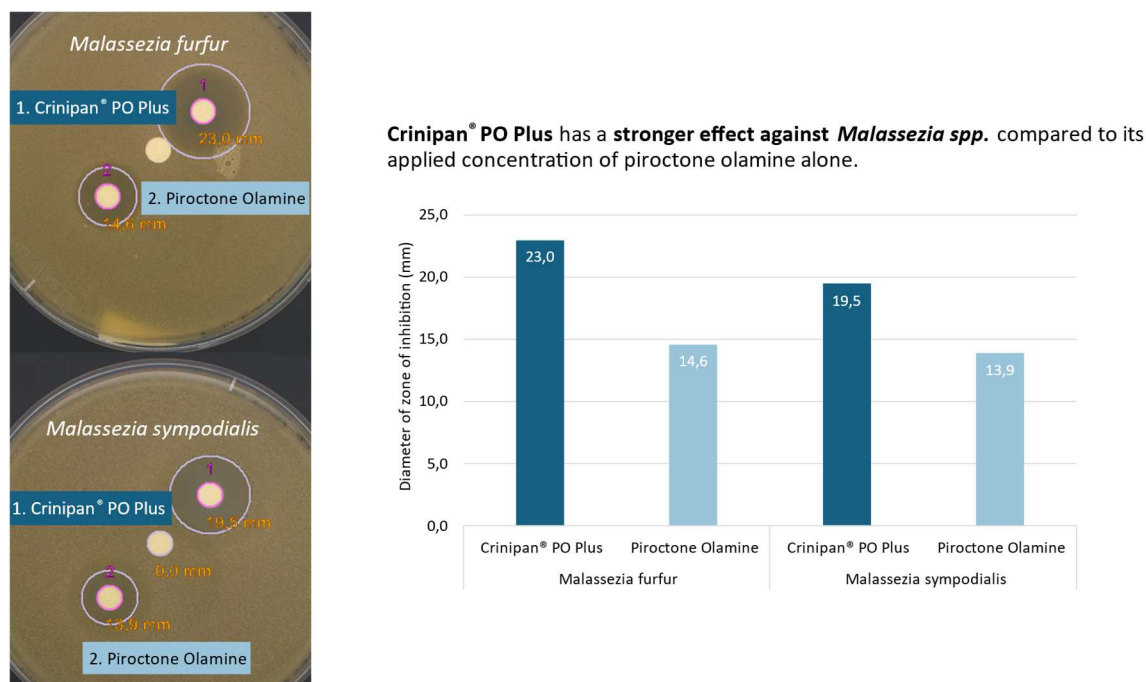


Figure 1: Zone of Inhibition (ZOI) Assay with piroctone olamine and Crinipan® PO Plus

3.3. Formulation Considerations

Cosmetic formulators often suffer from ingredients that are solid, have an odour, a colour, or all above. Both piroctone olamine and decylene glycol are solid products, thus detaining the establishment of new functional formulations. Combining these ingredients with 1,2-hexanediol and glycerin, we succeeded to create a readily dispersible liquid blend, facilitating ease of handling and incorporation into cosmetic formulations. Even heating is not required during the formulation process.

4. Discussion

The results of this study demonstrate that it is possible to combine the positive properties of two specialized ingredients to create a blend that is stronger than its single parts. Blending DG and PO leads to an effective solution for dandruff control due to its synergistic combination, amalgamized by the interaction with 1,2-hexanediol and glycerin. The *in vitro* data confirms its efficacy in targeting both *Malassezia*- and *Staphylococcus* species, both key contributors to dandruff formation. Piroctone olamine, a well-established anti-dandruff agent, exerts its effect by disrupting the fungal cell membrane, inhibiting growth and proliferation. Decylene glycol complements the action of piroctone olamine by providing broad-spectrum antimicrobial activity and contributing to a healthier scalp environment. The synergistic blend of these ingredients results in enhanced antimicrobial activity compared to the individual components.

The ease of formulation of the newly developed blend is an additional advantage. Its liquid form and ease of dispersion simplify the manufacturing process, making it a convenient and cost-effective ingredient for the whole range of hair care formulations, including shampoos, conditioners, and serums, providing manufacturers with flexibility in developing effective anti-dandruff products tailored to diverse consumer needs.

5. Conclusion

The creative blending of two known ingredients, aided by the addition of only two additional additives like 1,2-hexanediol and glycerin, can lead to an effective solution for dandruff control. Through this process, we are able to offer a synergistic combination of ingredients, adding ease of formulation, and regulatory compliance. The resulting blend provides Crinipan® PO Plus, a valuable tool for manufacturers looking to deliver effective anti-dandruff products addressing the multifaceted etiology of this common scalp condition. Future research should focus on evaluating the long-term efficacy, as well as exploring its potential in combination with other anti-dandruff agents.

6. References

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