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Advanced Metal-Soap Powder for Makeup Applications "Achieving a Viable Alternative to Talc"

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1. Introduction

In makeup products, powder ingredients significantly impact both the texture and functionality of the product. Common powder components include extender pigments, white pigments, colored pigments, and pearlescent pigments (pearl agents), each blended according to their purpose and formulation [1].

Traditionally, talc of mineral origin has been primarily used as an extender pigment. Talc is essential in pressed foundations and eyeshadows due to its excellent moldability, moderate covering power, and smooth texture [1,2]. However, concerns over asbestos contamination in talc and the tightening of environmental regulations have driven the need for alternative materials [3].

In particular, some manufacturers in Europe have declared that they do not use talc, leading to an increased demand for substitute raw materials. Despite this demand, no effective alternative has yet emerged. Furthermore, as the demand for "Natural origin index" increases in recent years, there is growing interest in alternative ingredients that are not only safe and environmentally friendly but also naturally derived [4,5].

Requirements for talc substitutes include the ability to replicate talc's unique moldability, moderate coverage, and smooth feel. Additionally, they must comply with regulations in various countries, have low environmental impact, and be highly safe [1,2].

Currently, synthetic mica is considered a talc substitute; however, it has the drawback of a low natural origin index. Similarly, mica and sericite are also cited as alternatives, but they face challenges such as low moldability when used in pressed powders. Other ingredients like barium sulfate and metallic soaps offer high moldability but may cause caking or result in excessively hard formulations when blended into pressed powders [6].

The shortcomings of these powders as talc alternatives are thought to stem from differences in shape and particle size. This study focuses on metallic soaps, whose shape and particle size can be controlled by adjusting reaction conditions.

Metallic soaps used in cosmetics are generally produced by a double decomposition method, which forms a slurry of metallic soap in an aqueous solution. While this method allows for the production of fine powders with uniform shape and particle size, the degree of control is limited. Therefore, this study attempts to more precisely control particle size and shape by using inorganic crystal nucleating agents [7-9].

As a result, a composite metallic soap powder was successfully developed, exhibiting molding performance, texture, and water repellency equal to or better than talc. Moreover, this material possesses high safety and a high natural origin index, making it a promising candidate for practical application as a talc alternative.

2. Materials and Methods

2-1. Synthesis of Composite metallic soap powders

Composite metallic soap powders containing 20% of various inorganic crystal nucleating agents were synthesized using the double decomposition method.

- Calcium myristate and boron nitride
- Calcium myristate and glass
- Calcium myristate and barium sulfate
- Calcium myristate, barium sulfate and magnesium myristate

2-2. Selection of Core Powder Types for Composite Metallic Soap Powders

The four types of composite metallic soaps synthesized in section 2-1 were evaluated alongside silicone-treated talc, which was used as a positive control.

2-2-1. Selection of Core Powder Types for Composite Metallic Soap Powders: Pressability

The appearance of each powder (10.0 g) was observed after being pressed using a dry press machine.

In addition, the hardness was measured using a durometer (TECLOCK GS-701N TYPE C).

2-2-2. Selection of Core Powder Types for Composite Metallic Soap Powders: Oil Absorption Capacity

A total of 100 g of powder was gradually mixed with small amounts of liquid paraffin using a spatula, and the state of the powder was observed. The oil absorption point was defined as the point at which the powder changed from a crumbling state to a cohesive mass. The amount of oil (g) added at this point was recorded as the oil absorption value (n = 3).

2-2-3. Selection of Core Powder Types for Composite Metallic Soap Powders: Water Repellency

A 0.001 g portion of each powder was evenly applied to a 1 cm × 1.5 cm piece of double-sided adhesive tape.

A 5.0 μL droplet of water was placed on the surface, and the contact angle was measured using a microscope immediately and again after 15 minutes (n = 6).

2-2-4. Selection of Core Powder Types for Composite Metallic Soap Powders: Slipperiness

A 0.005 g portion of each powder was evenly applied to a 2 cm × 5 cm area of artificial leather. Slipperiness and smoothness were evaluated using a friction tester (KES-SE, Kato Tech Co., Ltd.) with artificial leather as the sensor contact surface (n = 3).

2-2-5. Selection of Core Powder Types for Composite Metallic Soap Powders: Sensory Evaluation of Texture and Appearance

The appearance of each powder was visually inspected, and the texture was evaluated manually by fingertip application.

2-2-6. Selection of Core Powder Types for Composite Metallic Soap Powders: Formulation Compatibility Evaluation

A dry press foundation formulation consisting of 90% powder phase and 10% oil phase was used. In the powder phase, silicone-treated talc (18.9%) was replaced with the evaluation powders, and the state during pressing and the surface condition after rubbing were observed. The same location on the puff (4 locations on each side, totaling 8 locations) was used to apply the foundation in the daily routine manner, repeating the action five times for each location.

2-3. Selection of Core Content Ratio

Three powders containing glass flakes, an inorganic crystal nucleating agent, were evaluated, with their content adjusted to 5%, 10% and 20%.

2-3-1. Selection of Core Content Ratio: Oil Absorption Capacity

The test method is identical to 2-2-2.

2-3-2. Selection of Core Content Ratio: Water Repellency

The test method is identical to 2-2-3.

2-3-3. Selection of Core Content Ratio: Slipperiness

The test method is identical to 2-2-4.

2-3-4. Selection of Core Content Ratio: Sensory Evaluation of Texture and Appearance

The test method is identical to 2-2-5.

2-3-5. Selection of Core Content Ratio: Formulation Compatibility Evaluation

The test method is identical to 2-2-6.

2-4. Basic Evaluation of Composite Metallic Soap Powder

The synthesized composite metallic soap was compared with glass flakes, untreated talc (5–8 μm), untreated talc (7–11 μm), alkylsilane-treated talc, and silicone-treated talc.

2-4-1. Basic Evaluation of Composite Metallic Soap Powder: Pressability

The test method is identical to 2-2-1.

2-4-2. Basic Evaluation of Composite Metallic Soap Powder: Oil Absorption Capacity

The test method is identical to 2-2-2.

2-4-3. Basic Evaluation of Composite Metallic Soap Powder: Dispersibility

Additional oil was added beyond the amount used in the oil absorption test, and the point at which the powder began to flow was defined as the *flow point*. Dispersibility was evaluated by the difference between the flow point and the oil absorption point.

2-4-4. Basic Evaluation of Composite Metallic Soap Powder: Water Repellency

The test method is identical to 2-2-3.

2-4-5. Basic Evaluation of Composite Metallic Soap Powder: Slipperiness

The test method is identical to 2-2-4.

2-5. Evaluation of Formulations Containing Composite Metallic Soap Powder

A dry pressed foundation formulation consisting of 92% powder phase and 8% oil phase was used. In the powder phase, 20% of the talc was replaced with the evaluation powders. The condition during pressing, drop strength, and sensory evaluation of texture were assessed.

2-5-1. Evaluation of Formulations Containing Composite Metallic Soap Powder: Drop Strength

A tabletop drop tester (Nanyo Co., Ltd.) was used to evaluate the drop strength of the foundation. The drop height was set at 50 cm, and each sample was dropped. The integrity of the foundation after dropping was assessed (n = 3).

2-5-2. Evaluation of Formulations Containing Composite Metallic Soap Powder: Sensory Evaluation

A sensory evaluation of the texture during use was conducted using the dry press foundation. Six male and female subjects (20s-40s) evaluated the product based on 10 criteria.

3. Results

3-1. Synthesis of Composite metallic soap Powders

The four types of composite metallic soap powders described in Section 2-1 were synthesized.

3-2. Selection of Core Powder Types for Composite Metallic Soap Powders

Among the evaluated types, the composite metallic soap powder containing glass flakes exhibited the most favorable performance in terms of moldability, oil absorption capacity, water repellency, slipperiness, sensory texture, visual appearance, and formulation compatibility (Table 1).

Table 1. Characteristics of composite metallic soap powders

Composite metallic soap powders		Pressability	Oil absorption capacity	Water repellency	Slipperiness	Texture			Appearance (Coverage)	Formulation compatibility evaluation
						Soft	Smooth	Adhesive		
Silicone treated Talc		✓✓	45.6	✓✓	✓	✓✓	✓✓	✓✓	Appropriate	✓
Calcium myristate	Boron nitride	✓✓	59.2	✓	✓✓	✓✓	✓✓	✓✓	Appropriate	✓
	Glass	✓✓	58.8	✓✓	✓✓	✓✓	✓✓	✓✓	Appropriate	✓
	Barium sulfate	✓✓	58.9	✓	✓✓	✓	✓✓	✓✓	High	Poor
	Barium sulfate and Magnesium myristate	✓✓	54.9	✓✓	✓✓	✓	✓✓	✓✓	High	Poor

3-3. Selection of Core Content Ratio

In the evaluations of oil absorption, water repellency, slipperiness, sensory feel, visual appearance, and formulation compatibility, the composite metallic soap powder containing 20% of the inorganic crystal nucleating agent, glass flakes, showed the most favorable results (Table 2).

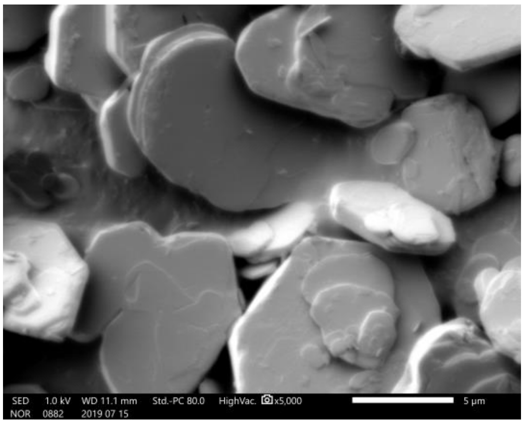
Table 2. Characteristics of composite metallic soap powders of different core content ratios

Composite metallic soap powders		Oil absorption capacity	Water repellency	Slipperiness	Texture	Appearance (Coverage)	Formulation compatibility evaluation	
Calcium myristate	Glass						Texture	Appearance
95%	5%	Low	✓	✓	Adhesive	Transparent	Soft and adhesive	Uneven
90%	10%	Middle	✓	✓	Soft and adhesive	Transparent	Soft and adhesive	Uneven
80%	20%	High	✓	✓	Soft, smooth and adhesive	Appropriate coverage	Soft, smooth and adhesive	Even

3-4. Basic Evaluation of Composite Metallic Soap Powder

The appearance photograph and SEM image of the composite metallic soap powder were examined. The appearance photograph confirmed that the powder is white. The SEM image revealed that the powder consists of plate-like particles, approximately 14 μm in size, with rounded edges (Figure 1). The composite metallic soap powder demonstrated performance comparable to or exceeding that of talc in various parameters, including moldability, water repellency, dispersibility, and slipperiness (Table 3). In particular, the evaluation of slipperiness and smoothness resulted in better performance compared to other powders (Figure 2).

(a)



(b)

Figure 1. Composite metallic soap powder (a) appearance (b) electron micrograph (SEM image)

Table 3. Comparison between composite metallic soap powder and talc

Ingredient	Pressability	Oil absorption capacity	Dispersibility	Water repellency	Slipperiness
Composite metallic soap powder (Calcium myristate, Glass)	✓✓✓	45.6	✓✓✓	✓✓✓	✓✓✓
Glass	✓✓	98.7	✓	Fair	✓✓
Untreated Talc (5-8 μm)	✓✓	56.9	✓✓	Fair	✓
Untreated Talc (7-11 μm)	✓✓	45.3	✓✓	Fair	✓✓
Alkylsilane-treated Talc	✓✓✓	43.0	✓✓	✓✓✓	✓
Silicone-treated Talc	✓✓	38.2	✓✓	✓✓✓	✓✓

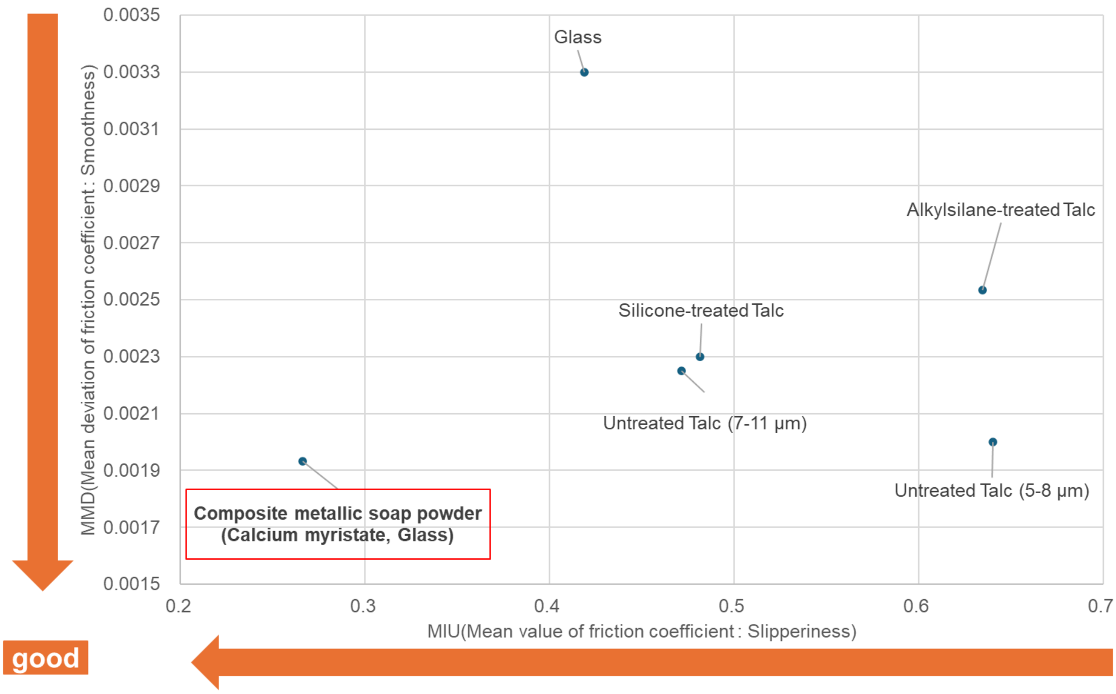


Figure 2. The slipperiness and smoothness of the powders

3-5. Evaluation of Formulations Containing Composite Metallic Soap Powder

In the drop strength test, the Composite Metallic Soap powder demonstrated higher durability than talc. In terms of sensory feel, the powder showed excellent characteristics in various aspects, including a natural finish, a moist texture, moderate pickup, and a subtle glow (Figure 3).

3-5-1. Evaluation of Formulations Containing Composite Metallic Soap Powder: Drop Strength

The foundation containing talc cracked on the third drop, with an average of 2.3 drops before cracking.

In contrast, the foundation containing the Composite Metallic Soap powder cracked on the sixth drop, with an average of 5.7 drops before cracking.

3-5-2. Evaluation of Formulations Containing Composite Metallic Soap Powder: Sensory Evaluation of Texture

The Composite Metallic Soap powder exhibited high adhesion to the skin and a soft, moist feel. The pickup from the cake was moderate, neither excessive nor insufficient, making the foundation easy to spread. It provided a thin, even application with no heavy or powdery appearance, delivering natural coverage. A subtle, natural glow was also observed.

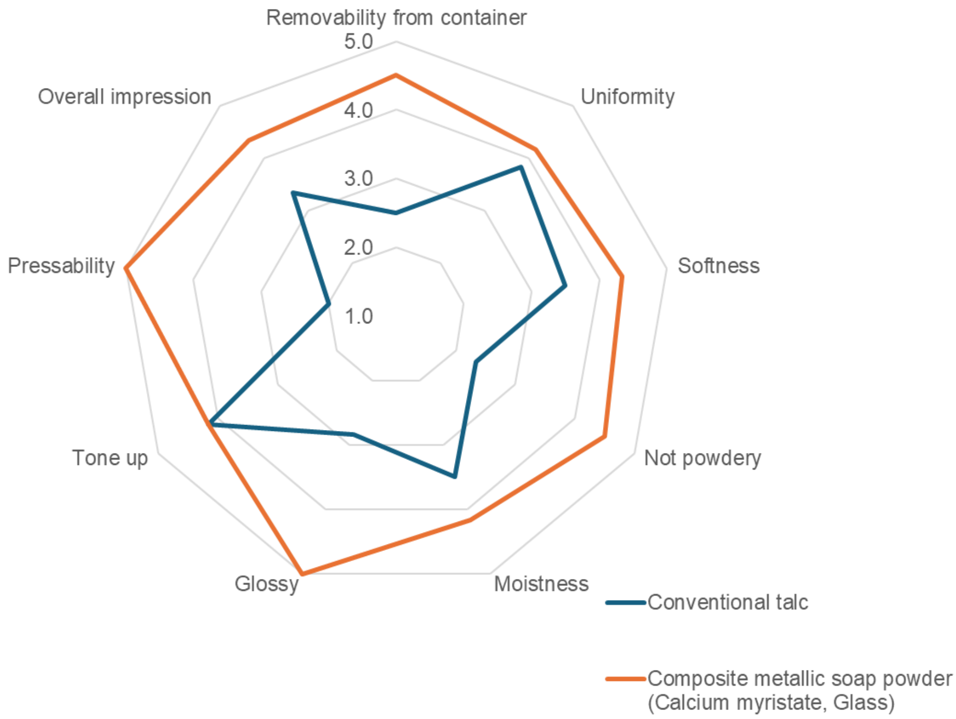


Figure 3. Sensory evaluation of formulations containing composite metallic soap powder and talc

4. Discussion

The composite metallic soap powder developed in this study demonstrated strong potential as alternative powder materials to talc, which has been widely used in conventional formulations. In various evaluations including moldability, water repellency, dispersibility, and slipperiness the composite metallic soap powder exhibited performance comparable to or exceeding that of talc, which is highly significant.

Regarding moldability, conventional metallic soaps have been known to be overly rigid, presenting a challenge for use in pressed formulations. In this study, this issue was addressed by employing a double decomposition method and incorporating inorganic crystal nucleating agents. In particular, the inclusion of glass flakes as a core component effectively suppressed cracking and caking during pressing, resulting in foundations that were more resistant to breakage and better suited for actual use.

In terms of water repellency, the contact angles observed were comparable to those of silicone-treated talc, suggesting that the composite metallic soap powder maintain strong retention against moisture, such as sweat and sebum. This is a critical factor in improving the longevity of cosmetic wear and offers a substantial practical advantage.

Furthermore, the composite metallic soap powder outperformed all comparison powders in evaluations of slipperiness. As slipperiness directly affects the sensory feel during application, it plays a major role in consumer satisfaction. The powders demonstrated high adhesion to the skin, a soft and smooth application sensation, and a natural finish with minimal powderiness characteristics that not only complement but also surpass the strengths of talc, while addressing its known shortcomings.

With regard to dispersibility, the difference between the oil absorption point and the flow point indicated that the composite metallic soap powder possess high affinity with oil agents and exhibit uniform dispersion within formulations. This property significantly influences the texture and finish of cosmetic products and broadens the application potential of the powders.

In addition, the fact that the composite metallic soap powder have a natural origin index of 1.0 is highly relevant in the context of clean beauty and sustainability-oriented product development. As consumer awareness of safety and environmental impact continues to grow, the use of naturally derived, high-safety ingredients serves as a significant advantage in enhancing product appeal.

Moreover, the findings suggest the potential for adjusting the shape and particle size of the powders, paving the way for further developments such as larger particle variants or the incorporation of different inorganic core materials to enhance functionality. For example, powders with enhanced light-diffusing properties or those with added sebum absorption capability could be developed, leading to even more advanced cosmetic ingredients.

In this way, the present study not only contributes to the development of talc alternatives, but also provides a new direction for future research into powder materials, from the perspective of creating safer and higher-performance cosmetic ingredients.

5. Conclusion

In this study, novel composite metallic soap powder (Advanced Metal-Soap Powder) was developed by using a double decomposition method and incorporating inorganic crystal nucleating agents. The resulting composite metallic soap powder exhibited excellent moldability, water repellency, dispersibility, and slipperiness, comparable to or exceeding that of talc, indicating their high practical applicability in cosmetics.

By controlling the particle shape and size through this method, we have developed viable alternatives to talc, with potential applications in sustainable products. This technique also opens the possibility of creating powders with new particle morphologies and sizes, which could replace materials like mica and microplastic beads, addressing both environmental and regulatory concerns. Additionally, the powders show potential for use in products with different pigment properties, expanding the flexibility in cosmetic formulations.

The high natural origin index of the developed powders highlights their suitability for clean beauty and sustainability-focused product lines. These characteristics position the material as a safe and functional alternative to talc, offering significant value in the development of future makeup products.

This study provides an innovative solution for the cosmetics industry and contributes to the advancement of next-generation powder materials.

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