# Development of novel cosmetic formulation using spherical cellulose beads, “feeling like using silicone elastomer beads”

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**Abstract**

Microplastic beads such as silicone elastomer beads, polyurethane beads and polymethyl methacrylate have been facing a major social problem in the environment, especially in marine. There is the movement to prohibit to formulate microplastic beads in all cosmetic applications. Therefore, the development of cosmetic formulations without microplastic beads is inevitable. In this study, we have developed novel cosmetic formulation by combining spherical cellulose beads and synthetic mica, which shows silicone elastomer beads-like moist and smooth feel without microplastic beads.

**Keywords**

Cosmetic formulations, Microplastics alternative, Biodegradable, Cellulose, Surface treatment

## 1. Introduction

Spherical cellulose beads[1),2),3)] will be the one of the best candidate alternating microplastics beads, since it is the degradable product in the nature (under the regulation of OECD 301F and ASTM D6691 for the biodegradability in marine).

In recent year, silicone elastomer beads have been widely used in cosmetics application, liquid and powder foundations[4),5)]. This product can give very good moist and smooth feeling in application. However, this product, silicone elastomer beads, is the microplastics, so that it is inevitable to find the alternative product. Although spherical cellulose beads have almost same shape as silicone elastomer beads, it shows different characteristics compared with silicone elastomer beads, such as harder mechanical property and less creamier nor smoother feeling.

In this study, we evaluated the texture of liquid and powder foundation by human sense, and we developed novel cosmetic formulation feeling like using silicone elastomer beads. The formulation using metal soap surface treated cellulose beads and synthetic mica shows the almost same moist and smooth feel using silicone elastomer beads.

## 2. Materials

Spherical cellulose beads (INCI Name: Cellulose) and synthetic mica (INCI Name: Synthetic fluorophlogopite) were evaluated in w/o liquid foundation and powder foundation formulations. As a comparison, silicone elastomer beads (INCI Name: Vinyl dimethicone/methicone silsesquioxane crosspolymer) and spherical silica beads (INCI Name: silica) were evaluated with spherical cellulose beads.

### 2.1. Spherical cellulose beads

The particle size of cellulose beads is 5-15μm, and we have used non treated powder itself and metal soap surface treated one in comparison.

### 2.2. Synthetic mica

The particle size of synthetic mica is 5-20μm, and we have used non treated powder itself and metal soap treated one in comparison.

### 2.3. Surface treated pigments

Spherical cellulose beads and synthetic mica were treated with metal soap (MS). MS treated pigments show water repellency and superior dispersibility in oil. In this study, MS treated pigments contribute to the development of a similar moist and smooth feel using silicone elastomer beads. In case of liquid foundation, titanium dioxide and iron oxides were treated with polyglyceryl-2 tetraisostearate (P2T). P2T treated pigments show excellent dispersibility in various oil, and it allows to skip premix process for saving manufacturing time. Pigments treated with MS and P2T were obtained from Daito Kasei Kogyo Co., Ltd.

## 3. Evaluation in cosmetic applications

The cosmetic evaluation was carried out with w/o liquid foundation and powder foundation. When we changed silicone elastomer beads into spherical cellulose beads in the ordinal formulations, the moist and smooth feelings are not enough satisfied same as that with silicone elastomer beads. Therefore, we have developed novel formulations adding with synthetic mica in the formulations using spherical cellulose beads. In this study, the texture was evaluated by human sense.

## 4. Result

### 4-1. Biodegradability of spherical cellulose beads

In our ordinal formulations, liquid foundation and powder foundation, the addition of silicone elastomer beads usually gives the good characteristics, such as moist and smooth feeling. Because of the microplastics concern, silicone elastomer beads should be alternated into biodegradable beads. Spherical cellulose beads must be the best candidate from silicone elastomer beads.

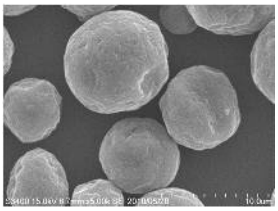
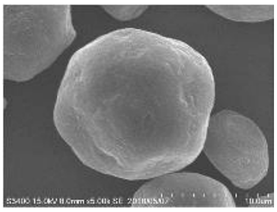
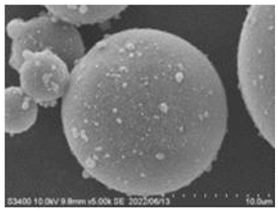
**Biodegradability**

The biodegradability of the cellulose beads was made evaluation by the methods of Organization for Economic Co-operation and Development (OECD) 301F and American Society of Testing Materials (ASTM) D6691. According to OECD 301F, the degree of biodegradation should be over 60% after 28 days for biodegradable substance. The degree of biodegradation of the cellulose beads in this study was 68% after 28 days surpassing the threshold by 7%. ASTM D6691 is the method for measuring biodegradability in seawater. Biodegradable substances should degrade over 90% after 6 months. Cellulose beads showed a very high biodegradability, which was 93% after 28 days and surpassed the threshold by 3.6% in just 1 month. From these results, the spherical cellulose beads will be biodegradable polymers.

### 4-2. Evaluation results of spherical cellulose beads

In Table-1, the characteristics of several spherical cellulose beads and slicone elastomer beads are summarized.

Table-1 Comparison of spherical cellulose beads and silicone elastomer beads

| | **Cellulose beads -5** | **Cellulose beads -10** | **Silicone elastomer beads** |
|---|---|---|---|
| Particle size (μm) | 8 ～ 10 | 12 ～ 15 | 12 |
| Total transmission Td (%) | 0.59 | 0.71 | 1.40 |
| Haze index H (%) | 53.1 | 33.1 | 1.40 |
| Surface area (m2/g) | 1.30 | 1.80 | 1.35 |
| Oil absorption (ml/100g, oleic acid) | 47.7 | 42.6 | 49.0 |
| SEM image (X5000) |  |  |  |

**Hardness**

A micro compression tester was used for hardness evaluation. Table-2 shows the result of required compressive force to deform 10%. 2.5mN was required to make 10% of the silicone elastomer beads deformed. On the other hand, 3-6 mN was required to make 10% of the cellulose beads deformed. For Silica beads, 119 mN was required. The results show that spherical cellulose beads are much softer than spherical silica beads. This effect contributes to a moist and smooth feel on the skin.

Table-2 Compressive force required to deform particles by 10%.

| | Compression force | Calculation Compression ratio | Shape | Particle size | Collapse |
|---|---|---|---|---|---|
| | P (mN) | (%) | | (µm) | |
| **Cellulose beads-5** | 3.09 | 10 | spherical | 8~10 | No |
| **Cellulose beads-10** | 5.74 | 10 | spherical | 12~15 | No |
| **Silica beads** | 119.6 | 10 | spherical | 10 | Broken |
| **Porous silica beads** | 1.29 (*) | 10 | Porous sphere | 5 | Broken |
| **Silicone elastomer beads** | 2.5 | 10 | Spherical | 12 | No |

(*) : Porous silica beads broke immediately.

**4-3. W/O liquid foundation**

The evaluated compositions of w/o liquid foundation are shown in Table-3. The main oil in liquid foundation is natural origin C9-12 alkane. The 4 proposing liquid foundations without silicon elastomer beads, (Trial 1L; with surface treated cellulose beads (in this formulation, we have tried 2 types of diameter of cellulose beads, 5 and 10 $\mu$ ), Trial 2L; with non-treated cellulose beads, Trial 3L; with silica beads), were prepared with 4% of spherical beads and 10% of synthetic mica, on the other hand The Ordinal L using silicon elastomer beads (formulating 8%) was prepared. The textures by human sense were evaluated (Fig.-1). Furthermore, by using cellulose beads, Trial 1L shows better moist and smooth feeling than Trial 2L. According to the result of Trail 1L, the smaller size of spherical cellulose beads shows better moist than the bigger one. The bigger one shows good balance of moist and smooth feel. Trail 3L shows less moist and smooth feel than Trial 1L or Trial 2L. The moistness and smoothness of Trail 3L was insufficient to reach The Ordinal L. Therefore, Trial 1L shows similar moist and smooth feeling as The Ordinal L.

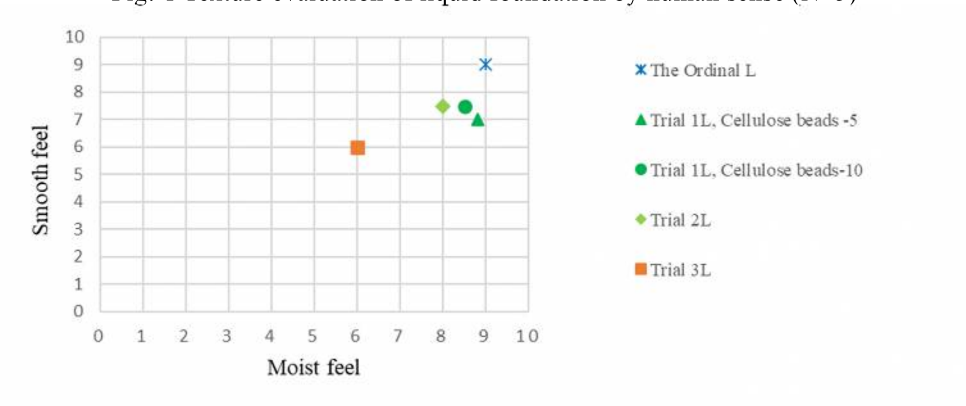
In case of liquid foundation, it is better to use P2T treated titanium dioxide and iron oxides to increase the dispersibility in oil. P2T is natural origin, and the surface treated pigments show superior dispersibility in various oil and allow to skip premix process for saving manufacturing time.

Table-3 Composition of liquid foundation

| | **The Ordinal L** | **Trial 1L** | **Trial 2L** | **Trial 3L** |
|---|---|---|---|---|
| Beads | Silicone elastomer beads | Cellulose bead -5/-10 | Cellulose beads-10 | Silica beads |
| Surface treatment of beads | None | MS*1 | None | None |
| Oil phase | 28.9% | 29.4% | 29.4% | 29.4% |
| Surface treated*1 synthetic mica | - | 10.0% | 10.0% | 10.0% |
| Various Beads | 8.0% | 4.0% | 4.0% | 4.0% |
| Surface treated*2 color pigments | 10.0% | 10.0% | 10.0% | 10.0% |
| Water phase | 53.1% | 46.6% | 46.6% | 46.6% |
| Total | 100.0% | 100.0% | 100.0% | 100.0% |

*1 MS treated pigments: Cellulose beads-5, Cellulose beads-10 and synthetic mica
*2 P2T treated pigments: Titanium dioxide and iron oxides

Fig.-1 Texture evaluation of liquid foundation by human sense (N=5)




**4-4. Powder foundation**

The evaluated compositions of powder foundation are shown in Table-4. For all compositions 7% of spherical beads materials are used. And for the proposing 3 trials 10% of surface treated synthetic mica is formulated. The textures by human sense were evaluated (Fig.-2). Furthermore, Trial 1P shows better moist and smooth feeling than Trail 2P, and it shows almost same texture as The Ordinal P. According to the result of Trial 3P, the moistness and smoothness were insufficient. In case of powder foundation, it should be better to use paste-like oil binders, such as vegetable (olus) oil, petrolatum or butyrospermum parkii (shea) butter in the formulation to obtain the similar feeling using silicone elastomer beads. Therefore, Trial 1P shows similar moist and smooth feeling as The Ordinal P.

The compact stability was evaluated with drop test from 50cm, 3 times (Table-5). Trial 1P and Trail 2P passed drop test without any crack. However, The Ordinal P and Trial 3P showed some crack. Therefore, spherical cellulose beads showed excellent compact stability against drop test.

Table-4 Composition of powder foundation

| | The Ordinal P | Trial 1P | Trial 2P | Trial 3P |
|---|---|---|---|---|
| Beads | Silicone elastomer beads | Cellulose beads-10 | Cellulose beads-10 | Silica beads |
| Surface treatment of beads | None | MS[*1] | None | None |
| (Powder phase) | | | | |
| Color Powder | 93.00 | 83.00 | 83.00 | 83.00 |
| Various beads | 7.00 | 7.00 | 7.00 | 7.00 |
| Surface treated[*1] synthetic mica | - | 10.00 | 10.00 | 10.00 |
| Total of powder compound | 100.00 | 100.00 | 100.00 | 100.00 |
| (Final compound) | | | | |
| Powder phase | 95.00 | 95.00 | 95.00 | 95.00 |
| Olive squalene | 5.00 | - | - | - |
| Vegetable (olus) oil | - | 5.00 | 5.00 | 5.00 |
| Total of final compound | 100.00 | 100.00 | 100.00 | 100.00 |

*[1] MS treated pigments: Cellulose beads-10 and synthetic mica

Fig.-2 Texture evaluation of powder foundation by human sense (N=5)

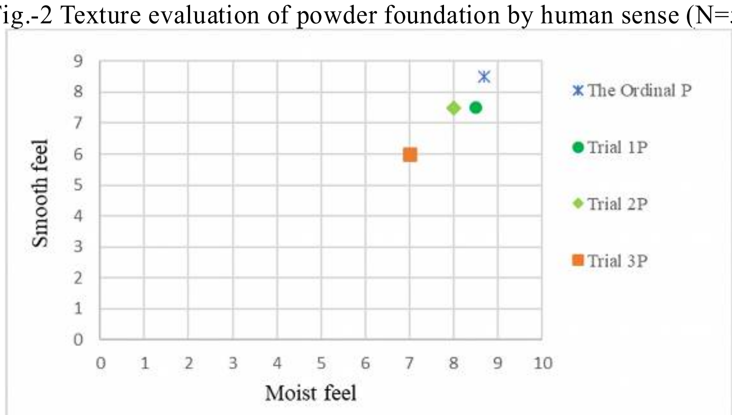



Table-5 Compact stability of powder foundation

| | The Ordinal P | Trial 1P | Trial 2P | Trial 3P |
|---|---|---|---|---|
| Drop test result of powder foundation (50cm X 3 times) |  |  |  |  |

**5. Conclusion**

By the combination of spherical cellulose beads and synthetic mica, liquid and powder foundations showing silicone elastomer beads-like moist and smooth feel could be prepared. Furthermore, by using MS treated spherical cellulose beads and synthetic mica instead of non-treated ones, which showed much better moist and smooth feeling almost same as using silicone elastomer beads. In case of powder foundation, that with spherical cellulose beads showed excellent compact stability against drop test.

Changing silicone elastomer beads into spherical cellulose beads, we are able to solve microplastics issue and obtain the same characteristics as utilizing silicone elastomer beads with the technique of novel cosmetic formulations with combination of the other ingredients.

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