

Preparation of Liquid Foundation Using Magnesium Myristate

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Synopsis

This study aimed to investigate the effect of magnesium myristate as a multifunctional excipient in the formulation of cosmetic liquid foundation and aimed to compare it with liquid foundations that use the conventional excipients. The formulation was evaluated for different parameters such as organoleptic, pH, viscosity, spreadability, adhesivity, hedonic test, storage stability at room temperature, and determination of sun protection factor (SPF) value using ultraviolet (UV)-visible spectrophotometry. The results confirmed that the liquid foundation formulated using magnesium myristate showed better results and stability because there was no change in its physical appearance, pH, and spreadability in comparison to the liquid foundation formulated using conventional excipients. The liquid foundation formulated using magnesium myristate recorded a moderate SPF value (11.02), which can be practical for daily use, especially in individuals with tanned skin. Therefore, we concluded that magnesium myristate contributed as an emulsifier, opacifier, viscosity controller, and smoothening agent with good spreadability, coverage, texture, and better UV protection in comparison to the mixture of different conventional excipients.

INTRODUCTION

The desire to look our best is of high importance in society. Over the recent years, the cosmetics sector has experienced remarkable advancements and holds immense growth opportunities.¹ This unprecedented growth in the industry is fueled by a substantial desire for customized and cutting-edge products based on increasingly detailed scientific knowledge.²

Skincare cosmetics are the most widely used cosmetics, and are primarily used for protection, cleansing, and skin balance.³ One type of skincare cosmetic is liquid foundation. Liquid foundations are a color cosmetic that impact a smooth finish when applied to the skin, masking minor imperfections and evening out skin tones.⁴ It should be blendable, have

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adequate play time, should not be greasy or occlusive to the skin, should feel comfortable to the customer, and should not sink into facial lines.⁵ Foundations are emulsion-based formulations containing pigments, dispersants, emulsifiers, and preservatives, and are applied to the skin either by hand or with the aid of a sponge or brush. Formulation of liquid foundation is complex and difficult, and requires the right ingredients in correct proportions to gain these characteristics.

Cosmetic formulation combines science and art in response to the unmet needs of consumers. Raw materials are tools for creating formulation options and contribute to tactile sensory, stability, and efficaciousness of the formulation. There are many cosmetic ingredients with multiple functions that provide benefits to meet consumer demands.⁶

Magnesium myristate is a multifunctional excipient used as a binder, adherent, dispersant, and emollient.⁷ In this study, an attempt was made to formulate cosmetic liquid foundation using magnesium myristate. Its functionality in the formulation was also investigated by utilizing D-optimal design using Design-Expert® software (Stat-Ease, Inc., Minnesota, USA) to optimize the formulation.

MATERIALS

Magnesium myristate (new excipient) was obtained as a gift sample from Koel Colours Private Limited, Mumbai, India. Dimethicone, propylene glycol monostearate, iron oxides, and titanium dioxide were also obtained as a gift sample from Koel Colours Private Limited. All other excipients used were of analytical grade.

METHODS

PREFORMULATION STUDIES OF MAGNESIUM MYRISTATE POWDER

Bulk density. Bulk density was measured by transferring the weighed amount of powder into a measuring cylinder and the volume was noted. Average values of triplicates were noted and expressed in g/mL.

$$\text{Bulk density} = \frac{\text{Weight of powder}}{\text{Bulk volume}} \quad (\text{eq. 1})$$

Tapped density. Tapped density was measured by transferring the weighed amount of powder into a 100 mL measuring cylinder. The volume was noted by tapping the powder to a constant volume. Average values of triplicates were noted and expressed in g/mL.⁸

$$\text{Tapped density} = \frac{\text{Weight of powder}}{\text{Tapped volume}} \quad (\text{eq. 2})$$

Carr's index and Hauser's index. The flowability of powder was determined by substituting bulk density and tapped density in eq. 3 to calculate Carr's compressibility index (CI) and in eq. 4 to calculate Hausner ratio.⁹

$$\% \text{ compressibility} = \frac{(\text{Tapped density} - \text{bulk density})}{\text{Tapped density}} \times 100 \quad (\text{eq. 3})$$

$$\text{Hausner's} = \frac{\text{Tapped density}}{\text{Bulk density}} \quad (\text{eq. 4})$$

Angle of repose. Angle of repose is the maximum angle formed by the surface of pile of powder and the horizontal plane. It was determined by the funnel method. Weighed powder was poured into a funnel fixed on a stand with the tip of the funnel closed. The powder formed a heap on the surface when allowed to flow freely. The diameter of the heap was noted when the tip of the funnel touched the tip of the pile formed. Noted values were substituted in eq. 5 to calculate angle of repose.¹⁰

$$\Theta = \tan^{-1}h/r \quad (\text{eq. 5})$$

Where, h = height of the pile, and r = radius of the pile.

Loss on drying. A calibrated rapid infrared moisture analyzer (METTLER TOLEDO GmbH, Giessen, Germany) was used to precisely assess the moisture content of the powder sample. 1 g of powder sample was placed into the disk and the dial reading was noted for its final weight. Noted values were substituted in eq. 6 to calculate moisture content.¹¹

$$\text{Moisture content} = \frac{(\text{Initial wt} - \text{Final wt})}{\text{Initial wt}} \times 100 \quad (\text{eq. 6})$$

PREPARATION OF LIQUID FOUNDATION

The liquid foundation was prepared in two steps. Initially, the oil phase was prepared by melting stearic acid, propylene glycol monostearate, dimethicone, cetyl alcohol, liquid paraffin, and cosmetic pigments (iron oxide and titanium dioxide) on a water bath at 70°C. The aqueous phase was prepared by dissolving tween 80, methyl paraben, and xanthan gum in distilled water heated at 70°C, followed by the addition of propylene glycol. The oil phase was transferred into the aqueous phase with continuous stirring using a homogenizer at 1,500 rpm for 30 minutes.¹²

EXPERIMENTAL DESIGN

OPTIMIZATION OF LIQUID FOUNDATION USING CONVENTIONAL EXCIPIENTS

Design-Expert® software (13.0.11.0 version, Stat-Ease, Inc., Minnesota, USA) was used to develop three factors and a two level (2³) design, generating eight experimental runs.¹³ The factor interaction between the variables was assessed using response surface graphs. The concentration of three independent variables used was stearic acid (X1), propylene glycol monostearate (X2), and dimethicone (X3). The dependent variables were viscosity (Y1) and

Table I
2³ Factorial Design of Liquid Foundation Using Conventional Excipients

Independent variables	Levels		Responses (Dependent variables)
	Low (-)	High (+)	
X1: Stearic acid (% w/w)	2	3	Y1: Viscosity
X2: PGM (% w/w)	1	2	Y2: Spreadability
X3: Dimethicone (% w/w)	5	7	

spreadability (Y2). The obtained data from Table I was used to predict desirability values, and a response surface analysis was performed.

OPTIMIZATION OF LIQUID FOUNDATION USING MAGNESIUM MYRISTATE

A 3² factorial design was applied (total nine experimental runs) using Design-Expert® software (13.0.11.0 version, Stat-Ease, Inc., Minnesota, USA). The independent variables investigated were magnesium myristate (X1) and liquid paraffin (X2), and the dependent variables were viscosity (Y1) and spreadability (Y2). The obtained data from Table II was used to predict desirability values, and a response surface analysis was performed.

QUANTITATIVE ASSESSMENT OF RESPONSES FOR VARIABLES.

Viscosity. Viscosity of the formulated product was determined using a Brookfield viscometer (AMETEK Brookfield, Massachusetts, USA) with spindle number 1 at room temperature set at 100 rpm. A dial reading in cps was noted for triplicate samples.¹⁴

Spreadability. The glass slide method was used to assess the spreadability of the liquid foundation (in triplicates). A 1 cm diameter circle was drawn in the center of the glass slide into which 0.5 g of sample was placed. A sandwich configuration was formed by placing another glass slide over the liquid foundation. The upper plate was loaded with a 25 g weight for 10 seconds and the increase in diameter was measured. The noted values were substituted in eq. 7 to calculate spreadability.¹⁵

$$S = \frac{\text{Mass} \times \text{Length}}{\text{Time}} \quad (\text{eq. 7})$$

PREPARATION OF OPTIMIZED BATCH

Values for calculating sun protection factor (SPF) are shown in Table III. Using optimized concentration as tabulated in Table IV and Table V, final products F1& F7 were prepared and evaluated.

Table II
3² Factorial Designs of Liquid Foundation Using Magnesium Myristate

Independent variables	Levels			Responses (Dependent variables)
	Low (-)	Medium (0)	High (+)	
X1: Magnesium Myristate (% w/w)	1	2	3	Y1: Viscosity
X2: Liquid paraffin (% w/w)	5	6	7	Y2: Spreadability

Organoleptic test. The external attributes of the formulated product were assessed for its color, odor, texture, and homogeneity by physical visualization.¹⁶

pH. pH was measured (in triplicate) by dissolving an aliquot of formulation in distilled water (10% w/v).¹⁷

Adhesivity test. The adhesivity was measured using a round-scale glass.¹⁸ The retention time of the product on the glass slide was noted in seconds for triplicate samples.

Hedonic test. The hedonic test was used to determine the acceptability and quality of formulated liquid foundation. Humans subjectively rate the quality of a product in hedonic tests. As a result, panelists were obligated to provide honest feedback on the product's performance.¹⁹

Determination of SPF value. The SPF value was determined using an ultraviolet (UV)-visible spectrophotometer to assess the effectiveness of sun protection. One gram of formulated foundation was diluted with ethanol to obtain a homogeneous mixture and was then vigorously agitated to dissolve the components of the liquid foundation. The mixture was centrifuged at 3,000 rpm for 15 minutes to separate the phases, and the supernatant (top phase) was collected. The absorbance was measured at wavelengths ranging from 290–320 nm with an interval of 5 nm. The readings were substituted in eq. 8 to calculate SPF value of liquid foundation.²⁰

$$\text{SPF} = \text{CF} \times \sum_{320}^{290} \text{EE}(\lambda) \times \text{I}(\lambda) \times \text{abs}(\lambda) \quad (\text{eq. 8})$$

Where: CF = correction factor (10), EE(λ) = erythemogenic effect radiation wavelength, I (λ) = intensity of the sunlight at a given wavelength, and abs(λ) = absorbance of the solution formulation containing liquid foundation at a given wavelength (λ).

SHORT-TERM STABILITY STUDIES

According to the stability guidelines, the physical and chemical stability of the formulations were assessed. A plastic container was used to hold the samples. The prepared optimized

Table III
Standard Values of EE(λ), I (λ) Used to Calculate SPF

Wavelength (nm)	EE(λ), I (λ)
290	0.0150
295	0.0817
300	0.2874
305	0.3278
310	0.1864
315	0.0837
320	0.0180
Total	1

Table IV
Composition of Liquid Foundation Using Conventional Excipient (25% w/w)

Ingredients (% w/w)	F1	F2	F3	F4	F5	F6	F7	F8
Stearic acid	0.5	0.5	0.75	0.75	0.5	0.75	0.5	0.75
Propylene glycol monostearate	0.25	0.25	0.25	0.25	0.5	0.5	0.5	0.5
Dimethicone	1.25	1.75	1.75	1.25	1.25	1.25	1.75	1.75
Cetyl alcohol	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21
Liquid paraffin	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21
Iron oxides	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Titanium dioxides	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Tween 80	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10
Methyl paraben	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Propylene glycol	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51
Xanthan gum	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Distilled water	16.63	16.13	15.88	16.38	16.38	16.13	15.88	15.63

samples were exposed at room temperature for 3 months. During this time, organoleptic properties, pH, viscosity, and spreadability were assessed. All measurements were taken at 0, 15, 30, 60, and 90 days.²¹

RESULTS AND DISCUSSION

PREFORMULATION STUDIES OF MAGNESIUM MYRISTATE POWDER

The determined bulk density, tapped density, Carr's index, Hausner's ratio, and angle of repose all showed excellent flow properties in accordance with IP.⁸ Loss on drying was found to be $0.019 \pm 0.0002\%$, confirming less moisture content. The results have been tabulated in Table VI.¹²

QUANTITATIVE ASSESSMENT OF RESPONSES FOR VARIABLES.

Liquid foundation using conventional excipients and magnesium myristate was prepared as per Table IV and V and was assessed for viscosity and spreadability.

Viscosity. Viscosity was determined to assess the flowability of the formulated product. An excellent topical formulation has a viscosity of 2,000–50,000 cps.¹⁴ Liquid foundation using

Table V
Composition of Liquid Foundation Using Magnesium Myristate (25% w/w)

Ingredients (% w/w)	F1	F2	F3	F4	F5	F6	F7	F8	F9
Magnesium myristate	0.625	0.625	0.25	1.25	1.25	0.625	0.25	0.25	1.25
Liquid paraffin	1.75	1.25	1.75	1.25	1.75	1.5	1.25	1.5	1.5
Cetyl alcohol	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21
Iron oxides	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Titanium dioxides	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Tween 80	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10
Methyl paraben	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Propylene glycol	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51	1.51
Xanthan gum	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Distilled water	17.40	17.96	17.84	17.34	16.84	17.71	18.34	18.09	17.09

Table VI
Preformulation Parameters of Magnesium Myristate Powder

Parameters	Result	Flow property
Bulk density (g/ml)	0.436 ± 0.011	Excellent Flow
Tapped density (g/ml)	0.573 ± 0.025	
Carr's index (%)	10.88 ± 2.671	
Hausner ratio	1.13 ± 0.036	
Angle of repose ($^{\circ}$)	$24.204^{\circ} \pm 1.645$	
Loss on drying (%)	0.019 ± 0.000	

conventional excipients showed viscosity in the range from $2,608 \pm 6.50$ to $2,880 \pm 23.06$ cps, while liquid foundation using magnesium myristate showed viscosity in the range from $2,618 \pm 6.55$ to $3,304 \pm 15.04$ cps. The results have been depicted in Figure 1.

Spreadability. The spreadability of the formulated product was determined to assess if it spreads well when applied to the skin. Good topical preparation has a spreadability of 7–31 gm.cm./sec. The spreadability of liquid foundation using conventional excipients was found from 6.33 ± 0.14 to 7.12 ± 0.12 gm.cm./sec, while the spreadability of liquid foundation using magnesium myristate was found in the range from 6.41 ± 0.144 to 8.18 ± 0.288 gm.cm./sec. The results have been depicted in Figure 2.

OPTIMIZATION OF LIQUID FOUNDATION USING CONVENTIONAL EXCIPIENTS

Design-Expert® software (Stat-Ease, Inc., Minnesota, USA) projected a total eight experimental runs from the 2^3 factorial design for the three components: stearic acid (X1),

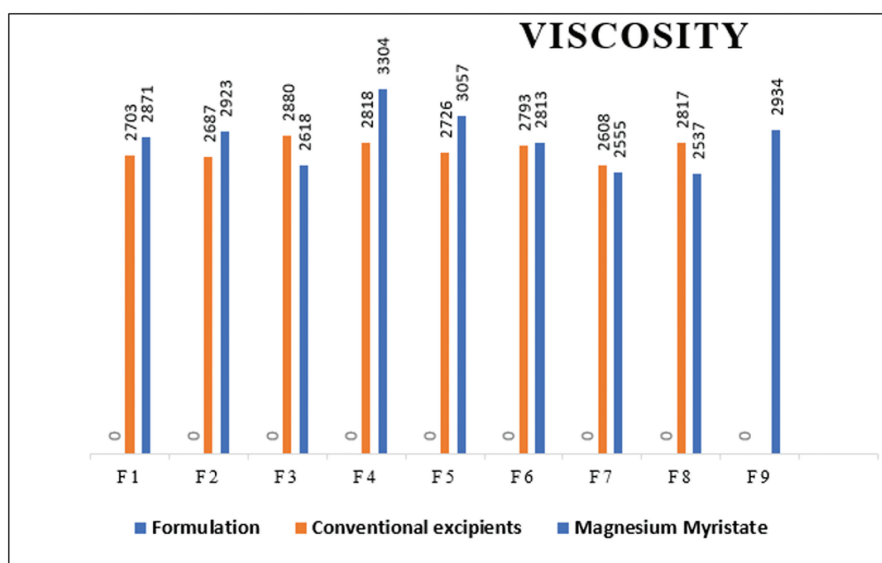


Figure 1. Viscosity of liquid foundation using magnesium myristate and conventional excipients.

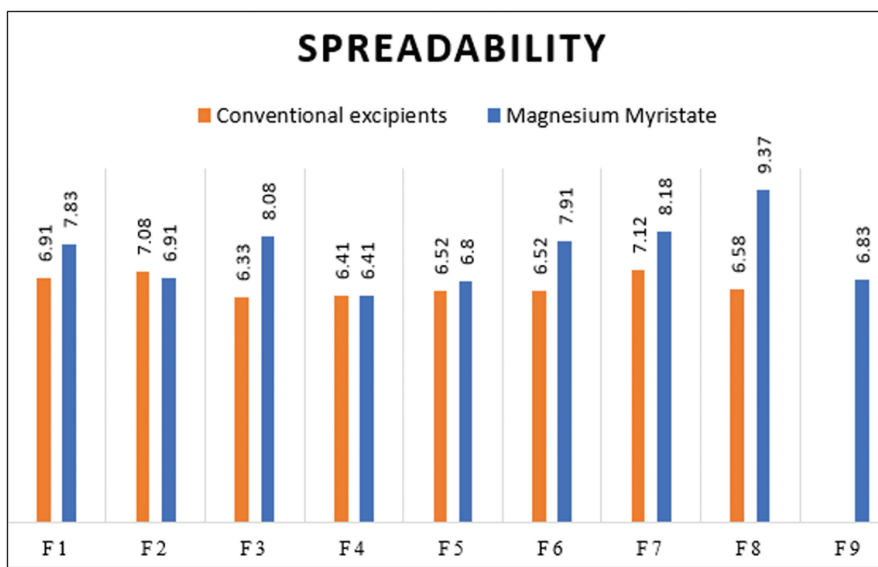


Figure 2. Spreadability of liquid foundation using magnesium myristate and conventional excipient.

PGM (X2), and dimethicone (X3), which were modified at three distinct levels (coded as -1, 0, and 1). The response parameters of viscosity (Y1) and spreadability (Y2) were examined. ANOVA was used to estimate the quantitative effects of the variables. Data analysis produced a quadratic model. Model terms are considered significant when $p < 0.05$. The residual equations in terms of coded factors for two dependent variables are shown below.

For dependent variable 1 (viscosity):

$$\text{Viscosity} = 2,754.00 + 73.00 \times A - 18.00 \times B \quad (\text{eq. 9})$$

For dependent variable 2 (spreadability):

$$\text{Spreadability} = 6.68 - 0.2238 \times A + 0.0937 \times C \quad (\text{eq. 10})$$

The relevant factors were identified as stearic acid concentration (X1), PGM concentration (X2), and dimethicone (X3), all of which had a synergistic influence on the response Y1 and Y2 with p values of 0.0124 and 0.0452, respectively.

The response surface graph (Figure 3A) indicates an increase in viscosity with an increase in the concentration of both stearic acid and propylene glycol monostearate. Figure 3B indicates an increase in spreadability with an increase in the concentration of dimethicone and a decrease in the concentration of stearic acid.

The ideal values for the responses were determined using numerical analysis based on the desirability criterion. The optimal stearic acid, PGM, and dimethicone concentrations have been found to be 2.01%, 2.24%, and 6%, respectively.

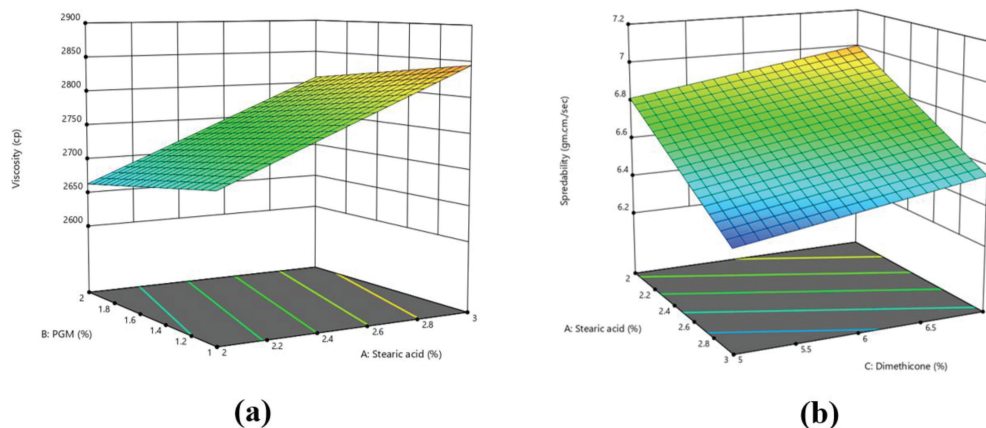


Figure 3. 3D surface plot showed the effects of concentration of stearic acid, propylene glycol monostearate and dimethicone on (A) viscosity and (B) spreadability.

OPTIMIZATION OF LIQUID FOUNDATION USING MAGNESIUM MYRISTATE

The 3^2 factorial design for the two ingredients magnesium myristate (X1) and Liquid paraffin (X2) which were adjusted at three different levels (coded as -1, 0, and 1), projected a total of nine trial runs. The response parameters of viscosity (Y1) and spreadability (Y2) were investigated in this work (Table VII and Table VIII). The residual equations in terms of coded factors for two dependent variables are shown below.

For dependent variable 1 (viscosity):

$$\text{Viscosity} = 2,867.11 + 255.93 \times A - 39.33 \times B$$

For dependent variable 2 (spreadability):

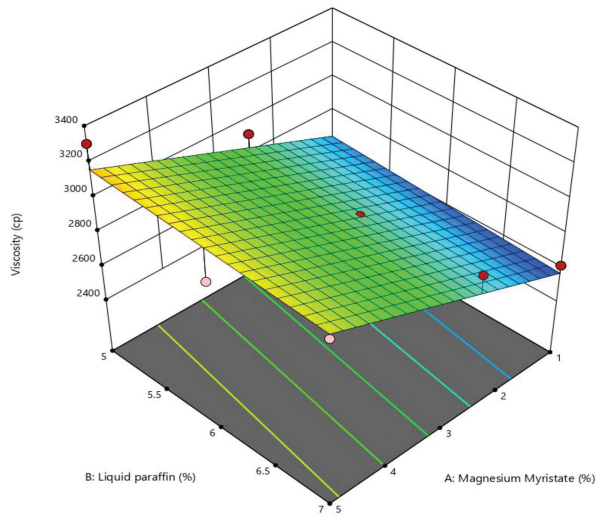
$$\text{Spreadability} = 7.52 - 0.9076 \times A + 0.2017 \times B$$

Table VII
Predicted Responses for 2^3 Factorial Design

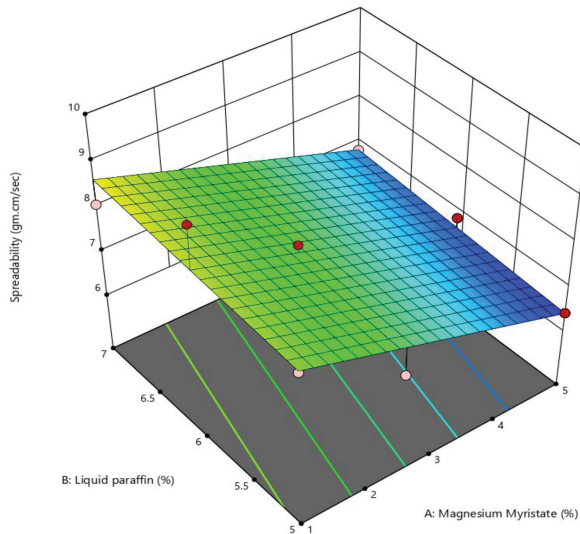
Analysis	Predicted mean	95% CI low for mean	95% CI high for mean	95% TI low for 99% pop	95% TI high for 99% pop
Viscosity (cp)	2,754.123	2,714.512	2,793.423	2,489.312	3,018.641
Spreadability (gm.cm./sec)	6.683	6.514	6.461	5.489	7.878

Table VIII
Predicted Responses for 3^2 Factorial Design

Analysis	Predicted mean	95% CI low for mean	95% CI high for mean	95% TI low for mean	95% TI high for mean
Viscosity (cp)	2,667.110	2,765.942	2,968.251	2,178.032	2,556.183
Spreadability (gm.cm./sec)	7.925	7.081	7.949	5.557	10.473



(A)



(B)

Figure 4. 3D surface plot showing the effects of the concentration of magnesium myristate and liquid paraffin on (A) viscosity and (B) spreadability.

The relevant factors were identified as concentration of magnesium myristate (X1) and Liquid paraffin (X2), all of which had a synergistic influence on the response Y1 and Y2 with p values of 0.0060 and 0.0141, respectively.

The 3D surface plot (Figure 4A) showed an increase in viscosity with decreasing concentrations of both magnesium myristate and liquid paraffin. Figure 4B showed an

increase in spreadability with increasing both concentrations of magnesium myristate and liquid paraffin.

Numerical calculations were used to determine the ideal values for responses based on the desirability criterion. The optimal concentrations of magnesium myristate and liquid paraffin were determined to be 2.130% and 7.00%, respectively.

COMPARATIVE STUDY OF MAGNESIUM MYRISTATE WITH CONVENTIONAL EXCIPIENTS IN THE FORMULATION OF COSMETIC LIQUID FOUNDATION.

Using optimized concentrations as tabulated in Table IV and V, final products F1 and F7 were prepared and evaluated. The formulated liquid foundation using magnesium myristate and conventional excipients appeared to be a brownish-yellow color, odourless, smooth textured, and had a pH in the range of skin. The obtained adhesivity values were as per the requirements (more than four seconds). Liquid foundation containing magnesium myristate exhibited lower viscosity than conventional excipients, which is suitable for topical preparations with good spreadability (Table IX).

SPF VALUE

According to the results obtained, formulated liquid foundation using conventional excipients showed absorption maxima at 295 nm (0.997), whereas liquid foundation using magnesium myristate showed absorption maxima at 305 nm (1.06). Using these λ_{\max} values for both liquid foundations using conventional excipients and magnesium myristate, the SPF value was calculated to be 9.11 and 11.02, respectively (Table X). Therefore, the SPF value of magnesium myristate showed better UV protection than conventional excipients.²⁰

SHORT-TERM STABILITY STUDIES

Stability studies ensure quality, safety, and efficacy criteria for consumer acceptance. No changes in color, odor, and texture were observed during storage. There were very slight alterations in the physical features of the liquid foundation. Those results were tabulated in Table XI and Table XII. After 90 days of incubation, the viscosity was found to be increased with reduced spreadability. No change in pH was observed, suggesting good stability properties of the prepared formulations.

CONCLUSION

Liquid foundation was successfully prepared using magnesium myristate as a multifunctional excipient, offering suitable characteristics of flowability, spreadability, coverage, texture, and UV protection. It was demonstrated that a multifunctional excipient could suitably replace the different excipients used in liquid foundation to attribute to various functions, thereby reducing process time and cost in production.

Table IX
Comparative Study of Liquid Foundation Using Conventional Excipients and Magnesium Myristate

Evaluation parameter	Liquid foundation using conventional excipients	Liquid foundation using magnesium myristate
1. Organoleptic properties		
Color	Brownish-yellow	Brownish-yellow
Odor	Odorless	Odorless
Form	Liquid	Liquid
2. Homogeneity	Homogenous	Homogenous
3. Emulsion type	Oil in water	Oil in water
4. pH	6.17 ± 0.043	6.04 ± 0.018
5. Viscosity (cps)	2,767 ± 1.021	2,671 ± 0.626
6. Spreadability (gm.cm./s)	6.75 ± 0.144	8.33 ± 0.144
7. Adhesivity test (s)	5.01 ± 0.127	4.75 ± 0.030
8. Hedonic test	Average spreadability, coverage, and texture	Good spreadability, coverage, and texture

Table X
Absorption Maxima of Liquid Foundation Using Conventional Excipients and Magnesium Myristate With Mean Value-Based SPF Calculation

Wavelength (nm)	Liquid foundation using conventional excipients	Liquid foundation using magnesium myristate
290	0.923 ± 0.093	0.985 ± 0.148
295	0.997 ± 0.487	0.976 ± 0.798
300	0.985 ± 1.681	1.04 ± 2.989
305	0.976 ± 1.888	1.06 ± 3.476
310	0.969 ± 1.060	0.989 ± 1.843
315	0.964 ± 0.472	0.976 ± 0.817
320	0.958 ± 0.100	0.986 ± 0.178
SPF	9.11	11.02

Table XI
Stability of Liquid Foundation Using Conventional Excipients

Days	Organoleptic properties	Viscosity (cps)	Spreadability (gm.cm./sec)	pH
0	Brownish-yellow	2,767 ± 1.021	6.75 ± 0.144	6.17 ± 0.043
15	Brownish-yellow	2,769 ± 0.734	6.73 ± 0.234	6.16 ± 0.036
30	Brownish-yellow	2,781 ± 0.456	6.70 ± 0.278	6.16 ± 0.042
60	Brownish-yellow	2,784 ± 0.321	6.67 ± 0.423	6.17 ± 0.035
90	Brownish-yellow	2,790 ± 0.654	6.63 ± 0.369	6.18 ± 0.048

Table XII
Stability of Liquid Foundation Using Magnesium Myristate

Days	Organoleptic properties	Viscosity (cps)	Spreadability (gm.cm./sec)	pH
0	Brownish-yellow	2,671 ± 0.626	8.33 ± 0.144	6.04 ± 0.018
15	Brownish-yellow	2,673 ± 0.344	8.31 ± 0.125	6.05 ± 0.632
30	Brownish-yellow	2,675 ± 0.421	8.28 ± 0.146	6.06 ± 0.125
60	Brownish-yellow	2,678 ± 0.234	8.26 ± 0.247	6.08 ± 0.452
90	Brownish-yellow	2,772 ± 0.354	8.22 ± 0.236	6.10 ± 0.165

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