Formulation of Foundation Makeup (Liquid) Using D-Optimal Mixture Design

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Abstract

Formulation of foundation makeup (liquid) was performed using D-optimal mixture design. Design expert software 7.0 was used to set up D-optimal mixture design and 15 formulations were conducted. Each formulation was judged its properties of pH, viscosity, and skin irritation to obtain the most appropriate composition. The optimum formulation of foundation makeup (liquid) was 227.43 ml of deionized water (DI), 1.40 g of carboxy methyl cellulose (CMC), 4.37 g of triethanolamine (TEA), 20.94 g of propanediol (PD), 31.84 g of titanium dioxide (TiO_2), 5.25 g of iron oxide (Fe_3O_4), 7.0 g of kaolin (Kao), 1.40 g of methyl paraben (MP), 34.97 ml of mineral oil (MO), 5.25 g of stearic acid (SA), 8.75 g of glyceryl monosterate (GMS) and 1.40 g of propyl paraben (PP) based on its properties of pH 6.93, 1722.3cP of viscosity and 0 of skin irritation. Regarding the evaluation sheet performed by the Hedonic scale test, satisfactory scores of foundation makeup (liquid) was 7.4 out of 9.

Keywords: formulation of foundation makeup (liquid), D-optimal mixture design, skin irritation

Introduction

Formulation of cosmetic products is complex and difficult to meet the proper composition of the required physical and chemical properties. When a product is formed by mixing two or more ingredients, the product is called a mixture, and the ingredients are called mixture components. Generally, the measured response is assumed to depend not only on the proportions of the ingredients in the mixture but also the amount of the mixture. The properties of cosmetic products might depend on the proportion of ingredients formulated. The response of a mixture experiment also depends not only on the proportions of ingredients, but also on the settings of variables in the process of making the mixture. It is also affected by process variables such as temperature, pressure and time used in the experiment. One of the purposes of conducting a mixture design experiment

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is to find the best proportion of each component and the best value of process variable, in order to optimize a single response or multiple responses simultaneously (Whitney and Rolfes, 2008).

The present research focused on formulation of foundation makeup (liquid) using D-optimal mixture design by setting up 15 formulations and data analysis of 12 components system. The optimal composition of formula of makeup was judged by its pH, viscosity and skin irritation.

Materials and Methodology

Materials

Chemicals (Analar Grade) such astriethanolamine, carboxy methyl cellulose, propanediol, titanium oxide, iron oxide, kaolin, methyl paraben, mineral oil, stearic acid, glyceryl monostearate, propyl paraben, color, perfume and preservatives were purchased from Empire chemical shop, 27th street, Pabedan Township, Yangon.

Methodology

Preparation of Foundation Makeup Using D-Optimal Mixture Design

Basic formulation of foundation makeup (liquid) was followed the formulations described in http://www.duponttateandlyle.com/sites/default/files/Foundation Liquid Makeup Water Oil Formulation Zemea_CPC.pdf. Formulation of Foundation Makeup was based on the levels as shown in Table (1) and (15) formulations were conducted according to the design arrangement. Design expert software 7.0 was used for D-optimal mixture design. Firstly, the water phase was prepared as follows: about 1.40 g of carboxy methyl cellulose (CMC), 4.37 mLof triethanolamine (TEA) and 20.94 mL of propanediol (PD) were dissolved into 227.4 ml of deionized water (DI). The mixture was homogenized using a homogenizer. The mixture of 31.84 g of titanium dioxide (TiO_2), 5.25 g of iron oxide (Fe_3O_4), 7 g of kaolin (Kao) and 1.40 g of methyl paraben (MP) was prepared and added into the previous mixture until they were dissolved. All the mixture was heated at 75ºC with constant stirring at 200 rpm using a magnetic stirrer. Secondly, the oil phase was prepared as follows: about 35 mL of mineral oil (MO), 5.25 g of stearic acid (SA), 8.75 g of glyceryl monostearate (GMS) and 1.40 g of propyl paraben (PP) were placed into a

beaker. The mixture was thoroughly stirred by magnetic stirrer with 200 rpm at 75ºC.

The oil phase was gradually added into the water phase with constant stirring of 200 rpm at 75ºC and kept for 15 min. until emulsion was formed. 0.1 mL of perfume and 0.01 g of color were then added and mixed. The mixture was cooled to room temperature of 32ºC. Finally, the foundation makeup was filled into a sterilized bottle and kept in dry place.

Table 1. Level of Components in the Formulation of Foundation Makeup (Liquid)

Sr. No	Component	Low level	High level
1.	DI (ml)	220	235
2.	CMC (g)	1	1.8
3.	TEA (g)	4	4.75
4.	PD (ml)	14	28
5.	TiO_2(g)	29.5	34.2
6.	Fe_3O_4(g)	4.5	6
7.	KaO (g)	5	9
8.	MP (g)	1	1.8
9.	MO (ml)	30	40
10.	SA (g)	5	5.5
11.	GMS (g)	8	9.5
12.	PP (g)	1	1.8

Analysis of Foundation Makeup

pH

Sample 2 mL was added into a 50 mL beaker and dissolved to 10 ml of distilled water. The pH was measured using SM 100 pH meter (Pen Type).The glass electrode assembly was first calibrated using buffer solution of pH 4 and pH 7. After the electrode was calibrated, pH of the samples was measured.

Viscosity

Viscosity was measured using PRO-L type rotary viscometer. Sample 350 ml was poured into a 500 ml capacity cup and the cup was

placed in viscometer. The spindle L_4 was used with a controlled speed of 100 rpm.

Skin Irritation Test

Skin irritation test of formulated each sample was performed according to the procedures described in Bono, Krishnaiah and Rajin, 2008. 1 mL of the sample was spread on the skin and rubbed. The result of the skin irritation test was interpreted as 1 for skin irritation and 0 for no skin irritation.

Investigation of Consumer Acceptance for Formulated Foundation Makeup (Liquid) by Hedonic Scale Test

A nine- point hedonic scale with ratings ranging from 1-9 was used for the study (Madukwe, 2013). The consumer acceptance of foundation makeup formulated with optimum composition was rated and represented as; 9 (the highest score) for like extremely, 8 for like very much, 7 for like moderately, 6 for like slightly, 5 for neither like nor dislike, 4 for dislike slightly, 3 for dislike moderately, 2 for dislike very much and 1 for dislike extremely.

Results and Discussion

Table (2) shows the different formulae of 12 components and responses of foundation makeup (liquid). The properties of foundation makeup such as pH, viscosity and skin irritation were judged for the optimum formulation. Table (3) shows the optimum composition of the foundation makeup (liquid) predicted by Design Expert Software 7. This formulation included 227.43 mL of DI, 4 g of CMC, 4.37 g of TEA, 20.97 mL of PD, 31.84 g of TiO_2, 5.25 g of Fe_3O_4, 7 g of Kao, 1.40 g of MP, 34.97 mL of MO, 5.25 g of SA, 8.75 g of GMS and 1.4 g of PP. This composition was judged by pH 6.93, viscosity 1722.3 cP and 0 of skin irritation of prepared foundation makeup (liquid).

From the design expert program the linear mixture models for pH (Eqn:1) and viscosity (Eqn:2) in terms of pseudocomponents are as follows;

$$y = 5.07\,x_1 - 20.23\,x_2 + 69.85\,x_3 + 6.32\,x_4 + 14.42\,x_5 + 12.91x_6 + 0.18x_7 + 8.32x_8 + 4.57x_9 + 19.20x_{10} - 5.47x_{11} + 42.30x_{12} \quad \text{....Eqn: 1}$$

$$y = 10.41\,x_1 - 6595.56\,x_2 + 63413.12\,x_3 + 3396.73\,x_4 - 3407.45\,x_5 + 225.11x_6 + 2094.02x_7 + 19109.55x_8 - 961.67x_9 + 69390.95x_{10} - 4037.36x_{11} - 42769.01x_{12} \quad \text{....Eqn: 2}$$

Table 2. Formulation of Foundation Makeup (Liquid)

Formulation	Component												Response		
	DI (mL)	CMC (g)	TEA (g)	PD (mL)	TiO_2 (g)	Fe_3O_4 (g)	Kao (g)	MP (g)	MO(mL)	SA (g)	GMS (g)	PP (g)	pH	Viscosity (cP)	Skin Irritation test
1	227.73	1.52	4.52	19.67	32.85	5.33	6.13	1.42	34.83	5.36	9.12	1.46	7.4	2506.2	0
2	228.39	1.58	4.31	19.38	33.02	5.38	7.37	1.20	33.87	5.13	8.91	1.42	7.3	2546.4	0
3	226.39	1.54	4.23	23.81	30.71	5.62	7.79	1.47	33.18	5.34	8.55	1.32	7.5	2405.6	0
4	231.53	1.52	4.27	18.80	29.91	5.27	7.90	1.41	34.24	5.39	8.35	1.35	7.5	2403.1	0
5	228.83	1.19	4.40	23.11	31.64	4.64	8.44	1.04	31.03	5.20	9.27	1.16	7.4	1736.8	0
6	223.99	1.48	4.38	22.93	33.18	4.61	7.36	1.28	36.23	5.20	8.14	1.16	7.6	326.5	0
7	225.22	1.29	4.41	23.58	32.36	4.74	5.86	1.10	36.77	5.28	8.07	1.25	7.4	2326.4	0
8	230.51	1.39	4.46	17.25	31.68	4.55	7.94	1.17	35.65	5.33	8.73	1.29	7.8	2454.4	0
9	227.40	1.60	4.54	22.91	33.02	4.89	6.19	1.37	32.56	5.25	9.01	1.21	7.1	1807.5	0
10	229.49	1.02	4.31	22.93	31.18	4.68	7.83	1.21	32.63	5.18	8.25	1.24	6.9	1366.9	0

Formulation	Component												Response		
	DI (mL)	CMC (g)	TEA (g)	PD (mL)	TiO_2 (g)	Fe_3O_4 (g)	Kao (g)	MP (g)	MO(mL)	SA (g)	GMS (g)	PP (g)	pH	Viscosity (cP)	Skin Irritation test
11	225.63	1.60	4.20	19.02	32.98	4.69	8.63	1.46	36.45	5.07	9.13	1.08	7.2	1166.7	0
12	227.86	1.60	4.55	19.15	30.91	5.62	6.90	1.60	36.06	5.14	9.09	1.48	7.3	1050.0	0
13	230.72	1.42	4.53	17.73	31.48	5.62	6.13	1.36	35.53	5.27	8.90	1.27	7.2	710.0	0
14	228.11	1.12	4.27	24.86	32.68	4.50	6.53	1.09	31.35	5.27	8.97	1.20	7.2	965.5	0
15	225.50	1.36	4.55	22.19	31.21	4.89	6.71	1.60	36.21	5.37	9.04	1.34	7.3	1743.6	0

Table 3. Predicted Formula of the Foundation Makeup (Liquid)

Sr. No.	Component	Composition	pH	Viscosity (cP)	Skin irritation test
1	DI (mL)	227.43	6.93	1722.30	0
2	CMC (g)	1.40			
3	TEA (g)	4.37			
4	PD (mL)	20.94			
5	TiO_2 (g)	31.84			
6	Fe_3O_4 (g)	5.25			
7	Kao (g)	7.00			
8	MP (g)	1.40			
9	MO (mL)	34.49			
10	SA (g)	5.25			
11	GMS (g)	8.75			
12	PP (g)	1.40			

Figure (1) shows 3-D surface plots of foundation makeup (liquid) for the properties of pH and viscosity. Surface plots are important to interpret the result of each formulation. Based on the results, pH was influenced by the composition of DI, PD and MP. pH of foundation makeup was affected by increasing DI from 220 to 235, decreasing PD from 29 to 14 and increasing MP from 1 to 16. pH could be decreased by increasing in PD. The viscosity of foundation makeup is an important property for strong

bonding of all components and provides the extension of shelf life. The viscosity was also affected by increasing DI from 220 to 235, decreasing CMC from 15 to 1 and decreasing PD from 29 to 14.

Table 4. Analysis of Variance (ANOVA) for pH and Viscosity

Response	pH	Viscosity
R-squared	0.8995	0.8023
Mean squared	7.34	1701.04
F- value	2.44	1.11
Pred R-squared	-4.1745	-10.6378

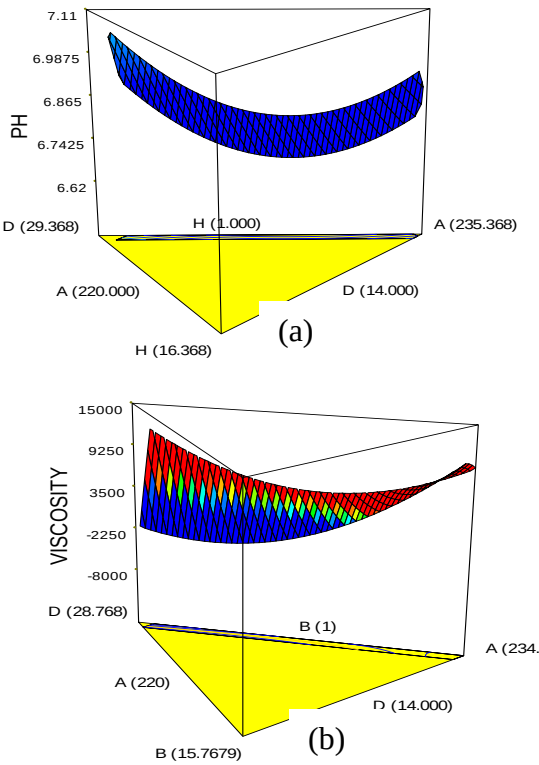

Figure 1. 3-D Surface Plots of (a) pH and (b) Viscosity of Foundation Makeup (Liquid)

For the viscosity the composition of DI, CMC and PD were the main influencing factors. With increased in CMC, the viscosity will increase. Table (4) presents summary of ANOVA (analysis of variance) for pH and viscosity. The sequential F-test by design expert indicated that the linear model and the F-value were significant. There were only 2.44% and 1.11% chances that model F-values could occur due to noise. A negative Pred R-square implied that the overall means was a better prediction of response than the current model. Investigation of consumer acceptance on makeup prepared with optimum composition was carried out by hedonic scale test. 10 panelists judged the quality of makeup in terms of color, odor and smoothness. Total score was 7.4. It was between like very much and like moderately.

Conclusion

Fifteen samples were prepared and three responses such as pH, viscosity and skin irritation were tested based on the formulation. The analysis using D-optimal mixture design indicated that both pH and viscosity followed the linear model. The characteristics of foundation makeup (liquid) can be manipulated by changing the composition of DI, CMC, PD and MP. Consumer acceptance of prepared makeup totally scored 7.4 out of 9.

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