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Foundations
A Guide to Formulation and Manufacture

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The formulation and manufacture of foundations offer the cosmetic scientist a variety of challenging and interesting problems to which there may be a number of solutions.

The importance of setting the objectives for the foundation before any development work starts cannot be over-stressed since mid-term changes are often difficult.

A check list of the following criteria should be considered:

—marketing claims and requirements
—technical requirements
—colour handling
—production method
—quality control requirements

Marketing Requirements

The shades should be set using a colour reference book such as the Pantone Colour Specifier and the degree of coverage agreed (i.e., tinted moisturiser through to heavy cover makeup).

The finish of the foundation must also be decided, whether the product is going to be matte or semi-matte, or whether it will be a normal finish requiring a matching face powder to complete the makeup.

The "weight" of the foundation must be indicated which is closely linked to the skin feel and coverage of the foundation. Great contributions come from the emulsion base chosen, the pigment loading and the viscosity.

The advent of mousses has provided an ideal vehicle for foundations, and these light, fluffy emulsion foams can be spread evenly and feathered out in the neck area very easily while offering a variety of options for application and weight.

Finally, the pack requirement should be known so that the rheology of the system can be tailored accordingly.

Technical Considerations

The emulsion base should be a good moisturiser that does not "soap" or whiten on rub out since this would affect the colour of the foundation during application.

Skin penetration should not be too rapid, or else there will be insufficient time to spread the foundation and "feather" or blend it into the natural skin tones. The result would be a sharp line at the foundation boundary and overall patchiness which with further manipulation of the foundation could lead to "balling."

In general terms the colour loading is related to the viscosity of the base. Thin flowing lotions (fluid makeup) often contain the least pigment, whereas foundation creams contain the most.

The majority of foundations are oil-in-water (o/w) emulsions, though some (particularly the heavy coverage makeup) are water-in-oil (w/o). This last group invariably dries to a fairly shiny finish and requires additional face powder (compact or loose powder) in order to achieve a matte finish.

The major constituents in the foundation would be an emulsifier system, a humectant, a moisturizing component, a pigment wetting agent, pigments/extenders, a suspending agent, and fragrance and preservative.

Anionic emulsions based on stearate soap have a smoothness and soft skin feel that complement a

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foundation well. The addition of a self emulsifying glyceryl monostearate improves both the stability and creaminess of the emulsion.

Nonionic emulsions based on Tweens[a] and Spans[a] (or Arlacels[a]) are also extremely successful, tending to be slightly crisper on application. Performance and skin feel are further improved by the addition of materials such as lanolin derivatives, oleyl alcohol, glyceryl monostearate, or petrolatum, to name but a few. Of course the emulsions in this group may be pH balanced.

Cationic based foundations are gaining increasing popularity. The application is different in skin feel to the nonionic and anionic based formulae and they often feel lighter and smoother. A recommended emulsifier in this category would be Ceraphyl 65[b] (Quaternium 26).

Many consumers complain that the foundation is incompatible with their moisturiser and does not key in, but goes smeary or balls on application. In most cases foundations are compatible; however, occasionally an anionic moisturiser and a cationic foundation (for example) do interact to the detriment of application performance. The most obvious solution is to sell an "undercoat" moisturiser alongside the foundation.

In order to keep the foundation moist and to compensate for the potential drying effect of the pigments on the skin it is customary to include a quantity of humectant (such as glycerin, sodium PCA, sorbitol or propylene glycol) to the emulsion. The use of lactic acid and lactate salts is also effective.

The moisturizing component should ideally be provided by esters, of which there are a vast number to choose from. The use of porosity esters such as Wickenol[c] 161 or 163 (by virtue of their branched chain structure) allows a certain degree of skin respiration (and thus skin comfort when applied) while improving lubricity and ease of spreading on the skin.

A foundation can be prepared without the use of a wetting agent, but logically a greater efficiency of colour development can be extracted if the pigment has been fully wetted out. One noticeable advantage is that the amount of pigment that settles or clumps around mixer heads and stirrer blades is greatly reduced.

It is reasonable to argue that in a nonionic containing emulsion (e.g., Tween) that the need for another wetting agent is unnecessary—for the most part this may be true—however, a specific wetting agent may produce less foam and aeration. Examples would include dioctyl sulphosuccinate, acrylic/acrylate copolymer, lanolic acid, block copolymer polyols.

[a] ICI Ltd.
[b] Van Dyk (S. Black, agents in U.K.)
[c] Wickhen Products

Formula 1. Low Coverage, Light Weight Fluid Makeup (O/W)

	%
Demineralized water	30.00
Polysorbate (Tween 20) (1)	1.20
Magnesium aluminium silicate (Veegum) (2)	1.00
Pigment dispersions, 50:50 talc	7.00
Talc	3.00
Water	q.s. to 100.00
Sodium PCA (Ajidew N50) (3)	1.00
Propylene glycol	6.00
Silicone defoaming agent	0.10
Mixed porosity esters (Wickenol 161) (4)	1.00
Mineral oil	8.00
Glyceryl monostearate, N/E	2.00
Stearic acid	1.50
Xanthan gum	0.15
Sodium hydroxide	q.s.
Methylchloroisothiazoline (Kathon CG) (5)	0.05
Perfume	q.s.

Formula 2. High Coverage, Heavy Weight Cream Makeup (O/W)

	%
Demineralized water	q.s. to 100.00
Magnesium aluminium silicate (Veegum) (2)	1.50
Propylene glycol	5.00
Poloxamer 184 (Pluronic L64) (6)	0.20
Pigment dispersions	11.00
Talc	4.00
Dimethicone	1.50
Hydroxypropyl methylcellulose	0.40
Mineral oil	8.00
Isopropyl palmitate	7.50
Stearic acid	1.50
Ethoxylated lanolin	1.00
Cetyl alcohol (Aqualose L30) (7)	1.00
Glyceryl monostearate, s/e (GMS 0743) (8)	4.00
Sodium hydroxide	q.s.
Methylchloroisothiazoline (Kathon CG) (5)	0.05
Perfume	q.s.

Suppliers of Ingredients in Formulas

1. ICI Ltd.
2. R.T. Vanderbilt
3. Ajinomoto
4. Wickhen
5. Rohm and Haas
6. BASF Wyandotte
7. Westbrook Lanolin
8. Croda
9. Union Carbide
10. Van Dyk (S. Black, agents in U.K.)
11. Dow Corning

Formula 3. High Coverage Medium Weight Matte Makeup (O/W)

	%
Demineralized water	30.00
Acrylic/acrylate copolymer	0.20
Magnesium aluminium silicate (Veegum) (2)	1.00
Blender	
Kaolin	3.00
Talc	10.00
Pigment	5.00
Demineralized water	q.s. to 100.00
Propylene glycol	8.00
Silicon defoaming agent	0.10
Mixed porosity esters (Wickenol) (4)	2.50
Stearic acid	1.50
Cetearyl alcohol (and) ceteareth 20	1.50
Glyceryl monostearate (GMS NSE 803) (8)	1.00
Mineral oil	3.00
Isopropyl palmitate (Crodamol IPP) (8)	6.00
Carboxy methyl cellulose	0.40
Sodium hydroxide	q.s.
Methylchloroisothiazoline (Kathon CG) (5)	0.05
Perfume	q.s.

Formula 4. Medium Coverage, Medium Weight Cream Makeup (O/W)

	%
Demineralized water	63.55
Hydroxyethyl cellulose (Cellosize QP 30,000) (9)	0.30
Diethylaminoethyl stearate (Cerasynt 303) (10)	1.00
Phosphoric acid, 85% ortho	0.30
Glycerine	5.00
Pigment blend	15.00
Quaternium 26 (Ceraphy 65) (10)	2.00
Glyceryl stearate (Cerasynt SD) (10)	10.50
Octyldodecyl stearoyl stearate	7.50
Glyceryl dilaurate	7.50
Cetyl alcohol	1.00
Dimethicone (Dow Corning 200 Fluid, 100 cps) (11)	1.00
Methylchloroisothiazoline (Kathon CG) (5)	0.05
Perfume	q.s.

Formula 5. Medium Coverage, Light Weight Aerosol Mousse (O/W)

	%
Demineralized water	49.90
Hydroxypropyl methylcellulose	0.10
Proplyene glycol	2.00
Pigment blend	12.00
Glyceryl dilaurate (Emulsynt GDL) (10)	2.00
PEG-20 stearate (Ceraphyl 840 (10)	1.00
Stearic acid	5.00
Cetyl alcohol	0.50
Octyl dimethyl PABA (Escalol 507) (10)	2.00
Isodecyl oleate (Ceraphyl 140-A) (10)	4.00
Triethanolamine	0.50
Ethyl alcohol	20.00
Concentrate, as above	95.00
Propellant	10.00

Method as in text, add alcohol at 35 degrees C. Transfer bulk to aerosol use and fill.

The most commonly used pigments include red, brown, russet, black, and yellow iron oxides and yellow titanium dioxide. Common extenders include talc and kaolin. Certain materials such as chalk, magnesium carbonate or Fuller's earth are occasionally used to achieve special features or effects.

Extenders can be useful for a number of reasons. First, they can be used to prepare colour dispersions and so compensate for colour variation of incoming pigment raw material. Second, the extender can be used as a filler so that a constant percentage of total powders is added to the emulsion base, thus keeping constant the physical parameters between shadeways (i.e., density, viscosity and stability). Finally, since the pigments are pulverised into the extender, they are subject to processing energy that develops much of the latent colour strength.

The use of a suspending agent is vital if the pigments are not to settle on standing over a period of time. A combination of thickeners is not uncommon. One particular combination would be hydroxypropyl methylcellulose (e.g., Methocel[d] 60HG4000) with magnesium aluminum silicate (e.g., Veegum[e]) which has been proved effective. Another combination would be carboxymethyl cellulose in combination with sodium magnesium silicate (e.g., Laponite XLG[f]). The choice is limitless; however, a straight viscosity builder in combination with a thixotrope generally works well.

The choice of preservative should be determined by examining the microbiological integrity of the system and performing an adequate challenge test on the final formula.

Fragrance selection is very much a matter of personal preference, as is the choice of special extracts or inclusion of a sunscreen.

Handling the Colour System

The colouration of the emulsion base may be handled in a number of ways: direct pigment, pigment dispersions, mixed pigment blender, tinters, or dyestuffs. As might be expected, each method has merits and disadvantages. The objective should be to extract the optimum performance from each pigment through maximum colour development and to achieve the required colour match with the least number of additions.

Direct Pigment

The pigments are weighed directly into the aqueous phase of the emulsion and dispersed using a high shear mixer (e.g., Vortex) or colloid mill after which the emulsion is formed in the normal way.

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[d] Dow Chemical
[e] R. T. Vanderbilt
[f] Laporte

The major problem associated with using straight pigments is that no account is taken of the variation of incoming pigments strength at the time of manufacture. Ideally, the pigments in each formula should be numerically adjusted for percentage over strength or weakness. This would have to be determined by incoming raw material quality control colour matching each pigment in talc versus the standard and calculating the appropriate correction. In practice, the time involved in accurate colour matching and then readjusting every relevant formula is unrealistic.

Pigment Dispersions

The pigment is mixed in talc as a 50:50 dispersion and pulverized through a hammer mill (or equivalent) to match the standard. The pigment dispersions eliminate most of the error from pigment strength variation and reduce to a great extent the number of colour corrections needed to match the final foundation standard. The energy input to the dry pigment also develops some of the latent colour and so reduces the effect of differential colour development during the aqueous stage of processing. The dispersions may be considered as half strength colour pigments and used as in the direct pigment method.

The disadvantage is the time taken to prepare separate dispersions in the powder plant and the additional space required to store what is essentially a new raw material.

Mixed Pigment Blender

In this method the pigments and extenders for the required shade are premixed in a powder or ribbon mixer and pulverized. The resultant mixture, called a blender, is colour matched to the standard. (The quality control technique is discussed later.)

The blender is dispersed into the aqueous phase using high shear mixing and the foundation emulsion formed in the normal way.

The method has many advantages. The finished shade is essentially colour matched at the powder blender stage with much of the colour being developed at the milling stage.

The quality control approved blender can be transferred from the powder room to the emulsion area and since the dispensary weighs out essentially one colour, the chances of error are greatly reduced. The number of colour corrections are substantially lower.

Tinters

The pigments are formed into concentrated colour tinters in a compatible foundation base (i.e., w/o or o/w tinters have to be made depending on the emulsion type of the foundation). Tinters are, essentially, concentrated monochrome foundations with appropriate suspending agents incorporated.

The tinter method has advantages over the use of pigment dispersions in as much as the tinter can be added directly to a formed emulsion base. Colour matching is no harder than it would be, say, for a lipstick or nail varnish.

The disadvantage of tinter use would be that the continual opening and closing of drums can lead to contamination, not only through transfer of one colour to another, but also microbiological contamination. There is also a real risk of the tinters drying out and the colour strength increasing. The drums must be thoroughly stirred before each weighing since at the heavy pigment loadings involved there is a high risk of settlement.

Finally, as with the pigment dispersions, one is essentially creating a new raw material that consumes both manufacturing time and space.

Dyestuffs

Dyes are normally used for tinted moisturisers and fall outside of the scope of this paper.

Production Requirements

The requirements depend on the method chosen; the following section offers a general guideline.

The pigment(s) and extender (usually talc) are weighed into a high speed or ribbon mixer and mixed until the colour is evenly dispersed. A small quantity is passed through the pulveriser and submitted to quality control for approval or adjustment to standard. On approval, the whole batch is pulverised and stored in drums.

The equipment required for finished foundation production depends to a large extent on the batch size, however, the constituent parts remain the same. Normally a steam pan is needed to melt the waxes and heat up the oil phase. A high shear mixer disperses and grinds down the pigments. The head should be fitted with a fine mesh to ensure maximum particle break down. Then a steam jacketted mixing vessel with propellor mixer or agitator and anchor blades or gated stirrer is used. Larger batches may be handled in a vacuum mixer where all the mixing facilities will be present; most incorporate a colloid mill, which is extremely efficient at grinding pigment and can be adjusted to fine limits.

Small production batches can be made very successfully in contra rotating mixers (e.g., Hobart Mixer).

A typical method of manufacture would look as follows:

1. Charge oils and waxes into the steam pan and heat to 85°C
2. Charge the main mixer with part of the water and wetting agent
3. Add powders to main mixer and high shear mix for 15-20 minutes
4. Charge the rest of the aqueous phase, stop high shear mixing and change to fast mixing (propeller) and heat to 85°C
5. At 85°C stop all mixing, allow air to rise and add antifoaming agent
6. Run in the oil phase and commence stirring at a speed that does not create a vortex. Mix for a further 15 minutes before commencing cooling
7. At 40°C add preservative
8. At 35°C add fragrance
9. At 30°C submit to quality control
10. Once approved, transfer to storage containers ready for filling

Pigments tend to develop their colours at different rates and it is important to control processing times within very strict limits. The thermal or mechanical energy input should be accurately defined and adhered to on the processing specification. The greater the processing time and energy, the greater the possibility of differential colour development and quality control having to "chase" to colour match. Aeration should be kept to a minimum, especially if a vacuum mixer is not employed. Slow mixing at ambient temperature will eventually reduce aeration but the process is time consuming. Good manufacturing procedure (GMP) should be followed at all times.

Quality Control Criteria

Intermediates

Pigments are normally tested as a let down in talc versus a similarly prepared standard of known age and batch or lot number. Any differences in strength should be calculated by colour matching in talc back to the standard.

The talc and pigment are weighed into a coffee mill and ground for 5 seconds, after which the powders are turned out onto a sheet of clean paper and turned with a spatula. The blend is then returned to the mill and ground for a further 5 seconds.

A small heap of the powder sample is placed next to the standard sample onto a folded piece of white paper and the powders gently sandwiched between the two halves of paper with light pressure being applied by a palette knife.

The paper is carefully opened and the two colours compared. (See figure 1.) If a number of colour corrections have been used, the final match should be remade to check that there was no colour development during milling.

Pigment dispersions are treated in a similar fashion to the pigments described above.

Blenders for finished shades can be evaluated by a number of techniques. First the blender can

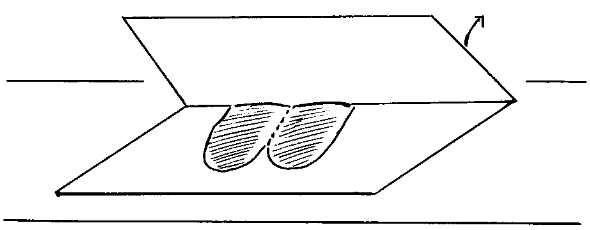

Figure 1

be dispersed into a Carbopol[g] solution and drawn down onto a nail lacquer comparison card against the similarly prepared standard. The cards are compared both wet and dry for colour and approval or adjustments made as required.

In another technique the blender is weighed into the finished emulsion base and dispersed using a laboratory high shear mixer. The test foundation is then compared to standard. The method, though attractive in principle, has many shortcomings since the pigments do not always fully wet out in the emulsion (especially in emulsions with a high oil content) and also tend to suffer from excessive aeration.

Finally the foundation base may be held as two stock solutions, namely the water phase and the oil phase (both adequately preserved). The blender is weighed into the appropriate quantity of the aqueous phase and dispersed using a laboratory high shear mixer. The two phases are heated to 85°C and the procedure followed as for that of manufacture already outlined. The finished foundation is compared to standard (as detailed under finished foundations).

Tinters are diluted in emulsion base and compared to a similarly prepared standard as for a finished foundation.

Titanium dioxide pigments require a special treatment and should be mixed with an appropriate quantity of iron oxide black in order to produce a grey which is easier for comparison studies.

Finished Foundations

The finished foundation should be compared to a standard for the following colour criteria:

—when rubbed out on hand or forearm—wet
—when rubbed out on hand or forearm—dry
—when compared to standard on a white tile
—when filled into the final pack

The best colour match is often a compromise, with the skin application taking highest priority.

Other criteria which apply to the finished foundations are pH, viscosity (as measured using a Brookfield Viscometer, model LVT or RVT as appropriate) specific gravity, solids content, and microbiological evaluation of total viable count.

[g] B F Goodrich

Colour Correction in Production

Colour correction in the finished foundation should be handled carefully. Direct pigment or pigment dispersion addition should be made to a small portion of the batch and not added directly to the bulk. Ideally this portion of the batch should be heated to 40°-50°C to ensure maximum colour development with a high shear mixer. This technique ensures minimum work on the batch as a whole and leads to more accurate colour correction. The colour corrected portion is stirred into the master batch using the anchor blades only.

Where top tone of the foundation is weak compared to the standard, but the application colour is correct, it is a fair assumption that the pigments are not fully developed in the emulsion. It is a matter of chance whether the bulk can be further processed to bring up the top tone without altering the overall shade.

Though the tinters have disadvantages they are extremely useful for colour matching, since they can be stirred directly into the master batch without shear mixing or heating, and therefore eliminate the risk of aeration.

Conclusion

The preparation of foundations is extremely complex and this paper has concentrated mostly on the aspect of colour. In practice this is only half the story since formulation of the emulsion should be carried out with as much care as would be given to a skin care cream.

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