Pigment primer for the skin care formulator

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Traditional foundation and face powder makeup are an important part of the consumer's beauty routine and several new trends are contributing to the rise in number and type of cosmetics available for the face.

The 'alphabet cream' trend has resulted in the development of BB creams (followed by CC, DD and EE), which have the colour correction properties of foundation and a multitude of other benefits from ingredients like sunscreens, antioxidants and botanicals.

Due to the blurring of these lines between skin care and colour cosmetics, skin care formulators need to develop a solid understanding of the unique nature of pigment chemistry and processing to achieve consistent colour in production and maximise the value of colourants.

Typical pigments used in matching skin tones

Much like foundation, the typical pigments used to create various skin tones in 'alphabet creams' are inorganic oxides (titanium dioxide, yellow iron oxide, red iron oxide and black iron oxide). Lake pigments are not typically used in products for face makeup as their chemical and physical properties differ greatly from oxides and their colours are often too bright to mimic skin tones.[1]

Rutile and anatase forms of titanium dioxide can be used. The rutile form provides a higher degree of coverage for hiding blemishes and imperfections. Titanium dioxide is available in oil soluble, water soluble, and multipurpose grades. Selection depends on the nature of the continuous phase of the desired emulsion. Silica or alumina are used to coat cosmetic grades of titanium dioxide to improve photostability.[2]

Iron oxides are in many ways ideal pigments with regard to stability. However, processing temperatures in the range of 125 – 150 °C yellow ($Fe_2O_3{\bullet}H_2O$) and black iron oxides (Fe_3O_4) can shift to a more red shade. Red iron oxide (Fe_2O_3) is made by calcination of yellow iron oxide at very high temperatures and is quite stable with respect to heat.

Additionally, black iron oxide is slightly magnetic and will coat iron or mild steel containers resulting in issues with colour development during manufacture. Iron oxides are also available as blends described as brown, russet (reddish-brown), tan, etc. Blended iron oxides reduce formulation and processing time to develop finished shades of product.[3]

Occasionally ultramarine blue is used to aid in achieving darker skin tones as long as the pH is above 7, otherwise it decomposes and gives off an unpleasant hydrogen sulfide gas.[3]

Pigment standards and quality control

When selecting pigments for use in formulation it is important to evaluate multiple lots of material from the supplier, including the designated standard lot. The supplier's standard lot should always be used for quality control in comparing receipt of new lots of pigment.

Additionally, due to the presence of agglomerates and aggregates discussed in further detail later, colour quality evaluations must be performed in dispersion. Subjective visual evaluations of colour can be made under a controlled light source. However, objective measurements read on a colour computer are far more reliable.

As the formulations and compositions of base formulas vary widely between end users or pigments, internal tests can be developed by manufacturers to better understand and prepare for shade adjustments in production.

Pigment dispersion

Classical cosmetic pigments are made in large batches and there are unavoidable, slight variations in shade or other qualities from batch to batch. Pigments are typically supplied as dry powders where primary particles exist in various states of aggregation and agglomeration that often amplify the variation in colour properties when evaluated as dry powders. Pigments must be fully extended or dispersed in a vehicle to get as close as possible to primary particle size in order to see the full development of colour and maximise financial value.

Dispersion is the process of wetting, separating and distributing pigment particles in a vehicle. Additionally, the particle must be stabilised against flocculation and settling. Separation of pigment particles requires intense energy input by specialised equipment like a 3-roll mill for liquids or use of a pulveriser for powders. Ensuring a reproducible mean particle size through dispersion is crucial to achieving uniform colour while avoiding streaking and grittiness.[2,3]

Wetting pigments

The first step in the dispersion process of dispersion is wetting by displacing the air surrounding pigment particles, which facilitates the separation of aggregates and agglomerates. Vehicles are often used in formulation for other purposes and have inherent wetting properties. *Ricinus communis* (castor) seed oil and mineral oil have historically been used to wet pigments for anhydrous dispersions because of their ubiquity and low cost.

Natural oils, including castor oil, are subject to oxidation resulting in off odours. Selection oils with good oxidative stability such as *Limnanthes alba* (meadowfoam) seed oil and the use of antioxidants is recommended when using naturals.[4,5] Branched esters are excellent wetting agents and experimentation with levels is important in emulsion systems where they can have significant effects on the viscosity of the final formulation.[6]

The degree to which each pigment absorbs oil varies. Pigments with higher oil absorption need a higher oil-to-pigment ratio to ensure there is enough of the vehicle to fill the spaces around the pigments. This differential in oil absorption is also important in balancing the amount of oils and fillers across different shades of a formulation so that they maintain the same characteristic aesthetics and stability.

The use of lecithin or high-HLB surfactants aids grinding pigments into water and talc is used almost exclusively for dry powder applications.[2,3]

Pre-dispersed pigments

Many cosmetic companies purchase dry pigment and disperse it in their factories. However, pigments can be purchased pre-dispersed in a wide variety of vehicles including castor oil, synthetic waxes, and water. Pre-dispersed pigments are convenient and provide consistency in colour, especially when a manufacturer does not have the know-how and proper equipment for producing a good dispersion.

Surface treated pigments

Most pigments and powders used in cosmetics have a hydrophilic surface comprised of polar hydroxyl groups where water is adsorbed. Consequences of hydrophilic surface in formulation include agglomeration of particles contributing to poor skin-feel, poor dispersion/wetting in cosmetic fluids, and poor stability.

Surface treated pigments overcome these challenges and provide additional benefits. They are far easier to disperse, leading to more consistent colour and quality in finished goods, and provide long wear, improved sensory attributes or other characteristics.

Oil absorption is also reduced, making it easier to balance formulations across different skin tones. Surface treatments can also improve suspension, hindering flocculation and settling.

Surface treated pigments were developed when more women began to powder their faces in the early 20th century and found the need to 'touch up' during the day. They were confronted with the problems of carrying loose powder around in their handbag.

Early loose powder containers suffered from numerous issues which were sources of annoyance, including bulkiness, the need for frequent filling, as well as leaks and spills.

In an effort to improve the durability of decorative cosmetics, silicone treated pigments were developed and introduced in Japanese formulations in 1976. These early treatments paved the way for the development of 'two-way' makeup cakes, which could be applied dry, or with a wet sponge.

Higher in bulk density, metal soap treatments were introduced in 1977 to improve compressibility and impart a creamy skin-feel.

Amino acid treatments were introduced in 1979. This treatment was particularly useful in the formulation of long wearing liquid foundation. The combinations of surface treatments and substrates have grown dramatically, including innovative natural and super hydrophobic options.[3,7]

Below are some currently available surface treatment types and their benefits:

Disodium stearoyl glutamate

This amino acid based treatment is well suited for liquid makeup. It enhances the perception of moisturisation, improves compressibility, and has good compatibility with skin. It is also naturally derived. The slight acidity of this treatment renders the pigments more compatible with skin pH and thus helps preserve the delicate chemistry of the stratum corneum.

Dimethicone

Dimethicone treated pigments provides long wear and waterproofing properties, and improves dispersion and compatibility with silicones used in emulsions for foundations and other liquid makeup. This treatment also imparts a smooth, creamy feel during application.

Alkyl silane

Trimethoxycaprylylsilane treatment provides water repellency and is more lipophilic than silicone treatments. It is good for long-lasting, waterproof, transfer resistant cosmetics. Silane treatment improves compressibility in powders and gives a velvety skin-feel.

Methicone

This treatment exhibits strong hydrophobicity for long wear and high performance applications, such as the current 'athleisure' makeup trend. Methicone treatment allows for easy dispersion of pigments in oils and silicones. Methicone gives a soft skin-feel and reduces drag of pigments on application to skin.

The choice of surface treatment type will depend on the application and what particular properties are desired or need to be improved in the finished formulation.

Pearlescent effect pigments

Nacreous, or pearlescent, pigments are

widely used in the cosmetic industry to add lustre or sparkle, impart colour or colour-travel effects, and provide coverage.

The adjective nacreous is derived from nacre, which is pronounced NAY-ker. It refers to the material that makes up pearls and the iridescent mother-of-pearl produced in mollusc shells. Several types of cosmetic pearls are available based on different substrates, such as mica, guanine, bismuth oxychloride, and fluorophlogophite. Each substrate has its own advantages and disadvantages.

More formally, cosmetic micas are postassium aluminum silicate dihyrdrate. Silicates, much like silica, are based on interconnected SiO_4 tetrahedra. However, in silicates the ratio of Si to O is greater forming silicone-oxygen anions. To form neutral solid silicates, cations like potassium are needed to balance the negative charge.

Micas are subject to size restrictions; particles are not to exceed 150 mm. Other substrates are not specifically regulated for particle size. Naturals micas can darken with oil absorption, including sebum from the skin.

Guanine, a common biological molecule, is derived from fish scales and provides a soft pearly shimmer. It is the photonic crystalline structure of guanine that scatters and reflects light to produce the pearl effect. Cosmetic grades are, of course, purified and often dissolved in a suitable solvent for ease of handling. Although this might qualify as a true natural pearl, cost is often prohibitive.

Though more frequently used as a filler in cosmetic formulations, bismuth oxychloride provides a silvery, white tone. The various particle sizes available allow for different levels of transparency, however larger crystal forms are supplied as dispersion because these larger crystals can be broken in their dry form. Bismuth oxychloride can darken with light exposure and should be protected with opaque packaging.

Referred to as synthetic micas, fluorophlogophites are one of the newest innovations in pigments. Unlike mica, which carries more natural impurities along with it, the synthetic version is cleaner and more transparent. This allows for more brilliant sparkle effects.

Pearls are fragile and should not be milled or exposed to harsh mixing. They are truly stir-in ingredients and should be added to formulas late in the process. All pearls need to be suspended in formulation. In emulsion and gel formulas, ingredients like carbomer or xanthan gum can provide sufficient yield value to suspend pearls.

Soft focus effects

Soft focus effects help optically blur fine lines and other imperfections, providing an immediate effect after application. Their incorporation into numerous cosmetic and skin care products has grown in not only anti-ageing categories but are now incorporated into makeup primers for everyday use as social media trends continue to drive the desire for a flawless complexion.

A wide variety of optical blurring ingredients have been utilised in cosmetics, such as very small particle sizes of synthetic mica, alumina, polyethylene microspheres, and silicone elastomers. Some of these materials can be cost prohibitive. A composite of talc and titanium dioxide (Spectraflex Illusion) is a new, novel approach to soft focus that is cost advantageous, leading to the possibility that it can even be used in body care to improve the appearance of imperfections like cellulite on thighs.

Soft focus materials balance the scattering of light from the surface of the skin and into the skin.[8] Diffuse transmission is what typically comes to mind when thinking of optical blur. Diffuse transmission is the amount of light that is spread out, away from the source after it passes through an object.

While it seems beneficial, designing materials solely around diffuse transmission is not the most efficient means. The ideal properties for an optical blur effect are a balance of reflectivity and transparency. Both of these traits need to be optimised in both their diffuse and total nature. Reporting diffuse transmission without reference to the total transmission (or overall transparency) can be misleading.

Traditional TiO_2 diffuses and scatters light incredibly well, but the overall transparency (total transmission) is too low to be useful in true optical blurring. Balancing reflectivity with transparency is another, paradoxical obstacle. Optical blurring is at its best when there is sufficient hiding to cover blemishes and discoloration but not overbearing as to create a film or chalky appearance.

A high degree of transparency will allow for the natural glow of the skin to show but without diffuse reflectivity, the contrast of wrinkles and creases cannot be hidden. The novel composite of talc and titanium dioxide has been tailored to balance transparency, diffuse transmission, and diffuse reflectivity to achieve the noticeable optical blurring effects.

Conclusion

Utilisation of pigments in cosmetics and skin care is complex. Pigment chemistry and processing play an important role, as well as innovation in surface treated pigments and soft focus effects. PC

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