LINKING SURFACE ENERGY TO COSMETIC BEAUTY ON THE SKIN

Adriana Altuve[1], Ph.D., Steve Page[2], Sarah Vickery[1] and Stephen Jones[3]
[1]The Procter & Gamble Company, Color Cosmetics, Hunt Valley, MD
[2]The Procter & Gamble Company, Beauty Technology Analytical, Cincinnati, OH
[2]Ciba Specialty Chemicals Corporation, Tarrytown, NY

Introduction: Effective color cosmetic foundations provide the look of flawless skin without introducing an unnatural appearance. The design of a natural looking foundation is inspired by a combined knowledge of the chemistry of the foundation ingredients and skin surface with the optical properties of healthy skin. One key element for improving product performance is surface energy optimization between liquid make up formulations and skin. Matching the surface energy (SE) of the particulates in the foundation to that of the skin can create consumer noticeable benefits in a multitude of areas. Among the benefits to matching skin SE, particularly the polar component of SE, are improved skin comfort, a more beautiful finish, visibly closer fit to the skin, and higher overall preference versus traditional colorants.[1,2]

A detailed SE study was undertaken for which measurements of SE of dry and moisturized skin, individual foundation raw materials (including new to the world encapsulated organic colorants), and the product as a dried film on the skin were performed. In order to correlate SE values to application properties and end look benefits, panelists were asked to apply a Procter and Gamble (P&G) foundation as well as a leading competitive foundation. The results showed that when the encapsulation and/or coating material minimized the difference in SE between skin and colorants, then improved aesthetic attributes (such as even spreading and natural appearance) occurred. As a result of this work, we were able to correlate SE to product deposition onto the skin, and further demonstrated that our foundation was superior to the competitive product for providing a more natural look with better adhesion properties.

Method: Surface tension of liquids was determined by the Wilhelmy plate method (total surface tension)[3] followed by sessile drop or advancing contact angle analysis on Teflon sheets (nonpolar component of surface tension)[4]. Surface energy of pigments was determined by compressing the pigments into a pellet. Sessile drop or advancing contact angle analysis was performed on the pellets using diiodomethane, formamide, and water. In-vivo sessile drop contact angle analysis on facial skin was performed using video imaging. Mineral oil, glycerin, and water were used on facial skin. SE of dry skin, moisturized skin and skin with foundation applied were determined. The Fowkes equation of state was used to convert contact angles into surface energy values. [5]

Designing Colorants that Match the Surface Energy of Bare Skin: A key opportunity for improving cosmetic foundations is to develop colorants which more closely match the SE of skin. Commonly utilized iron oxides have SE characteristics that are very different than those of bare skin, which can have a negative impact on foundation aesthetics. Spreading properties, adhesive properties and overall appearance of the colorants can be improved by more closely matching the SE components of skin.[1,2] Interestingly, internally conducted research shows that 81% of liquid foundation users apply a facial moisturizer prior to using their liquid makeup. These habits and practices will significantly alter the SE of the face, and as a result, the SE of moisturized skin must be taken into account when optimizing the surface treatments and/or encapsulation material of colorants in a foundation.

Organic colorant encapsulation technology developed by Ciba Specialty Chemicals Inc.[2,6] has been specifically designed to enable the highest degree of natural look benefits in a foundation (i.e., chroma variation comparable to naturally flawless skin, increased vibrancy, and SE matching to the skin). Measurements of SE have been conducted on a wide range of commonly available organic and inorganic colorants along with a broad range of surface treated pigments and solvents. In Figure 1, the results of these measurements are plotted along with measures of SE for the novel encapsulated organic colorants tailored to match dry and moisturized skin. As Figure 1 reveals, common uncoated and ITT treated iron oxide pigments, as well as silicone and alkyl silane coated pigments, have a SE that is very different from that of skin. To address this issue, two different sets of encapsulated organic colorants were designed with different SE profiles. In contrast to the traditional colorants, when the SE of the two types of encapsulated organic colorants is plotted alongside that of the moisturized or dry skin, it can be seen that the SE components are extremely well matched. Figure 1 further shows that the SE value of the non-encapsulated colorants is different than that of the encapsulated material. This proves that the chemistry of the encapsulation matrix actually drives the SE differences, and most importantly, provides the chemical flexibility to match the SE of these novel colorants to the SE of different skin types. These results show that proper choice of the encapsulating material can improve upon the difference in SE between skin and colorants. Subsequently, this can allow for improved aesthetic attributes when these skin-matched SE colorants are incorporated into foundation products.

Measurements of Surface Energy and Work of Adhesion of Foundations:

- Surface energy: A good SE match between the foundation and the skin represents a favourable low energy state that facilitates advantageous surface interactions. As a result, the foundation will spread out evenly and "merge" effectively with the skin. In contrast, a poor SE match implies that the surface interactions between the foundation and the skin are not optimal, so the foundation either (1) resists spreading & coating evenly or (2) superficially spreads without adherence. In case 1, the unfavourable energy state can also drive the pigments in the foundation to flocculate / agglomerate into larger particles instead of spreading uniformly on the surface. In case 2, the foundation tends to sit on the skin as a separate layer, often resulting in an obvious, unnatural look and poor resistance to product transfer onto clothes or other surfaces.

An in-vivo SE study was conducted on facial cheek skin of panelists after applying either a P&G color cosmetic foundation product or a competitive foundation product. Measurements were performed mainly on moisturized skin, since internally conducted consumer research reveals that 81% of liquid foundation users apply a facial moisturizer prior to using their liquid makeup.

Figure 2 shows the polar and nonpolar contributions to SE of the P&G foundation, competitive foundation, and moisturized cheek skin. Polar components are responsible for the long range and strong interactions (hydrogen bonding or Lewis acid/base complexation), while nonpolar components drive the short range and weak interactions (Lifshitz /van der Waals). Polar components usually dominate interactions due to their long range and strong nature. Bare skin is relatively nonpolar, but as can be seen in Figure 2, moisturized skin has a significant polar component. The P&G product is a Si/W emulsion and it is therefore very hydrophilic, whereas the competitive product is a W/Si emulsion, making it much more hydrophobic than the P&G product. Both products have almost equivalent nonpolar components to the SE of moisturized skin. More importantly, the polar component in the competitive product is almost absent, whereas the polar component in the P&G product is very high; thus, the P&G product can also interact with polar components of the moisturized skin. As a result, the P&G product will have stronger and more favorable overall interactions with the skin.

- Work of Adhesion: Work of adhesion is a measure of the amount of energy required to remove the foundation from the skin. Higher works of adhesion reflect higher affinity between the foundation and the skin, and therefore better wear properties. As shown in Figure 3, the P&G product has a stronger affinity for skin and thus adheres to the skin better than the competitor product.

Relationship Between Surface Energy and Cosmetic Beauty on the Skin: Overall, the P&G formulation has a good SE match with moisturized skin. The water continuous phase and volatile oils evaporate upon application to the skin, leaving behind a dry film composed of the pigment system and the non-volatile oils. This film spreads out evenly and flawlessly merges with the skin in the absence of any driving force for the pigments to flocculate or agglomerate. Therefore, the benefit of this product is that the foundation is continuous with the skin, resulting in a flawless and natural look rather than product pooling or migrating into areas of texture.

In an internal consumer study where panelists were asked to use the P&G product, 97% of panelists agreed that the foundation provided a natural look. This natural look can be directly related to a good SE match between the formula and skin's surface. As a result, SE has proven to be an invaluable technical tool to understand how to best deliver color to the skin and to improve overall foundation performance on the skin.

References

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Figure 1. Surface energy results of common surface treated pigments, solvents, encapsulated and non-encapsulated organic colorants, dry and moisturized cheek skin.

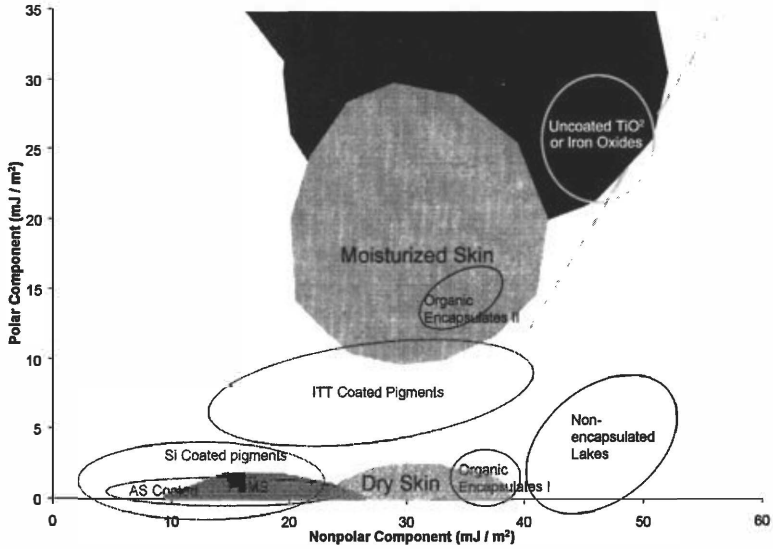

Figure 2. Surface energy results comparing P&G product, competitive product and moisturized cheek.

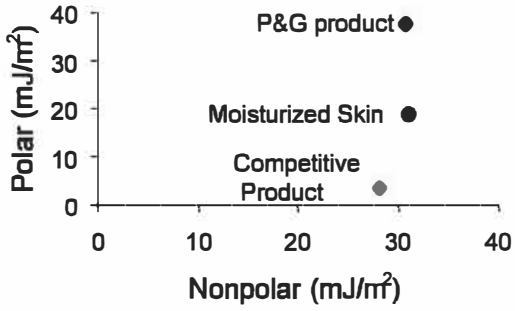

Figure 3. Work of Adhesion of the P&G product and competitive product on moisturized cheek