ZINC OXIDE IN FACE POWDER*

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Introduction

According to definition, face powder fulfils the useful and ornamental purpose of altering the appearance of the face to conform to the current criterion of beauty. Face powder is sold because it replaces shininess with a delicate sheen and at the same time covers up surface imperfections in the skin. In addition, of course, face powder lends a bit of color and fragrance.

Ingredients which are to be used for this purpose must fulfil certain preliminary requirements. U.S.P. zinc oxide meets these initial demands because it has a bright white color, fine texture, is unaffected by exposure to light and is not toxic or irritating to the skin.

Covering Power

Beyond the above characteristics, satisfactory covering power is probably first in importance. Face powder is called upon for a certain degree of camouflage. High covering power is not the criterion—it is how well the powder blends in with the surroundings rather than how well it covers. Too much covering power is worse than too little because of the unnatural effect which it creates.

The measurement of covering power has been a controversial subject for a long time. By varying the test conditions, the pigment concentration or the method of measurement one can obtain widely different values for the relative covering power of pigments. Tabulations of such covering-power values have been published in journals of the paint industry, the paper industry, and the cosmetic industry. No experimental data will be presented in this paper but, in order not to avoid the subject completely, values for covering power have been calculated.

In order to compare the covering power of several face powder ingredients, calculations have been made based upon the refractive indices of the pigments and various media in which they may be used for cosmetics. Fresnel's law (1) states that the reflectivity of an absorbing medium is proportional to the square of the difference in refractive index between the two components

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divided by the square of their sum. It is written

$$R = \frac{(n_2 - n_1)^2 + k^2}{(n_2 + n_1)^2 + k^2}$$

Because the absorption coefficient K is very small in the case of white pigments, the second term in numerator and denominator has been ignored in calculating the data shown in Table 1. In each medium the covering power of zinc oxide arbitrarily has been designated as 100. Actually the values decrease progressively from 100 to 37 to 21 as zinc oxide is placed in air, water and petrolatum, respectively, and the values for the other pigments decrease proportionately. Titanium dioxide has greater covering power per pound than zinc oxide and the latter is superior to chalk and talc. On the basis of cost per unit of covering power, however, zinc oxide is in a more favorable position.

Particle Size

Refractive index, used in the above calculations, measures the power of a substance to bend light and gather it into itself. Light-gathering power is important but the light also must be reflected back and this is done at the crystal surface. The greater the surface present, the more light will be reflected. Thus as the particles of a material are made smaller, more surface is created per pound and greater opacity results. Any discussion of covering power would be incomplete without reference to the effect of particle size. Generally greater covering power per pound results as the degree of subdivision is increased but there are limiting factors, as shown in Fig. 1.

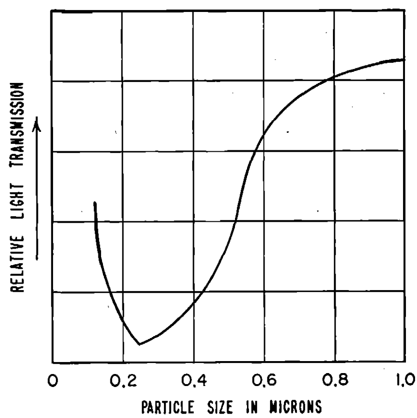

Figure 1.—Effect of particle size on light transmission of ZnO in water suspension

This chart is a calibration curve used for routine checking of particle size of zinc oxide in our plant operations. The turbidimetric method used in this test has been described in the literature (2) and will not be detailed here. It is sufficient to say

Table 1—Calculated Covering Power of Pigments

Pigment	Refractive Index	Relative Covering Power: In Air ($n = 1.00$)	In Water ($n = 1.33$)	In Petrolatum ($n = 1.475$)
TiO_2	2.52	166	232	292
Zinc Oxide	2.008	100	100	100
Chalk	1.658	55	29	15
Talc	1.589	46	19	6

that particle size increases along the abscissa and opacity decreases along the ordinate. You will note the sharp maximum in opacity that occurs in the neighborhood of .25 micron. This is the particle size for optimum opacity of zinc oxide in water. The optimum size for other pigments varies with refractive index, the higher refractive index pigments having their maximum opacity at a finer size. The sharp decrease in opacity noted below .25 is due to the fact that the particles have become so small in respect to the wavelength of light that scattering becomes more dominant than normal reflection. The particles scattering light act as new light sources, sending light in all directions. Instead of light being reflected back (as with a coarser pigment) enough is scattered in a forward direction to make the material appear less opaque.

An analogy from nature will clarify the point. During a rainstorm, distant objects are not hidden appreciably because the raindrops are large and do not have much reflecting surface. On a foggy day, the particle size has been reduced to the optimum size and the atmosphere is really opaque. On a damp humid day, distant objects may be no more obscured than during a rainstorm even though the quantity of water present in the air in all three cases may be identical. In the last case the particles are so infinitely small that they can no longer reflect light.

Our line of zinc oxide pigments covers a wide range of particle size. Our U.S.P. zinc oxide falls in the range of .25 to .40 micron and is in the high opacity classification. The product of extremely fine size is used in the rubber industry and for special applications where the chemical properties of zinc oxide are desired without its attendant opacity. The coarse types are used in ceramics and wherever else a reduced reaction rate is required.

Preventing Shine

A second desired function of a face powder is to eliminate the skin shininess caused by excessive oily secretion in certain facial areas. The prime requirement of a material for this purpose is a high absorptive capacity. Zinc oxide of the desired particle size for optimum covering power will retain less liquid than some materials specially prepared for this purpose but its oil absorption capacity is in the range of other face powder constituents.

In addition to having a capacity to absorb oil or moisture, it is helpful for the material to have a high-refractive index. All pigments are less opaque in an oil medium than in water, and less in water than in air. Table 2 has been prepared using the data from Table 1 and calculating

Table 2—Relative Covering Power Retained After Wetting Dry Pigment

Pigment	With Water, %	With Petrolatum, %
TiO_2	51	37
Zinc Oxide	37	21
Chalk	20	5
Talc	15	3

the percentage relative covering power in changing from an air to water and air to petrolatum medium.

As face powder absorbs moisture and oil from the skin, its covering power decreases. Under these conditions the high-refractive index pigments will lose proportionately less opacity than the materials of low-refractive index which are used in face powder primarily for their absorbing characteristics. The exact proportion of ingredients used to satisfy the demands of covering power, absorbency, slip and adherence is, of course, the decision of the cosmetic chemist.

Ultraviolet Absorption

Zinc oxide may be of value in face powders because of its protective filtering action in absorbing ultraviolet from sunlight. Its protective action in prolonging the life of exterior paint by delaying breakdown of the organic binder is well known and perhaps it applies here to a more limited extent. Data are available showing the percentage of light transmitted by various pigments at various wavelengths through the ultraviolet spectrum (3). The values shown in Table 3 were obtained from films which were only a few particles thick (.00092 mm.) and should be applicable to face powder considerations.

Zinc oxide cuts off the ultraviolet more sharply than any other white pigment used in face powders. It is generally recognized that erythema is produced most rapidly by ultraviolet varying in wavelength from 2950–3150 Angstrom units. Zinc oxide and, to a lesser degree, titanium dioxide, should be quite useful in preventing severe sunburn. It is pointed out in de Navarre's book (4) that investigators have found longer wavelength ultraviolet produces specific effects upon the skin. Although these longer rays produce effects which are much less severe than sunburn, it seems possible that the greater absorption of zinc oxide for these longer rays might be advantageous. This is hypothesis without proof.

Table 3—Ultraviolet Transmission Characteristics of Pigments

	Per Cent Transmitted of Wavelength					
Pigment	4358	4047	3655	3342	3131	3023
Zinc Oxide	46	40	0	0	0	0
TiO_2	35	32	18	6	$^1/_2$	0
China Clay	63	61	59	57	55	54
Chalk	87	86	84	82	80	79
Talc	90	90	90	89	88	87

Medicative Value

One of the intangible values of zinc oxide for cosmetics may lie in that property which makes it valuable in pharmaceuticals (5). It is used in ointments as a mild local sedative and protective agent and has slight antiseptic and astringent qualities. Its fungistatic action has been utilized by the paint and textile industries as well as by the cosmetic industry. Zinc oxide is soothing to the skin. On the hardness scale it lies between chalk and titanium dioxide (6).

Chemical Characteristics

Chemically, zinc oxide is amphoteric, forming salts with both acids and alkalies. A water slurry of U.S.P. grade zinc oxide has a pH about 7.3 which classifies it as a mildly alkaline material. Although there is considerable controversy regarding the effect of pH upon skin health, it would seem that a mildly alkaline material to neutralize acid exudations would be beneficial. Certainly some such neutralization action must account for the deodorizing qualities long associated with zinc oxide in cosmetic usage.

Zinc oxide is a highly water insoluble solid; even in its finely divided state only .005 gram dissolves in a liter of water at 25°C. Chemical impurities are kept at a minimum in the U.S.P. grade. The U. S. Pharmacopoeia specifies relatively low amounts of impurities in U.S.P. zinc oxide and our product is designed to be appreciably lower than these limits.

Physical State

In addition to the foregoing it is probably the finely divided state of zinc oxide that makes it *the* outstanding face powder ingredient. Zinc oxide is an air-born product. Its particles are formed separately and stay separated throughout their processing. It is a dry process—there is no cementation of particles together on drying as in the case of wet precipitated pigments. Dry milling can never quite bring precipitated pigments to as fine a degree of air dispersion as a pigment which has never been wetted and dried during the course of its manufacture. Zinc oxide and other fume products possess characteristics in the dry state which no wet-processed pigments attain. It is this quality of air dispersion that probably accounts for the greater ease of blending and tinting of zinc oxide.

References

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