

Spectrophotometric Reflectance Method for Matching the Color of Solid Dosage Forms

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The chromaticity coordinates and brightness of nearly 50 pharmaceutical colorants have been determined. The coordinates were calculated by a weighted ordinate method from the spectrophotometric reflectance curve of tablets prepared using the colorant. The use of the coordinates and the reflectance spectra in selecting colorants to match a color is explained. The modified Kubelka-Munk equation is used to calculate the concentration of colorant required for the match. Several examples are given which demonstrate how to match the color of a tablet to another tablet, to a color chip, or to other colored material. The method can be adapted to other nontransparent dosage forms such as ointments.

THE COLOR OF a pharmaceutical product is usually given to the colorist by higher management or a committee which selects the color for new products. The colorist may be presented a piece of colored paper, cloth, a chip from a paint catalog, etc., as the color to be matched. The colorist will then proceed, on the basis of his experience, to match the color by trial and error methods. With luck, he may achieve a satisfactory match in a few tries, particularly if it is a familiar color. On the other hand, it may require months of work before a match can be obtained. It is particularly difficult if more than two dyes must be used; this is because of the great increase in color variations possible with three or more dyes.

Part of the problem is that the colorist cannot use the same dyes in pharmaceuticals that have been used in the sample that he is given to match. In these cases, a metameric match is usually the best that can be obtained; that is, the colors will not be a match under all illumination, *e.g.*, daylight and tungsten light.

The decertification of dyes and pigments by the government has increased the problems of the colorist. When a color in current use in a product is removed from the approved list, most companies would prefer to match the old color of the product as closely as possible using different dyes. In this case the colorist has a reference sample of the same material as the final product, but the color may be no easier to match by trial and error methods than a sample of paper.

However, the trial and error method is not the only method available. Spectrophotometric

techniques have been successfully used in the paint, plastic, and other industries for years (1-3). The work described here adapts these techniques to the color problems met with solid dosage forms of pharmaceuticals. The method requires suitable sample preparation for correct measurement of the diffuse reflectance of the sample, transformation of the reflectance data to tristimulus (4) and Kubelka-Munk terms (5), mathematical treatment of the data (preferably by computer methods), and the preparation of the final dosage form according to the formula predicted by the method.

To demonstrate the application of the spectrophotometric method, the study was performed in two parts. First, a group of six dyes was chosen which would be used in various combinations on tablets in the preparation of a series of different colored unknowns. Although the dye composition of the tablets was not disclosed until after the completion of the experiments, it was known that an exact match could be achieved by using the original six dyes. The second part of the experiment was more difficult because the colors to be matched were not prepared with certified dyes or pigments but were colors selected from a paint catalog. Thus, the same pigments used to make the color could not be used in the match; whereas in the first part of this study, the same dyes used to make the unknowns could be used.

THEORY

The concentration of a dye in a solid or on a surface is not directly related to the reflectance of the material or to its logarithm. (In solutions which obey Beer's law, the logarithm of the transmission is inversely proportional to the concentration.) A more complicated series of equations relating concentration and reflectance was developed by Kubelka and Munk (6, 7) and others (8, 9). These equations have been applied to the kinetics of fading of dyes on solid or coated surfaces, and a discussion of the restrictions on the equations in relation to pharma-

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ceuticals has been given (10). The modified Kubelka-Munk equation is

$$\Theta = (1 - R)^2/2R = \frac{a_1 C_1 + a_2 C_2 + \dots + a_n C_n}{2R} \quad (\text{Eq. 1})$$

where Θ is the ratio of the absorption coefficient to the scattering coefficient of the material, R is the reflectance at a given wavelength, the a 's are proportionality constants, and the C 's are concentrations, the subscripts referring to components, 1, 2, etc.

The tristimulus values, X , Y , and Z (4), of a color can be considered as the amounts of each of the three primary lights—red, green, and blue—which must be mixed to match the color in question. The tristimulus values are obtained by integration of the reflectance spectra

$$X \equiv \frac{\int_0^\infty E_c \bar{x} R d\lambda}{\int_0^\infty E_c \bar{y} d\lambda} \quad (\text{Eq. 2})$$

$$Y \equiv \frac{\int_0^\infty E_c \bar{y} R d\lambda}{\int_0^\infty E_c \bar{y} d\lambda} \quad (\text{Eq. 3})$$

$$Z \equiv \frac{\int_0^\infty E_c \bar{z} R d\lambda}{\int_0^\infty E_c \bar{y} d\lambda} \quad (\text{Eq. 4})$$

where E_c is the luminous efficiency of the spectral energy distribution of illuminant C ,¹ \bar{x} , \bar{y} , and \bar{z} are the tristimulus values of the equal-energy spectrum; R is the reflectance of the sample; and λ is the wavelength. The denominator in the definitions normalizes the tristimulus values. The Y function, in addition to being green, was chosen by the International Commission on Illumination to match the response of the eye to brightness; consequently, the magnitude of the Y value is a measure of the brightness of the sample.

The chromaticity coordinates, x and y , are defined

$$x \equiv \frac{X}{X + Y + Z} \quad (\text{Eq. 5})$$

$$y \equiv \frac{Y}{X + Y + Z} \quad (\text{Eq. 6})$$

z is redundant since

$$x + y + z = 1 \quad (\text{Eq. 7})$$

that is, only two coordinates in Eq. 7 are independent. By convention, x and y are used as the chromaticity coordinates. The chromaticity coordinates x and y , and Y completely specify a color.

The chromaticity coordinates are normally plotted on a chromaticity diagram which has a number of useful properties. For example, the coordinates of the colors which result from mixing two dyes lie approximately on a line connecting the chromaticity coordinates of the dyes. For a mixture of three dyes, the resulting colors lie within a triangle with the coordinates for each dye at the apices. The brightnesses, Y , of colors resulting from

¹ Illuminant C is defined by the International Commission on Illumination as "average daylight," such as light obtained from an overcast or north sky (see Reference 11).

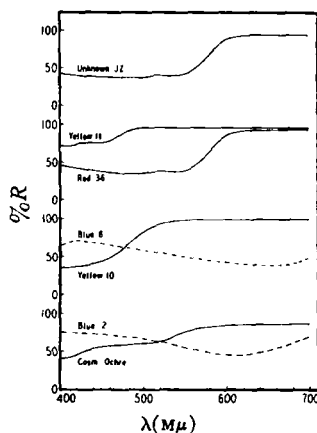


Fig. 1.—Reflectance spectra of the colorants used in the *Experimental* of this study and unknown JZ. The concentrations of the colorants are those shown in Table III.

TABLE I.—COMPARISON OF THE ACTUAL AND CALCULATED DYE CONCENTRATION

Sample Identification	Dye	Actual wt. %	Calcd. wt. %
KA	Cosmetic ochre, C1624	0.5	0.4
	D&C Red No. 36	0.1	0.08
JZ	D&C Red No. 36	0.1	0.09
	D&C Yellow No. 11	0.1	0.1
JB	D&C Blue No. 6	0.01	0.008
	D&C Red No. 36	0.1	0.09
KC	Cosmetic ochre, C1624	0.1	0.08
	D&C Blue No. 6	0.005	0.005
	D&C Yellow No. 11	0.2	0.5
LC	FD&C Blue No. 2	0.02	0.02
	D&C Yellow No. 10	0.04	0.06

mixtures of dyes will always be somewhat lower than those of the single dyes.

A more complete discussion of the above concepts can be obtained in the literature (4, 5, 11).

EXPERIMENTAL

Preparation of Tablets.—Standard tablets of each colorant were prepared at a concentration which gave a moderate color. The concentrations varied for each colorant, depending on their individual tinctorial strengths. Normally, pigment concentration ranged from about 0.1 weight % to 1.0 weight % except for Ebonine confectioners black,² which was used in a concentration of 0.01 weight %. The water and alcohol-chloroform soluble dyes, in general, were of higher tinctorial strength. Their concentration ranged from 0.01 weight % to 0.1 weight %.

The general formulas for the standard tablets and the color matching studies are: acacia U.S.P., 0–5 weight %; pigment, *q.s.*; dye, *q.s.*; water or alcohol-chloroform, *q.s.*; magnesium stearate U.S.P., 1.0 weight %; and lactose U.S.P. *q.s. ad.*, 100.0 weight %.

Tablets containing one or more pigments were prepared by mixing the pigments with lactose and magnesium stearate and pulverizing the blend. Tablets containing only the water or alcohol-chloroform soluble dyes were prepared by wetting the

² Product of H. Kohnstamm and Co., Inc., New York, N. Y.

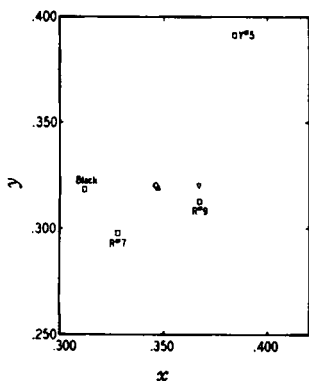


Fig. 2.—Chromaticity diagram for “camellia” match. Key: □ Y#5, 0.1% FD&C Yellow No. 5; □ R #9, 0.2% D&C Red No. 9; □ R #7, 0.1% D&C Red No. 7; □ Black, 0.01% Ebonine confectioners black; ○ Spiffy “camellia”; ▽, first trial “camellia”; ▴, second trial “camellia.”

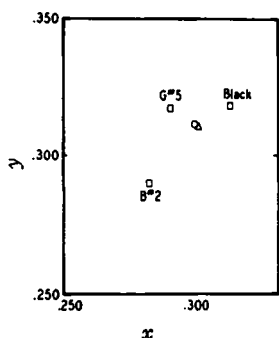


Fig. 3.—Chromaticity diagram for “moonglow” match. Key: □ Black, 0.01% Ebonine confectioners black; □ B #2, 0.04% D&C Blue No. 2; □ G #5, 0.04% D&C Green No. 5; ○, Spiffy “moonglow”; ▴, compressed tablet match for “moonglow.”

lactose-acacia mixture with the dye solution. After drying at room temperature and in an oven at 37° for several hours, the powder was pulverized and the lubricant added. If a formula contained both pigment and dye, a combination of the above procedures was used.

One-inch tablets weighing 3 Gm. were pressed out on the Carver press at a pressure of 5000 p.s.i. One-inch compressed tablets were used for this study because of the ease of measuring the reflectance properties of this type of sample. Small, coated, capsule-shaped tablets have been measured to some degree of accuracy by mounting several tablets side by side in order to fill completely the beam of the spectrophotometer.

Reflectance Measurements and Calculations.—The diffuse reflectance measurements were made on the Bausch and Lomb spectrophotometer, model 505, using BaSO₄ as a white standard. Tristimulus values were calculated on a digital computer by a weighted-ordinate method using a wavelength interval of 10 m μ (4). The reflectance of the spectra used in matching “camellia” and “moonglow” were converted to θ at every 20 m μ by consulting a table (12). These θ values were entered into the COMIC analog computer³ for the matching of the colors of

“camellia” and “moonglow.” The tristimulus difference computer (TDC), model 80,³ was used to obtain a corrected formulation for the dyes in the matching of “camellia.”

The Pierce Spiffy 116C decorator handbook⁴ is a series of colors printed on paper strips about 3/4 × 2 in. This book has been used as a color library and is referred to as the Spiffy paint catalog and the individual paper strips as paint chips.

METHOD

To match a color, the chromaticity coordinates of the unknown color are plotted on a chromaticity diagram which also has the coefficients of the available dyes plotted on it. Then the coordinates of the dyes which form a small triangle about the unknown are selected. There may be several choices of triangles which can be made. The decision regarding which dyes to pick is made on the bases of the Y values (which should be close to the Y value of the unknown) and on the stabilities and costs of the dyes.

In an unusual case, the coordinates of the unknown may lie on a line between those of two dyes. The unknown could be matched by using these two dyes; however, a small off-color shift in a subsequent batch of the dye would result in an off-color product which could not be corrected by the other dye. Using a third dye in the match, a change in one of the dyes can be compensated by adjusting the concentration of the other two dyes. The use of more than four dyes would almost never be required.

After the dyes are selected from the chromaticity diagram, the reflectance spectra are examined to see that the gross features of the dyes conform to those of the unknown. It is most important that the spectral regions of rapidly changing slope correspond in both the dye and in the unknown. If they do not, one of the other dyes must compensate for the differences. The matching of the reflectance minimum is not as critical as matching the regions of rapidly changing slope. This will be pointed out below in the matching of “camellia.”

If the spectra appear satisfactory, the modified Kubelka-Munk equation is used to calculate the concentration of dyes to use in the match. The exact method will be shown below in the examples. With experience, the use of the chromaticity diagram can be eliminated, and the matching can begin by examination of the spectra of the available dyes or tablets prepared from them.

EXAMPLES

In the *Experimental* of this study, five colored tablets were prepared using various combinations of six dyes in unknown amounts. The spectra of these dyes and one of the unknowns is shown in Fig. 1. In matching these tablets, it was not necessary to use the tristimulus data because, with only a limited number of dyes involved, it was possible to see which dyes had been used to prepare the unknowns by comparing the reflectance spectra of the unknown and each of the six dyes.

For example, in matching sample JZ (Fig. 1), the slope of the reflectance spectra from 550–600 m μ is compared to the slope of individual dyes. This slope

³ Davidson and Hemmendinger, Easton, Pa.
⁴ F. O. Pierce Co., Long Island City, N. Y.

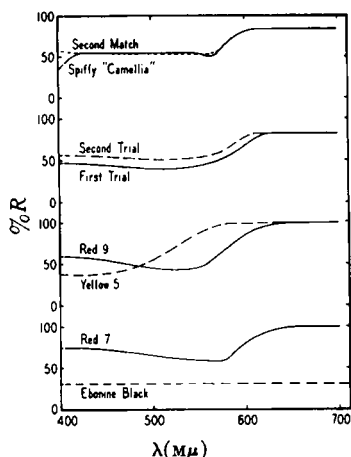


Fig. 4.—Reflectance spectra of the colorants used in the "camellia" match, the Spiffy "camellia" paint chip, the first trial match, and the second trial match.

could result only from D&C Red No. 36. The small slope of the unknown between 400–500 $m\mu$, compared to D&C Red No. 36, indicates the presence of a yellow. Cosmetic ochre, C 1624,⁵ can be ruled out immediately because it begins absorbing at about 580 $m\mu$, and the yellow in the unknown does not contribute to the absorption until about 490 $m\mu$. The choice between D&C Yellow No. 10 and No. 11 is a difficult one since their reflectance spectra are very similar. The chromaticity coordinates of D&C Yellow No. 10 and No. 11 are too similar to choose between them on that basis. However, careful examination of the spectra of D&C Yellow No. 10 shows that the slope between 450–500 $m\mu$ is too steep to be used in the match. The slope of D&C Yellow No. 11 between 450–500 $m\mu$ is more appropriate in this case. If D&C Yellow No. 10 had been used in attempting a match, it would probably be possible to get a suitable color by using a very small amount of the dye.

Having chosen the dyes to use in the match, the concentration of each dye is calculated using Eq. 1. The yellow dye does not contribute to the absorption above 500 $m\mu$ where the red dye has a maximum absorption. Therefore, the amount of red dye to use can be easily calculated at 535 $m\mu$ as

$$\text{For the 0.1\% Red No. 36 standard:} \\ \theta_{535} = (1 - R_{535})^2 / 2R_{535} = a_r C_r \quad (\text{Eq. 8})$$

$$\text{For the unknown, using primes:} \\ \theta'_{535} = (1 - R'_{535})^2 / 2R'_{535} = a_r C'_r \quad (\text{Eq. 9})$$

where the 535 refers to 535 $m\mu$ and the subscript r refers to Red No. 36. Dividing Eq. 8 into Eq. 9 and solving for C'_r gives

$$C'_r = (C_r) (\theta' / \theta) \quad (\text{Eq. 10})$$

Substituting the known values into Eq. 10, the θ values can be read from a table which converts R to θ (see Reference 12)

$$C'_r = (0.1\%) (0.4172 / 0.4660) = 0.090\% \quad (\text{Eq. 11})$$

In Eqs. 8–11, the background absorption due to the inert ingredients was neglected because the inert

⁵ Product of H. Kohnstamm Co., Inc., New York, N. Y.

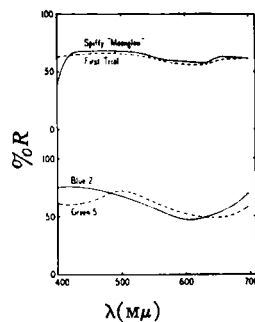


Fig. 5.—Reflectance spectra of the colorants used in the "moonglow" match, the Spiffy "moonglow" paint chip, and the match.

materials were all white. The absorption due to this white material is constant from 400–700 $m\mu$, but can only be detected beyond 620 $m\mu$ where the dyes are not absorbing. The correction is too small to affect the results of this calculation.

The amount of yellow dye cannot be calculated quite so easily as the red dye because wherever the yellow absorbs, the red absorbs also. However, the concentration of red dye has been calculated above, and the absorption of the red dye at 450 $m\mu$ can be calculated based on the absorption of the standard. This can then be subtracted from the absorption of the unknown, and the resulting absorption is due only to the absorption of the yellow dye. Application of Eq. 10 using the data at 450 $m\mu$ and solving for θ'_r gives

$$\theta'_r = (C'_r / C_r) (\theta_r) = (0.090 / 0.10) (0.4660) = 0.4194 \quad (\text{Eq. 12})$$

θ'_r is subtracted from the measured θ of the unknown at 450 $m\mu$ to obtain the θ'_y due to the yellow dye. Then Eq. 10 is applied to solve for the concentration of yellow dye using the 0.1% D&C Yellow spectra as the standard.

$$C'_y = (C_y) (\theta'_y / \theta_y) = (0.1) (0.0391 / 0.0321) = 0.12\% \quad (\text{Eq. 13})$$

A tablet was prepared according to the calculated amount of each dye. The spectra of this tablet was very close to that of the original unknown; the two tablets could not be distinguished by visual inspection (see Fig. 1.).

Table I shows the actual concentration of dye used in the unknowns and the calculated amount of dye using the above described technique. In each case the unknown tablet could not be distinguished visually from the tablet prepared by the calculated formula.

TABLE II.—CONCENTRATION OF DYE TO MATCH "CAMELLIA" AND "MOONGLOW"

Dye	"Camellia" Trial 1	"Camellia" Trial 2	"Moonglow" Trial 1
D&C Red No. 7	0.070	0.044	...
D&C Red No. 9	0.060	0.021	...
FD&C Yellow No. 5	0.012	0.008	...
Ebonine confectioners black	0.001	0.001	0.0070
FD&C Blue No. 2	0.0072
D&C Green No. 5	0.0056

TABLE III.—TRISTIMULUS DATA: CHROMATICITY COORDINATES AND BRIGHTNESS

	Concn.	x	y	Y		Concn.	x	y	Y
BLUES					ORANGES				
FD&C Blue No. 1	0.04	0.235	0.280	0.501	D&C Orange No. 11	0.04	0.379	0.329	0.687
FD&C Blue No. 1 Lake	1	0.232	0.267	0.460	REDS				
FD&C Blue No. 2	0.04	0.276	0.285	0.561	FD&C Red No. 2	0.04	0.328	0.287	0.514
FD&C Blue No. 2 Lake	1	0.269	0.276	0.466	FD&C Red No. 2 Lake	1	0.339	0.284	0.371
D&C Blue No. 4	0.04	0.235	0.280	0.508	FD&C Red No. 3	0.05	0.359	0.269	0.524
BLACKS					FD&C Red No. 3 Lake	1	0.378	0.271	0.455
Ebonine confectioners black	0.01	0.312	0.318	0.651	FD&C Red No. 4	0.1	0.381	0.317	0.509
BROWNS					FD&C Red No. 4 Lake	1	0.371	0.320	0.538
D&C Brown No. 1	0.04	0.385	0.369	0.688	D&C Red No. 7	0.1	0.328	0.298	0.680
GREENS					D&C Red No. 9	0.2	0.367	0.313	0.617
FD&C Green No. 1	0.04	0.255	0.319	0.507	D&C Red No. 10	0.2	0.385	0.314	0.544
FD&C Green No. 1 Lake	1	0.264	0.318	0.565	D&C Red No. 17	0.1	0.395	0.305	0.356
FD&C Green No. 2	0.04	0.260	0.326	0.536	D&C Red No. 18	0.1	0.346	0.275	0.306
FD&C Green No. 3	0.04	0.252	0.314	0.478	D&C Red No. 19	0.05	0.317	0.226	0.361
D&C Green No. 5	0.04	0.290	0.317	0.618	D&C Red No. 22	0.1	0.383	0.286	0.529
D&C Green No. 7	0.04	0.247	0.297	0.547	D&C Red No. 27	0.1	0.342	0.277	0.621
IRON OXIDES*					D&C Red No. 35	1	0.421	0.315	0.361
Cosmetic red oxide A6205	1	0.400	0.333	0.333	D&C Red No. 36	0.1	0.404	0.338	0.551
Cosmetic red oxide A6202	1	0.378	0.327	0.369	VIOLETS				
Cosmetic red oxide 3469	1	0.396	0.334	0.356	FD&C Violet No. 1	0.04	0.258	0.217	0.324
Lt. tab. brown 3228	1	0.379	0.337	0.387	FD&C Violet No. 1 Lake	0.1	0.280	0.263	0.554
Tab. brown 3330	1	0.348	0.324	0.302	YELLOWS				
Cosmetic umber	1	0.339	0.332	0.352	FD&C Yellow No. 5	0.1	0.384	0.391	0.852
Cosmetic suntan	1	0.350	0.335	0.615	FD&C Yellow No. 5 Lake	1	0.391	0.396	0.822
Cosmetic ochre 1624	1	0.339	0.346	0.832	FD&C Yellow No. 6	0.1	0.411	0.358	0.636
ORANGES					FD&C Yellow No. 6 Lake	1	0.404	0.353	0.603
D&C Orange No. 10	0.04	0.368	0.316	0.656	D&C Yellow No. 10	0.1	0.358	0.391	0.943
					D&C Yellow No. 11	0.1	0.351	0.384	0.928

* Products of H. Kohnstamm Co., Inc., New York, N.Y.

Although matches KC and LC contain too much yellow, θ changes only a small amount with large changes in concentration for these particular dyes and allows these matches to be accepted. Furthermore, the eye is not very sensitive to concentration changes of yellow, compared to blues and reds, which is shown by the color perception work of MacAdam as described by Judd (5). If a closer match were desired, the amount of dye needed for a match could be recalculated using the first trial tablet as a standard.

After the success in matching these tablets, the second part of the experiment was begun. In this half of the work, two colors from the Spiffy paint catalog were matched in tablets. In these matches it was necessary to use an analog computer to obtain a match because the same pigments used in the paint chip could not be used in tablets.⁶ The output of the computer is fed to a cathode ray tube where the effect of various concentrations of dye on the resulting spectra can be displayed. A detailed discussion of the computer has been given (13), so only a brief summary will be given here.

The computer method is identical to the method described above, except that the computer solves for

⁶ Matches have been calculated using a desk calculator; however, because the matches are metameric, it is difficult to pick the best concentrations without calculating tristimulus values for each possible match. These calculations are ideally suited to an analog computer.

the sum of the θ values for all dyes at 16 different wavelengths simultaneously. The output is displayed on a cathode ray tube which allows the unknown curve to be compared to the curve which results from the dyes used in the match. By adjustment of potentiometer dials, the concentration of each of the dyes can be altered electronically until the mixture curve corresponds to the unknown curve. The settings of the potentiometers are directly related to the weight per cent of dye.

The choice of dyes to use in the match is made the same way described in the first part of this study. If there is a choice between two dyes, both can be entered into the computer; the dye which gives the closest match can be selected after viewing, on the cathode ray tube, the effect of both dyes on the mixture.

A tristimulus difference computer (TDC) can be used as an attachment to the basic computer. This indicates the difference in tristimulus values between the sample (standard) and the curve which results from the mixture of dyes used to match the sample. It is extremely useful when making a metameric match because it allows the choice of dye concentration which gives the closest tristimulus match. The best match cannot always be determined on the cathode ray tube because, in a metameric match, there is considerable overlapping of the spectra of the sample and of the mixture. The TDC shows

which combination of dyes gives the closest tristimulus values and, therefore, the best match.

If the trial tablet prepared according to the formula calculated by the computer is not a sufficiently close match, the θ values of this first trial tablet are determined and entered into the computer. The operator can then correct this first trial formula by adjustment of the concentration potentiometers and obtain a better match. Usually the second trial will be a satisfactory match.

The chromaticity diagram plots of the dyes used to match "camellia" and "moonglow" are shown in Figs. 2 and 3. These plots show that the color which results from a combination of dyes lies within the boundary of the triangle (Fig. 3) and quadrangle (Fig. 2), described by the chromaticity coordinates of the dyes used in the match.

Figure 4 shows the reflectance spectra of the dyes used in the "camellia" match. The first trial tablet was too dark (the chroma was too high),⁷ but it was the correct hue.⁸ The reflectance data from the first trial tablet were converted to θ values and entered into the computer; a satisfactory match was achieved with the corrections calculated on the second trial. The reflectance spectra of the second trial is shown next to the first trial and also next to the "camellia" for comparison.

The comparison of the reflectance curve of the second match of "camellia" to the Spiffy "camellia" shows two significant points. First, the minimum in the Spiffy "camellia" curve at about 565 m μ was not matched; second, the two curves cross over several times. The failure to match the minimum was not so important as matching the rapidly changing slope from 570–600 m μ , as was mentioned under *Method*. The sharp absorption from 400–415 m μ in the Spiffy "camellia" is caused by TiO₂ and is of no concern to the colormatcher. The crossing over of the spectra produces a metameric match.

Figure 5 shows the reflectance spectra of the dyes, other than black, used for the "moonglow" match. In this instance, the first trial was a satisfactory match. The ultimate dosage forms for these colors are sugar-coated, capsule-shaped tablets. No difficulties were encountered in changing from the com-

pressed tablets used in obtaining the match to the capsule shaped tablets. The correct color was obtained by using 20 coats of a syrup solution containing one-half the calculated dye concentrations. Table II shows the concentrations of dyes used in the matching of "camellia" and "moonglow."

TRISTIMULUS DATA

The tristimulus data for nearly 50 colorants are given in Table III. The tablets were prepared according to the procedure described above, and the tristimulus data were calculated by the weighted ordinate method.

CONCLUSIONS

The problems in matching the color of a pharmaceutical product to a paint chip or any material which uses nonpharmaceutical colorants, have been mitigated by using a spectrophotometric approach. The ability to achieve a satisfactory color match in one or two tries is a significant improvement over a trial and error procedure. It can only be properly appraised by considering the number of man hours freed by this method for more productive tasks. The closeness of the matches achieved with the spectrophotometric technique establish this as the preferred color matching method. The technique should work equally well with other nontransparent dosage forms such as ointments.

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⁷ Chroma is the degree of vividness of the hue or saturation.

⁸ Hue is the attribute of a color which allows it to be described as red, blue, etc.