THE INSTITUTE OF PAPER CHEMISTRY

Appleton, Wisconsin

REVIEW OF STUDIES CONCERNED WITH THE COLOR OF UNBLEACHED KRAFT LINER

√ Project 1108-24

A Report

to

TECHNICAL DIVISION
FOURDRINIER KRAFT BOARD INSTITUTE, INC.

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INTRODUCTION

At the request of the technical committee, a series of studies were carried out by The Institute of Paper Chemistry some years ago to develop methods for measuring and specifying the color of 42-lb. unbleached kraft liner. These studies were prompted by the reaction of the linerboard consumer at that time to the wide differences in color exhibited by boxes from the same or different suppliers. The color differences were aggravated by the introduction at that time of linerboards which were considerably brighter and lighter in color.

According to the International Commission on Illumination, the color of any surface may be characterized numerically in terms of the following optical properties: (1) dominant wave length, (2) purity, and (3) luminous reflectance. A recording spectrophotometer is usually employed to obtain a spectral reflectance curve over the visual range. The reflectance curve is then used to calculate the above optical properties. Because of the initial cost of a spectrophotometer and the skilled manpower required for its operation and maintenance, such equipment was felt to be unsuited for routine color measurement and control.

For this reason an important objective of the research studies was to investigate the feasibility of using the brightness tester with appropriate filters to determine the color characteristics of kraft liner.

A change in any one or more of the three color characteristics is sufficient to change the visual appearance of the surface. In the general case, a com-

therefore, color standardization involves selection of a standard level and tolerance for each of the three characteristics.

It would be economically and probably physically impossible to hold the color level of liner within tolerances which would permit no perceptible difference. The nature of the product, the process by which it is made and the use to which the product is put do not justify close tolerances. A color tolerance must be reasonable and practical. When the study was initiated, it was felt that the "critics" were not endeavoring to eliminate small but perceptible differences in color, rather they were concerned with large variations in "color." Thus, the problem was one of determining methods or procedures whereby individual mills or the FKBI as a whole could establish maximum allowable limits for the color characteristics. It should be emphasized that all work in the area of standards and tolerances was solely for the purposes of determining whether the proposed methods were reasonable and practical.

Four reports were distributed to the group. The results obtained were as follows:

A. Report One. An investigation of a method of specifying and measuring the color of 42-lb. unbleached kraft liner. Project 1108-15. June 15, 1956.

In this report three aspects of the problem were investigated. These were (1) an investigation of the suitability of the Standard Brightness tester with appropriate filters for evaluating the color characteristics of linerboard, (2) a limited determination of the effect of corrugating on the optical properties of linerboard, and (3) the investigation of a method whereby the maximum differences

in the color characteristics of linerboard which would be acceptable to your membership and customers might be determined.

The following conclusions were reached:

1. The Standard Brightness tester could be used with four special filters to determine the dominant wavelength, luminous reflectance, and purity of unbleached kraft linerboard. [Note: The use of the brightness tester was based on the observation that the "color" curves for unbleached kraft liner were of two types – i.e., (1) a relatively straight line or (2) a curve consisting of two intersecting straight lines. Since, then, the Standard Brightness tester has been equipped with appropriate filters to convert it into a four-filter colorimeter for color matching and control in the paper industry (1).]

2. The corrugating operation did not appear to introduce significant effects in so far as color is concerned.

3. Of the three optical characteristics, the dominant wavelength was approximately constant at about 582 mμ for all 42-lb. kraft samples. This indicated that the problem of measuring and controlling the color of unbleached kraft linerboard is essentially one of measuring and controlling the purity and luminous reflectance.

4. To test one method of determining maximum allowable color tolerances, the members of the technical committee were requested to judge the acceptability of a large number of linerboard samples with reference to a linerboard sample having nearly average optical characteristics. In all cases the panel rejected samples having purity or luminous reflectance values greatly different from the average.

Samples differing from the average by 3 or 4 units of either purity or luminous reflectance tended to be considered unacceptable by 75% or more of the panel. Therefore, it appeared that this method could be used in establishing levels of acceptable color differences.

B. Report Two. An investigation of the optical characteristics of 42-lb. unbleached kraft liner. Project 1108-15. April 25, 1947.

At the conclusion of the work summarized in Report One, it was felt desirable to obtain more information regarding the color characteristics of the linerboard manufactured by the various mills. These data would then serve to better define the differences in optical characteristics exhibited by linerboard for the group as a whole and for individual members of the group. The Institute was therefore authorized to evaluate for a 6-month period the optical characteristics of the 42-lb. liner samples submitted in connection with the liner baseline study. These measurements commenced in September 1956 and were terminated in February, 1957.

Among the conclusions reached were the following:

1. *Extreme sample lots differed in purity by about 12 units and in* luminous reflectance by about 13 units. The major number of samples fell in a purity range from 27 to 33% and a luminous reflectance range from 22 to 29%.

2. The above ranges in either purity or luminous reflectance were considerably greater than what were considered acceptable by the panel in the first study.

3. For the group, the average luminous reflectance and purity values were 25.6% and 29.2%, respectively.

4. Chance circumstances in the manufacture of kraft liner result in some correlation between luminous reflectance and purity – i.e., the lower the luminous reflectance, the higher the purity. It was not a precise relationship, however, as the overall correlation coefficient was only about 0.57. If a favorable relationship existed, color control in terms of either luminous reflectance or purity alone would be possible.

C. Report Three. A simplified method for determining the purity and luminous reflectance of 42-lb. unbleached kraft linerboard. Project 1108-15. May 1, 1958.

In Reports One and Two, a method for measuring the color characteristics of 42-lb. unbleached kraft liner was developed based on reflectance measurements at four wavelengths – namely, 457, 512, 582, and 596 mμ. Measurement of the color characteristics of a large number of samples by this method indicated that the dominant wavelength for all samples was essentially a constant near 582 mμ. Assuming the dominant wavelength is constant, the purity and luminous reflectance of such samples may be computed if reflectance measurements at only two wavelengths (457 and 596 mμ) are known.

In this report the "two" and "four" reflectance measurement methods were compared. Closely equivalent results were obtained. Therefore, the simplified method based on two reflectance measurements was recommended for use in the measurement of the purity and luminous reflectance of 42-lb. unbleached kraft linerboard.

D. Report Four. The development of a single-filter method for determining luminous reflectance and comparison of visual ranking of color differences in 42-lb. unbleached kraft linerboard with its optical characteristics. Project 1108-15. January 30, 1961.

Based on the previous results various members of the FKBI suggested that:

1. Mill specifications and control in terms of both purity (p) and luminous reflectance (Y) would be impractical.

2. Visual ranking of linerboard samples appeared to be primarily influenced by differences in luminous reflectance. Therefore, color standards based on luminous reflectance alone might be practical for 42-lb. unbleached kraft liner.

To pursue this approach the Institute carried out a study with the following objective:

1. To develop a special filter for the brightness tester to permit direct measurement of luminous reflectance.

2. To compare luminous reflectance values determined with the single filter against values obtained by the two-reflectance method developed in previous work.

3. To test the hypothesis that visual ranking of color differences in kraft linerboard are primarily influenced by luminous reflectance rather than luminous reflectance and purity.

The characteristics of the special filter were computed and the Institute is prepared to furnish such filters to interested mills [Note: A description of the characteristics of this filter may be found in reference (1).] However, because of variations in phototube response and in the spectral transmission of the lenses, it is essential that the brightness tester be returned to the Institute to permit initial adjustment of filter and instrument.

Among the other conclusions reached were the following:

1. Luminous reflectance values determined using the single-filter method were in reasonably good agreement with values determined by the two-reflectance method. Thus, the measurement of luminous reflectance was considerably simplified.

2. When mill personnel were requested to rank a series of samples with respect to their color characteristics, it was noted that for the method used, luminous reflectance was more highly correlated with the visual rankings than purity.

3. On the basis of these results it appeared that luminous reflectance, by itself, will predict the visual ranking of unbleached kraft linerboard having optical characteristics similar to those used in the study as well as luminous reflectance plus purity.

LITERATURE CITED

1. Dearth, L. R., Shillcox, W. M., and Van den Akker, J. A. A study of photoelectric instruments for the measurement of color: Reflectance and transmittance. Part XIV. The Standard Brightness Tester as a four-filter colorimeter. Tappi 46:1 (January, 1963).