Use of trichromatic colourimetery for measurement of brightness and yellowness of bleached pulps

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SUMMARY

Brightness measurement of bleached pulp and paper is conventionally carried out in the Indian pulp and paper Industry, on a spectral reflectance meter of the Elrepho type using the R 457 filter.

The peak reflectance value of this filter lies in the blue region of the spectrum at 457 μ and is quite suitable for overall brightness measurement of the sample. However, no direct method for measurement of the degree of yellowness is available, if the R 457 filter is used.

This study evaluates the use of Trichromatic Colourimetery using Tristimulus Red (X), Green (Y) and Blue (Z) filters. A more direct measurements. of % yellowness is obtained by this method. Comparison of R 45 7 measurements and the Tristimulus filter measurements show very good correlation between brightness, yellowness and the post colour numbers of bleached and aged pulps using the two methods independentlyt Values of initial yellowness of the samples have been used to predict the post colour numbers obtained after ageing the samples. This method can be used with advantage in commercial practice.

The measurement of brightness of bleached pulp and papers is commonly carried out on a spectral reflectance instrument of the Elrepho[1] type using a Blue Filter (R 457).

However, this filter gives peak reflectance values at 457 μ i.e in the blue region of the spectrum. Since this value indicates only the total brightness or whiteness of the sample, it is not possible to obtain a measure of the yellowness in the sample.

A more direct method for obtaining the extent of yellowness in bleached samples, uses the three trichromatic filters viz. Trichromatic Red (X), Trichromatic Green (Y) and Trichromatic Blue (Z).

A detailed discussion of this method is given in the literature review. This study also evaluates a rapid and direct method of measuring the brightness and yellowness of bleached pulps.

When bleached samples are aged in sunlight or subjected to the accelerated ageing process[2], their discolouration is further enhanced, and expressed in terms of post colour number (P.C. No.).

In this study the % yellowness obtained by using trichromatic filters and the P.C. No. using only the R 457 filter are also correlated.

LITERATURE REVIEW

Colors are interpreted psychophysically by the human brain through a system of nerves which are sensitive to three primary colours. Light reflected by a coloured object is passed through the eyes on the retina, and the image is analysed and interpreted for its colours by excitations of colour sensitive nerves in the brain[3].

Any colour can be defined by measurement of its reflected components through the Red, Green and Blue Tristimulus filters using a white light sources for illumination. The trichromatic method for measurement of colours uses the directional reflectance of the sample with three tristimulus filters, viz. green, amber, and blue, the value being relative to magnesium oxide or barium sulphate as a standard white surface. A, G and B represent the readings obtained with the amber, green and blue filters respectively. The tristimulus values X, Y and

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Z for illuminant 'C' are computed according to the following equations :—

$$X = 0.782\ A + 0.198\ B$$
$$Y = 1.00\ G$$
$$Z = 1.181\ B$$

The numerical values involved in the above equations are specific for the type of illuminant used.

These tristimulus values X, Y, Z are then converted to the chromaticity co-ordinates x, y, z as follows :—

$$x = \frac{X}{X + Y + Z}$$
$$y = \frac{Y}{X + Y + Z}$$
$$z = \frac{Z}{X + Y + Z}$$

As $x + y + z = 1.0$, it is sufficient to specify only the co-ordinates x and y for defining any colour since $z = 1-(x + y)$.

Thus three filter colourimetry serves an important practical purpose by defining unambiguously any colour.

Bleached pulp and paper samples are usually defined in terms of their percent brightness i.e. the relative reflectance of light by the blue filter as compared to a standard white surface such as Magnesium oxide or Barium sulphate. The discolouration of bleached pulp and papers is caused by storage, exposure to light etc. and is indicated by a decrease in brightness which is taken as a measure of colour reversion. As the discolouration of bleached pulp or paper is in the yellow region, measurement of the blue reflectance by the use of R 457 filter is not so well suited for determination of yellowness.

In this study, the Trichromatic system of colour measurement is used for obtaining the brightness and yellowness of Bleached papers and an attempt is made to correlate these data with the % brightness and P.C. Nos. obtained by the equations stated below. James clerk Maxwell[4] and others pointed out that a proper description of colour always requires three dimensional array. Hence it may be more acceptable to use tristimulus values for the measurement of brightness, yellowness and P.C. No.

The standard practice is to difine the percent brightness and the post colour No. as

% Brightness = % reflectance given by the R 457 filter

$$\text{P.C. No.} = [(1-R_2)^2/2R_2-(1-R_1)^2/2R\ ] \times 100$$

Where :

R_1 = Diffused reflectance of paper sheet.

R_2 = Diffused reflectance of aged paper sheet.

Rao, G.V. and Maheswari, H.K.[5] have also measured yellowness using three different tristimulus filters Fmx/C, Fmy/C, Fmz/C, which are the Amber (A), Green (G) and Blue (B) filters respectively. The yellowness is then calculated by using the formula

$$\frac{A-B}{G} \times 100 = \%\ \text{yellowness.} \quad (6)$$

RESULTS AND DISCUSSION

BLEACHING :

From Table I it is seen that the % Brightness of the bleached samples ranges from 77 to 85.3. This is measured by the conventional R 457 filter. Corresponding % reflectance values for the FMX, FMY and FMZ filters, after computing as per the formulae are also given in Table-I

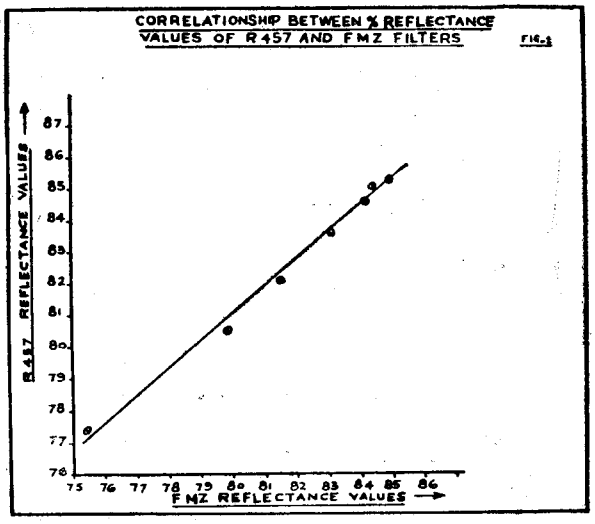
TABLE—I PERCENT REFLECTANCE VALUES OF BLEACHED PULP SHEETS USING THE R 457 AND TRISTIMULUS FILTERS

Sl. No.	Initial Brightness (R-457)	'A' FMX	'G' FMY	'B' FMZ	Yellowness, % $= \frac{A-B}{G} \times 100$
1.	77.4	89.2	87.1	76.4	14.69
2.	80.5	91.1	89.3	79.8	12.65
3.	80.1	89.8	88.7	80.0	11.04
4.	82.1	90.7	89.3	81.4	10.41
5.	83.6	91.7	90.4	83.0	9.62
6.	84.6	92.0	90.8	84.2	8.59
7.	85.1	91.7	90.7	84.4	8.04
8.	85.3	91.9	90.7	84.9	7.71

COMPUTION OF BRIGHTNESS AND YELLOWNESS :

Excellent correlationship is obtained between the % brightness values (R 457) and the reflectance values of FMZ (Blue) filter. This is expected since the FMZ trichromatic filter gives peak reflectance at 455 μ and is thus nearly matching with the R 457 filter. Thus, when using the trichromatic method, the reflectance values shown by the FMZ filter will

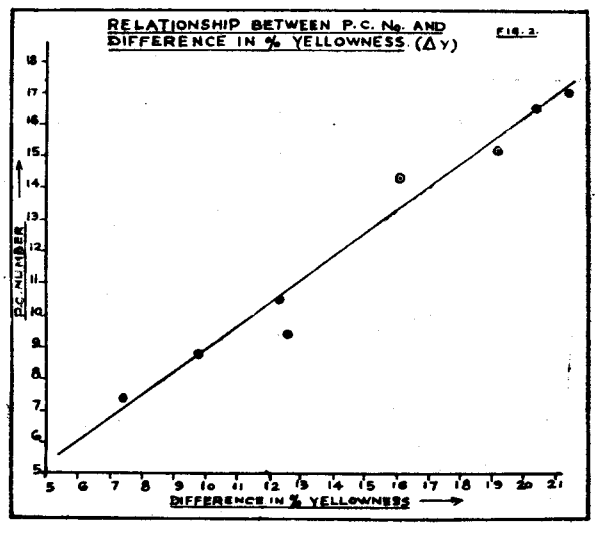
correspond to the % brightness values of the R 457 filter (Fig. 1).

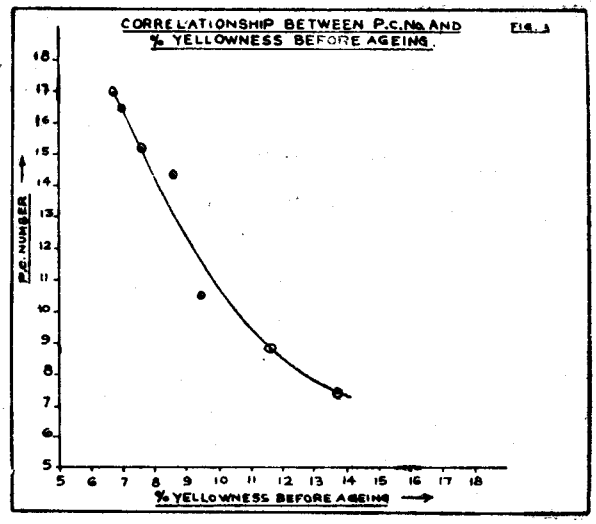


Secondly the data also show relative figures of % brightness as well as % yellowness, for a given sample are simultaneously obtained.

P.C. NUMBER AND % YELLOWNESS :

The P C. Number of bleached samples is computed by measurement of the % brightness before and after ageing (R 457) whereas the corresponding tristimulus method uses the increment in yellowness % ($\triangle y$) after agiing. Figure-2 shows the correlationship between these two parameters and a perfect linear relationship is obtained, indicating that ($\triangle$ y) can be used to represent the P.C. number. An inreresting application of the method has been tried out in this study in order to predict the P.C. number of given sample by correlating the initial yelloness of the bleached samples and their P.C. number. Since computation of the P.C. number involves ageing of the samples at 95°C for 1 hour followed by air drying for 24 hours, the method is elaborate and time consuming. Fig. 3 shows that this relationship is inverse and linear. Thus the method can be used to predict the P.C. numbers of bleached pulps in advance and can prove useful in commercial practice.





TABLE—II PERCENT REFLECTANCE OF BLEACHED PULP SHEETS AFTER AGEING, USING R 457 AND TRISTIMULUS FILTERS

Sl. No.	R-457	'A' FMX	'G' FMY	'B' FMZ	Yellowness, % $\frac{A-B}{G} \times 100$
1.	63.2	79.5	76.0	62.7	22.10
2.	62.6	79.0	75.3	62.1	22.44
3.	61.6	79.1	75.2	61.3	23.67
4.	61.0	77.6	74.0	60.8	22.70
5.	57.3	74.7	70.8	56.5	25.70
6.	56.6	76.2	72.0	56.2	27.77
7.	55.5	75 4	71.1	55.2	28.41
8.	55.1	75.0	70.5	54.5	29 07

CONCLUSION

Use of Tristimulus colourimatric method using the Red, Blue and Green (FMX, FMY and FMZ) filters, gives simultaneous data on % Btightness and % yellowness of bleached pulps.

TABLE—III. RELATIONSHIP BETWEEN P.C. No, AND PERCENT YELLOWNESS

Sl. No.	Brightness Before Ageing %	Brightness After Ageing %	P.C. No.	Yellowness before ageing, % 'M'	Yellowness after ageing, % 'N'	Increase in percent yellowness after ageing % (N—M)= Δy
1.	77.4	63,2	7.42	14.69	22.10	7.41
2.	80.5	62.6	8.78	12.65	22.44	9.79
3.	80.1	61.6	9.41	11.04	23.67	12.63
4.	82.1	61.0	10.52	10.41	22.70	12.29
5.	83.6	57.3	14.30	9.62	25.70	16.08
6.	84.6	56.6	15.23	8.59	27.77	19.18
7.	85.1	55.5	16.53	8.04	28.41	20.37
8.	85.3	55.1	17.03	7.71	29.07	21.36

The values show excellent correlationship with the % brightness values obtained by the R 457 filter (Blue) as well as the P.C. number values computed afrer ageing the samples.

In addition, the P.C. number of bleached pulp/ paper sheets can be predicted by measuring the initial yellowness values of the samples, and thus serve as a useful approach for prediction of P.C. numbers in a limited way.

EXPERIMENTAL

Bamboo pulp (*D. strictus*) was used in this study.

PULPING :

Bamboo chips from sound bamboo were cooked in a 15 ltr rotating digester with $NaOH + Na_2S$, and the cooking conditions, e.g. active alkali, time and temperature were adjusted to obtained unbleached pulp of kappa number 25 $\pm$ 1.

BLEACHING

This pulp was further defibrated and bleached with a CEH sequence. In chlorination, the optimum chlorine charge i.e. one-fourth of the kappa no. was given. In alkali extraction, alkali charge i. e. one-fifth of chlorine charge was given. In the hypochlorite bleaching stage, variation of Hypo charge as well as conditions of bleaching were maintained in order to obtain pulps of different brightness values. Constant conditions for bleaching are given in Table-IV.

TABLE—IV. HYPOCHLORITE BLEACHING OF CHLORINATED AND ALKALI EXTRACTED PULP.

Sl. No.	Particulars	1	2	3	4	5	6	7	8
1.	Hypo, %	4.5	5.5	4.5	6.0	8.0	10.3	11.5	12.6
2.	Buffee %	0.8	0.8	—	0.8	0 8	—	—	—

NOTE : Chemicals were added on O. D. Unbleached Pulp basis. Iu each case (1—8) 25 gm O. D. Unbleached Pulp was taken.

Constant conditions for bleaching :—

—	"C" Chlorination	"E" Alkali Extraction	"H" Hypochlorite Bleaching
Consistency, %	3	10	10
Temperature, °C	Ambient	55±2	Ambient
Retention Time, Hrs.	0 75	1	4

MEASUREMENT OF INITIAL BRIGHTNESS AND P.C. NO WITH R 457 FILTER :

Sheets were prepared from the bleached pulp according to TAPPI standard method. Accelerated ageing of the bleached sheets was carried out as per TAPPI standard method (T-260 pm 81). Per cent reflectance of the sheets was measured on the Elrepho Photo meter using R 457, FMX/C, FMY C, FMZ/C, filters) (Trichromatic Filters). Data for initial brihgtness and brightness after agieng are given in Table IV and II. Data for P.C. Nos. of corresponding samples are given in Table-III.

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