Paper Whiteness at The Point of Sale

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Introduction

There are many references discussing the measurement of paper whiteness during paper manufacture and at the point of quality control (1,2,3). Many experienced purchasers of paper use similar methods to determine which papers they should purchase or are expert at visually comparing shades to determine the best paper for their purpose. A great deal of research has been conducted into the field of whiteness measurement (4,5).

However, to many the situation is not so straightforward, although many attempts have recently been made to try to standardise whiteness methods, it is still difficult for the untrained person to compare paper whiteness at the point of sale. At the same time more and more people need to purchase paper today, since the number of households in the UK with a printer, for example, has now risen to 65% (6). Purchasing habits have therefore changed significantly over the years. The supermarket for example is a significant source of paper supplies to the general public. Internet use is growing (7) and on-line shopping is growing as a medium for purchasing paper.

Scope

This paper attempts to describe the current systems in place to communicate paper whiteness to those persons without training in colour measurement. Most of the information applies to uncoated woodfree A4 sheets of paper designed for photocopiers and home printers. Ink-Jet papers and

papers for home photograph printing are also included, which can be coated and which can also be available in alternative sizes. In this case “the whiteness of paper at the point of sale” refers to the information normally available at the place where the paper is purchased which in this case means information printed on the pack or in the descriptive text in the case of catalogues or internet sales. Many retailers are able to provide additional assistance in terms of samples and further information, on request. However this is not covered as it is normally reserved for those with more experience in the field and is usually not referred to by the general public.

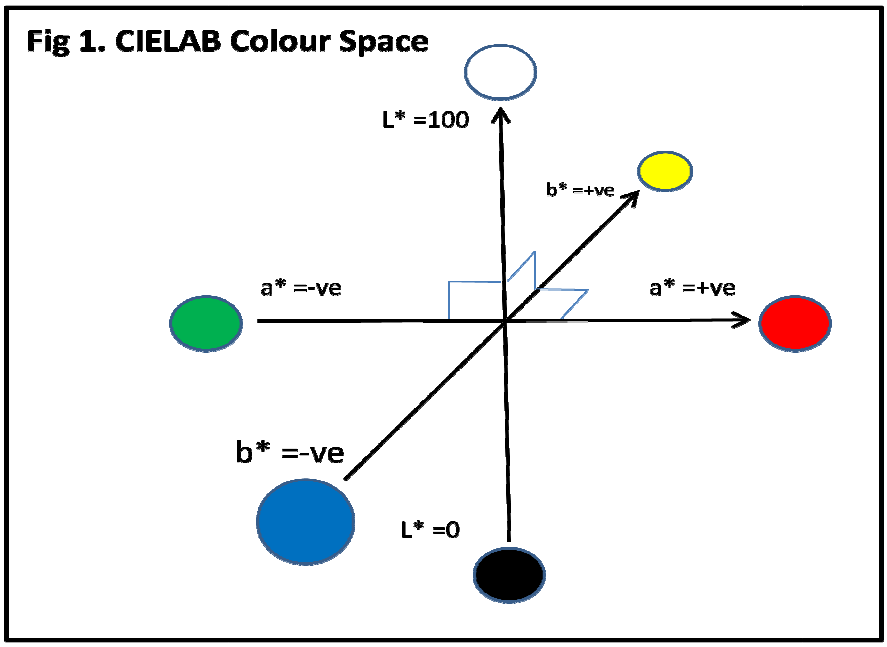
The world of colour

The science of colour is highly advanced, but the basic ground rules for describing a colour are very clear. Since colour space is 3 dimensional, colours are best described with 3 colour co-ordinates. There are several different ways of describing colour space but in this article we will use CIELAB L*,a*,b* co-ordinates (Fig. 1), because this system is the one that is most used in the paper industry (1,8). Any colour can therefore be described using the CIELAB system with three numbers (1):

L* value (Lightness or Black/White axis, where a low value is Black and a high value is White)

a* value (Red/green axis where a positive value is Red and a negative value is Green)

b* value (Yellow/Blue axis where a positive value is Yellow and a negative value is Blue)



When used with a good instrument and clear guidelines for viewing conditions illuminants etc, in general we can be pretty confident in using these co-ordinates to describe, communicate and reproduce any colour with a high degree of accuracy.

Why then when we come to one particular colour of paper, i.e. white, do we try to describe it with a single number?

Current Whiteness Communication Methods

There are in general, four main types of communication method for papers:

1) Descriptive Words
2) Visual
3) Brightness values
4) CIE Whiteness values

Descriptive Words

In this case the paper whiteness is described using words, typical phrases appearing are:

a) Bright White Paper

b) A Whiter Brighter Sheet than economy paper

c) A High White Sheet

Advantages

This system is simple and easily understood.

The phrases help the consumer to determine which papers are white, as compared to those that are off-white or cream.

In some cases (e.g. b above) they allow some comparison with other grades from the same brand series.

This system can be used to describe papers on the internet or in catalogues.

Disadvantages

Often no direct comparison can be made as to which paper is the whitest (e.g. High white or Bright White?).

No determination of the exact whiteness level is possible.

Definitions

At this point the general definitions of the words brightness and whiteness should be explained as these have another meaning to papermakers which will be explained later.

The Oxford Encyclopedic English Dictionary makes the following definitions:

Bright – adj. emitting or reflecting much light, shining adv. Brightness

White – adj. resembling a surface reflecting sunlight without absorbing any of the visible rays; or the colour of milk or fresh snow adv. whiteness

Visual

Most people when trying to compare two sheets of paper for whiteness would naturally try to compare the papers together. Some brands allow comparison through the use of clear windows in the ream wrapper allowing the consumer to see the paper. Others use clear ream wrapping material.

Advantages

The consumer can now see the paper and can therefore determine if the particular shade is close to what they require.

The consumer can determine in their own mind if the paper is high white or low white.

The consumer can compare papers at the point of sale when both are visible through windows or clear wrapping.

Disadvantages

Only papers with a clear window or clear wrapper can be compared. Many papers have opaque ream wrappers.

The system is of no use on the internet or in catalogues.

From a technical perspective, the illuminant or light source at the point of sale may vary and due to the phenomena of metamerism*, the visual comparison of the sheets may be different under one light source compared to another.

Where windows are used these can be quite small and therefore putting the sheets of paper close together can be physically difficult, due to the width of the reams.

The effect of the clear plastic on the absorbance spectrum of the sheet is undetermined.

*metamerism occurs when the reflectance spectrum of the paper appears different under different lighting conditions. This is because the output of different illuminants is dependent on the method used to generate light. For example a standard Tungsten Filament lamp has a different energy output across the spectrum from outside daylight, Fluorescent strip lighting has a different output again.

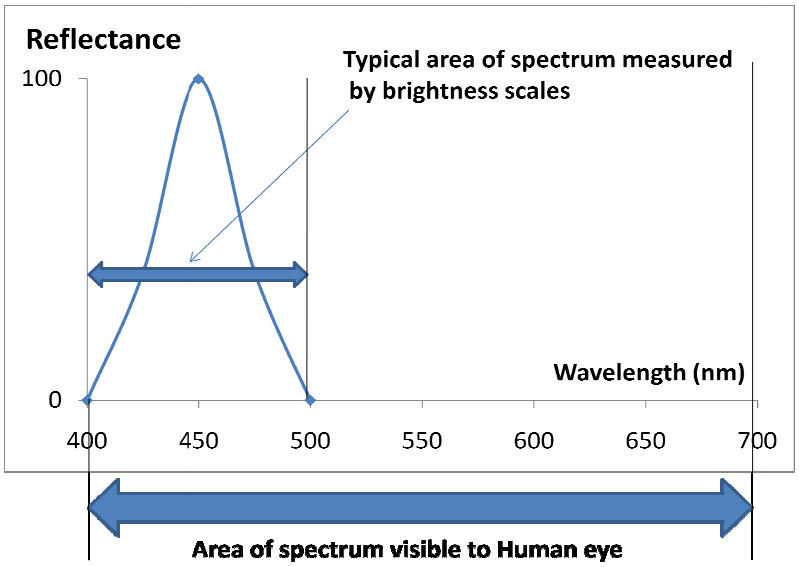
Brightness values

To the papermaker, brightness means a measurement of the reflectance of the paper at a particular narrow wavelength group (Fig.2). There are several methods for determining this value according to the conditions used for the instrument used, illuminant etc. that can all be grouped together for the purpose of discussion as “Brightness measurements” (9).

These are commonly used to assess the brightness of pulp, to which they are highly suited because pulp is a natural material and therefore has a simple reflectance spectrum which is predictable in the way that it responds to bleaching by increasing reflectance.

However, manufactured paper does not have a simple reflectance spectrum, therefore attempts to assess papers with brightness measurements often do not correspond well with what the eye sees. This is compounded because white paper contains trace amounts of colourants and often large amounts of Optical Brightening Agents (OBA). Whilst Brightness in a suitable instrument with an illuminant that has a good Ultra Violet portion can assess the OBA to some extent, it can never assess the effect of the colourant on the overall whiteness perceived by the eye.

Fig 2. Brightness



Advantages

Brightness provides a simple, easy to measure, value that can be used for direct comparison.

Brightness is widely used in the USA.

The measurement methods are very well described and controlled.

Disadvantages

There is more than one brightness term in use (for example TAPPI Brightness is used in USA and ISO Brightness is used in Europe), each brightness system generates different numbers that are not directly comparable with each other. This generates confusion.

As mentioned above, brightness does not include the shading colour component which is very important in high white shades.

The scale in use is not always easy to understand, what is the highest value available and the lowest?

CIE Whiteness values

CIE Whiteness is a measurement that compares the full reflectance spectrum of paper and generates a figure which corresponds to what the eye sees. It allows for both the blueness and the lightness to be compared simultaneously. It is, so far, the best system for comparing whiteness that we have today (10). However, there are certain factors which make the comparison of CIE Whiteness values very difficult in the paper industry today;

1) Instrumentation – Different Instruments can give different results for the same paper
2) Illumination – Depending on the Ultra Violet component of the illuminant, the OBA is activated more or less compared to the base colour of the sheet
3) Calibration – There are several different calibration systems in place today. The Ultra Violet component of illuminants is known to vary with the age of the bulb and the condition of the instrument

This means that in general CIE Whiteness values should only be compared where the papers to be compared were measured on the same instrument at the same time. Clearly this is not very practical at the point of sale.

Advantages

CIE Whiteness provides a simple number that covers the whole visual spectrum.

Measuring methods are very well described and controlled.

The effect of shading colourants is included.

Disadvantages

Variations in instrumentation, illumination and particularly Ultra Violet content of the illuminant can affect the result.

Values from different suppliers are not always compatible.

The scale is difficult to understand, which value is the highest available and the lowest?

Table 1

Method	Example	Advantages	Disadvantages
Descriptive words	Bright, white paper	Easily Understood Shows which papers are white Can be used for comparison in certain cases	Not easy to make comparisons No determination of the exact whiteness level possible
Visual	Clear window or clear packaging	Consumer can see paper & make up their own mind Can compare papers when both are visible	Only papers with a window or clear wrapping can be compared Not suitable for Internet or Catalogues Visual comparison can still be difficult due to size of window and lighting conditions
Brightness values	Brightness 105	Can be measured Widely used in USA Well described methods	More than one term in use Numbers are not always comparable Shading colours are not measured Which is the highest whiteness available?
CIE Whiteness values	CIE 167	Can be measured Covers the whole visual spectrum Shading colours are measured	Variations in measurement conditions affect result Values from different suppliers are not always compatible Which is the highest whiteness available?

The Costs of Paper Whiteness

When paper manufacturers produce paper of a particular whiteness, a significant part of the cost of the paper is due to the achievement of the particular whiteness required (8,11,12). Costs include:

1) High Brightness Pulp
2) High Brightness Fillers
3) Shading Colours (Although addition rates are low (50-150g/t) prices are relatively high)
4) Optical Brightening Agents for the wet-end (typically 0.1-1.2% by weight of pulp)
5) Optical Brightening Agents for the size-press (typically 1-40g/l of size-press starch)
6) Quality Control costs including On-line and Off-line Instrumentation and testing costs
7) Cost of lost Production and Broke when the paper is off-shade

These costs lead to the production of exactly the correct grade of paper that the manufacturer wishes to market. It is vital that the papermaker realises the final value that has been added to the product at the manufacturing stage.

Quality Control

During the manufacture of paper a single number cannot be used for quality control. Often the following measurements are taken and specified during each manufacture of a grade:

CIE Whiteness

L* value

a* value

b* value

Brightness (with UV)

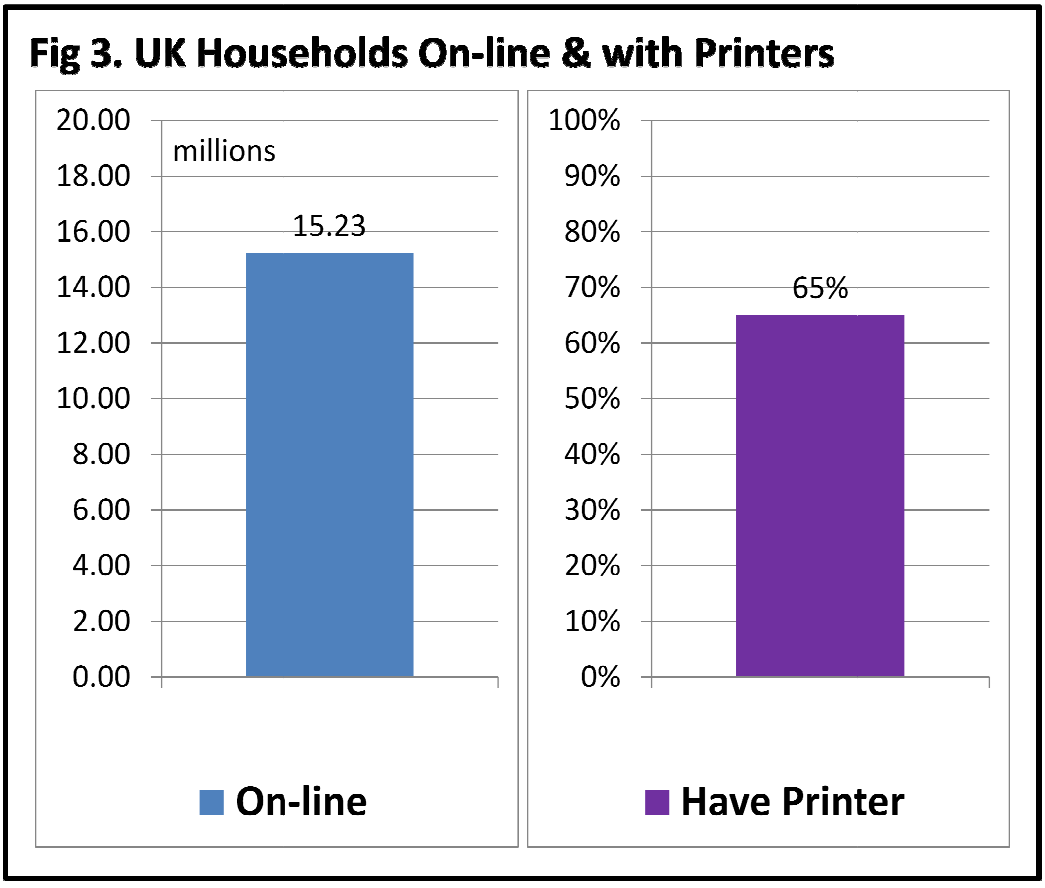
Brightness (UV excluded)

Delta Brightness (Brightness (with UV)) – (Brightness (UV excluded))

This will continue to be the case as the shade of white paper is complicated and the papermaker needs to ensure that each batch of paper produced is the same visually as every other batch of the same grade (13).

A Consumer View

The percentage of people in the UK who have printers has increased to 65% (Fig 3.) (6).



In recent years as technology has improved and a larger number of people either work from home or run a small business, more and more people are buying paper for their homes or small offices. Most of these people often have had no training in paper specifications and so are not familiar with the whiteness terms in use. At the same time they are buying their paper in outlets where less

technical advice is immediately available (e.g. supermarkets). Additionally, more households are on-line (Fig.3) and the internet is becoming a popular shopping medium (7).

A brief survey (14) was carried out amongst persons who buy paper (mainly for home or small office use, although some respondents purchased paper for larger offices), they were asked:

How do you decide which paper is the whitest today?

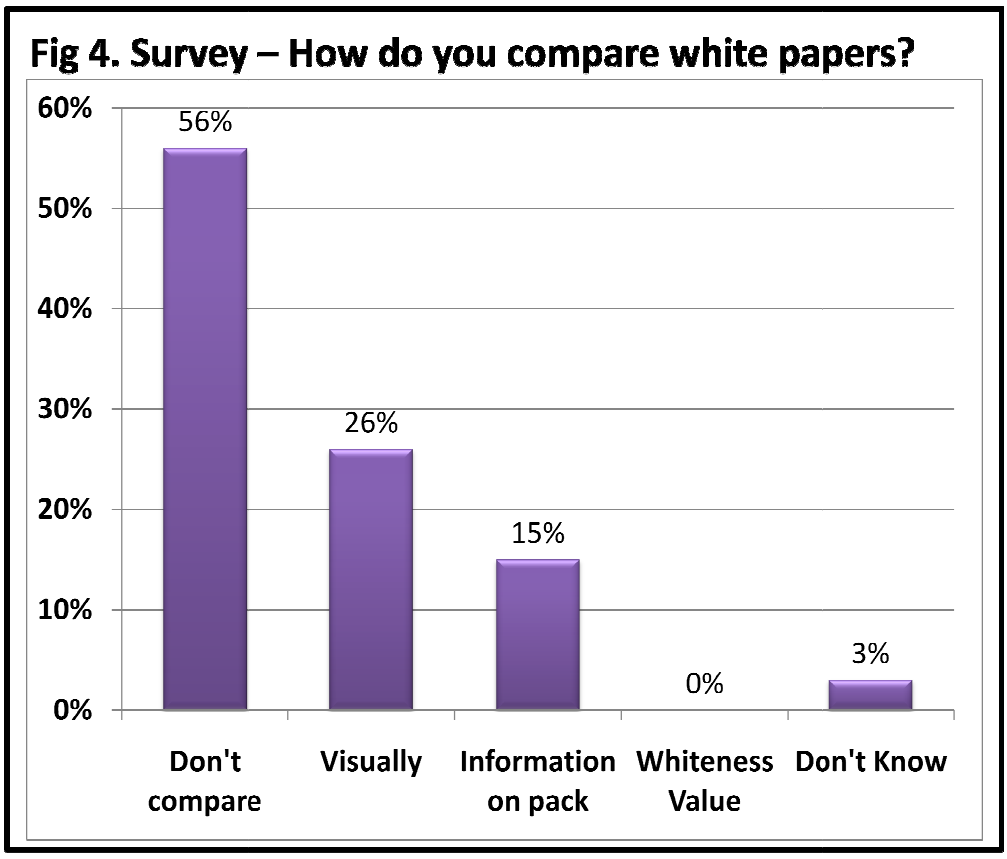
a. Compare sheets of paper

b. Read information on the paper packs

c. Look for whiteness measurement values on paper packs

d. Don't compare papers

The response is shown in Fig. 4 below:



More research is currently being conducted into this area.

Summary

So then, why do we try to describe whiteness with a single number? The answer is - because describing whiteness accurately is complicated and requires a system which is technically complicated and yet the consumer needs a system that is above all simple and easy to understand. Since colour is 3 dimensional and dependent on the light source, viewing conditions and to some extent the observer, no system will ever be perfect.

Of the systems in use today the most scientific are those using a number to rate the whiteness of the paper in some way, these are also the easiest to use for consumers.

Numeric systems are also useful for internet and catalogue points of sale.

However, the systems in use today are complicated to understand and the actual numbers vary according to the measurement systems and illuminants used and the system in use. The results of an initial brief survey in 2007 show that the whiteness values are not being used by the consumer.

Conclusion

The paper industry goes to great lengths to produce paper at a particular whiteness rating. Each brand of paper available in reams is pitched at the whiteness level that best suits the purposes of the end user. This takes a great deal of time, effort and expense. The science of whiteness has been studied in depth and many different methods are in use today.

The consumer on the other hand does not normally understand the science of colour and so it is difficult to use complicated 3 dimensional colour description systems to explain to them the level of the paper whiteness they are purchasing. This has lead to the use of simplified systems involving descriptive words, windows on the pack and simple numeric systems.

A brief survey shows that in fact only 15% of small consumers use any information provided when comparing papers at the point of sale and very few use whiteness ratings today.

It is clear that a distinction must be drawn between the paper manufacturers' view of whiteness properties for quality control and the consumers' requirements at the point of sale.

Further market research is to be carried out to confirm these results.

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