The Effect of Pigment Ratio in Offset Printing Inks on Lightfastness

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Abstract

Pigments are substances which give colour to inks. The pigment ratio in offset printing inks are in between 15 – 25 percent. Pigment ratio affects the light fastness of ink. The excellent value of lightfastness of inks is 8. The term, light fastness can be defined as the resistance of light energy in the ink environment against color change and fading degree. The lightfastness of ink can be affected from humidty, climate, light direction, alkaline and acid and the ink film thickness on the material used. It is important for printing inks to keep the lightfastness value for a long term in a standart and constant value.

The printed materials are used in a number area of our live. Especially, if prints have to be subjected to sunlight etc, some undesired effects in terms of colour fading, quality and functionality problems may be encountered.

In the present study, the effect of pigment concentration, which is one of the important factors affecting lightfastness, on light fastness were investigated. The ink samples which have pigment ratios of 10, 13, 15, 17 % were prepered from standart offset ink which has a ratio of 19 %. While this procedure was being applied, the other ingredients of ink were not changed. In addition, the other factors affecting lightfastness were kept constant. Then, test prints with these ink samples were taken on a IGT printing test press. The changes in prints were observed by holding the samples in a Xenon Lightfastness test equipment gradually at 0, 12, 24, 48, 72, 96, 120, 144, 168 and 192 hours.

The lightfastness values were evaluated according to Blue Wool Scale which was developed and accepted by British standarts. The results were graphically explained and the effect of pigment ratio on light fastness were described.

Introduction

Lightfastness

With the most general definition, lightfastness is the resistance of colours against the fading by a light source. If a specific definition is required, lightfastness of a given pigment is a degree of changing colour or fading of a substrate dyed with this pigment under the destructive influence of light energy[1].

Resistance to fading is important in several situations. The archiving of sensitive documents is one focus of research pertaining with fading and light fastness[2]. Pigment based inks behave differently than dye based inks[3].

The Factors Affecting Lightfastness

The fastness properties of ink prints are controlled by the nature of the coating components, as they determine the chemical and physical environment of the colorant in the print[4].

The ability of pigment- and dye-based inks to maintain accurate color strength over time due to light exposure and subsequent fading is an important research topic (Wilhelm, 1993)[5].

Humidity: When the test print is exposed to fading by the sun light, solar radiations are absorbed by the print. The amount of absorption changes depending on the color. The black colour is absorbed most, while the white colour is absorbed less. This absorption will increase the temperature of the test print. By the effect of temperature, the relative humidity on the print surface is less than the amount of the relative humidity in the air. The effect of the air and printing surface temparatures and the constitution of relative humidity to the humidity at the surface can be defined as effective humidity.

An increase in the effective humidity will cause a decrease in lightfastness. The rate of effective humidity is measured by a Blue Wool Scale with a humidity sensitive cotton fabric dyed with red azoic compound.

The average effective humidity value for daylight exposure in Britain is 45% and therefore the test apparatus should be capable of approximating to this figure[1].

The British Standards

The British Standards 4321 are recently used in a number of research and development laboratories. There are two methods for the lightfastness in the content of the standart. One of this procedures is carried out in the day light of natural conditions. The other is performed by Xenon Test Equipment. The results are evaluated by a Blue Wool Scale which is accepted by the British Standards.

When the British Standards 4321 test procedure is applied, the Blue Wool Scale is used to determine the values obtained. The Blue Wool Scale is consisted of the wool fabrics dyed with dyestuffs having eight different fading qualities and these dyestuffs are accepted by the British Standards. There is a specific number corresponding to each fading degree and the fading degree of a fabric dyed with each dyestuff is approximately two times higher than the fading degree of the next fabric. The Blue Wool Scale values and the evaluations corresponding to these values are given in table 1.

Table 1. Blue Wool Scale

8	Outstanding
7	Excellent
6	Very Good
5	Good
4	Moderate
3	Fair
2	Poor
1	Very Poor

Table 2. The range of the blue wool references is that established for textiles. The blue wool references shall be protected from light before use.

Light fastness rating	Dye
1	Acid blue 104
2	Acid blue 109
3	Acid blue 83
4	Acid blue 121
5	Acid blue 47
6	Acid blue 23
7	Solubilized vat blue 5
8	Solubilized vat blue 8

The destructive effects of UV lights on the chemical structure of the pigment

It is clear that the reflected lights from the sun are not only visible wavelengths. In addition to this, wavelengths with higher energy, uv, α and χ lights, cosmic wavelengths are also reached to the earth. A part of these wavelenghts with higher energy are absorbed by oson layer while another part is reflected. The reflected uv lights causes the break of π bonds with less energy. The pigment changing confuguration will cause emissions with different wavelengths. In this case, the colour perceived as red to eyes will change to light red at different wavelenghts[6].

The effects of deterioration of the chemical structure of pigment reveal the fading of pigments, discoloration, mattness and brittleness. The effects of uv lights are not only on the pigments, they also fade printing papers.

Experimental

ISO 12040 is defined the illumination for the printed ink on paper and the test conditions as follows:

The test pieces pieces and blue wool references are mounted together as closely as possible in a well-ventilated test chamber and shall be exposed to the same amount of radiation[7].

The temperature of the test pieces shall not exceed 45 ^{0}C as measured by the Black-Panel-Thermometer. If glass or water filters are used to avoid high temperatures resulting from infrared radiation, they shall be cleaned frequently in order to avoid filtering of the light caused by dirt. Furthermore, the instructions from the supplier concerning lifetime of lamps and exchange of filters shall be respected[7].

For the experimental work, a standard magenta ink with a pigment rate of 19% and test inks with pigment rates of 17, 15, 13 and 10 % were prepared.

Table 3. The physical properties of test ink used in the present study

Colour	Proses magenta
Tack	7,0-8,0 (400 rpm/32 ^{o}C/inkometer)
Solid Substance	55-80 %
Density	1,0-1,1 g/ml
Drying mechanism	Oxidation/Penetration
Viscosity	100-140 Pa.s (23 ^{o}C,PK5, 1o/Haake)

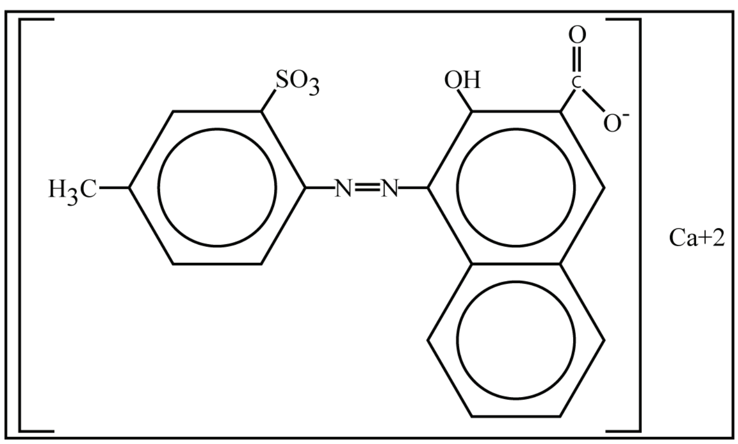

Figure 1. The chemical structure of Pigment Red 57:1 which was used in the mageta ink

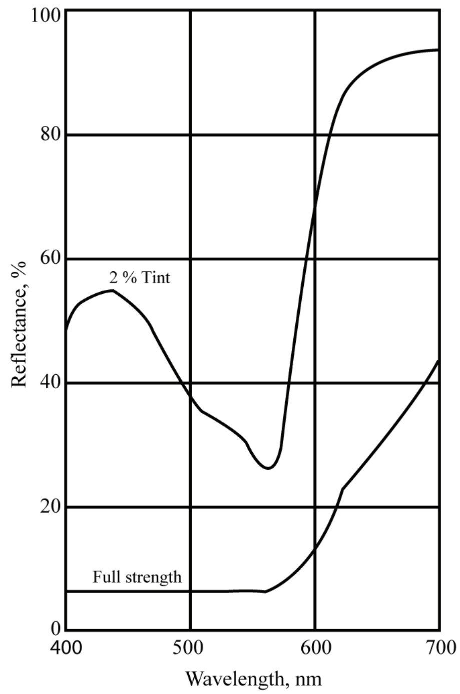

Figure 2. Pigment Red 57:1 typical spectral curves[1]

Table 4. The physical properties of pigment used in magenta ink

Specific gravity	1.42 - 1.80	(H_2O=1)
Solid bulk density	11.8 - 14.9	Ib/US gal
Melting Point	360	^oC
Particle Shape	Rodlike	
Particle size, mean	0.04 - 0.3	Micrometer
325-Mesh retention	0.1 - 0.5	% > 44µ
Surface area	21 - 105	m^2/g
pH	6.0 - 9.0	(10% slurry)
Hiding power	Semi-a opaque	
Oil absorption	20 -88	wt/100 wt

For the ISO 12040 performed in IGT C1 printability test equipment: inks shall be tested by first preparing standardized prints on a reference paper as specified in IS0 2834. The standard prints shall then be tested and evaluated as specified in clause 4 of this International Standard[7].

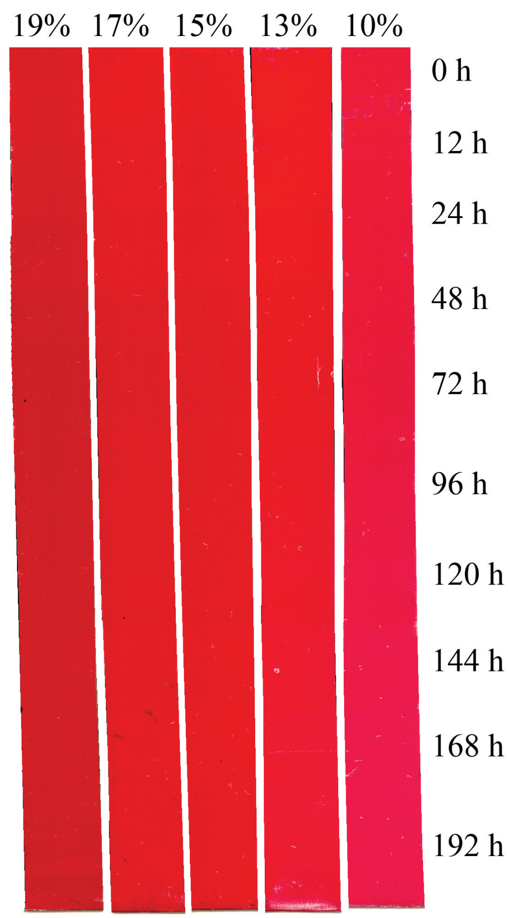

Figure 3. The image of offset print ink after printed with IGT C1 following exposured in the xenon light fastness solar box (the pigment rate are changed between 10 – 19 %)

Conclusion

When the pigment rate are decreased, the densitometric value of the ink also decreases in the prints carried out at the equal film thickness (Figure 4).

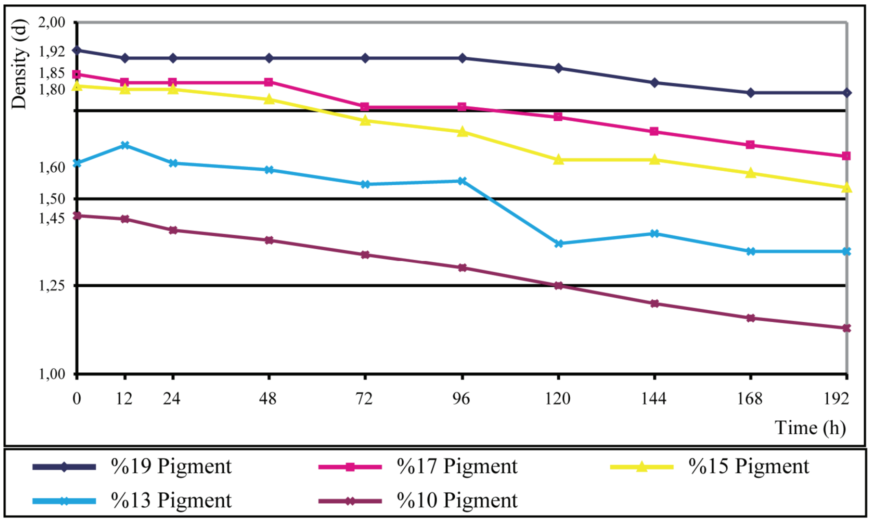

Figure 4. The backround density change of a standard magenta offset ink at 0-192 hours (pigment rate are changed in between 10 – 19 % in the graph)

The effect of the change of pigment rate on the ΔE was following:

Table 5. The Spectrophotometric ΔE measurements of the offset printing ink with the changed pigment rate of 10-19 % after printed in the IGT C1.

Pigment Rate (%)	**Time (h)**									
		12	**24**	**48**	**72**	**96**	**120**	**144**	**168**	**192**
19%	ΔE	0,7	1,6	1,7	2,5	2,9	3,2	3,4	4	4,4
17%	ΔE	1,1	1,6	2,1	3	3,3	3,9	4,5	4,6	5
15%	ΔE	0,9	1,4	2,1	2,6	3	3,8	4,5	4,5	5,2
13%	ΔE	0,8	1,2	2,1	2,8	3,5	4,3	4,4	4,8	5,7
10%	ΔE	0,9	0,7	1,9	2	2,6	3,5	5	6,4	7,1

ΔE values were calculated by L*a*b* values which were measured just after printing with each test inks.

A 2% decrease in the pigment rate caused a 5% decrease in the densitometric value. This also caused a fading in the light fastness in the acceptable tolerans (figure 4) when the pigment rate decreased from 19% to 10%, a decrease of 25% was observed in the densitometric value (figure 4). When the pigment rate decreased, the time dependent color fading also increased (figure 4).

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