Image Stability of Digital Photographic Printing Materials

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Abstract

Test methods and criteria for the estimation of life expectancy for the items listed below are proposed based on experimental data and market surveys:
1) Dark stability, 2) Lightfastness, 3) Ozone gas fastness, including reciprocity failure problem, 4) Humidity fastness, and 5) Short-term color shift.

Image stability of the following digital printing materials was evaluated based on the proposed methods; a) Ink-jet, b) Xerography, c) Dye-sublimation, d) Pictorography, and e) AgX color photographic paper.

Introduction

Image stability of digital printing materials is becoming more and more important as they are increasingly used for photo printing. The standardization of test methods and specifications are required for these materials. Here, we will describe our evaluation methods and specifications which are based on our experience and surveys of many years.

Dark Stability

Arrhenius prediction is applied using data from heat accelerated fading test. We usually adopt two humidity conditions, i.e. dry (30%RH) and humid (70%RH). We make a point of 70%RH based on the following reasons;

1) Humidity of places used for storing photographic prints is prone to higher humidity. In fact, the average humidity of the storage places in some humid areas, such as Japan, South East Asia and Florida etc., is nearly equal to 70%RH, shown in Fig.1.1
2) Some of the printing materials deteriorate faster in higher humidity, illustrated in Fig.2. It may be important to inform consumers of the possible worse cases.

It was verified that we can get linear Arrhenius plot even in 70%RH in some of the AgX materials.

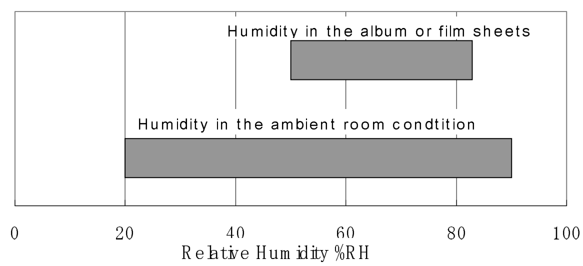

Figure 1. Humidity of storage area and the surroundings

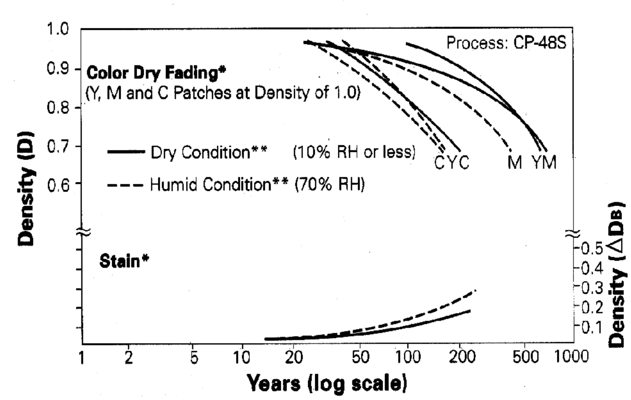

Figure 2. Dark storage stability of Fuji Color Ever Beauty (AgX color paper) at 25C estimated by Arrhenius method.

Lightfastness

Xe light test is used. We apply dark / light cycle exposure for both indoor and outdoor simulation in order to simulate night / day cycle. The conditions are

	Light	Dark
Time	3.8 hrs	1 hr
Temperature (C)	40 +/- 5	25 +/- 5
Humidity (%RH)	40 +/- 5	85 +/- 5

We also use UV cut filter (T_{50}=366nm) in addition to soda-lime glass filter in our Xe apparatus, in order to simulate indirect sunlight coming through a window.

The dark / light cycle exposure and UV cut filter remarkably approximate the accelerated Xe light test in relation to actual fading. Fig. 3[1] shows the agreement of Xe test and the actual fading of AgX color paper displayed in several show windows in the market.

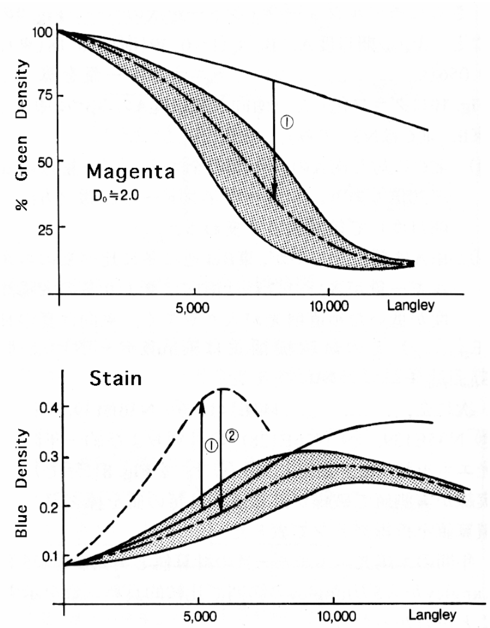

Figure 3. Relation between Xe test to actual fading. Shadow: Actual fading in show windows; Solid line: Continuous Xe exposure without UV cut filter; Chain line: Intermittent Xe exposure with UV cut filter

We can estimate life expectancy of displayed prints based on the assumption that the following represent average conditions;

"500 lx , 12 hours a day".

A typical light condition found in ordinary houses and offices reported in the Japan Illumination Society magazine[2] and CIE recommendation[3] for proper viewing of photographs are summarized in Fig. 4. Brightness level can vary widely, i.e. from one hundred lx to several thousands lx., but we regard 500 lx as a typical center value.

Lightfastness of some of the latest digital printing materials were evaluated based on the aforementioned procedures. The results are shown in Table 1. The endpoint criteria will be explained later.

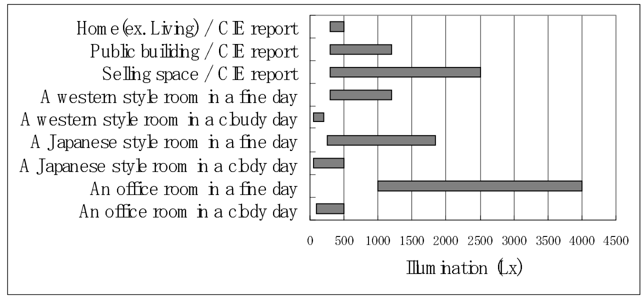

Figure 4. Light condition reported by a) CIE, and b) Illumination and Engng. Inst. Japan

Table 1. Lightfastness related life expectancy of various digital printing materials

Material		Life expectancy (years) estimated by the ISO criteria		
		YMC Patch	Gray Patch	Dmin
AgX Color Paper	Fuji	18	35	> 40
	Manufacturer A	10	20	> 40
	Manufacturer B	7	10	18
	Manufacturer C	8	16	17
Pictorography		16	17	14
D2T2 (Dye Sublimation)	Manufacturer D	16	12	> 40
	Manufacturer E	6	2	> 40
	Manufacturer F	8	3	> 40
Xerography	Fuji	21	> 40	9
IJ (Inkjet) Dye	Manufacturer G	8	18	> 40
	Manufacturer H	8	18	> 40
	Manufacturer I	6	4	> 40
IJ Pigment	Manufacturer J	> 40	> 40	> 40

Ozone Gas Fastness

Ozone gas fastness is evaluated using ozone gas chamber. It is indispensable to control the humidity. An example of humidity dependence on ozone gas fading for a dye base inkjet print on micro-porous media is shown in Fig. 5 a).

It may be also important to check reciprocity failures, although we have observed little reciprocity failure influence in the aforementioned prints as shown in Fig. 5b)

In case of a print which shows no reciprocity failure, it is possible to estimate the life expectancy.

We would like to suggest that the average concentration of ozone gas in the ambient room be presumed as "10 ppb". According to an air pollution monitoring bureau in our area, the average outdoor ozone level is about 20 ppb. Concentration of indoor ozone is lower than that of outdoor and it varies from zero to the same value as outdoors. The average ozone concentration of typical indoor air would be 10 ppb.

Ozone gas fastness of some of the latest digital printing materials was evaluated and the life expectancy was calculated as shown in Table 2.

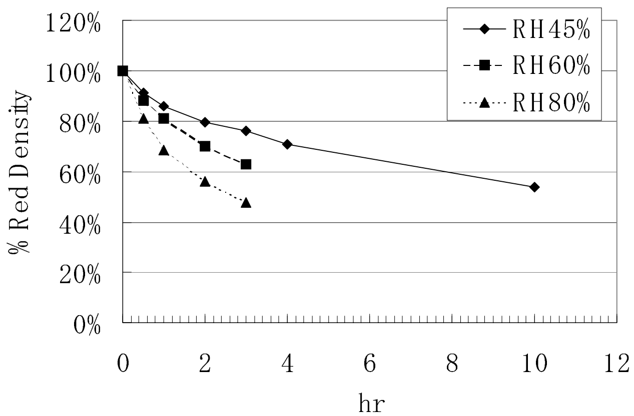

Figure 5a. Humidity dependence on ozone gas fading in a dye base inkjet print on micro porous media

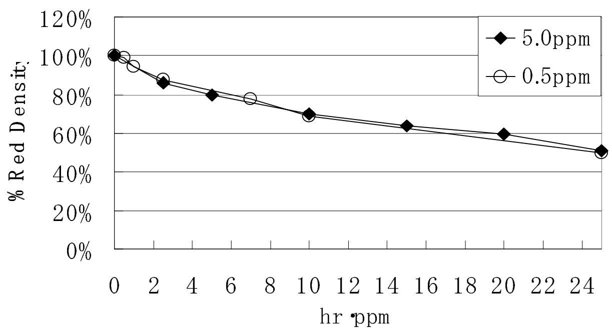

Figure 5b. Ozone gas concentration dependence on fading of a dye base inkjet print on micro porous media.

Table 2. Ozone gas fastness related life expectancy of various digital printing materials

Material		Life expectancy (years) estimated by the ISO criteria		
		YMC Patch	Gray Patch	Dmin
AgX ColorPaper	Fuji	> 15	> 15	> 15
Pictorography		> 15	> 15	> 15
D2T2	Manufacturer D	12	5.2	> 15
Xerography	Fuji	> 15	> 15	> 15
IJ Dye	Manufacturer G	1.1	0.05	> 15
	Manufacturer H	0.13	0.03	> 15
	Manufacturer I	> 15	> 15	> 15
IJ Pigment	Manufacturer J	> 15	11	> 15

Short Term Color Shift

In case of dye base inkjet prints, significant color and density drifts are observed after the printing. The delta E value of the color shifts can reach and exceed a level of 5 as shown in Fig. 6. The phenomenon may deteriorate the accuracy of any kind of image stability evaluation.

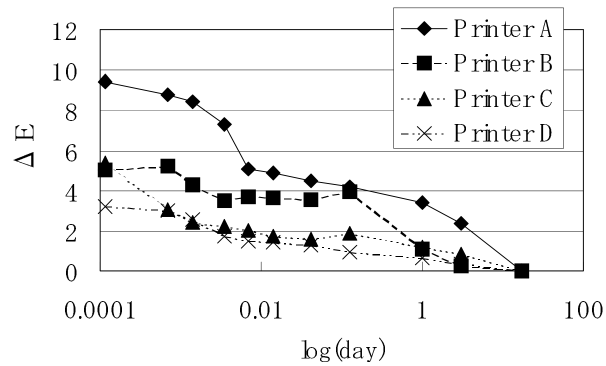

Figure 6. Color shift after printing in various inkjet prints.

Table 3. ISO criteria for end point

Parameters	Illustrative end points
% change in neutral patches of Dn(R), Dn(G), Dn(B)	30%
% change in color patches of Dn(R), Dn(G), Dn(B)	30%
% change in color balance of neutral-patches; %Dn(R-G), %Dn(R-B),%Dn(G-B)	15%
Change in the Dmin patch dmin(R), dmin(G), dmin(B)	0.10
Change in color balance in the Dmin patch	0.06

Criteria for End Point

Criteria of end point prescribed in ISO are reviewed in Table 3.

We compared the estimated life based on the each ISO criterion to the subjective evaluation of the end point using an actual picture shown in Photo 1. The results are shown in Fig 7.

As you can see in Fig 7, the ISO criterion on neutral patch well suits the subjective evaluation in case of the picture seen in the Photo 1. It can depend on the composition, density and color distribution of the original seen.

Photo1. Image for the subjective evaluation

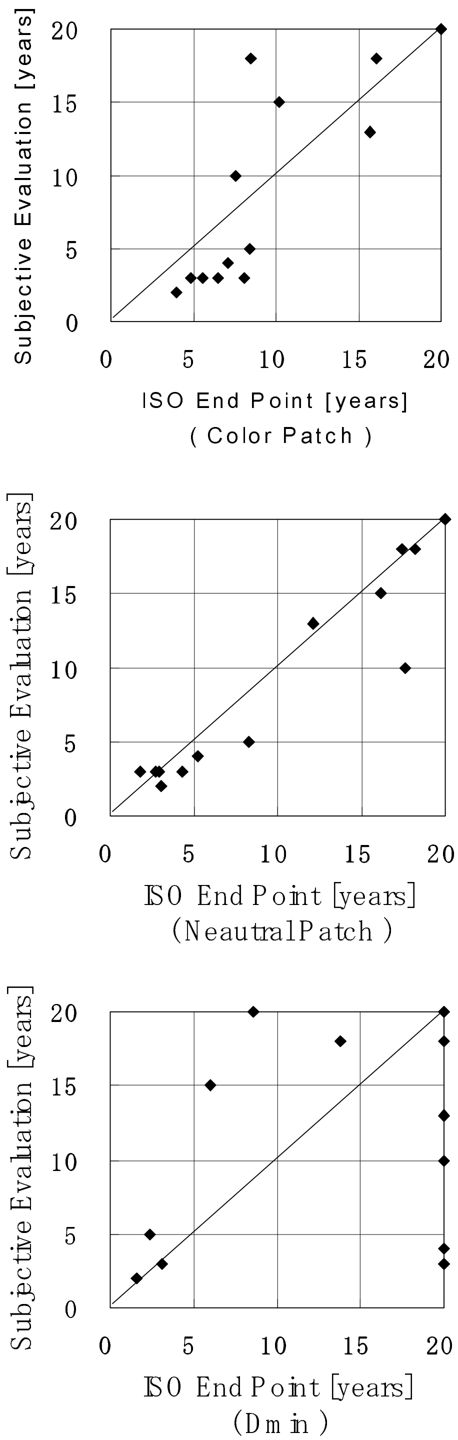

Figure 7. Relation between calculated life to subjective evaluation.

Conclusion

Test conditions and life expectancy criteria for printing material were proposed. The evaluation canon provided reasonable results to a certain point. We will still go on to improve the methods further. We believe that the proper evaluation will enhance the development of stable materials which lead to the prosperity of photographic culture.

References

1. Yoshio Seoka, et all “Preservation, display and restoration of photography”, pg126, 78, J. Soc. Photogr. Sci, Image Preservation Research Group (1996)
2. Hiroshi Nakamura et all, J. Illum. Engng. Inst. Jpn. **79,** 49 (1995), J. Illum. Engng. Inst. Jpn, **81**, 88 (1997)
3. CIE No 11C “Lighting practice education” (1964)
4. ISO CD 18909

Biography

Yoshihiko Shibahara received his M.A degree in engineering from the Kyoto University in Japan in 1978. Since 1978, he has worked in the Ashigara Research laboratory at Fuji Photo Film in Japan. His work has primarily focused on the research, development and evaluation of imaging materials. He is a Japanese expert of ISO TC42 WG5.