Image Permanence of Ink Jet Print System for Portrait

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Abstract

Thanks to the improved technology with high quality in high speed and to competitive prices of mega-pixel digital cameras and high resolution scanners, color ink jet printers have popularly filtered into our daily life. We expect that the color ink jet printers, both in professional and high amateur markets, will take an important role to pull the digital photographic industry.

With this background, Seiko Epson Corporation has developed the portrait printer "Gemini" system. With a set of 6 pigmented inks, this system enables us to print on ink jet media with high quality and with very good image permanence and to use them as commercial photographs.

In this report, I will explain the good stability of ink jet media printed by the Gemini system focusing especially on light and gas that are believed to be the more important factors than water, heat, humidity and plasticizer.

Introduction

Recently after the growth in the print-for-pay photo market, digital cameras are getting popular as well in photo print studios. As a result, this helps photo studios to shift to use digital photos rather than using conventional photos.

Looking at this current situation, the ink jet print system "Gemini" has been developed and launched. This system takes a maximum advantage of digital ink jet print in the professional digital photo market.

In the professional photo market, prints are so valuable as photographers' works, so that the 6-color pigmented ink system has been used to ensure the stability and quality of these prints.

Understanding the importance of stability of the prints that are made by ink jet printers, this report focuses more on light and gas that are important parameters to decide the image stability rather than other factors such as water, heat, humidity and plasticizer. For lightfastness test, the regular accelerated test as well as test on reciprocity failure with light energy have been implemented, while the accelerated gastfastness test with O_3, SO_2 and NO_2 are implemented for gasfastness test.

Experimental

The critical factors that determine the permanence of ink jet recorded images are listed below.

1) Water
2) Humidity
3) Thermal
4) Plasticizer
5) Light
6) Atmospheric gases

Factors like water, humidity, thermal and plasticizer of the above factors have been drastically improved with dye ink with the great matching of ink jet recording media.

However, dye ink still has a problem with light stability considering the reciprocity failure, and also has a problem with gases, which are often said to be a subject of color change in such a short period of time.

Studies and findings are reported in this document using pigmented inks with ink jet recording media focusing on these two factors, light and gas (as shown at Table 1).

Table 1. Test Conditions

Ink Jet Printer	Portrait print IJ system, "Gemini"
Recording ink	Genuine ink (a set of 6 pigmented inks)
Recording media	Premium Luster Photo Paper (porous ratio of Approx. 70%)

Lightfastness (Indoor Light Stability)

Lightfastness test was evaluated in accelerated testing by continuous illumination using an accelerated fluorescent light tester. In order to clarify the reciprocity failure, 3 standards of light intensity has been applied. The testing criteria is listed at Table 2.

Table 2. Test Conditions of Lightfastness

	Test 1	Test 2	Test 3
Light Source	Fluorescent lamp		
Lighting Intensity	70 klux	10 klux	5 klux
Temperature	24°C		
Humidity	55%		
Glass frame	mount		

The acceleration factor under the preceding conditions is hypothetically about 300 times in test 1 and about 40 times in test 2 according to our calculations which assume the accumulated illumination for one day in an ordinary office or home is about 450 lux for 12 hours.

In order to eliminate the effects of factors other than light (i.e. moisture on the sample surface and fluctuating wind and gas effects in the chamber), the test was conducted with the sample protected by 2 mm thick soda-lime glass (simulation assumes the photo is in a glass frame). A 2 mm gap was also inserted so the glass is not in direct contact with sample.

Evaluation samples were prepared by printing patches of composite black and pure colors (yellow, magenta and cyan) with a reflection density of about 1.0 at 24 °C with 55% relative humidity, and then leaving them to dry between 24 and 48 hours to eliminate any residual solvent.

Following accelerated fluorescent light testing, the samples were set aside at 24°C with 55% relative humidity for 24 hours, the retained density for yellow, magenta, cyan and composite black were measured, and the relationship between accumulated illumination (lux×hour) and retained density were plotted on a graph.

2) Gasfastness

Because dye inks on highly porous recording media are exposed to atmospheric gases, oxidizing and reducing gases in the atmosphere may degrade and fade colors. This makes gasfastness a top priority with dye inks.

Compared to dye inks, pigmented inks are supposed to have big advantages with the speed and degree of the color change.

Gasfastness was tested by exposing color patches with a optical density of 1.0 for 24, 48 and 72 hours in oxidizing gas and reducing gas exposure apparatus. The gases selected for the test were O_3, SO_2, and NO_2 at concentrations of 10ppm, respectively. Each gas was tested under environmental conditions maintained at 24°C with 60% relative humidity. The amount of discoloration on composite black with an initial O.D. of 1.0 due to the gases was evaluated by measuring the change in color (delta E) by CIELAB colorimetry.

Results

Lightfastness:

Figs. 1(a), 1(b), 1(c) show the results from Test 1 (accelerated testing at 70,000 lux), Test 2 (accelerated testing at 10,000 lux) and Test 3 (accelerated testing at 5,000 lux). The vertical axis shows the retained density with respect to initial density following accelerated fluorescent light testing, while the horizontal axis shows the number of years calculated on the assumption that the image will be exposed to light for 12 hours at an accumulated illumination volume of 450 lux per day.

Although the evaluations have been done for 100 years of equivalent time with 70,000 lux, 40 years of equivalent time with 10,000 lux and 20 years of equivalent time with 5,000, only the results up to 40 years are shown in order to explain the reciprocity failure.

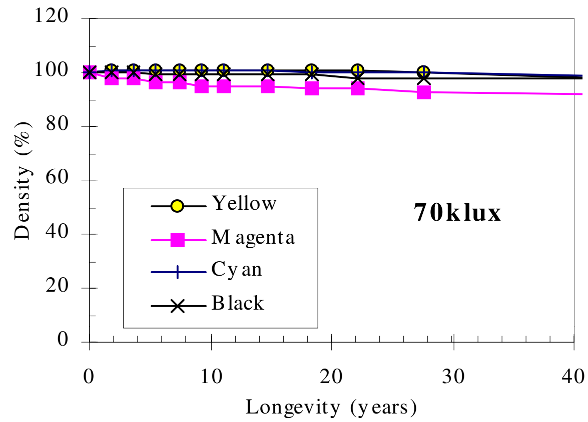

Figure 1(a). The Lightfastness of prints using PLPP. The test was maintained at 70 Klux×24ºC×55%RH.

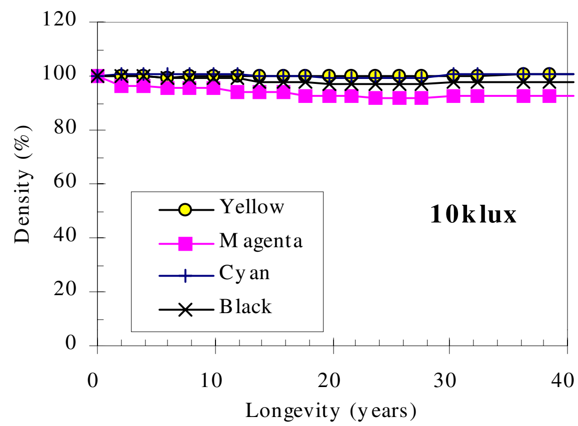

Figure 1(b). The Lightfastness of prints using PLPP.The test was maintained at 10 Klux×24ºC×55%RH

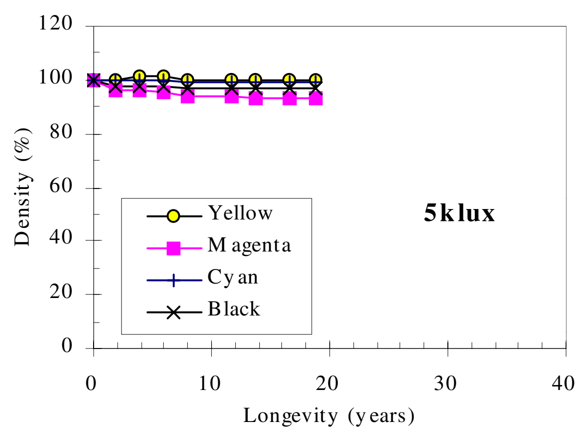

Figure 1(c). The Lightfastness of prints using PLPP. The test was maintained at 5 Klux×24ºC×55%RH.

The results were identical with 70,000lux, 10,000lux and 5,000lux. In another word, based on these results, the reciprocity failure does not exist in this system, which has been said to be an issue.

Also with these test results, each life doesn't reach to the end point with 70,000lux even up to 100 years. Therefore, it is natural to assume that the expected longevity is over 100 years.

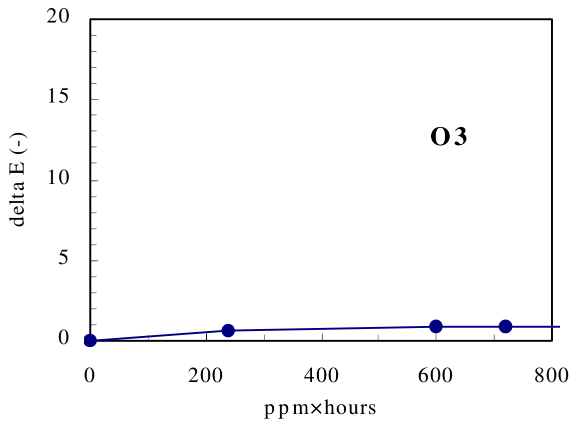

Figure 2(a). Test results of the O_3 at 24ºC×60%RH

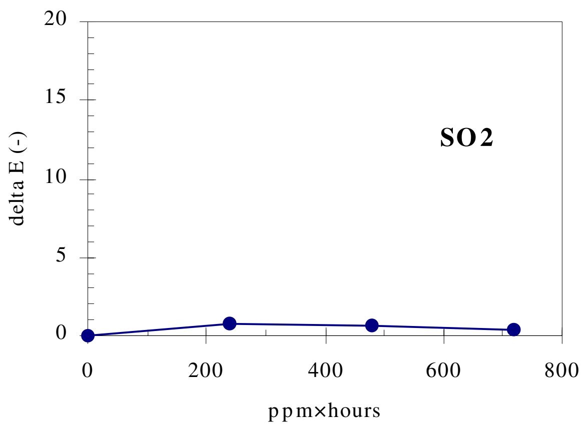

Figure 2(b). Test results of the SO_2 at 24ºC×60%RH

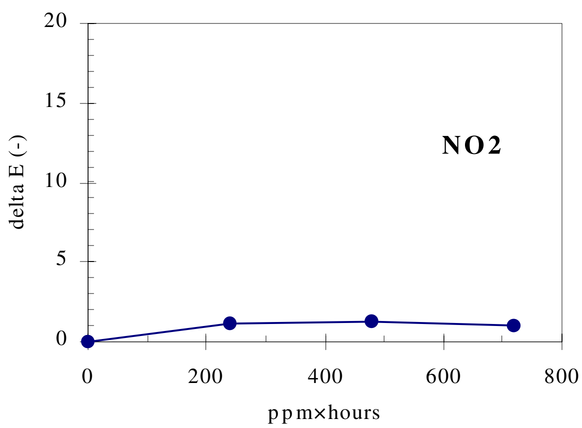

Figure 2(c). Test results of the NO_2 at 24ºC×60%RH

2) Gasfastness

Figure 2(a), Figure 2(b) and Figure 2(c) show the relationship between the amount of exposure (ppm x hours) to delta E for composite black in single gas testing with O_3, SO_2 and NO_2. Based on the results, it is clear that O_3, SO_2 and NO_2 had virtually no effect.

In the previous report, it was stated that O_3 had a great effect on fading of all 3 gases. In this evaluation, however, it is clear that the prints made by the "Gemini" system had virtually no effect with any gases as well as O_3. This shows that this system can be used under any environments.

Conclusion

The critical factors that determine the permanence of ink jet recorded images are listed below.

1) Water
2) Humidity
3) Thermal
4) Plasticizer
5) Light
6) Atmospheric gases

In this report, the evaluation was implemented with gases and light of these factors. Based on the evaluations on lightfastness accelerated test using 3 intensity standards (70,000lux, 10,000lux and 5,000lux), the results were almost identical, therefore, it is clear that the reciprocity failure does not exist. In conclusion, the test with 70,000lux justifies the appropriate method of its lightfastness test for the "Gemini" system.

The longevity simulation shows over 100 years of lightfastness according to this test result.

Meanwhile, it was clear that O3 as well as NO_2 and SO_2 had less effect on gasfastness, which posed problems with dye inks.

The ink jet system "Gemini" has a specially image permanence and is expected to burst in the digital photo market.

References

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Biography

Hiroyuki Onishi is a manager in the Printer Development Division of SEIKO EPSON CORPORATION. He received his B.E. in chemical engineering from Kanazawa University, Japan in 1986.

He worked on the development and design of ink jet recording ink for five years and is currently working on the development of ink jet recording media and ink jet printing technology.

His primary responsibilities are improving the performance of ink jet recording media for dye-based and pigment-based inks, developing matching technology for ink jet ink and ink jet media combinations, and establishing evaluation technology for permanent ink jet print images.