Study on Gas Fastness of Ink Jet Prints

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Abstract

Actual environment factors such as O_3, NO_2, SO_2, temperature, and humidity in ordinary homes and offices were measured. Color density on Inkjet and Silver halide digital photo images under such environment were traced and how such environmental factors multiply lay impact on each digital images were discussed.

The discussion was made in relation with acceleration test results and made based on multiple regression analysis. Both of the discussion results show that the fadings on digital images are caused by number of gas factors such as O_3, NO_2, and SO_2 according to the color. Mixed gas acceleration test using O_3, NO_2, and SO_2 gases represents the actual color-fading more accurately than the single O_3 gas test.

To simulate the accurate and fair lifetime of gas fastness of various digital photo images, mixed gas test, including O_3, NO_2, and SO_2 is more appropriate.

Introduction

Since there are rapid improvement in image qualities for digital photo images, the actual lifetime of digital photo images have drawn much attention recently. Numbers of test methods to simulate such lifetime have been presented and discussed in the areas such as light fastness, gas fastness, dark stability, humidity fastness, water resistance, and definition of lifetime.

Under these tests, gas fastness is one of the major issues for the ink jet images because of their weakness against air born pollutants. The O_3 exposure test is being proposed for the gas fastness test because numbers of experiments show that O_3 is the major factor for the color fading on inkjet images. However, O_3 is not the only gas that exists in the actual environment, and there are other pollutants such as NOx and SOx. Few reports are made on how digital prints effected and change color under such *actual* mixed pollutant environment.[1-4]

In order to simulate the actual fading occurring in the real environment, and to present the standard test methods for the gas fading on digital photo images, experiments were made under real environments. The test took place in ordinary homes and offices, measuring gas concentrations such as O_3, NO_2, and SO_2, along with temperature, humidity, and color fading in digital prints.

Experimental Methods

Test Locations and Period

The test took place in Tokyo and Kanagawa, Japan. Locations were at homes and offices, including outdoors, living rooms, corridors, office rooms, entrances, etc. For outdoor samples, direct sunshine and rain were avoided.

Measurement started from February 2003. Samples were collected, measured, and returned to the test locations once every month.

Table 1. Measuring Locations

		Place	Gas	Temp. / Humid.	Color sample
Home	Home A	Outdoor	○		○
		Living (a, b)	○	○	○
		room a	○	○	○
		roomb	○		○
	Home B	Outdoor	○		○
		Living (a, b)	○	○	○
		restroom	○		○
		corridor	○		○
	Home C	Outdoor	○		○
		Living (a, b)	○	○	○
		front door	○		○
		room	○	○	○
	Home D	Outdoor	○	○	○
		room (a, b)	○	○	○
		entance	○	○	○
		Hall	○	○	○
Office	Office A	Outdoor	○	○	○
		room (a, b)	○	○	○
		passage (a, b)	○	○	○
		room c	○	○	○
		room d	○	○	○
	Office B	Outdoor	○		○
		room (a, b)	○	○	○
	Office C	Outdoor	○	○	○
		room (a, b)	○	○	○

Air Born Gas Measurement

O_3, NO_2, and SO_2 gas concentrations were measured using passive sampler. Passive sampler is the small, battery-free gas sampling kit which has a filter that react with each type of gas respectively. Filters are collected after sampling, extracted, and analyzed by ion-chromatography. Each gas concentrations are calculated from the chromatography results.

Temperature and Humidity

They are measured in automatic data logger, which runs on battery and records the value once every hour.

Color Fading

Color samples were printed with Canon printer F900 and printed on Professional Photo Paper. Color fading was measured by color densities. Spectrolino (GretagMachbeth) was used for measuring the color densities.

Multiple Regression Analysis

Influence of environmental factor against color fading was discussed based on Multiple Regression Analysis.

Gas Acceleration Test

Gas concentration ratio in the test chamber was controlled to the average ratio of the actual *indoor* gas concentration. Temperature was kept at 24 centigrade, and relative humidity at 60%. Test time was set to 72 hours as the standard 1 cycle.

Results and Discussion

O_3 Concentration

The average concentration from spring to fall was higher than winter for both outdoors and indoors. Overall outdoor average was much higher than that of indoor average.

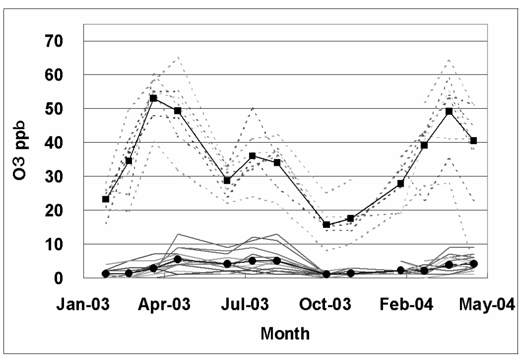

Figure 1. O_3 concentration (dotted line: outdoor, solid line: indoor, ■ : outdoor average, ●: indoor average)

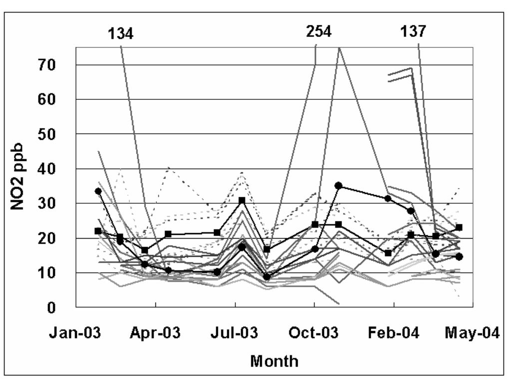

Figure 2. NO_2 concentration (dotted line: outdoor, solid line: indoor, ■ : outdoor average, ● : indoor average)

NO_2 Concentration

Overall outdoor average was a little higher than the indoor average. However, very high concentrations were detected during winter in some houses. This phenomenon was caused by gas heater.

SO_2 Concentration

Overall outdoor average was higher than indoor average, although the concentration was lower compared to other gases.

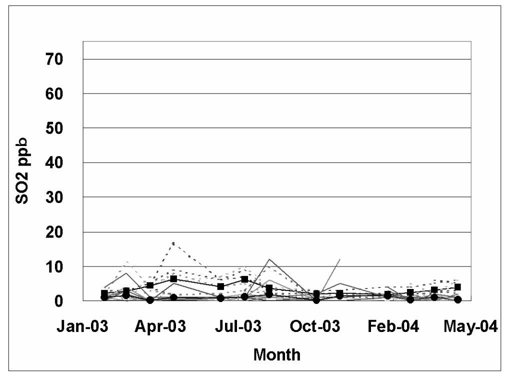

Figure 3. SO_2 concentration (dotted line: outdoor, solid line: indoor, ■: outdoor average,● : indoor average)

Temperature and Humidity

Both temperature and humidity average were high during summer compared to that of winter.

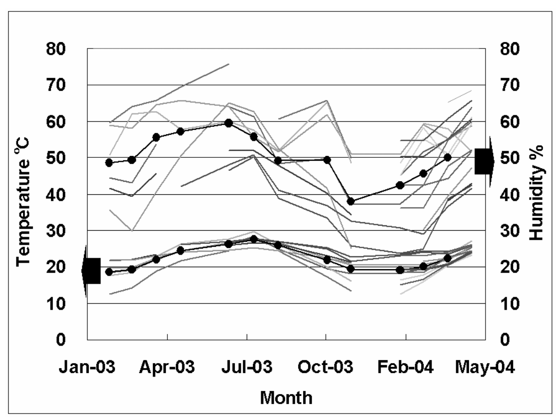

Figure 4. Temperature and Humidity (solid line: indoor, ●: indoor average)

Average of Each Environment Factors Through Out the Year (2003)

Gas concentration average ratio was:

O_3 average: outdoor >> indoor
NO_2 average: outdoor > indoor
SO_2 average: outdoor > indoor

Table 2. Environmental Factor Average (2003)

	O3 ppb	NO2 ppb	SO2 ppb	Temp.	Humid.
Outdoor	32	22	4	-	-
Middoor	10	20	2	24	42
Indoor	3	19	1	23	51

Besides the above averages, locations that had frequent outdoor air exchanges had higher average than nominal indoors. Here it is defined as "middoor", and entrances or corridors of the buildings belong to this criteria.

This middoor result supports the idea that indoor O_3 gas concentration depends on the frequency of outdoor air exchanges.[4] The ratio of indoor O_3 average against outdoor average was 0.1. Middoor average was 0.3 of outdoor average.

Color Fading

Color fading of inkjet prints showed rapid change during spring to fall compared to that of winter. Fading outdoors was much more rapid than that of indoors.

Silver halide prints fades faster outdoors than indoors, although their residual OD were over 80% through out the year.

Multiple Regression Analysis

In order to analyze the influence of all environmental factors on a same stage, Multiple Regression Analysis was used. The SPSS ver.11.5J was used for calculation. Step-wise method was taken for the analysis, and the impact of environment factors against each color fading were extracted. Calculated O.D. that best represents the actual faded O.D. was determined for each color with this analysis.

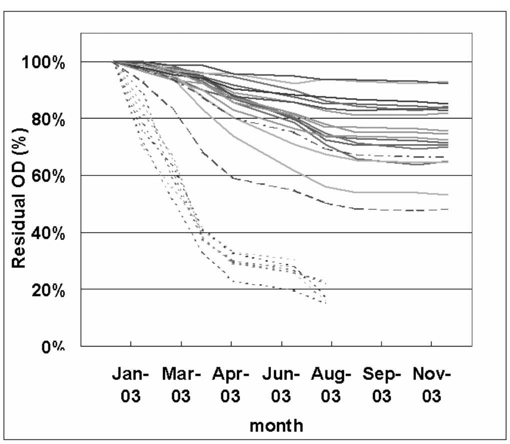

Figure 5. Cyan color fading of ink jet image (dotted line: outdoor, solid line: indoor)

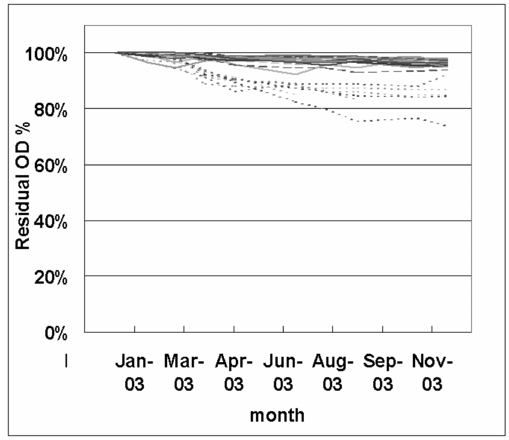

Figure 6. Cyan color fading of silver halide image (dotted line: outdoor, solid line: indoor)

Multiple regression analysis Scheme

$$A + B \times O_3sum + C \times NO_2sum + D \times SO_2sum + E \times Temp.sum + F \times Humid.sum = calc.O.D. \quad (1)$$

Multiple Regression Scheme: Each constant (A, B…E, F) represents each environment impacts against the calc O.D. The pairs that best represent the calc O.D. against actual O.D. was chosen with stepwise method.

O_3 had strong influence against inkjet prints followed by NO_2 and SO_2. Humidity had effect on suppression of color fading visually. For cyan color, O_3 was the only fading factor. Magenta color faded on O_3, but NO_2 had effect suppressing the fade. Fading of yellow color was suppressed by humidity. All factors had impact on composite black color.

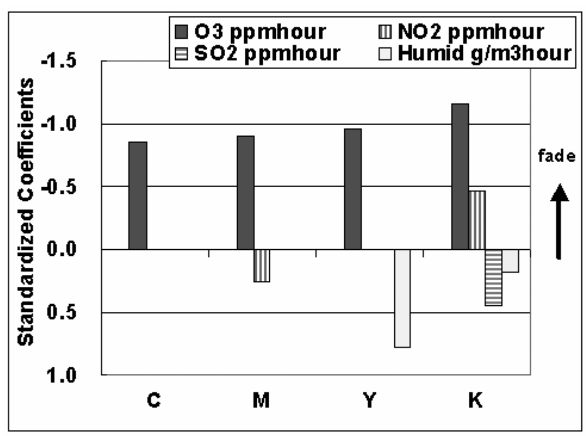

Figure 7. Standardized Coefficients on Multiple Regression for Ink jet printer

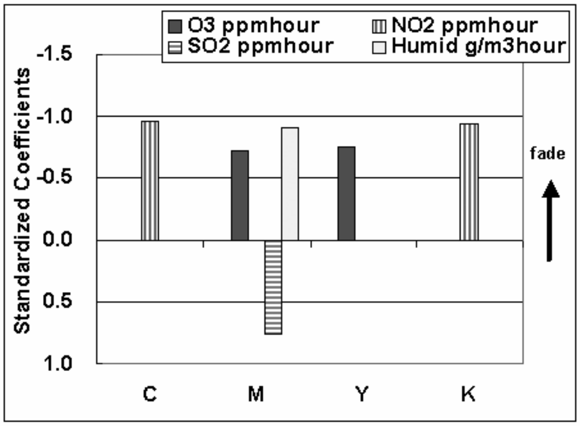

Figure 8. Standardized Coefficients on Multiple Regression for Silver Halide

On silver halide prints, the influence of NO_2, O_3, and humidity against color fading was seen. However, the color fading on silver halide was small, there for a continued test is necessary to come to an appropriate conclusion.

Gas Acceleration Test

Mixed gas test and single O_3 gas test was discussed. Ratio of gas in mix gas test was set according to the ratio of the actual average detected indoors. Different levels of concentrations were tested with mixed gas, and the results were compared with the actual fading. Mix gas test simulated well with the actual fading color balance at all different concentrations, which covered various data of fastness under actual environment. Under these conditions, Condition B simulated the 1-year fading of inkjet print. Single O_3 gas test data were different to that of actual fading with magenta. These results indicate that the mixed gas test, including O_3, NO_2, and SO_2, represents the real-color fading more accurately than the single O_3 gas test.

The difference between mixed and single gas test were also studied for silver halide images. The actual fading of silver halide image has been traced for three years. A clear decrease of color density was found, although the level is small. When silver halide images were tested on Mixed and O_3 gas test, mixed gas had impact on influence changing the color density, however O_3 gas did not. This result also indicates the good representation of mixed gas test against the actual fading for digital images.

Table 3. Concentration Ratio of Gas Acceleration Test

	O3 ppb	NO2 ppb	SO2 ppb
Indoor(average)	3	19	1
Condition A	75	450	25
Condition B	150	900	50
Condition C	225	1350	75
Condition D	300	1800	100
Condition E	150	-	-

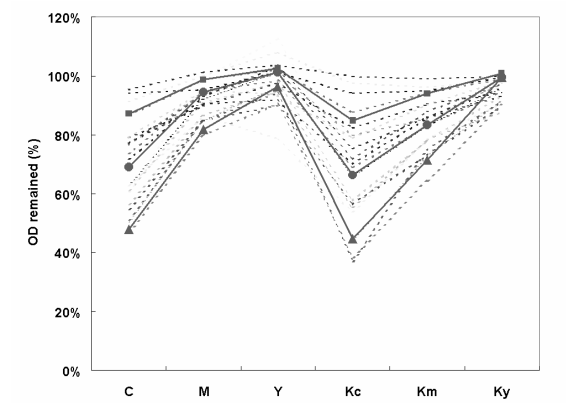

Figure 9. Mixed gas acceleration test for Ink jet image (dotted line: indoor fading, solid line with marks: mixed gas test result.)

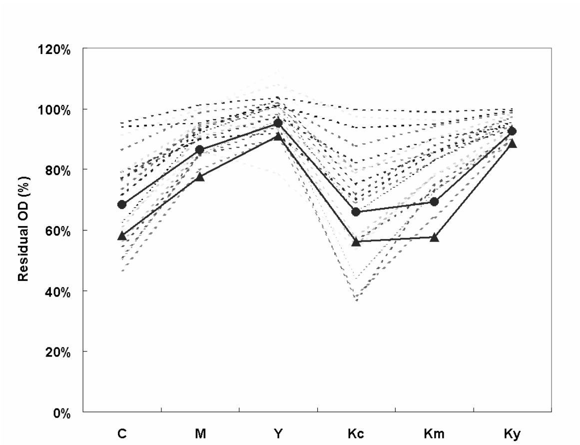

Figure 10. Single gas acceleration test for Ink jet image (dotted line: indoor fading, solid line with marks: O_3 gas test result.)

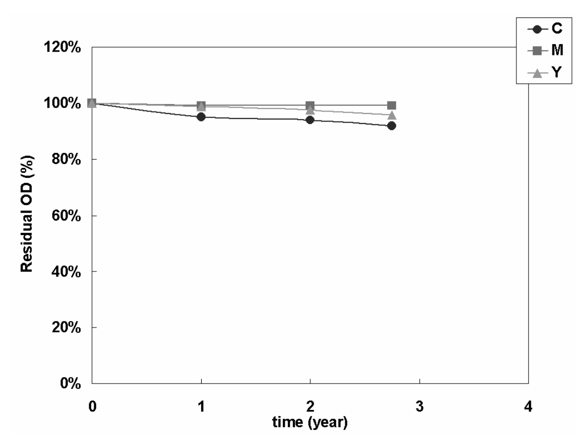

Figure 11. Actual indoor fading of silver halide

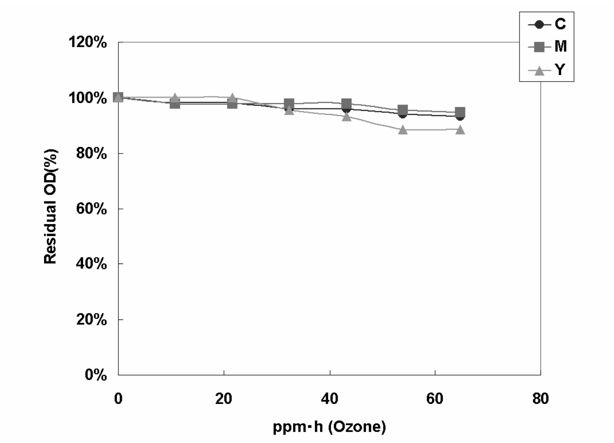

Figure 12. Mix gas acceleration test on silver halide

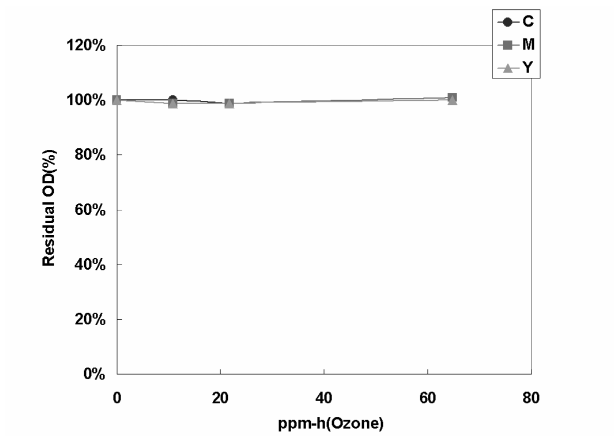

Figure 13. Single gas acceleration test on silver halide

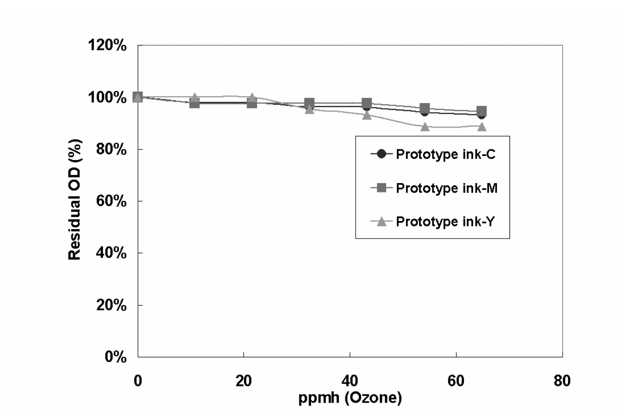

Figure 14. Permanency on Prototype Ink

Prototype Ink

Inkjet images using certain prototype ink were tested and compared to the images made with current ink and silver halide. As a result, such prototype ink images had longer lifetime than silver halide images. Therefore, this test indicates the potential of Ink jet images to have highest image permanency of digital photos.

Conclusions

Measurements of environmental factors and actual image fading ware taken and the influence of such factors were discussed. The average concentration ratio was $O_3 : NO_2 : SO_2 = 32 : 22 : 4$ for outdoors, and $O_3 : NO_2 : SO_2 = 3 : 19 : 1$ for indoors. This indoor gas ratio was applied to the gas fade test to simulate indoor condition. Multiple Regression Analysis result showed the influence of all gases, O_3, NO_2, and SO_2, and also the effect of humidity. Mixed gas test simulated the actual fading more accurately than the single O_3 gas test.

Mixed gas test which applies such pollutants, O_3, NO_2, and SO2, simulates more precisely to the actual gas fading on various types of digital image compared to O_3 gas test.

References

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Biography

Yojiro Kojima received MSc in material chemistry form Keio University. From 2002, he has been working for Canon in Inkjet Supply Material Development Center in Kanagawa, Japan. His current work is on image permanence, especially on the studies for color fading mechanisms in real life environment.