Test Methods of Humidity Fastness of Inkjet Printing Materials

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Abstract

Humidity fastness is an important attribute for inkjet printing materials. The test methods of humidity induced color change and loss of line quality are presently discussed in the ISO/TC42/WG5, where a method using checkerboard pattern as the test target is proposed for the quantitative estimation. In this study, we assessed the effectiveness of the method investigating the correspondence between the checkerboard measurement to the psychophysical evaluation, where we carried out extensive tests with a wide range of commercially available inkjet inks and media. At the same time, we reviewed test conditions, such as temperature, humidity and duration, in order to determine the appropriate standard test method as the ISO.

Introduction

In recent years, inkjet printing systems have been widely used for home photo printing to output photos from digital cameras, as a replacement for conventional photographs. For these reasons, there has been strong demand for improved permanence, and various companies have made repeated improvements in this area. One of the well-known characteristics of inkjet printing, which uses dye inks, is that the dyes travel within the paper when it is in a high humidity environment, causing colors to change and a loss of line quality.

Quantitative evaluation parameters and test conditions are needed in order to evaluate humidity fastness. Several evaluation methods have been proposed ref.[1]–[2]. Studies aimed at standardization are also underway at ISO/TC42/WG5/TG3. In this report, we have utilized an evaluation method that is based on the ISO/TC42/WG5/TG3 discussions and verified the correlation with psychophysical evaluation scores using actual photo prints. In this way, we aimed to confirm the validity of this evaluation method, and also to identify appropriate test conditions.

Test Method

Correlation between the psychophysical evaluation and objective measurement values

In order to conduct the test over a broad range from good levels to poor levels of humidity fastness, humidity fastness was evaluated using five types of inkjet printers, including dye printers and pigment printers, eight types of swellable type and porous type photo gloss media, and a total of 14 samples (Table 1).

Table 1: Print Samples Used for Humidity Fastness Evaluation

No	Printer (manufacture)	Media (manufacture)	Printing mode
1	A / Dye (X)	G / Porous (X)	The manufacturers recommendation
2	A / Dye (X)	H / Porous (W)	
3	B / Dye (X)	G / Porous (X)	
4	B / Dye (X)	I / Porous (X)	
5	B / Dye (X)	J / Swellable (U)	
6	C / Dye (Y)	H / Porous (W)	
7	C / Dye (Y)	K / Porous (Y)	
8	D / Dye (Y)	H / Porous (W)	
9	D / Dye (Y)	K / Porous (Y)	
10	E / Pigment (Y)	K / Porous (Y)	
11	F / Dye (Z)	H / Porous (W)	
12	F / Dye (Z)	L / Swellable (Z)	
13	F / Dye (Z)	M / Swellable (W)	
14	F / Dye (Z)	N / Porous (Z)	

The settings recommended by the printer manufacturer and paper manufacturer were used when printing, and the pictures Ｔwere printed in an environment of 23°C and 50% RH. After printing, the pictures were dried for two weeks at 23°C and 50% RH before the humidity fastness test was performed. The temperature and humidity conditions were either 30°C and 80% RH or 30°C and 90% RH, and the test periods were one week and two weeks.

As the test images used to find objective measurement values, two types of checkerboard patterns were used to identify loss of line quality and color changes, and one type of line chart was used to identify loss of line quality (Fig. 1). A comparison was made of two types of checkerboard patterns: an original pattern from Mark McCormick-Goodhart *et al*, and a simplified pattern.

For the psychophysical evaluations, three images were selected: a portrait, a landscape, and a snapshot (Fig. 2).

Color measurement was performed in a laboratory using a specrolino from GretagMachbeth under the following measurement conditions: D50 light source, view angle 2 degrees. The ΔE and I* for each patch were calculated before and after the test.

The psychophysical evaluation was performed by 10 persons with experience in evaluating printed images. Pre-test and post-test versions of the three pictures shown in Fig. 2 were placed side by side for comparison, and the following standards were used to score the images and calculate the total score for the three pictures.

5: No change
4: Slight change, but little effect of the value of the photo
3: Change which affects the value of the photo
2: Significant change
1: No value at all

Selection of Test Conditions

Some of the samples which were used in the psychophysical evaluation were samples with known humidity fastness that were selected from the market. We used these samples to verify the

Figure1. *Test Target for Objective Measurement (a) Checkerboard - Mark's original version (b) Checkerboard - Simple version (c) Line Chart - Combination of seven colors*

Figure2. Test Target for Psychophysical Evaluation(a) 3 women (Portrait), (b) Harbor (Landscape), (c) 3girls & cruiser (Snapshot).

effects of the drying time after printing and of the humidity during the humidity test. Three drying conditions were selected: no drying, one day drying at 23°C and 50% RH, and two weeks drying at 23°C and 50% RH. For the effects of humidity, three conditions were used for comparison (all at 30°C): 80%, 85%, and 90%.

Results and Discussion

Fig. 3 shows the changes in ΔEav for the various printed samples. It was shown that humidity has an extremely large effect on the changes in ΔEav. For the test period, it was found that most of the samples showed large changes in ΔEav at the start, and then were approximately stable after one week, however there were also exceptions where changes continued to occur for two weeks. Fig. 4 shows the relationship between the psychophysical evaluation score and the humidity and evaluation period. The score was generally 4 or higher at 30°C and 80% RH, suggesting that these

with a large loss of line quality or color change, the score would decline significantly, and we expected that the correlation

test conditions were too mild. At 30°C and 90% RH there was a broad range of psychophysical evaluation scores ranging from 1 to 5. This was determined to be a good test condition for observing the correlation with the objective measurement values.

Fig. 5 shows an example of line spreading measurement. A large number of modes occurred, possibly because the ways that the lines spread are related to complex factors such as the line color ink properties, background color dye, and effects of the ink medium. Comparison using a single evaluation measure is difficult, and detailed study will be required if line spreading measurement is to be used as the standard test method.

Fig. 6 (a)-(e) shows the correspondence between each of the parameters and the psychophysical evaluation score. Of the five parameters which were verified in this study, the ΔE average for all measurement values had the best correlation with the psychophysical evaluation score. At the psychophysical evaluation we first expected that if there was even a single part of the picture

would be best with the average values of the worst 10%. However, in fact, the correlation was best with the average of all

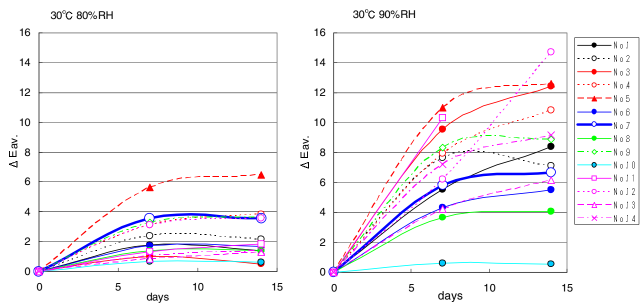

Figure3. *Changes in ΔEav at 30℃ 80%RH and 90%RH*

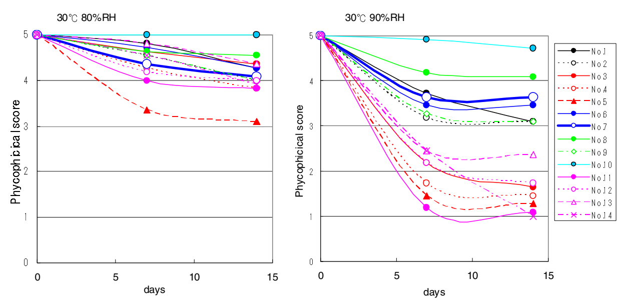

Figure4. *Changes in the Psychophysical Score*

measurements. Moreover, the amount of change in the laboratory was less with the solid patch than with the checkerboard patch, and correlation of both ΔE and I* with the psychophysical evaluation was low. Based on these results, we concluded that the average value of ΔE for all patches is the most

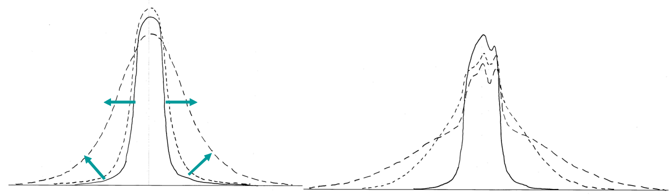

Figure5. *Examples of Line Chart Spreading*

suitable evaluation parameter, as it corresponds best with the psychophysical evaluation.

The Mark McCormick-Goodhart *et al* original patch and simplified patch were compared for use as the evaluation image (Fig.6(a)-(e)). It was found that the original patch and simplified patch correlated approximately equally with the psychophysical evaluation score. These results showed that there was no problem with using a simplified pattern as the evaluation image. The colors which are used in each level of the simplified patch have particular characteristics. For example, there was a clear tendency toward larger ΔE in levels which used black if the sample had a larger loss of black line quality, and there was a large loss of quality in letters or lines. We believe that this data can be applied easily in product development areas.

The effects of humidity are shown in Fig. 7. In terms of ΔEav, the effects of a 5% difference in relative humidity is more important than the effects of drying time. When we examined differences in humidity using samples with known humidity fastness levels from the market, the 80% RH condition was found to be too weak making differences between the samples difficult to determine. On the other hand, the 90% RH condition was too strong, again

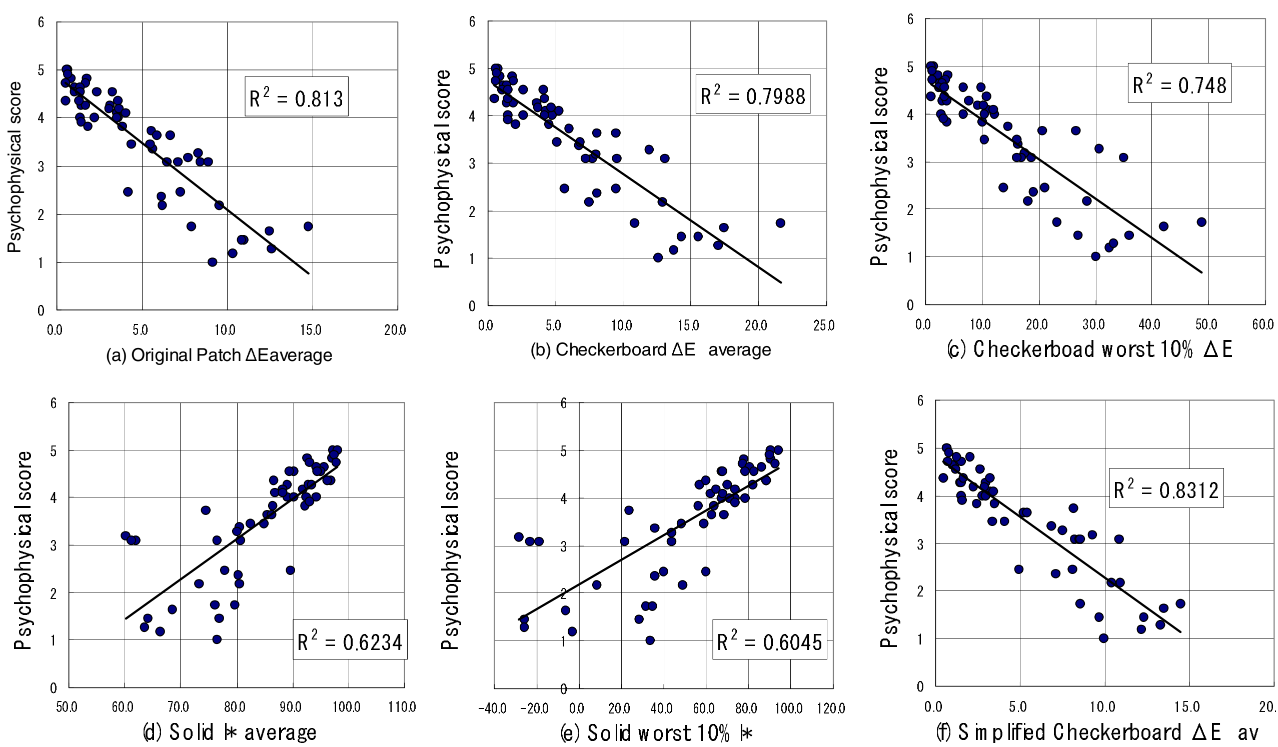

Figure6. *correspondence between each of the parameters and the psychophysical evaluation score*

making the differences difficult to determine. Because 85% RH made the differences between the samples clear, 85% is most suitable as the test condition.

Next, we considered adding ranks for each of the test samples. While the average ΔE correlated best with the psychophysical evaluation score, when we attempted to rank the individual samples on the basis of the ΔE value, there were cases when it was difficult to classify the samples into 4 – 5 ranks, in particular for samples where the psychophysical evaluation score was poor. For both the Mark McCormick-Goodhart *et al* original pattern and the simplified pattern, there was a clear tendency for the psychophysical evaluation score to be 3 or below when ΔEav > 5. For this reason, it is believed that under specific temperature and humidity conditions, humidity fastness is sufficient when ΔEav < 5. Therefore, it is most appropriate to specify the humidity at which ΔEav < 5 for the purpose of ranking.

Conclusion

For the evaluation image and parameters, a test chart which combines a checkerboard pattern and solid patch correlated well with the psychophysical evaluation. The most suitable parameter as a measure for the objective evaluation was the average value of ΔE. In addition, the simplified checkerboard chart was found to be sufficient for the humidity fastness evaluation. For the test conditions, although the drying time after printing did have an effect, the contribution was small, while the effects of the humidity level were large. In consideration for compatibility with field evaluations, evaluation conditions of 30°C and 85% RH are the most suitable. For ranking, it is difficult to break ΔEav into fine divisions, and it is thought best that the humidity condition be specified so that ΔEav < 5.

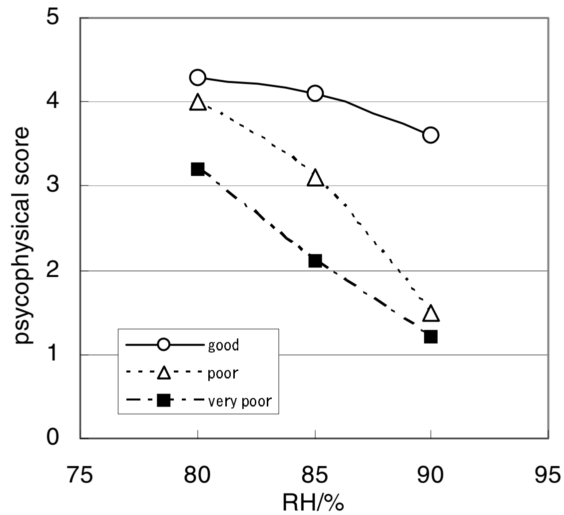

Figure7. *psycophysical score at 30 C 80%RH,85%RH and 90%RH*

References

[1] Mark McCormick-Goodhart and Henry Wilhelm , Japan Hardcopy 2005, pg. 95 (2005)

[2] Mark McCormick-Goodhart and Henry Wilhelm, NIP19, pg. 420 (2003)

Author Biography

Hideki Kaimoto received his BS in Chemistry from Kyushu University (1992) and his MS in Chemistry from Kyushu University (1994). Since then he has worked in the Research Laboratories Division at Fujifilm Corp. in Fujinomiya City. His work has focused on the development of digital printing medium.