

**AIC 2011 Midterm Meeting of the  
International Colour Association (AIC)**


Interaction of Colour & Light in the Arts and Sciences

**Conference Proceedings**

Much interest is devoted to the interaction of colour & light in today's scientific and artistic research communities. New technologies, materials and media are now being deployed to enhance and stimulate our experience of daily life in real and virtual, permanent and ephemeral environments. The aim of the AIC 2011 conference is to explore how the interaction of colour & light plays a crucial role in the perception, conception and realization of spaces and platforms in different fields from both theoretical and practical points of view. Using terms and concepts such as appearance, interaction, performance, event, and by privileging the materiality, mediality, and the interactive dimension of colour & light, the conference presentations demonstrate how productive the theme of the INTERACTION OF COLOUR & LIGHT IN THE ARTS AND SCIENCES is. The fields of inquiry include education, design, art, media, lighting, architecture, theatre, dance, as well as psychology, colour science and technology. The AIC 2011 Midterm Meeting aims to further discussion and nurture the latest findings in these various fields.

The International Colour Association – Association Internationale de la Couleur (AIC) or Internationale Vereinigung für die Farbe – is a learned society whose aims are to encourage research in all aspects of colour, to disseminate the knowledge gained from this research, and to promote its application to the solution of problems in the fields of science, art, design and industry on an international basis.

 **pro/colore**  
Schweizerische Vereinigung für die Farbe

 **AIC** International Colour Association  
Internationale Vereinigung für die Farbe  
Association Internationale de la Couleur

ISBN 978-3-033-02929-3





# **Interaction of Colour & Light** in the Arts and Sciences

Midterm Meeting of the  
International Colour Association (AIC)  
7-10 June 2011  
Zurich, Switzerland

## **Conference Proceedings**

Editors: Verena M. Schindler, Stephan Cuber

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Please use the following format to cite material from the AIC 2011 Conference Proceedings:

Author(s). "Title of paper". AIC 2011, Interaction of Colour & Light in the Arts and Sciences, Midterm Meeting of the International Color Association, Zurich, Switzerland, 7–10 June 2011: Conference Proceedings, edited by Verena M. Schindler and Stephan Cuber. Zurich: pro/colore, 2011, page number(s).

The Conference Proceedings contain the full papers of the technical programme cited in the cover and title page of this volume. They reflect the author's opinions and are published as presented.

The abstracts from the technical programme are published in the AIC 2011 Book of Abstracts, ISBN 978-3-033-02929-3.

Editors: Verena M. Schindler, Stephan Cuber

Design: Florian Bachmann, Zürich

Layout: Stephan Cuber, Bern

Produktion: CD-Fabrik, Zürich

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# Colorimetric characteristic of ink jet prints in function of environmental parameter

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## Abstract

The aim of this work is to determine the range of reproduction and colour deviation of the naturally and artificially aged prints obtained on the printers of different technologies and ecological characteristics. The prints obtained by piezoelectric, thermal and UV ink jet technologies were used. The investigation results point at the decrease of gamut volume of naturally aged prints HP 500 and HP 9000s with the exposition time, opposite to the prints made on Roland UV LEC 300 where the positive trend was determined. The artificially aged samples give gamut volumes which fit in earlier mentioned results. The aged prints HP 500 have greatest  $\Delta E$  values and belong to the class of obvious deviations.

## 1. Introduction

Ink jet technology is the printing technology using the ink droplets without the contact with the printing substrate. Criteria are set for the ink jet print quality, eligible features typically including large color gamut, sharp detail rendering, and long-term fastness of the printed image. These characteristics are highly dependent on the properties of both papers and inks and their chemical and physical interactions; Wilhelm, Holmes and M. McCormick-Goodhart (1998), and Blayo and Medlege (2001). Durability of colour prints has steadily improved. Improvements have targeted the following areas: light fastness, thermo stability, water-fastness, humidity-fastness, and pollution gas-fastness; McCormick-Goodhart and Wilhelm (2001) and Steiger and Brugger (1998). Light fastness is one of the most important items in ink jet printing; Možina et al.(2006) and Dobrić, Bolanča - Mirković and Z. Bolanča (2010) and Fricker, Hodgson, and M. Sand(2010). Degradation of dyes as it is known depends on a wide variety of environmental parameters like temperature, humidity, light intensity and spectral distribution. Pigment based inks have better resistance to gas and light and better water-fastness than dyes; Work and Brown (2001). The aim of this work is to determine the range of reproduction and deviation of colours of the naturally and artificially aged prints obtained on the printers of different technologies and ecological characteristic.

## 2. Experimental

The prints obtained by piezoelectric, thermal ink jet and UV technologies were used in the research. The following printers were used: HP Designjet 9000s, HP Designjet 500 and Roland UV LEC 300. HP Designjet 9000s uses carbon filters to absorb the air volatile organic compounds released during the printing process. The system is designed to absorb VOC from air at rates consistent with the print speed and number of compounds released during printing. HP Designjet 500 uses CMYK water -based ink. The environmentally friendly Roland UV LEC 300 uses safe, low-heat LED lamps. The test form contained ISO and ECI patterns. The part containing the ECI measuring form consists of fields with different combination color values of the subtractive

synthesis. The information quantity obtained by such measurements enabled the construction of 2D and 3D gamut in perceptual uniform color space. The samples in the first series were exposed to outdoor conditions in the duration from 3 months in interval from seven days. In the second series prints were exposed accelerated ageing in Solarbox 1500 e (ASTM F2366-05). The instrumental analysis comprised the measurements made by spectrophotometer, followed by the statistic data processing obtained by measurements of each field. Except that, the conversion from CIEXYZ into CIE L\*a\*b\* system was performed in order to enable the presentation of 3D gamut of samples in the threedimensional unified color space. By spectrophotometric measurements the obtained CIE L\*a\*b\* values were used for calculation the color difference, CIE LAB  $\Delta E_{2000}$ .

### 3. Results and discussion

Color management allows conservation of color information through the printing process. The only RGB or CMYK information is not sufficient. ICC profiles contain tables with correspondances between RGB or CMYK and L\*a\*b\* values. Gamut represents the total range of information on color, i.e. tone, saturation and lightness which can be reproduced by the given medium. Gamut limits present the volumes or surface which is determined by the gamut extremes. For objective evaluation of the print quality the ECI values of field samples of different combinations of color values of the subtractive synthesis were measured and the values for the construction of 3D color cubic units were obtained by the computer support and conversion. 3D gamut of prints before and after exposure to the outdoor conditions is presented in the figure. The exposure was done in the cold part of the year from 6.01. till 7.04. 2011. in the intervals of 7 days. The exposure place was near the frequent communication road; however there were no pollution source of industrial origin.

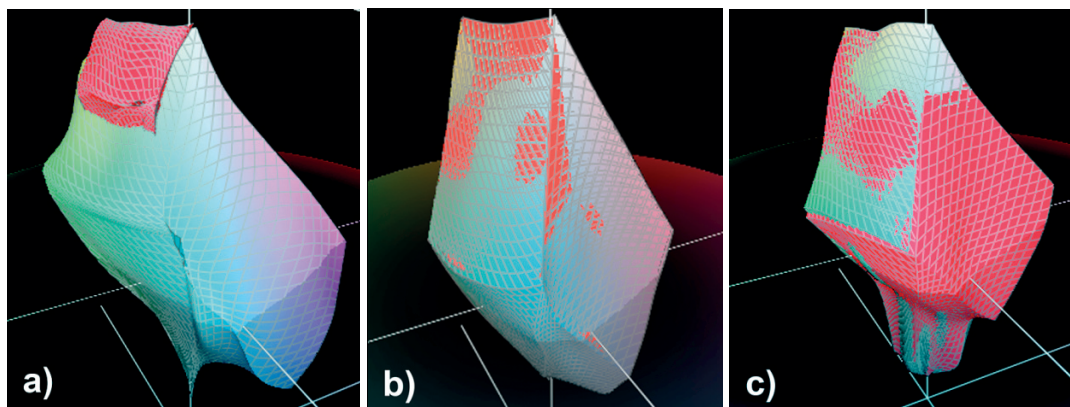


Figure 1: 3D gamut of prints after natural ageing in the interval of 70 days:  
a) HP 500 b) HP 9000s c) Roland UV LEC 303.

The investigation results show that HP 500 print has the greatest gamut volume (V 414610 g.u.) before exposing to the outdoor conditions in relation to the prints made on two other printers. However by natural ageing the gamut volume decreases drastically proportional to the process dynamics flow ( $\Delta V$  non aged/aged for 7 days -24834g.u.;  $\Delta V$  non aged/aged for 70 days -302257 g.u.). Because of great instability in the described conditions, the measurements were not possible to be performed for the sample exposed for 91 days. The non aged gamut volumes of prints HP 9000s is smaller (V 282964 g.u.) in relation to HP 500 printer (V414610 g.u.), which points at the lower reproduction quality. The decreasing trend of gamut volume with the exposition time was recorded on prints HP9000s. The gamut decrease by natural ageing is generally smaller according

the dynamics of the ageing process flow in relation to the HP 500. For the print HP 9000s after the seven days exposure, the calculated difference  $\Delta V$  for the non exposed/ 7 days exposed print is 5730 gamut units (for the same period  $\Delta V$  for HP 500 is 25834 g.u.) which is in fact only about 22% of that result related to the print HP 500. Such characteristic is more stressed after the long exposure period of prints to the conditions of natural ageing ( $\Delta V$  for HP 9000s prints on non exposed /exposed for 70 days is -15567 gamut units, and for HP 500 it is -302257 g.u.). From the presented investigations results it is visible that there is the question of more stable print. The non aged prints gamut volume for Roland UV LEC 300 is 330344 gamut units. In the process of natural ageing there is completely different trend of gamut volume change in relation to the described so far. In dependence on the ageing dynamics the increase of print gamut is noticeable in relation to the value for the non aged print ( $\Delta V$  naturally aged for 7 days /non aged is 12861 g.u.,  $\Delta V$  naturally aged for 70 days/non aged is 12268 g.u.;  $\Delta V$  naturally aged for 91 days /non aged is 13317 g.u.). In this case the change of the gamut volume by the dynamics of the natural ageing is the smallest and it oscillates relatively very little about the value for the non aged print mainly in positive direction. In any case the attention should be paid to different trend signs of gamut changes of prints in relation to the exposition period of prints to natural ageing in the described experimental conditions. The obtained results could be explained by the principles of the printing techniques, by the characteristic and the thickness of the ink layer of the used printers (Fig. 2a)

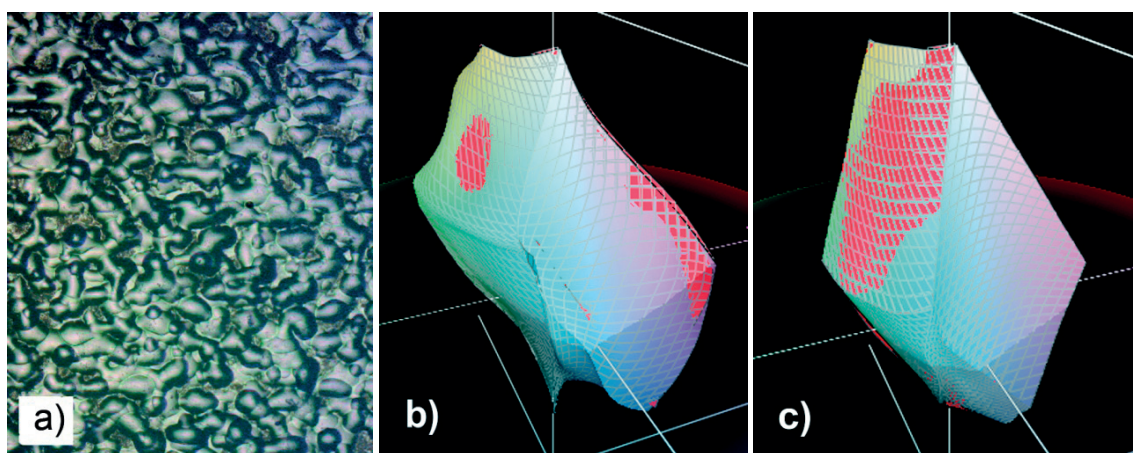
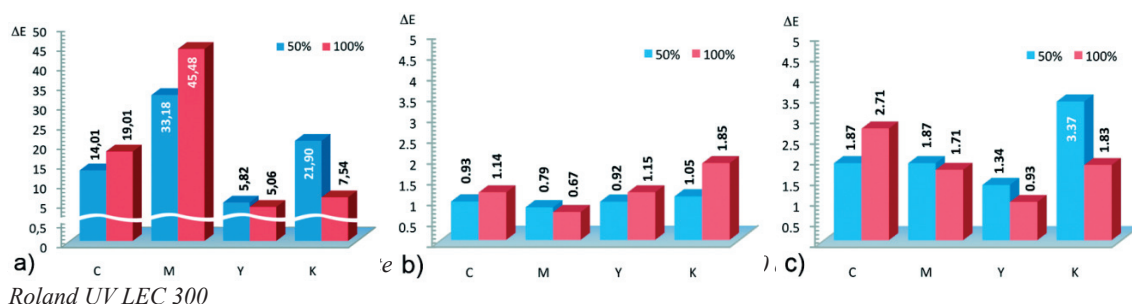


Figure 2.a: Print made on Roland UVLEC 300 with 100% of black ink coverage area  
2b and 2c: 3D gamut of prints after artificial ageing a) HP 500 b) HP 9000s

It could be concluded from the results that on the prints dried by means of the UV part of electromagnetic radiation, the process is in the determined degree present during the exposition time of print to natural ageing. Because the obtained gamut values, as already said, oscillate little and have no expressed linear function in relation to the increase of ageing period, it is legitimate to include into investigations the certain meteorological factors. From the extensive investigations in the field of artificial ageing only the results of 120 minute exposition for printers HP 500 and HP 9000s were chosen with the aim of more complex study within the exposition areas comprised by natural ageing, as already discussed. The gamut volume difference of prints HP 9000s non exposed/ exposed to artificial ageing of 120 minutes is 2027 gamut units, while for HP 500 prints, in the same conditions it is 52063 gamut units. These results match the earlier determined result on print stability. For determining the color deviations, the color difference  $\Delta E$  is used which indirectly describes the loss and deviation of three stimulus information of color of the observed sample. In figure 3 the investigation results of prints from all three printers are presented after the natural ageing of 70 days



for the color difference  $\Delta E$  of the characteristic inks CMYK for the area of solid patches and 50% screen value. On the prints HP 500 whose surface is covered with 50% screen, greater difference in  $\Delta E$  is noticeable, in relation to the print with the surface which are 100% covered.



Except that, in this case the values of  $\Delta E$  (minimum  $\Delta E$  5,06, maximum  $\Delta E$  45,48) are several times greater in relation to other two printers in the same experimental conditions. From the point of view of the standard observer, these values go over the obvious deviations. On the other hand, in the same conditions HP 9000s gives much better on the boundary of visible results.

#### 4. Conclusion

The investigation results of the natural ageing influence in the winter part of the year point at great decrease of gamut volume of prints HP 500. The greatest stability of prints in experimental conditions is determined for the print HP 9000s. The characteristic of the naturally aged prints made on Roland UV LEC 300 is the increase of gamut volume which is an opposite trend from the prints made on HP 500 and HP 9000s. The artificially aged prints give the gamut volumes which fit in the discussed results of the trends for naturally aged prints. The aged prints HP 500 have the greatest  $\Delta E$ , which is in the area of the obvious deviations. The greatest deviations are found for M and K.

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