



PULP AND PAPER INSTITUTE

***The influence of paper quality
on distribution of ink-jet inks***

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THE INFLUENCE OF PAPER QUALITY ON DISTRIBUTION OF INK-JET INKS - Trondheim 2004

INTRODUCTION

Goals

- ü determine the influence of paper surface on the print quality
- ü find out which of different techniques give us more information about radial and vertical distribution of colours on different types of papers



**Camag Video
Documentation
System (CCD camera)**

**We applied two methods which are used for
qualitative and quantitative evaluation
of Thin Layer chromatograms**

Slit-scanning densitometer



Subsequently for investigation of vertical distribution (z-direction) of colours we used also confocal microscopy - CLSM and optical microscopy – OM with microtome.

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EXPERIMENTAL

Paper and models

We used two different types of papers:

ü H – HP Premium Photo Paper which is one of the best, used only for Ink-jet printing (one side coating, high glossy, 150 g/m²)

ü I - the ICP Permanent Paper made at the Pulp&Paper Institute in Ljubljana, which corresponds to standard – ISO 9706 (without surface treatment, 70 g/m²)

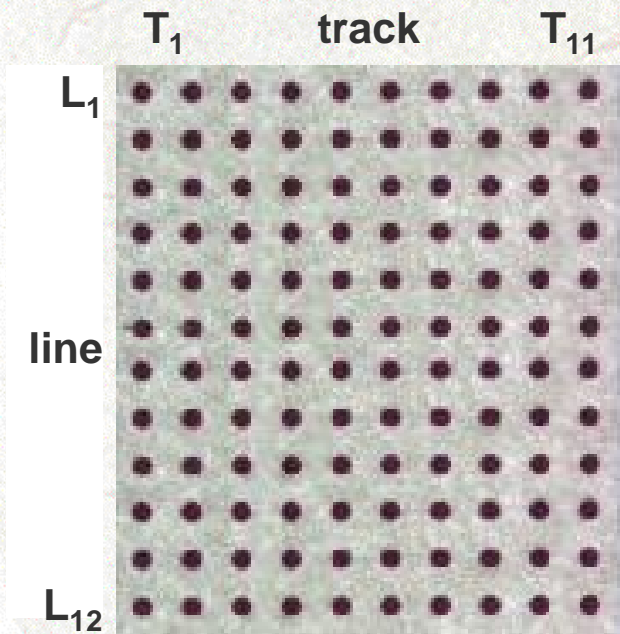
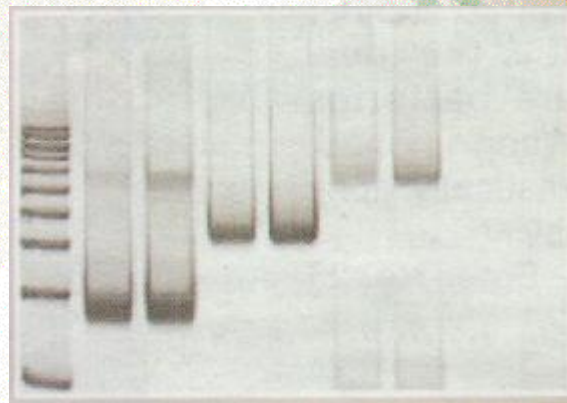


Image of model with printed spots.
(10 × 10 cm and the spot size 4 mm)



We have
simulated TLC
plate.

ü papers were printed (HP Desk Jet 720 C printer) with spots of four primary colours: C, M, Y and K
ü the printing quality was 600 dpi, while the colour intensity was 100%.

EXPERIMENTAL

MEASUREMENTS

Test on the paper surfaces

Before we printed paper models of different colours on the both type of paper we have done:

- the penetration test – PDA. The dynamic of penetration of papers was measured with recording the change of intensity of ultrasonic signals transmitted by papers while one of their faces is in contact with a water
- the dot formation test. With pocket CCD camera at 40-times magnification we were monitoring the formation of the droplet size 1 μL .

EXPERIMENTAL

Test of permanence and durability - Xenotest

- For determination of light resistance, the ISO 2853 (Xenotest) method was used. After 48 hours of exposure we measured the variation of intensity before and after light exposure with the CCD camera, densitometer and CLSM.
- The testing conditions for the Xenotest were as follows:
 - ü Relative humidity: 70% in the Xe-test chamber,
 - ü Laboratory conditions: temperature 22°C, relative humidity 65%.

Test of permanence and durability – Accelerated ageing test

- Models of printed spots on both papers (size A4) were exposed to conditions of accelerated ageing according to ISO-9706, at $80 \pm 1^\circ\text{C}$ and $65 \pm 2\%$ relative atmosphere humidity in a climate chamber for 24 days.
- All climatized samples were examined before and after ageing, following the optical stability (on the unprinted part of paper surface by measuring brightness and yellowness) and the change of the colour intensity by CCD camera, densitometer and CLSM.

EXPERIMENTAL

Study of the radial and vertical distribution of colours

On different types of paper we have studied the influence of the non-homogeneity of the paper on the signal by comparing the signals from different tracks and different lines of the models.

Measurements were made by:

- ü Camag Video Documentation System (CCD camera), Hitachi HV-C20 and by
- ü Slit – Scanning densitometr.
- ü Additionally for the investigation of vertical distribution of colours we used also confocal microscopy - CLSM and optical microscopy with microtom.

The testing conditions for measurements were as follows:

CCD camera:

- ü transmission mode,
- ü focus length 56 cm and
- ü diaphragm 14 (for ICP Paper),
diaphragm 8 (for HP Photo Paper).

Densitometer:

- ü remission and transmission mode,
- ü wavelengths: 460 nm for yellow, 580 nm
for magenta and 640 nm for C and K.

CLSM:

- ü scann area $460 \mu\text{m} \times 460 \mu\text{m}$
- ü air objective with numerical aperture 0,6
- ü laser beam wavelength 458nm
- ü resolution in z-direction $2,7 \mu\text{m}$, slice thickness $1,35 \mu\text{m}$

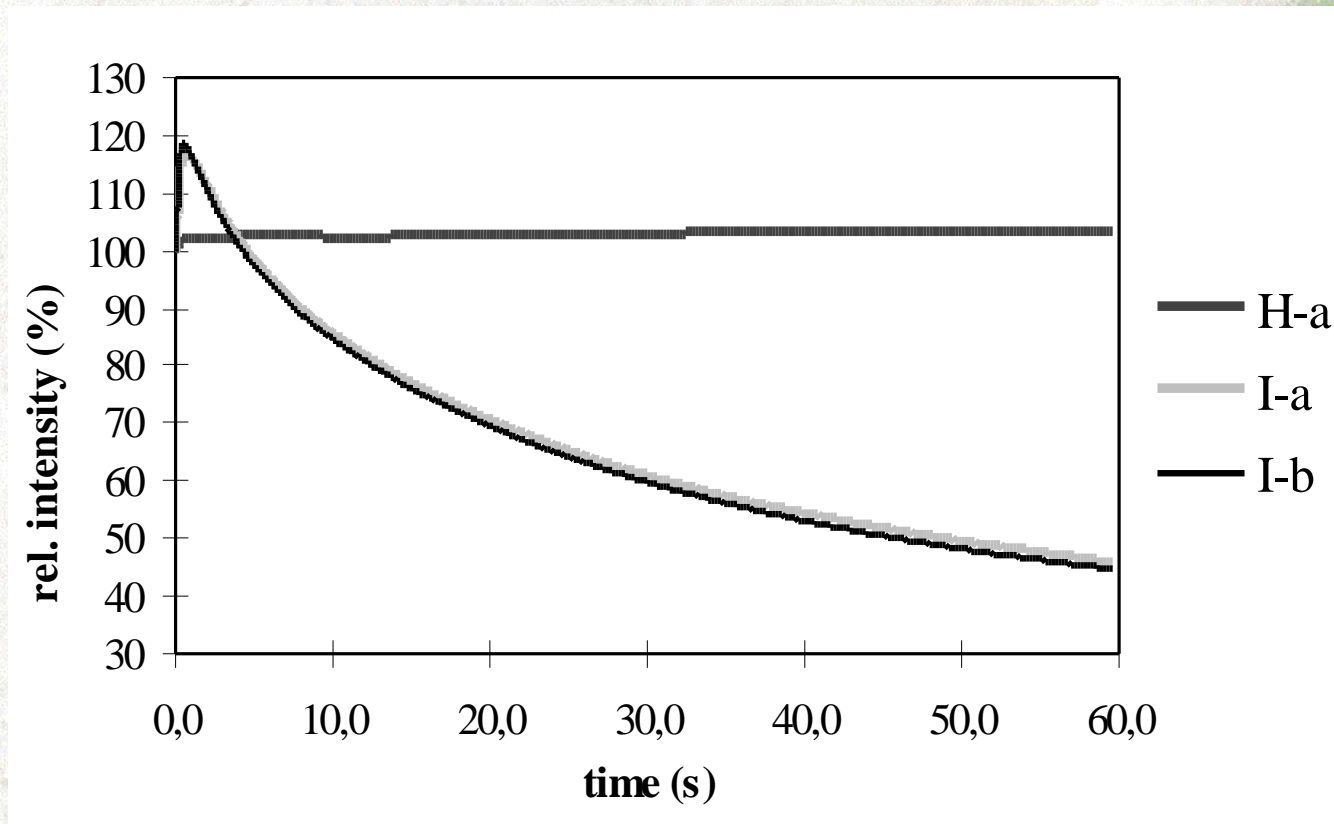
OM with microtome:

- ü magnitude 160x
- ü slice tickness $30 \mu\text{m}$

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RESULTS AND DISCUSSION

Sample analysis before printing – PDA

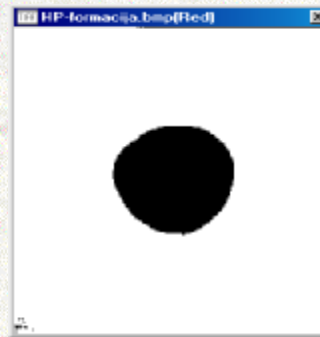


The change of relative intensity with time for both samples of paper / and H. (a – the top side of paper, b – the bottom side of paper)

RESULTS AND DISCUSSION

Sample analysis before printing – pocked-size CCD camera and image analysis

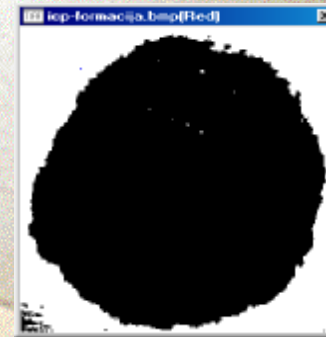
H paper



Info	
Black 10 %	
Count:	1
Area:	56826 square pixels
Mean:	26.01
Std Dev:	77.17
Min:	0.00
Max:	255.00
Black:	0.10
White:	0.90

The dot formation of the dropled size 1 μ L.

I paper



Info	
Black 65 %	
Count:	2
Area:	56826 square pixels
Mean:	166.78
Std Dev:	121.30
Min:	0.00
Max:	255.00
Black:	0.65
White:	0.35

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RESULTS AND DISCUSSION

Sample analysis immediately after printing

Results of measurements with CCD camera - transmission mode

sample	average peak area (a.u.), N=132	average RSD
I-C	43920.7	12.0
H-C	37553.7	6.7
I-M	56129.5	7.9
H-M	50551.8	5.3
I-Y	30290.4	18.7
H-Y	27864.2	8.9
I-K	67790.1	7.0
H-K	65532.2	5.9

The results of average peak area and RSD for each colour on both types of paper. I – ICP Permanent Paper, H – HP Premium Photo Paper

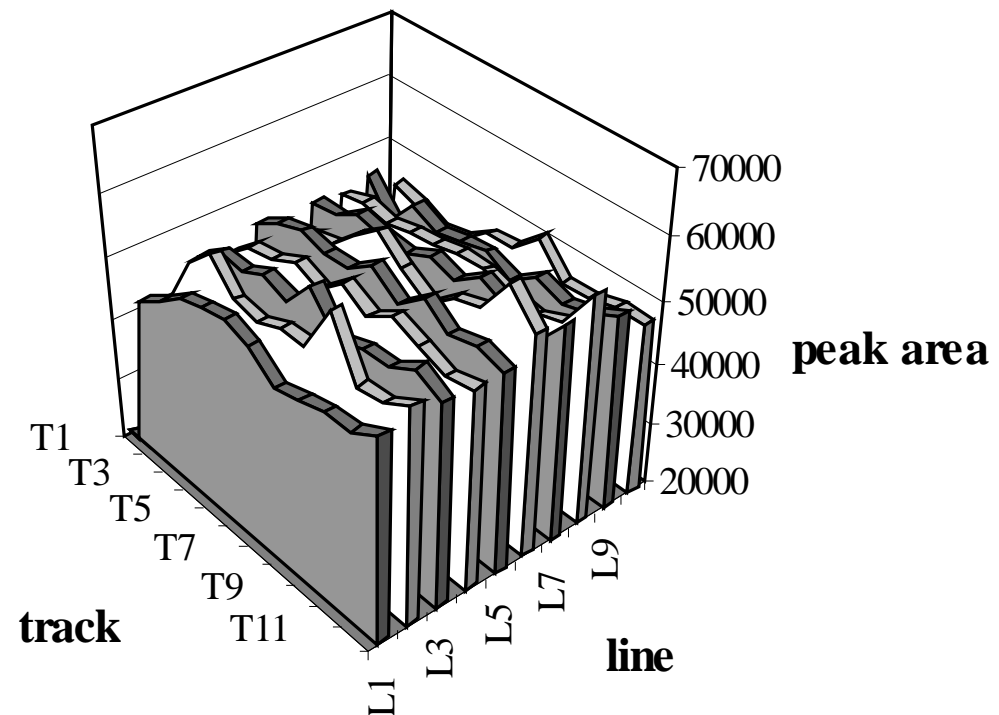
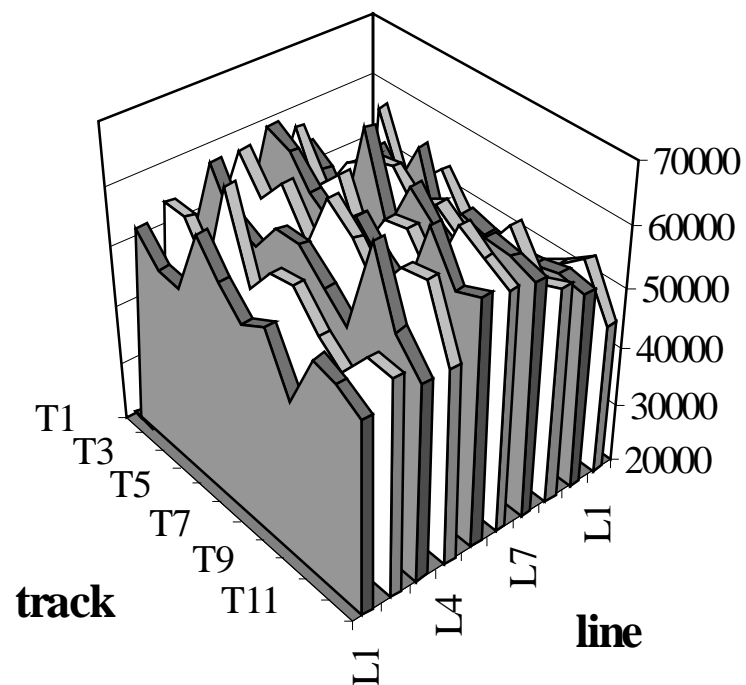
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RESULTS AND DISCUSSION

immediately after printing

Results of measurements with CCD camera - transmission mode

The peak area of magenta colour, measured with the CCD camera on the *I* paper (left) and *H* paper (right), immediately after printing.



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Results of measurements with CCD camera - transmission mode

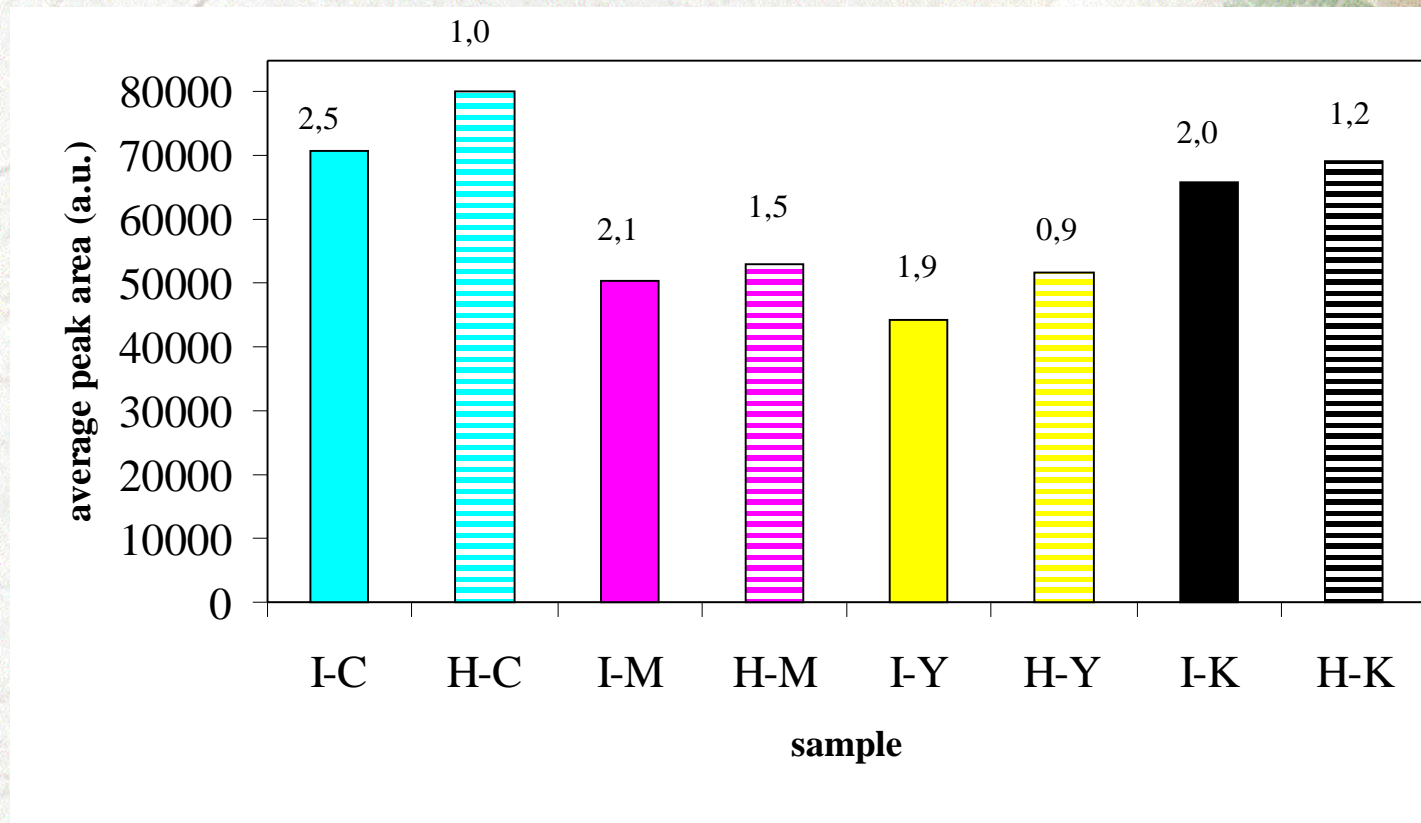


Radial distribution of the magenta colour on the *H paper* immediately after printing.

RESULTS AND DISCUSSION

immediately after printing

Results of measurements with densitometer – remission mode



The results of the average peak area for each colour on both types of paper immediately after printing:

I – ICP Permanent,

H – HP Premium Photo.

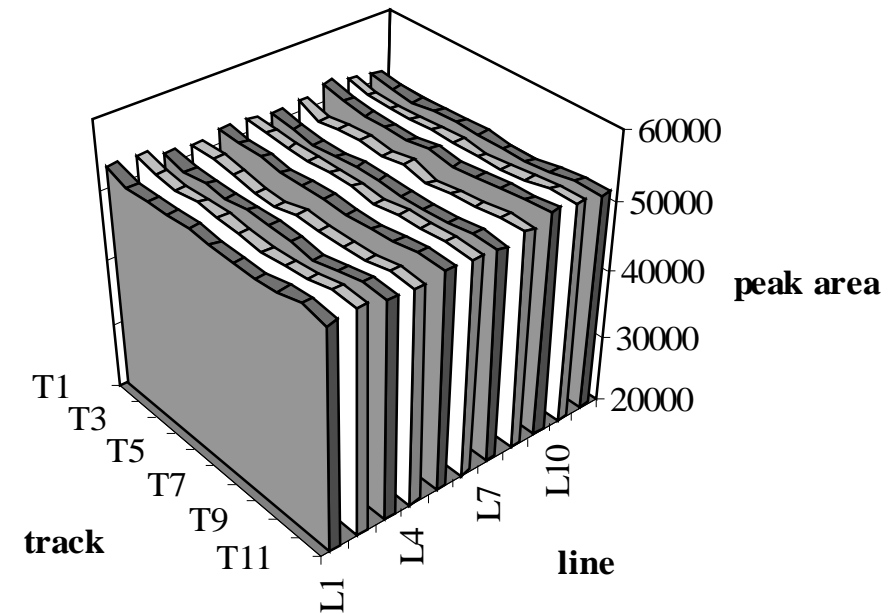
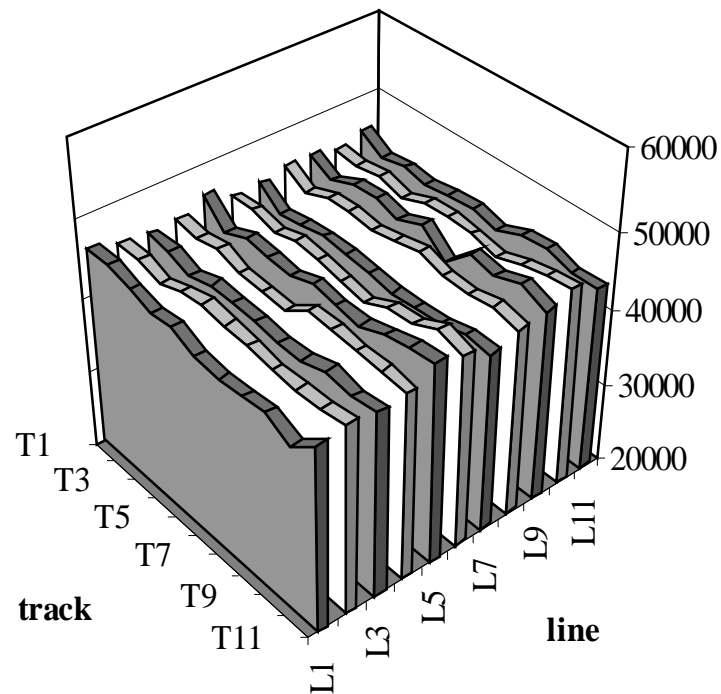
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RESULTS AND DISCUSSION

immediately after printing

Results of measurements with densitometer - remission mode

The peak area of yellow colour, measured on the *I paper* (left) and *H paper* (right), immediately after printing.

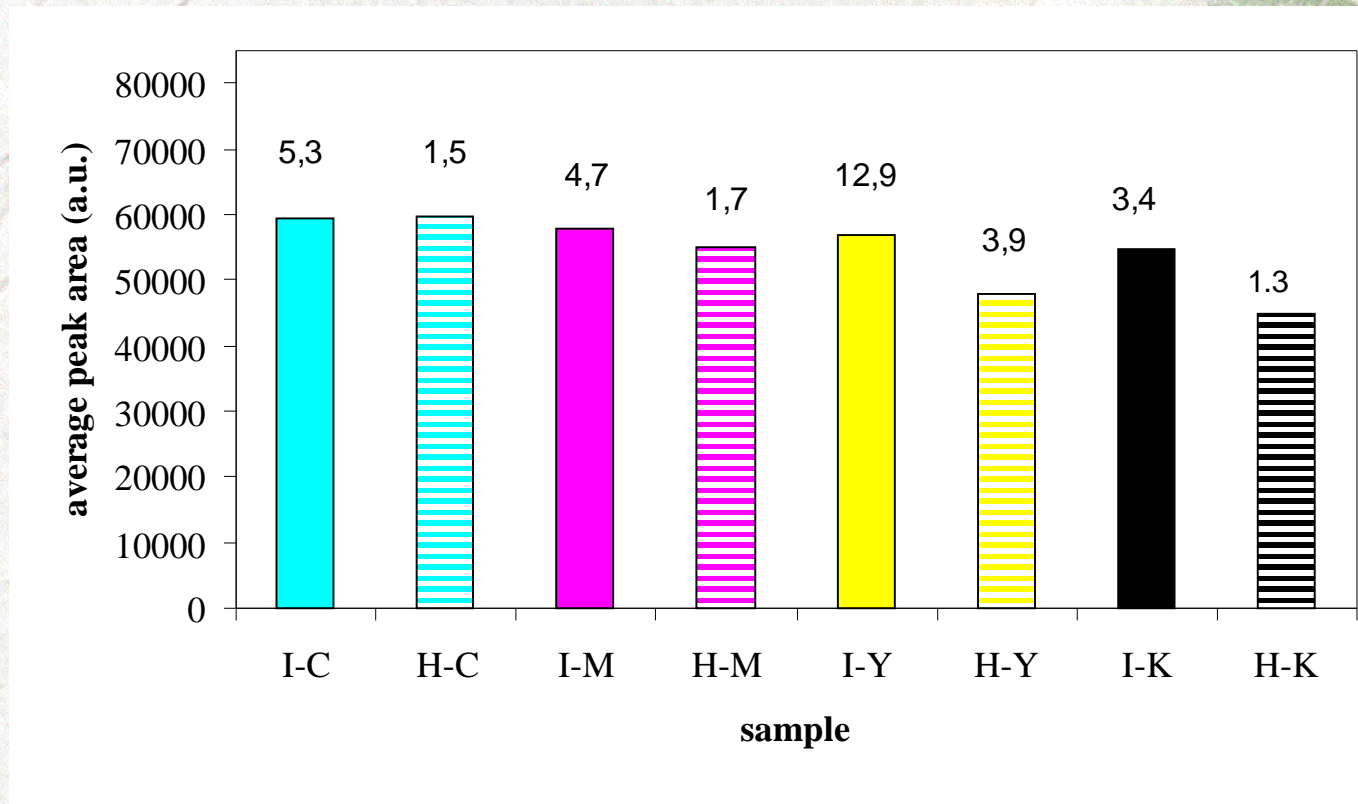


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RESULTS AND DISCUSSION

immediately after printing

Results of measurements with densitometer – transmission mode



The results of the average peak area for each colour on both types of paper immediately after printing:

I – ICP Permanent,

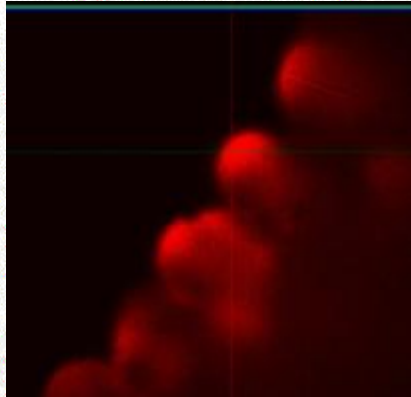
H – HP Premium Photo

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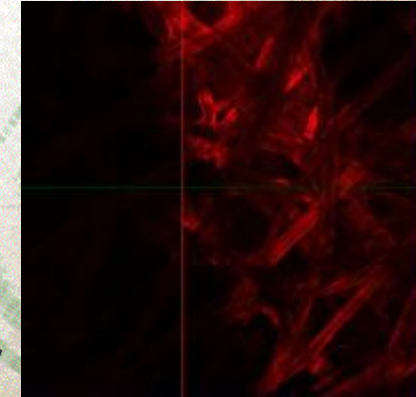
immediately after printing

Results of measurements with CLSM



H paper

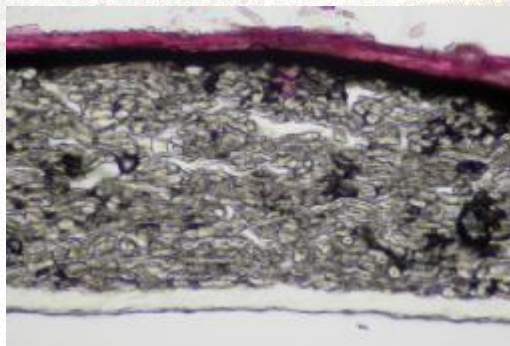
The border of the magenta dot observed with CLSM.



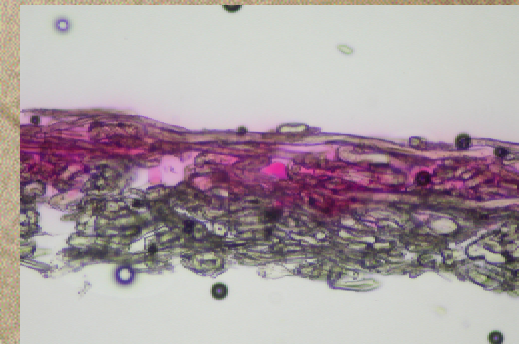
I paper

Sample	Number of z slices (μm)	ink thickness (μm)
H-M	14	18,9
I-M	27	36,5

Cross section analysis of magenta ink made by microtome and optical microscopy, immediately after printing.



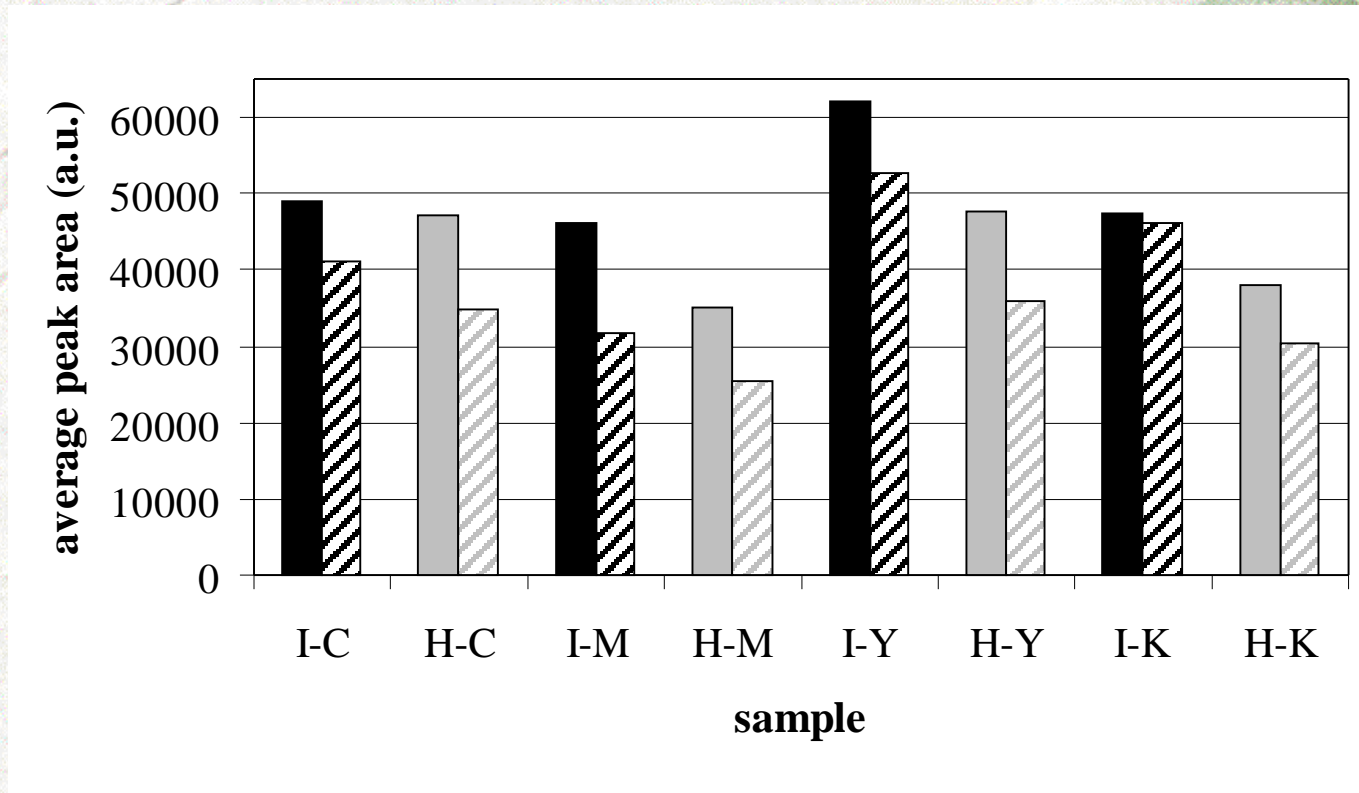
H paper



I paper

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Results of measurements with densitometer – transmission mode

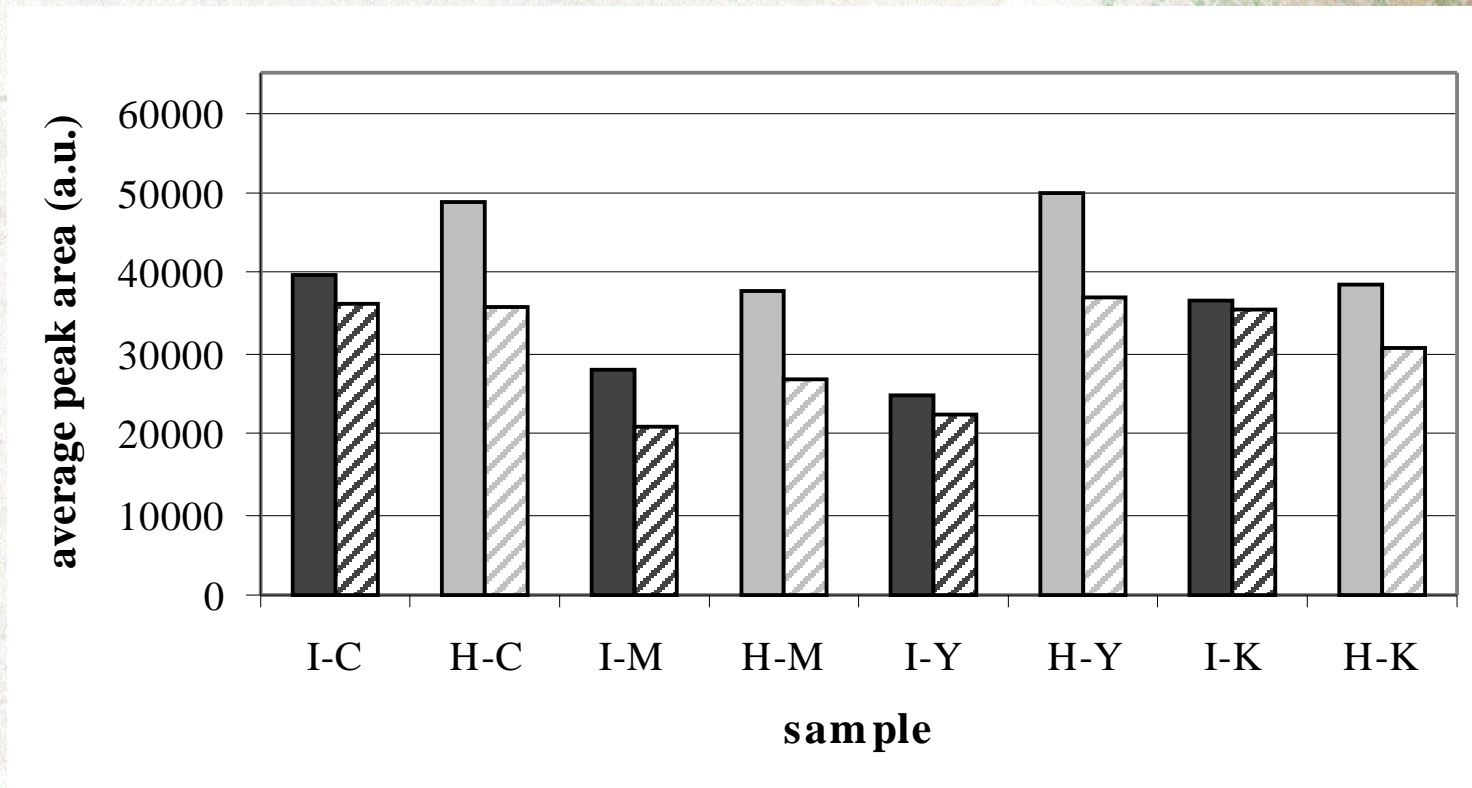


Average peak area for each colour on both types of paper before and after light resistance test. I – ICP Permanent Paper, H – HP Premium Photo Paper

RESULTS AND DISCUSSION

Sample analysis after light resistance test

Results of measurements with densitometer – remission mode

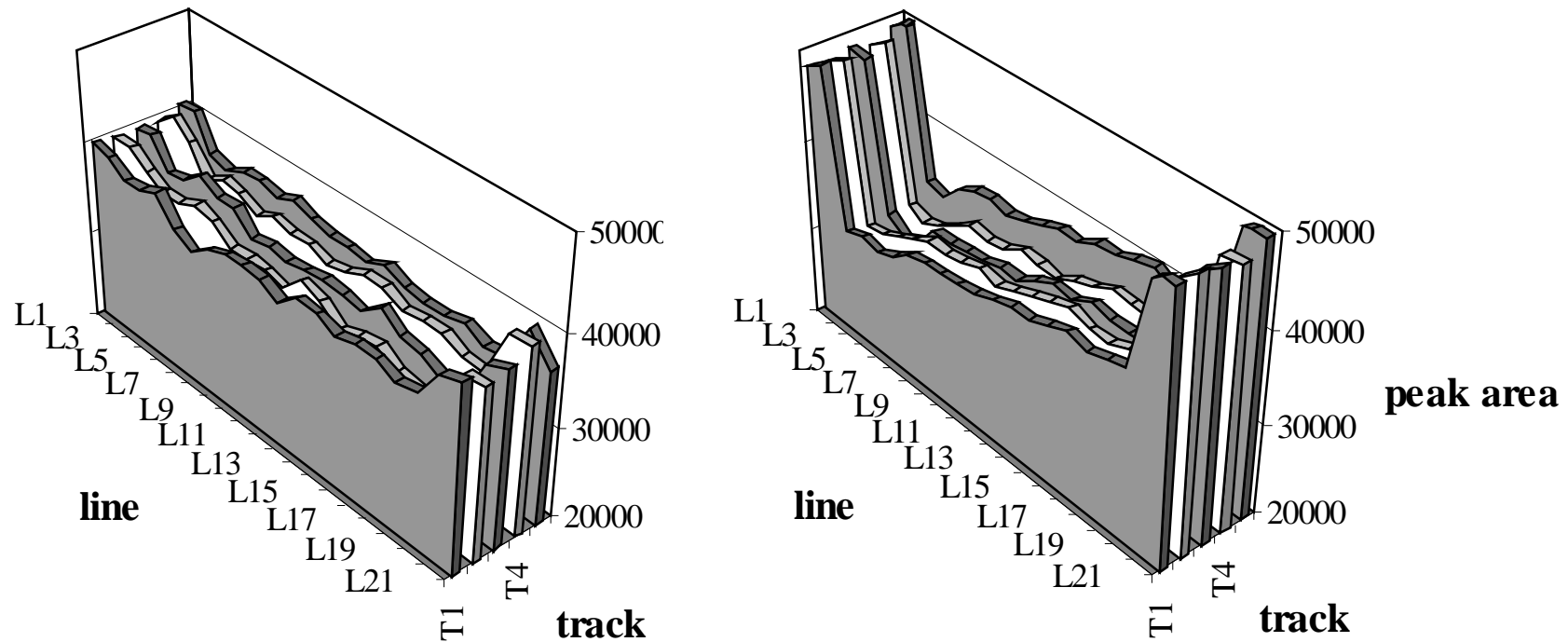


Average peak area for each colour on both types of paper before and after light resistance test. I – ICP Permanent Paper, H – HP Premium Photo Paper

RESULTS AND DISCUSSION

after light resistance test

Results of measurements with densitometer – remission mode

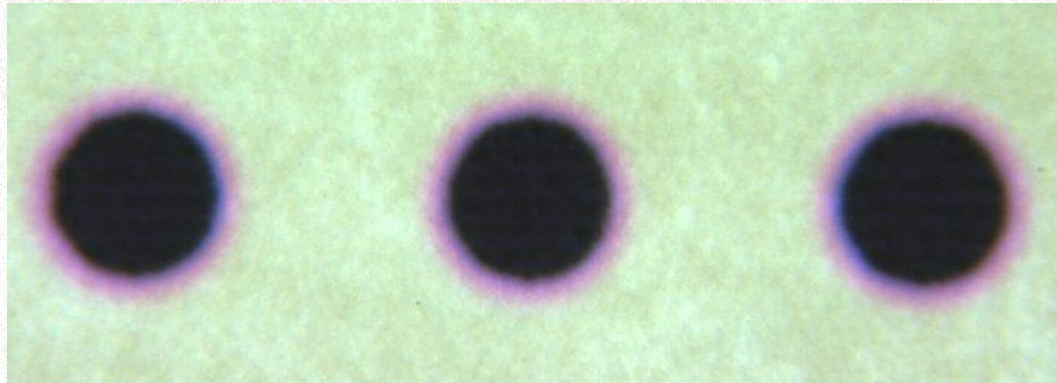


Variation of peak area of the cyan colour, on the *I* paper (right) and *H* paper (left) before and after light resistance test (L1-L2, L20-L22; before light resistance test, L3-L19; after light resistance test).

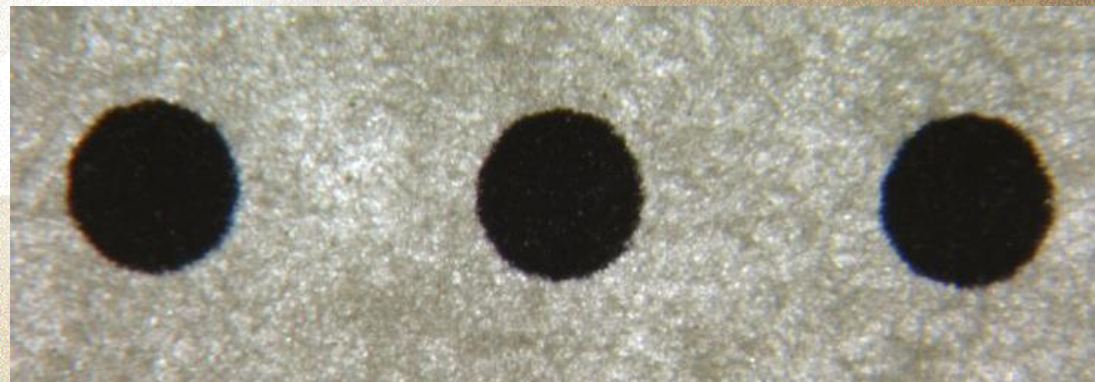
RESULTS AND DISCUSSION

Colour prints after accelerated ageing

Radial distribution observed with CCD camera of the black colour on the papers after accelerated ageing.



H paper



I paper

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RESULTS AND DISCUSSION

Measure of the vertical distribution of magenta ink with CLSM, before and after light resistance test and before and after Xenotest, optical slice 1,35 μm .

sample	Number of z slices (μm)	ink thickness (μm)	decrease of ink thickness, after permanence test (%)
H-M	14	18,9	0
H-Ms	12	16,2	14,3
H-MXe	7	9,45	50,0
I-M	27	36,5	0
I-Ms	20	27,0	26,0
I-MXe	15	20,25	44,5

* s – after accelerated ageing test

* Xe – after light resistance test

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CONCLUSION

Measurements:

ü in the remission mode with densitometer indicate higher intensity of colours on *H paper*,
ü in the transmission mode with densitometer and CCD camera indicate higher intensity of colours on *I paper*,
This statement is in accordance to the test results of PDA, droplet formation test and cross section analysis.

Compared to densitometer, the results obtained by CCD camera gave more information about the radial distribution of the colour on the paper.

The cross section analysis confirms the results obtained by other methods (CCD camera, Slit scanning densitometr).

By comparison of intensity separately for each colour in remission and transmission mode we can say, which of them stay on the paper surface and which of them go down into the paper.

In our following work we want to, for exact results (about deep profiling of colours in the paper), repeat all these measurements for each colour by the cross section analysis again and test a photoacoustic spectroscopy, which give good results in quantitative evualtion of TLC.

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