Effect of Various Contaminants on Ink Jet Photo Prints

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The Questions

- What is a photo?
- Is inkjet ‘as good as’ silver halide?
What is a Photo?

- Generally accepted as defined by silver halide print suppliers over a 100 year period
- Close to a faithful 2D reproduction of a scene
  - Image quality – color, density, detail
- Available to all
  - Cost
  - Convenience
- Has a look and feel
  - Weight
  - Appearance
  - Portability
  - Durability
Can Inkjet Make Good Photos?

- **Image quality, appearance, cost, convenience** are adequately addressed by many others.

- **Durability** has been partially addressed and has two components:
  - Image permanence
  - Ability to withstand pollutants and contaminants
Summary of Durability Testing

- Accelerated fade testing by UV exposure
  - Wilhelm
  - RIT Image Permanence Institute
- Ozone exposure
  - RIT Image Permanence Institute
- Temperature and Humidity
  - Very few results or comparisons available
- Effect of overcoats, glass protection
  - Very few results or comparisons available
- Common contaminants
  - No results available
Common Durability Factors

- UV Exposure
- Pollutant Gas Exposure
- Temperature
- Humidity
Purpose of this Test

- Directly compare AgH and Inkjet
- Include overcoated samples
- Test permanence by common durability factors
- Test exposure to a range of likely casual contaminants
- Lay the groundwork for a Standard Test Methodology
Casual Contact Materials

- Handling and Accidental Contaminants
  - Hand lotions, Spillage
- Writing Contaminants
  - Inks
- Storage Contaminants
  - Envelopes, plastic, glues
Handling and Accidental Contaminants

- Skin oil
- Hand lotion
- Deodorant
- Antiperspirant
- Acetone
- Lighter fluid
- Denatured alcohol
- Windex
- Isopropanol
- Water
Writing Contaminants

- Ball point pen
- Fountain pen
- India ink
- Permanent marker
- Water-based marker
- Dry erase marker
Storage Contaminants

- PVC
- Acetate
- Post-it Note
- Scotch tape
- Glue stick
- Rubber cement
Printers Used for the Test

- Silver Halide
  - Commercial digital photo print services
- Thermal Inkjet Photo Printers
  - HP Photosmart 1215
  - Kodak PM 200
- Piezo Inkjet Photo Printer
  - Epson Stylus Photo 2000
# Papers Used for the Test

<table>
<thead>
<tr>
<th>Silver Halide</th>
<th>HP 1215</th>
<th>Kodak PM200</th>
<th>Epson 2000P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kodak Professional</td>
<td>HP Colorfast</td>
<td>Kodak InkJet Photo</td>
<td>Epson Premium Luster</td>
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<tr>
<td>Fuji Crystal Archive</td>
<td>HP Premium Plus Photo</td>
<td>Kodak Premium Picture</td>
<td>Epson Premium Glossy</td>
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<td>Epson Archival Matte</td>
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<td>Epson Prof Glossy</td>
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</tbody>
</table>
Protections Tested

- Unprotected – All prints
- Protected by glass – All prints
- Lacquer-Mat Pearl High Gloss – All Prints
  - Solvent based (Toluene/Ethyl Acetate +)
  - Spray coated 7” 35 psi air sprayer
- Accutech Acculac Hydroluster – Some Prints
  - Water based
  - Roll coated
  - Cannot be used on thermal inkjet prints
Test Pattern Used – Digital File
Measurement Objective

- Assess user perception of color change
- Determine change in L*a*b* values
  - L* relates to lightness
  - a* relates to redness/greenness
  - b* relates to yellowness/blueness
- Relate L*a*b* values to noticeable change
- Assess other visual changes
  - Bleed
  - Smear
  - Curl
  - Edge and surface deterioration
CIE L*a*b* Color Space Definition

CIELAB

colour space is 3-dimensional

L is the Lightness
a is the Redness/Greeness
b is the Yellowness/Blueness
Test Points Map
Measurement Methods

- Control prints
  - Measured within 1 day of printing and/or overcoating
  - Stored in individual acid and lignin free envelopes
  - Stored at 72°F, 60% RH
- L*a*b* Measurement with X-Rite Model SP760 spectrophotometer
- Other
  - Subjective viewing in artificial daylight
  - Gretag-Macbeth Model Judge II-S at 6500°K
Color Change Measurement Method

- Absolute change of 3 or less in L* a* or b* is usually unnoticeable to the eye even under controlled lighting.
- In some cases, the eye cannot detect changes up to 6.
- To obtain a single rating system for each paper/overcoat combination, the overall value is given by:
  \[
  (\Sigma(\Delta L^* > 3))(\Delta L^*_\text{avg}) + (\Sigma(\Delta a^* > 3))(\Delta a^*_\text{avg}) + (\Sigma(\Delta b^* > 3))(\Delta b^*_\text{avg})
  \]
- This combines the frequency of changes greater than 3 in each site on the map, and the average value of those changes.
UV exposure Method

- High level indoor exposure is 450 lux
- TPR fixture, same design as used at RIT Image Permanence Institute
- Simulates daylight exposure
- 100,000 lux for 192 hours
- Intended to correlate to 10 years at 450 lux for 12 hours per day

Ref: Zinn, Nishimura, Reilly IS&T NIP-15 1999
UV Exposure Equipment
Ozone exposure Method

- Ozone incubation chamber at IPI
- Constant 75 °F and 60% RH
- 0.025 ppm is peak indoor level in polluted areas
- 10 ppm Ozone for 14 days
- Airflow through chamber
- Intended to correlate to 15 years exposure at .025 ppm

Ref: Zinn, Nishimura, Reilly IS&T PICS 1998
Temperature & Humidity Method

- TPR environmental chamber
  - Tenney BenchMaster BTRS
- 120°F 85% RH for 168 hours
- Two conditions were examined:
  - Single unconstrained sheets
  - Weighted stacks
    - 13 oz uniformly distributed on A4 size
    - Simulates 10 photo album pages
    - Stack includes 3 prints
    - Face to face and back to face
Contaminant Method

- Two samples used for each contaminant
- Two application methods for each
  - Contaminant applied by foam brush, print allowed to dry.
  - Foam brush followed by wiping with pH neutral inorganic wipe to simulate removal of accidental exposure.
- Measurements confined to solid color areas
UV Results Summary
Typical UV Induced Image Fade

Control Print                         Test Print
UV Induced Paper Background Fade

Control Print  Test Print
UV Results Interpreted

- **OBJECTIVE**
  - Single L*a*b* values did not exceed 8 on any image

- **SUBJECTIVE**
  - No noticeable changes in Epson or Fuji prints,
  - Noticeable changes in all others
  - Most noticeable change was uniform fade/lightness and paper background color change
  - All changes were slight
  - Glass appears to offer the best protection

- **CORRELATION**
  - Noticeable changes occurred when the number of changes >3 was higher than 40 in a single image
Ozone Results Summary
Ozone Results Interpreted

- **OBJECTIVE**
  - Single L*a*b* values did not exceed 8 on any image

- **SUBJECTIVE**
  - No noticeable changes in HP inkjet or Fuji and Kodak AgH prints
  - Noticeable changes in Epson and Kodak inkjet prints
  - Positive and negative color changes were noticeable
  - Relative color changes were noticeable
  - Changes were generally slight
  - Lacquer overcoat appears to offer the best protection

- **CORRELATION**
  - Noticeable changes occurred when the number of changes >3 was higher than 40 in a single image
T&H Results Summary – Weighted

Weighted Stack T&H excluding Epson and Fuji Papers
Image Color Change and Bleed

Control Print

Test Print
T&H Results Interpreted

- **OBJECTIVE**
  - Single L*a*b* values did not exceed 8 on any image

- **SUBJECTIVE**
  - No noticeable changes in Epson inkjet or Fuji AgH prints
  - Noticeable positive and negative color changes changes in HP and Kodak inkjet and Kodak AgH prints were all slight
  - Significant color bleed on HP and Kodak inkjet single sheet prints
  - Significant color bleed and ink transfer on HP and Kodak inkjet weighted stack prints
  - Lacquer overcoat gave the most protection but did not prevent bleed or transfer
Accidental Contaminant Results

- Significant objective damage to a wide range of prints
  - Hand Lotion
  - Windex
  - Deodorant

- Objective damage to some prints
  - Water
  - Denatured alcohol
  - Acetone
  - HP and Kodak inkjet prints unprotected
  - Most inkjet prints

- Little or no damage to any prints
  - Isopropanol
  - Lighter fluid
  - Paint thinner
Writing Contaminant Results

- Little or no damage to any prints
  - Ball point pen, fountain pen, India ink
  - Markers, permanent, water-based, dry erase
Storage Contaminant Results

- Significant objective damage to a wide range of prints, inkjet and silver
  - Glue Stick
- Objective damage to some prints
  - Tape, mainly to Epson prints
  - Rubber cement, to all inkjet prints
- Little or no damage to any prints
  - Post-it notes
  - Acetate
  - PVC
Typical Image Smear

Control Print  Test Print
Summary Observations

Overcoats

- Glass is the best protection for UV exposure
- Lacquer offers the best protection for ozone
- Water based inks are not significantly protected from humidity effects by overcoating
- Overcoats offer protection against many casual contaminants but usually little or no protection against organic solvents
Summary Observations

Inkjet vs. Silver Halide

- **UV Fading** - the best inkjet is as good as the best silver halide
- **Ozone** – silver halide is significantly better than most inkjet in resisting color change
- **Temp and Humidity** – the best inkjet is as good as the best silver halide
- **Casual contaminants** – inkjet prints are variously affected by contaminants, silver halide is almost impervious
Summary Observations
Pigment or Dye inkjet inks

CAVEATS

- Tests were performed on commercial systems in 2000/2001
- Epson is pigment, HP and Kodak are dye
- Epson is piezo, HP and Kodak are thermal ejection
- Ink solvent may have as much influence as colorant
- Ink/media interactions also play a part

- Aqueous dye based inks are subject to damage from water and humidity, piezo pigmented are not
- Aqueous dye based inks more subject to fading than piezo pigmented inks
- Both types can be affected by ozone
- There is no pattern in the data for casual contaminants
Conclusion

- This work is a first attempt at developing standard tests for durability, additional work is needed.
- In general, inkjet prints will perform acceptably for most photo requirements:
  - Display
  - Storage
- Exposure to water and humidity should be avoided.