# Rehydration of Aged Latent Fingerprints on Non-Porous Surfaces

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## Introduction

Evidence found at a crime scene can be instrumental in determining the guilt or innocence of an individual. In regards to fingerprints, there are few forensic methods that are as individualizing, with DNA being the notable exception. Because of this, it is imperative that forensic scientists are able to analyze any and all latent fingerprints found at a crime scene. Latent fingerprints are invisible to the naked eye and require additional methods to visualize. The development method used is dependent on a variety of factors including the type and texture of the substrate on which the print is deposited, the time since deposition occurred, and environmental conditions [1]. However, the effectiveness of these development methods changes as more time passes since deposition. Fingerprints begin to dry out almost immediately after deposition [2], which alters the composition of the print. Unfortunately, as the composition of the print changes, so do the abilities of the reagents that help develop the print. Additionally, as more time passes, fingerprints become more degraded and the development methods even less effective [3].

Luckily, development methods such as ninhydrin and physical developer have been shown to be effective methods for developing aged latent fingerprints [1]. Unfortunately, however, these development methods only work on porous surfaces. Currently, there is no widely-recognized technique to develop latent fingerprints on non-porous surfaces. This is detrimental because not all latent prints at a crime scene are deposited on porous surfaces, in fact the majority are on non-porous surfaces, and therefore latent prints on recovered evidence can be lost due to delays in reporting of an incident/locating the scene, delays in submission of evidence by investigators, or extended backlogs in crime labs.

Recently, personal communications between experts within the field of forensic science suggested the use of a humidifier to rehydrate aged latent fingerprints on non-porous surfaces. If rehydration is successful, the fingerprint could then hypothetically be subjected to commonly known methods of development such as fingerprint powder or cyanoacrylate fuming. The purpose of this project is to explore the effectiveness of and derive a method for the rehydration and development of high quality latent fingerprints located on various non-porous surfaces. Research into this theory helps fill the gap of knowledge that exist in the forensic science community and ensure that all evidence found at a crime scene can be utilized even if delays in recognition exist.

## Reproducibility Study

Prior to the initiation of data collection, a reproducibility study was ran to assess the consistency of ridge width measurements and to ensure that there were no statistically significant differences in the ridge widths measured between trials. Four fingerprints were analyzed and 50-65 ridges were measured per print. The measurement process for the same ridges was repeated twice more on separate occasions so that each ridge had been measured three separate times. An ANOVA test was then utilized to compare the three trials and determine the reproducibility of the results (**Fig. 1**).

**ANOVA: Print 1**

| *Source of Variation* | *SS* | *df* | *MS* | *P-Value* |
|---|---|---|---|---|
| Between Groups | 0.151 | 2 | 0.075 | 0.334 |
| Within Groups | 10.044 | 147 | 0.068 | |
| Total | 10.196 | 149 | | |

**ANOVA: Print 2**

| *Source of Variation* | *SS* | *df* | *MS* | *P-Value* |
|---|---|---|---|---|
| Between Groups | 0.00124 | 2 | 0.00062 | 0.998 |
| Within Groups | 63.022 | 177 | 0.356 | |
| Total | 63.023 | 179 | | |

**ANOVA: Print 3**

| *Source of Variation* | *SS* | *df* | *MS* | *P-Value* |
|---|---|---|---|---|
| Between Groups | 0.014 | 2 | 0.0068 | 0.939 |
| Within Groups | 18.983 | 177 | 0.107 | |
| Total | 18.997 | 179 | | |

**ANOVA: Print 4**

| *Source of Variation* | *SS* | *df* | *MS* | *P-Value* |
|---|---|---|---|---|
| Between Groups | 0.017 | 2 | 0.00864 | 0.910 |
| Within Groups | 17.634 | 192 | 0.0918 | |
| Total | 17.651 | 194 | | |

**Figure 1.** ANOVA results for four different fingerprints. P-values are highlighted for convenience.

- For every fingerprint, $p > 0.05$. This means that any differences in the measured ridge widths between trials were not statistically significant and rather due to random chance
- Reproducibility study was a success

## Methodology

### Evaporation

- Evaporation Tests (**Fig. 2**)
  - Calculate average ridge widths after various evaporation time periods to determine peak evaporation (percent reduction)
  - 0-180 minute periods for prints on the substrates (**Fig. 2**)
  - Percent reduction was maximized at 60 minutes on the glass substrate and 120 minutes on the plastic substrate (**Fig. 3**)
- Substrate cleaned with ethanol prior to fingerprint deposition
- Average of five replicate fingerprints deposited per experimental condition/rehydration interval
- Fingerprints age/evaporate for calculated time (**Fig. 3**) at 50-55% ambient relative humidity (RH)

### Rehydration

- Substrates with the aged fingerprints were placed in sealed chamber at 80-85% RH

### Analysis

- Rehydrated fingerprints were analyzed using Adobe Photoshop to measure chosen ridge widths of the print (**Fig. 5**)
- 4-8 ridges were measured per print (20-40 ridges per experimental condition)
- Ridge widths were averaged for each experimental condition
- Deposition and rehydration average ridge widths were compared to determine the percent recovery of the print
- Goal: 100% recovery/rehydration
  - Optimal for maintaining 3rd level detail
    - Greater than 100% can result in wider ridges
    - Less than 100% can result in narrower ridges
    - Either condition would invalidate 3rd level detail comparison

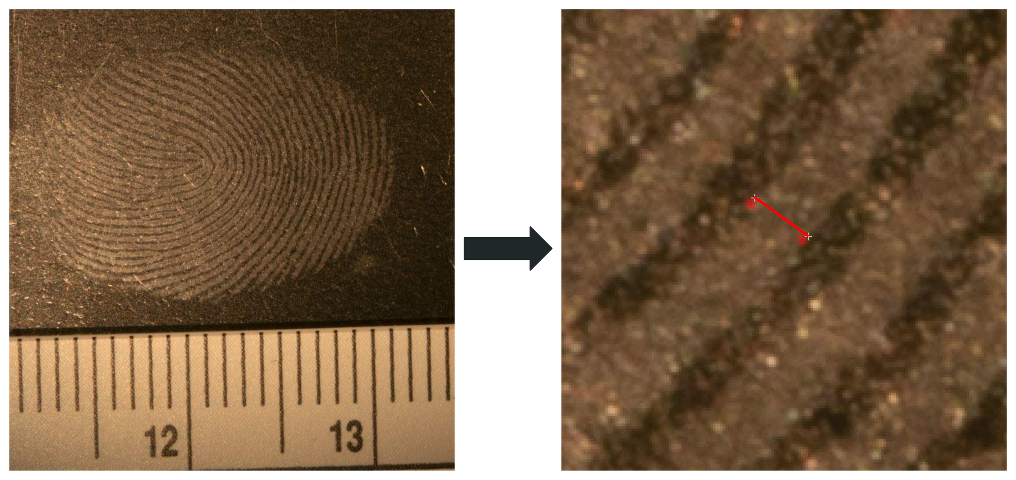



**Figure 5.** Photographs illustrating the process of ridge width measurement. The left photo shows the entire fingerprint. The right photo is magnified at 300x and shows the ruler (thin white line) that measures from one side of the ridge to the other. Red dots were used to ensure the same ridge location was measured on both the deposition and rehydration fingerprints.

### Print Imaging

- Images of the fingerprints were taken after:
  - Deposition → to obtain base ridge widths
  - Rehydration → for comparison with the initial image to derive the percent recovery (**Fig. 6**)
- Fingerprints on the plastic substrate were imaged differently due to difficulties obtaining a high-quality image of an undeveloped print on plastic
  - Prints were separated into two sets (deposited sequentially)
  - First set: develop immediately after deposition with powder and image
  - Second set: evaporate, rehydrate, develop with powder, and image

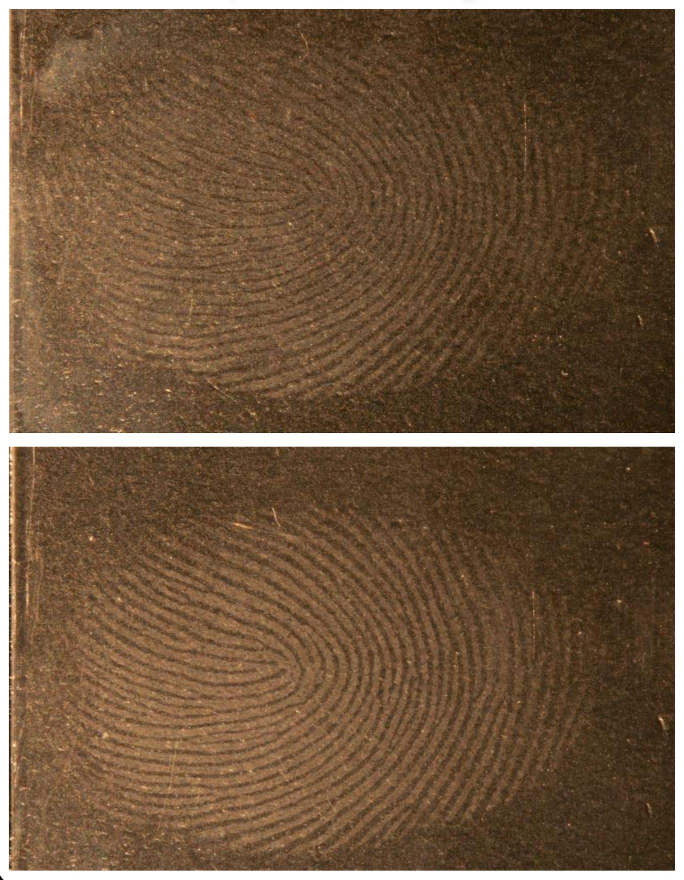
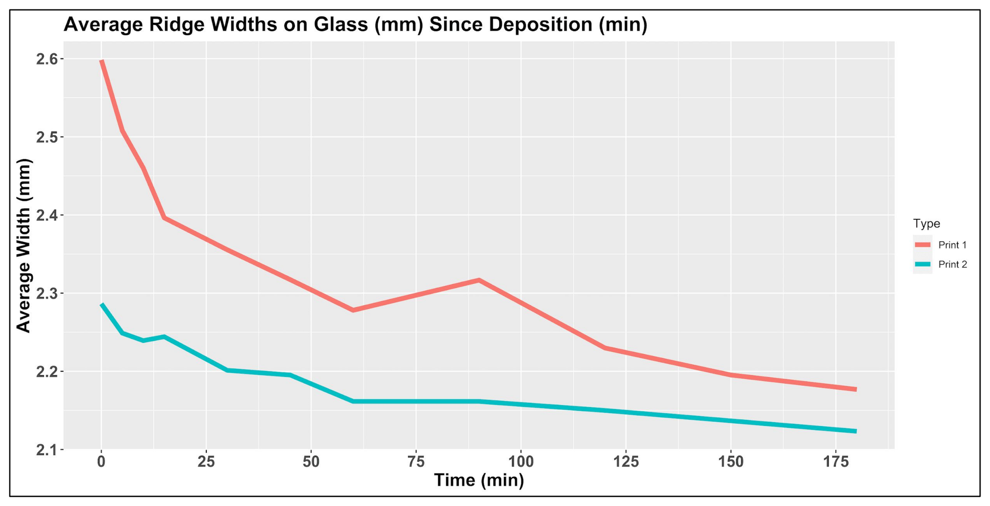


**Figure 6.** Example comparison between deposition (top) and rehydration (bottom) of a fingerprint.

## Results

### Evaporation Tests



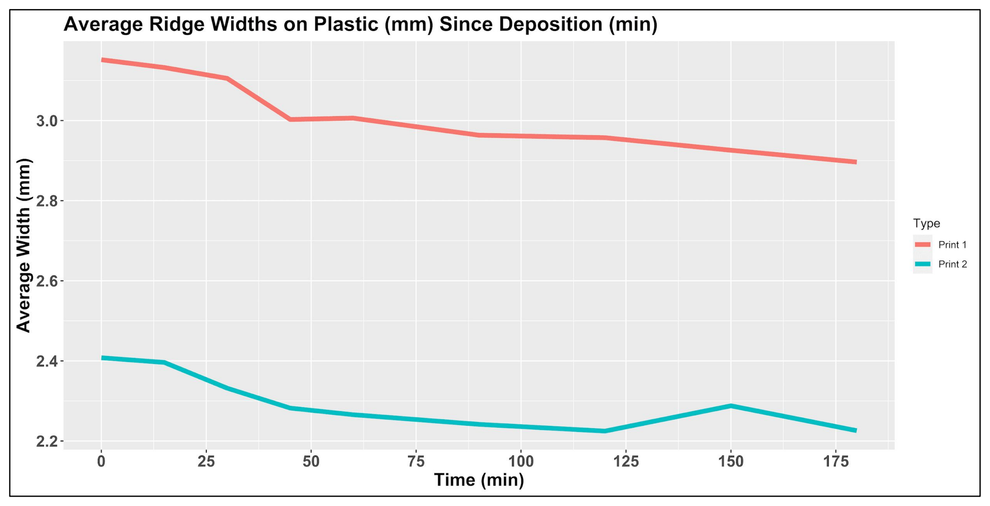




**Figure 2.** Average ridge widths (mm) of five ridges per fingerprint at variable evaporation time periods (min) on both glass (top) and plastic (bottom) substrates.

| Glass | | Plastic | |
|---|---|---|---|
| Time (min) | % Reduction | Time (min) | % Reduction |
| 60 | 7.64% | 60 | 5.27% |
| 90 | 6.15% | 90 | 6.44% |
| 120 | 7.40% | 120 | 6.89% |

**Figure 3.** Percent reduction of the fingerprint at time intervals between 60-120 minutes on both glass and plastic substrates.

### Rehydration Tests

**Rehydration of Glass**

| Rehydration Time (min) | n | Average Difference from 100% Recovery (%) |
|---|---|---|
| 15 | 2 | 0.890 |
| 20 | 2 | 1.500 |
| 25 | 12 | 1.208 |
| 26 | 6 | 2.057 |
| 2 | 4 | 1.600 |
| 28 | 2 | 1.310 |
| 29 | 2 | 1.220 |
| 30 | 18 | 1.002 |
| 31 | 2 | 2.960 |
| 35 | 4 | 1.095 |
| 40 | 2 | 2.500 |
| 45 | 2 | 8.450 |
| 50 | 2 | 2.110 |
| 60 | 2 | 1.330 |

**Rehydration of Plastic**

| Rehydration Time (min) | n | Average Difference from 100% Recovery (%) |
|---|---|---|
| 10 | 2 | 5.230 |
| 14 | 6 | 1.933 |
| 15 | 6 | 0.778 |
| 16 | 6 | 2.740 |
| 17 | 6 | 2.903 |
| 18 | 2 | 12.800 |
| 19 | 2 | 8.170 |
| 20 | 2 | 12.360 |
| 30 | 2 | 6.100 |
| 45 | 2 | 6.350 |

**Figure 4.** Average difference between the experimental percent recovery of a fingerprint after various rehydration time periods and 100% recovery on the glass substrate (top) and the plastic substrate (bottom). The number of replicate fingerprints per rehydration period has been included in the table to assist with contextualizing the average difference. Rehydration time periods with only 2 replicates yielded large differences between percent reduction and percent recovery and therefore subsequent replicates under those experimental conditions were deemed unnecessary. Highlighted values indicate the experimentally determined rehydration interval that yields the smallest difference between the experimental percent recovery of the fingerprint and 100% recovery

## Conclusions

- Aged latent fingerprints on non-porous surfaces can successfully be rehydrated using a humidifier
- Rehydration of latent fingerprints on the glass substrate (**Fig. 4, top**)
  - 30 minutes was experimentally determined to be the rehydration interval that yielded the smallest difference between experimental percent recovery and 100% recovery
    - 1.002% difference
  - Though the average difference at 15 minutes was smaller, there were significantly fewer replicates and therefore the average difference is skewed
  - More research should be completed to increase the number of replicates at various intervals, such as 25 and 35 minutes to further test this conclusion
- Rehydration of latent fingerprints on the plastic substrate (**Fig. 4, bottom**)
  - 15 minutes was experimentally determined to be the rehydration interval that yielded the smallest difference between experimental percent recovery and 100% recovery
    - 0.778% difference
  - Important Note: the fingerprints that were analyzed to determine this value were aged/evaporated for 60 minutes rather than the 120 minutes suggested by the evaporation test (**Fig. 3, right**). This was done for consistency in the lab due to time constraints. Continued research into the rehydration process with see fingerprints on plastic substrates being aged for the full 120 minutes

## Deliverables

- Documentation for the novel method of fingerprint development for aged fingerprints on non-porous surfaces
- Statistical analysis of all data
- Recommendations for the implementation of the developed methodology within forensic crime labs
- Preliminary evaporation study

## Future Directions

- Continued research into fingerprints on glass and plastic substrates
  - Glass: Increase replicates at rehydration intervals other than 30 minutes to test the current conclusion
  - Plastic: Compare if/how a 60 minute difference in aging (from 60 to 120 minutes) affects the rehydration interval
- Longitudinal study to assess the widespread application of this technique to latent fingerprints that have been aged for longer periods of time or in different environmental circumstances
- Model biological matrix interactions of fingerprints on metal surfaces, such as aluminum
  - Amino acid/alloy interactions result in oxidation which creates significant background noise in the print [4]
    - Leads to challenges in fingerprint analysis
  - Fingerprints can be removed from alloys when the humidity increases [5]
  - Is the rehydration process a viable, non-destructive method of recovering fingerprints on alloys?
- Development of rehydrated latent fingerprints
  - Assess viability of rehydrated fingerprints using the Fingerprint Quality Assessment Scale outlined in [3]

## References

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