The Simultaneous Development of Latent Prints on the Adhesive and Non-Adhesive Sides of Tape Using a Rhodamine 6G in Tween 20 Solution after Cyanoacrylate Fuming

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Abstract

Latent prints on the adhesive and non-adhesive sides of tape must be processed separately, which requires more time, steps, and materials. This study proposes a way to process latent prints on both sides of tape simultaneously. Latent prints on various types of tape were fumed with cyanoacrylate and dipped in an optimized solution of rhodamine 6G, Tween 20, and water. The prints were visualized using a green (500-525 nm) light with a 1% orange-red (549 nm) long pass filter. Prints were compared to standard methods of processing, and result in clear, identifiable prints yet requires less time and materials.

Introduction

Forensic laboratories process a variety of adhesive tapes for latent print evidence because they are commonly used in the binding of victims and the preparation of drug packaging [1]. Electrical tape, in particular, is used in the wiring of improvised explosive devices and as reinforcement for the stocks of sawed-off shotguns [2]. Even when the tape is touched with latex gloves, fingerprint evidence can still be recovered [1]. However, common powder methods are useless on adhesive surfaces. The powder sticks to the entire surface of the tape, giving no contrast between the print and the tape background [3]. The adhesive side of tape can be developed with techniques such as the sublimation of disperse dyes, Gentian Violet, TapeGlo, Sticky-Side Powder, Wetwop, and similar powder deposition methods [1, 3, 4-9]. However, some of these methods offer poor results when used to process dark tapes because of poor contrast between the processed print and tape background [6]. This resulted in the use of white powder and titanium dioxide in detergent and water mixtures which created a more visible contrast [6-8]. The non-adhesive side of tape is a standard non-porous surface with plenty of effective and thoroughly tested development methods [3]. For example, the tape can be fumed in cyanoacrylate, then dipped in a cyanoacrylate dye, followed by an application of latent print powder [10]. These methods, however, still require for both sides of the tape to be processed separately, and these processes often interfere with one another [10]. They also require more time, more steps, and more materials for the examiner. Schiemer investigated several methods of processing latent prints on black electrical tape using different suspensions of white powders and cyanoacrylate dyes in detergents like Liqui-Nox, Kodak Photo-Flo, and Citron [7]. Similar studies were performed by Wade and Williams using solutions of titanium dioxide in detergent Kodak Photo-Flo [7-8]. These methods developed clearly visible, fully identifiable prints on both adhesive and non-adhesive sides of electrical tape and duct tape. However, the solutions used were mixtures of different detergents, powders, and dyes. This study proposes a simpler, more universal method that can be used on different types of tapes, and is still easy and fast to perform.

Materials and Methods

All tapes were photographed using a digital SLR camera. Additionally, tapes processed with TapeGlo or rhodamine 6G were illuminated with a green (500-525 nm) alternative light source and photographed through a 1% orange-red (549 nm) long pass filter lens. Strips of original strength Duck Brand Duct Tape (ShurTech Brands, Avon, Ohio) were cut to approximately 15 cm in length. The pads of both thumbs, index, middle, and ring fingers were rubbed against the nose and forehead to maximize eccrine and sebaceous material, and fingerprints were deposited on both adhesive and non-adhesive sides of the duct tape. First, tapes were processed using several well-established techniques and rated for comparison. For the adhesive side, prints were processed using TapeGlo and black Wetwop. For the non-adhesive side, rhodamine 6G (0.05 g/L in water) and black powder were used. All were obtained from the Lightning Powder Company (Jacksonville, Florida) and manufacturer instructions were followed. The tapes were first fumed in Loctite "Hard Evidence" cyanoacrylate (Henkel Corporation, Westlake, Ohio) for 5 minutes. They were then dipped in solutions of varying concentrations of rhodamine 6G, de-ionized water, and Tween 20 (viscous liquid, cell culture tested, Sigma-Aldrich Corporation, St. Louis, Missouri) for 15 seconds and rinsed in cool water. The 15 seconds of submersion time was determined by making a solution of 0.02 g/L Rhodamine 6G in 10% Tween 20 and varying submersion times of different tapes. Times of 15 sec, 30 sec, 1 min, and 5 min were used. For the optimization of rhodamine 6G and Tween 20 in solution, a narrower range of concentrations was needed for more accurate testing. Thus, tapes were processed in triplicate using solutions with Tween 20 concentrations ranging from 0% to 100% (in 10% increments), in combination with rhodamine 6G concentrations ranging from 12.8 g/L to 0.0125 g/L (in serial dilutions by factors of 2). From the results of this initial testing, a narrowed range of concentrations was found, and the reliability of the method was calculated. So, tapes were developed in 9 different concentrations (10, 20, and 30% Tween 20, in combination with 0.2, 0.1, and 0.05 g/L of Rhodamine 6G) with 9 tapes per concentration, for a total of 81 tapes with 8 prints each. However, for each concentration, the 9 tapes weren't all developed in a single solution. 3 tapes each were developed in three different solutions with the same concentration. The different solutions ensured that the method was reliable across different days. Once the rhodamine 6G and Tween 20 concentrations were optimized, the same processing procedure that was applied to the duct tape was used on different types of tape. These were Temflex General Use Vinyl Electrical Tape 1700, Scotch Magic Tape 810 (both from 3M, St. Paul, Minnesota), and Duck Brand Standard Packaging Tape (ShurTech Brands, Avon, Ohio). These were chosen because they were the most readily available brands of tapes commonly encountered in crime laboratories. Print quality for all processed tapes was compared to a 3-point Likert scale:

3- Print of comparative value. Third level detail present.

2- Print could be useful with further enhancement. Second level detail present.

1- Print of no comparative value. First level detail present.

For comparison between processing techniques, the average quality and standard deviation were calculated. For goodness of fit of the proposed models, Pearson's Chi-Square distribution and probabilities were calculated.

Results

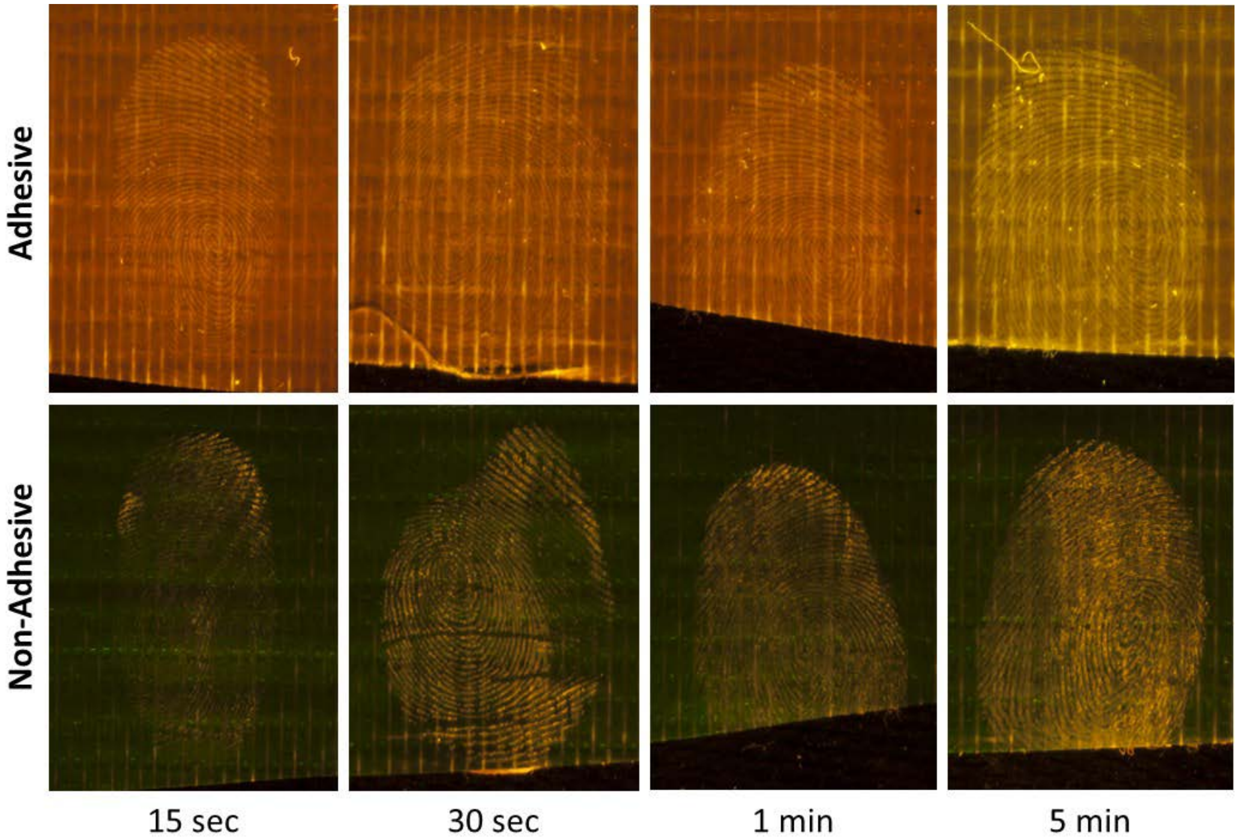


Figure 1- Prints from different pieces of duct tape processed in a 10% Tween 20/0.02 g/L rhodamine 6G solution for different times. Prints did not show any improvement in quality when submerged for longer times. Instead, for the adhesive side of the tape, the 5 minute submersion resulted in a bright, grid-like pattern which was brighter than the print itself. The solution soaked into the woven fibers of the tape, obscuring the print. For the optimization of the Tween 20 and rhodamine 6G concentrations, a 15 second submersion time was used.

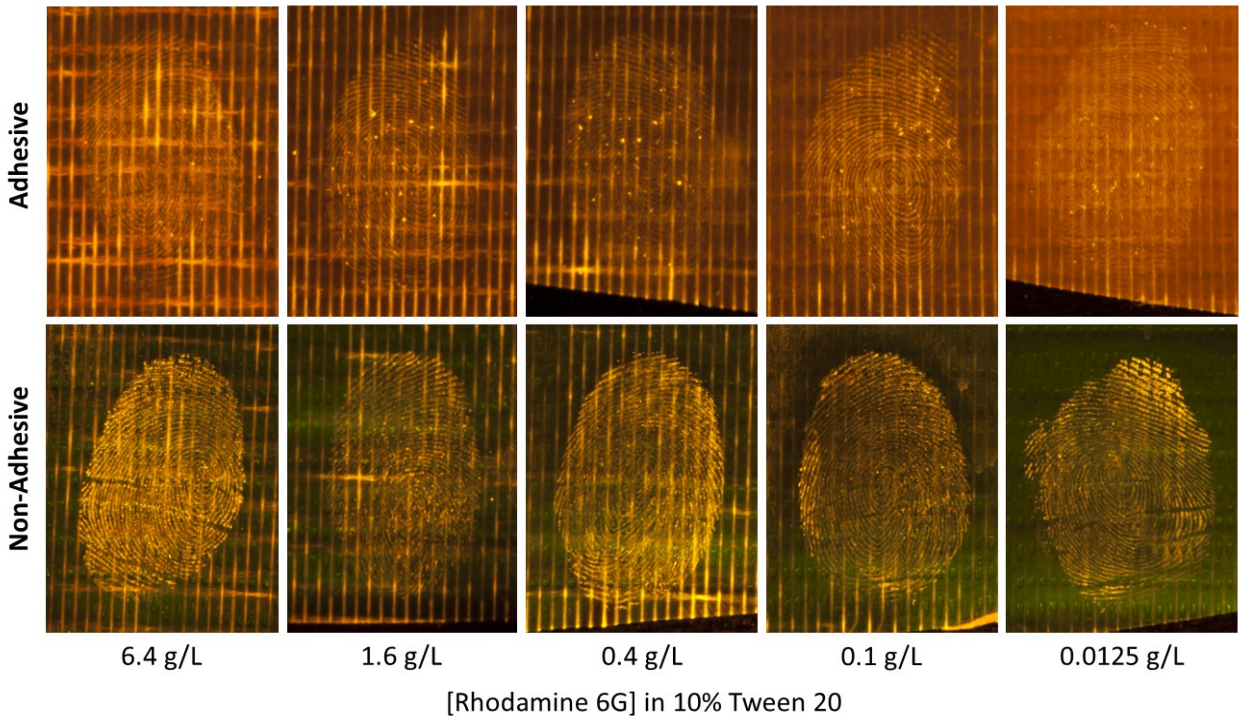


Figure 2- To narrow down a range of concentrations used for optimization, pieces of duct tape were processed in solutions of 10% Tween 20 and rhodamine 6G concentrations ranging from 12.8 g/L to 0.0125 g/L (in serial dilutions by factor 2). Concentrations higher than 0.2 g/L resulted in a bright, grid-like pattern which was brighter than the print itself. The solution soaked into the woven fibers of the tape, obscuring the print on both adhesive and non-adhesive sides of the tape. However, for concentrations lower than 0.05 g/L, the print was not bright enough to distinguish from the background. While no grid pattern appeared on the tape, there was little contrast between the print and the tape. For further optimization, rhodamine 6G concentrations of 0.2, 0.1, and 0.05 g/L were used.

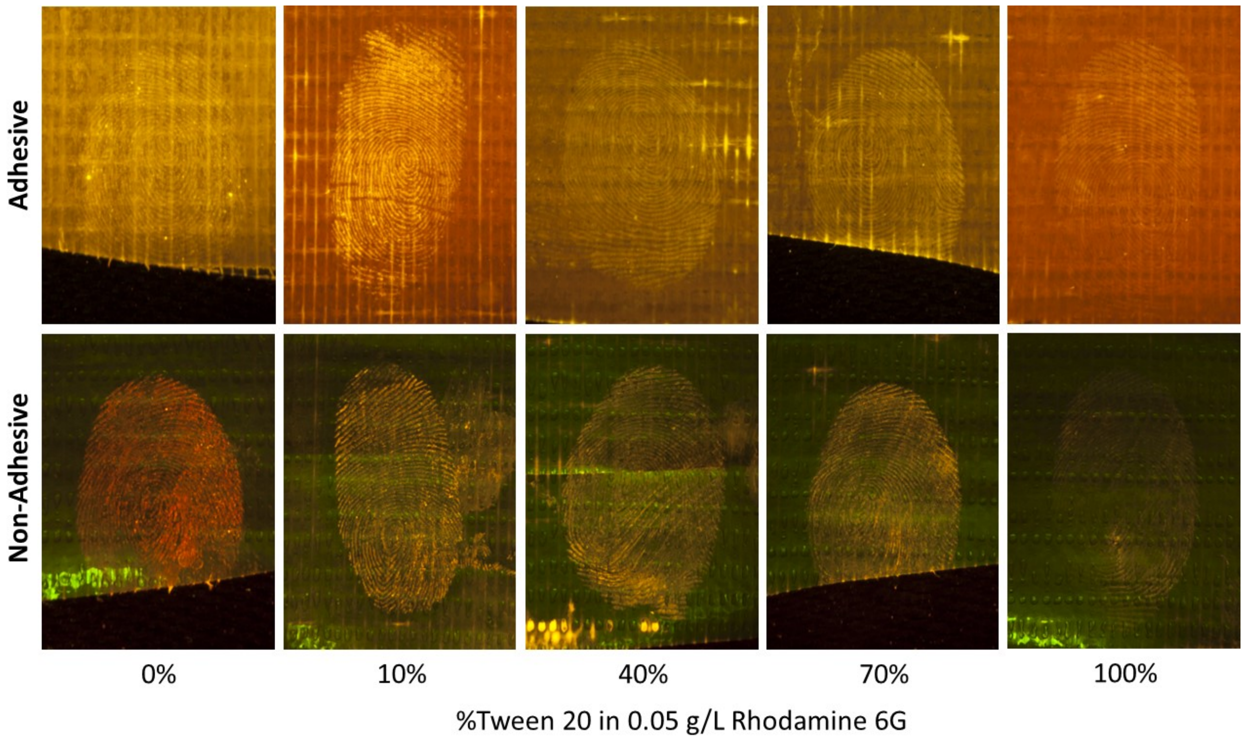
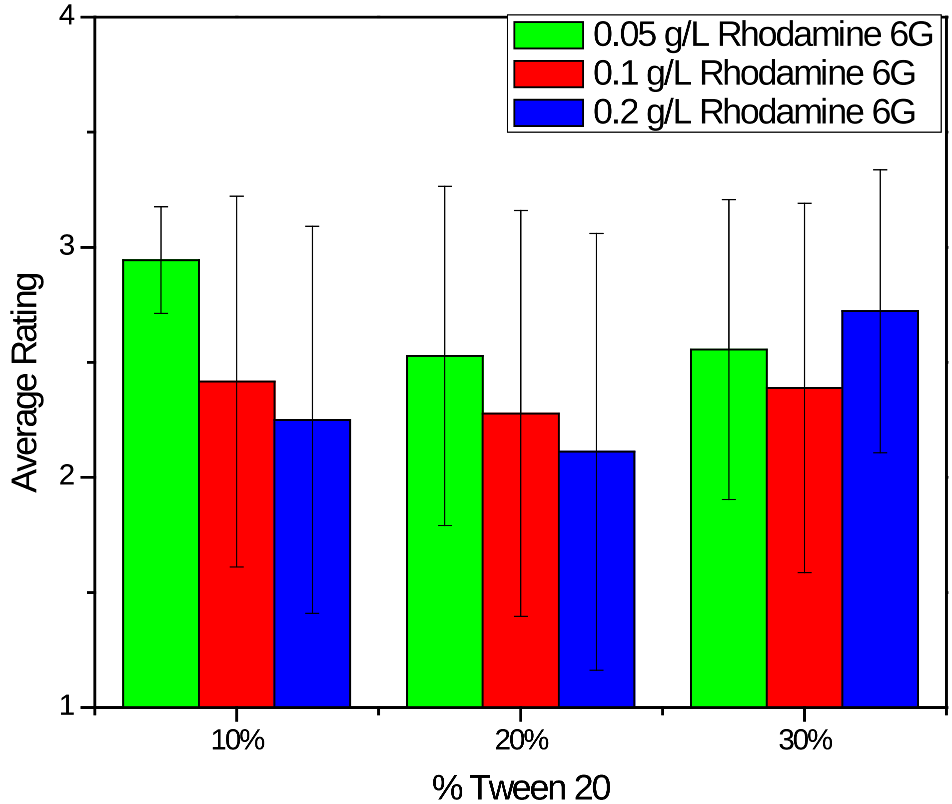
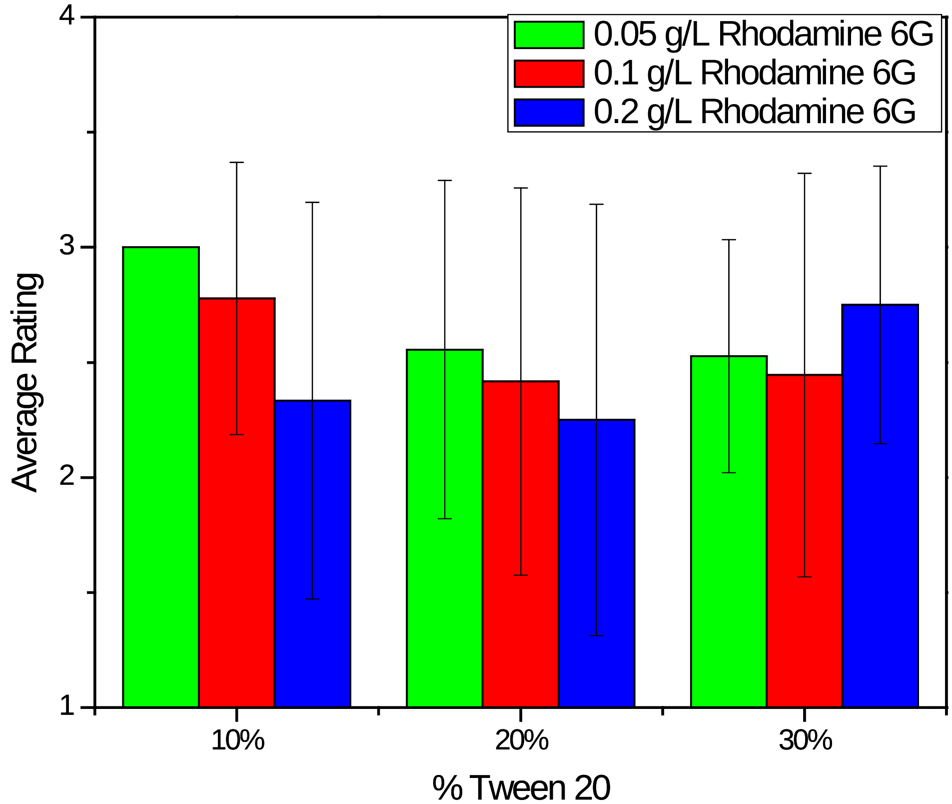


Figure 3- To narrow down a range of concentrations used for optimization, pieces of duct tape were processed in solutions of 0.05 g/L rhodamine 6G and Tween 20 concentrations ranging from 0% to 100% (in 10% increments). Print quality reached a maximum at a concentration of 10% for both adhesive and non-adhesive sides of the tape. Higher concentrations of Tween 20 inhibit the rhodamine 6G from reaching the prints, creating very little contrast between the print and the tape background. For further optimization, Tween 20 concentrations of 10, 20, and 30% were used.



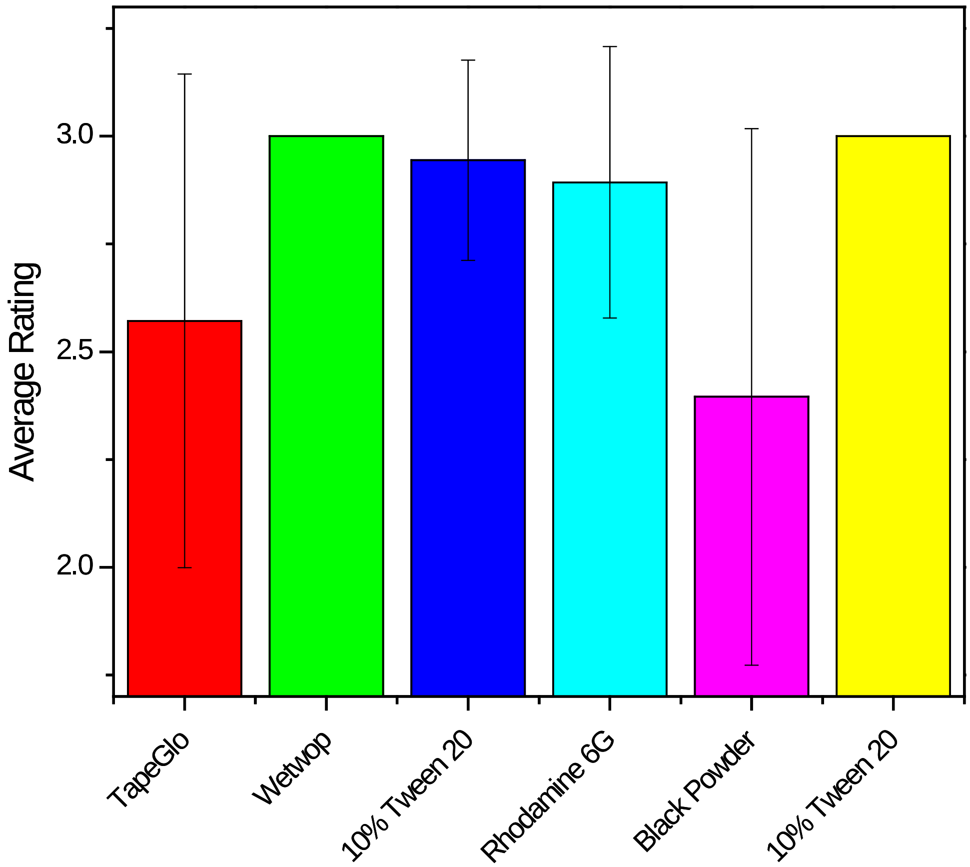
		[Tween 20]		
		10%	20%	30%
[Rhodamine 6G]	0.2 g/L	2.3 ± 0.84	2.1 ± 0.95	2.7 ± 0.61
	0.1 g/L	2.4 ± 0.81	2.3 ± 0.88	2.4 ± 0.80
	0.05 g/L	2.9 ± 0.23	2.6 ± 0.74	2.6 ± 0.65

Figure 4- Ratings for Tween 20 and rhodamine 6G concentration optimization for the processing of latent prints on the adhesive side of duct tape. Concentrations tested were 10, 20, and 30% Tween 20 in combination with 0.2, 0.1, and 0.05 g/L rhodamine 6G. The 10% Tween 20 and 0.05 g/L rhodamine 6G solution resulted in the most highly rated, and consistent prints, with a 2.9 ± 0.23 rating.



		[Tween 20]		
		10%	20%	30%
[Rhodamine 6G]	0.2 g/L	2.3 ± 0.86	2.3 ± 0.94	2.8 ± 0.60
	0.1 g/L	2.8 ± 0.59	2.4 ± 0.84	2.4 ± 0.88
	0.05 g/L	3.0 ± 0.0	2.6 ± 0.73	2.5 ± 0.51

Figure 5- Ratings for Tween 20 and rhodamine 6G concentration optimization for the processing of latent prints on the non-adhesive side of duct tape. Concentrations tested were 10, 20, and 30% Tween 20 in combination with 0.2, 0.1, and 0.05 g/L rhodamine 6G. The 10% Tween 20 and 0.05 g/L rhodamine 6G solution resulted in the most highly rated, and consistent prints, with a 3.0 ± 0.0 rating.



Adhesive

	Average
TapeGlo	2.6 ± 0.57
Wetwop	3.0 ± 0.0
Tween 20	2.9 ± 0.23

Non-Adhesive

	Average
Rhodamine 6G	2.9 ± 0.31
Black Powder	2.4 ± 0.62
Tween 20	3.0 ± 0.0

Figure 6- Ratings for common methods tested and 10% Tween 20/0.05 g/L Rhodamine 6G solution for the processing of latent prints on both the adhesive and non-adhesive sides of duct tape. For the adhesive side, Wetwop resulted in prints with a 3.0 ± 0.0 rating, compared to Tween 20's 2.9 ± 0.23 rating. For the non-adhesive side, Tween 20 resulted in the most highly rated and consistent prints, with a 3.0 ± 0.0 rating.

Table 1- Results of Pearson's χ^2 "Goodness-of-Fit" Tests for 10 % Tween 20/0.05 g/L rhodamine 6G solution and common methods tested.

Adhesive	χ^2	$\%H_0$
Tween20	61	6.7×10^{-12} %
TapeGlo	14	1.0×10^{-1} %
Wetwop	56	6.9×10^{-11} %

Non-Adhesive	χ^2	$\%H_0$
Tween 20	72	2.3×10^{-14} %
Rhodamine 6G	40	2.1×10^{-7} %
Black Powder	13	1.2×10^{-1} %

Discussion

Tapes submerged in the Tween 20 solution did not show any improvement in print quality when submerged for longer times (Figure 1). The 30 second and 1 minute submersions all showed the same quality as the 15 second submersion. The 5 minute submersion, while brighter in appearance, did not improve the contrast between the print and the tape background. Instead, a bright, grid-like pattern resulting in the solution soaking into the fibers of the tape appears, obscuring the print. For all subsequent tests, an immersion time of 15 seconds is used, as it maximizes print quality without resulting in the bright grid pattern. To narrow down the concentrations of rhodamine 6g and Tween 20 to be tested, tapes were processed in solutions of 0% to 100% Tween 20 in combination with rhodamine 6G concentrations of 12.8 g/L to 0.0125 g/L. Concentrations of rhodamine 6G higher than 0.2 g/L resulted in a very pronounced grid pattern on the tapes, in some cases completely obscuring the print (Figure 2). While the print itself was bright and noticeable, the grid and bright background created little contrast between print and tape. The rhodamine 6G seems to seep into the fibers of the tape and form a criss-cross pattern than is often brighter than the prints themselves. This effect was present on both the adhesive and non-adhesive sides of the tape. However, for any concentration lower than 0.05 g/L the print was not bright enough to distinguish from the background. While no grid pattern appeared on the tape, there was little contrast between the print itself and its background. Concentrations of Tween 20 higher or lower than 10% resulted poor contrast between the print and the tape background (Figure 3). Higher concentrations of Tween 20 seem to inhibit the rhodamine 6G from reaching the prints, making the visibility of the prints is so low that it cannot be distinguished from the background of the tape. Contrast between print and tape background reached a maximum at a Tween 20 concentration of 10%. This effect was present on both the adhesive and non-adhesive sides of the tape. Thus, a narrowed concentration range of 10%, 20%, and 30% Tween 20 in combination with 0.05 g/L, 0.1 g/L, and 0.2 g/L rhodamine 6G were tested. From the narrowed range of concentrations, solutions of 10% Tween 20 with 0.05 g/L rhodamine 6G resulted in the highest rated, most consistent prints for both the adhesive and non-adhesive sides of the tape (Figures 4-5). Prints had an average rating of 2.9 ± 0.23 for the adhesive side, and 3.0 ± 0.0 for the non-adhesive side. Of the standard methods tested for the non-adhesive side of tape, rhodamine 6G resulted in a 2.9 ± 0.31 rating and black powder resulted in a 2.4 ± 0.62 rating (Figures 6-7). For the adhesive side of tape, TapeGlo resulted in prints with a 2.6 ± 0.57 rating, and Wetwop resulted in the highest rated prints, with a 3.0 ± 0.0 rating. Though prints processed with Wetwop were rated slightly higher than prints processed with Tween 20, the difference was minimal. Both resulted in consistent, comparison-quality prints, and Tween 20 rated higher for the non-adhesive side than TapeGlo and black powder. In addition, the Tween 20 method was simpler to use, faster, and eliminated the problem of adhesive side processes interfering with non-adhesive side processes, and vice versa. A Pearson's chi-square test (2 degrees of freedom, n=28) was calculated to determine the goodness-of-fit for the proposed method (Table 1). High chi-square values (χ^2) correspond to a lower null hypothesis percentage ($\%H_0$), meaning a smaller probability that the distribution of print ratings is random. For the adhesive side, the Tween 20 method received a chi-square value of 61 ($\%H_0 = 6.7 \times 10^{-12}\%$) while Wetwop received a chi-square value of 56 ($\%H_0 = 6.9 \times 10^{-11}\%$). For the non-adhesive side, the Tween 20 method received a chi-square value of 72 ($\%H_0 = 2.3 \times 10^{-14}\%$). This indicates very low probabilities, practically zero, that the ratings for these methods is randomly distributed. Once the concentrations of Tween 20 and rhodamine 6G were optimized by processing duct tape, the solution was tested on commonly encountered tapes, such as electrical tape, transparent tape, and packaging tape (Figures 8-11). This method resulted in clear, comparison quality prints on both adhesive and non-adhesive sides of the various tapes.

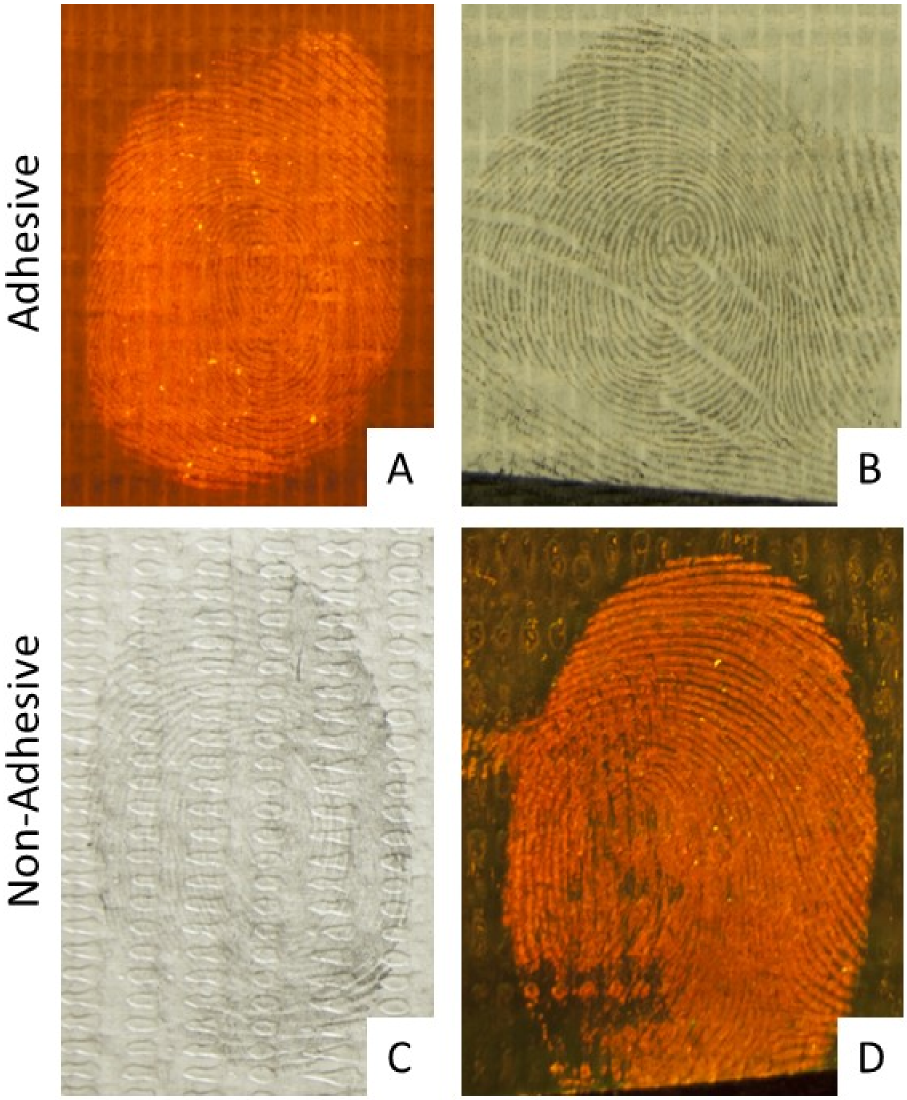


Figure 7- Duct tapes processed with A) TapeGlo, B) Wetwop, C) black powder, and D) rhodamine 6G.

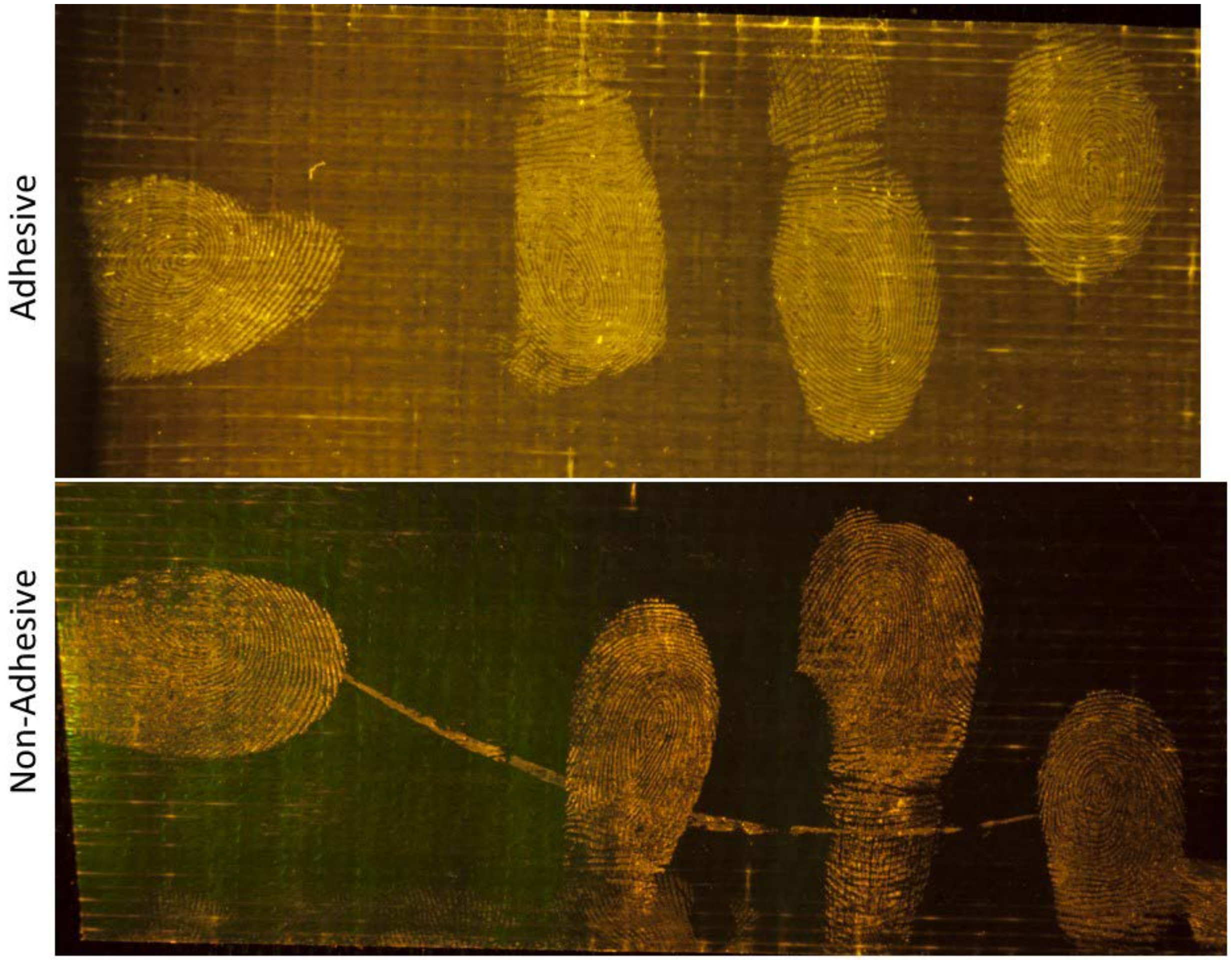


Figure 8- Duct tape processed in a solution of 0.05 g/L rhodamine 6G and 10% Tween 20.

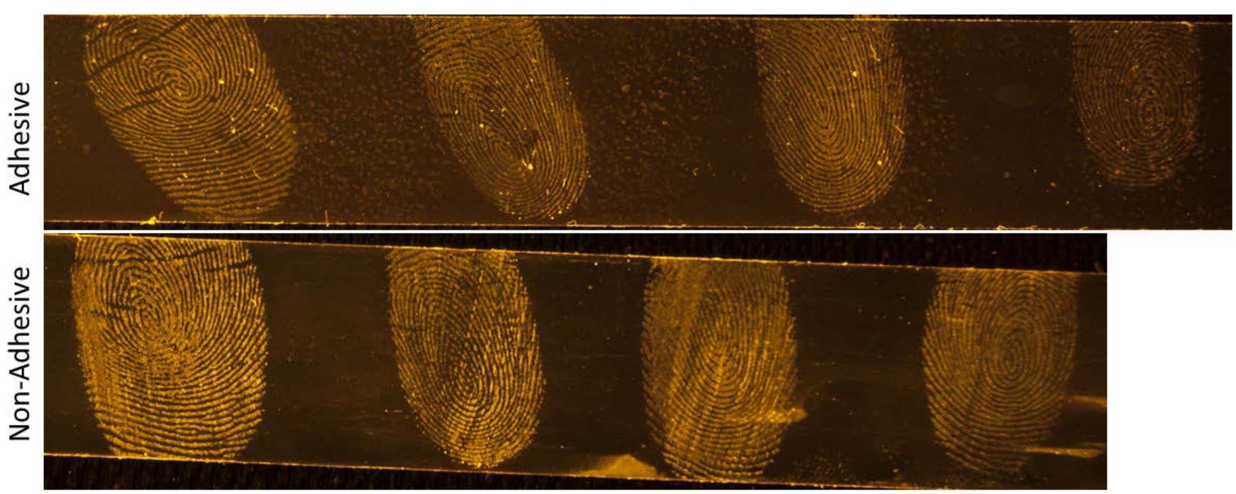


Figure 9- Electrical tape processed in a solution of 0.05 g/L rhodamine 6G and 10% Tween 20.

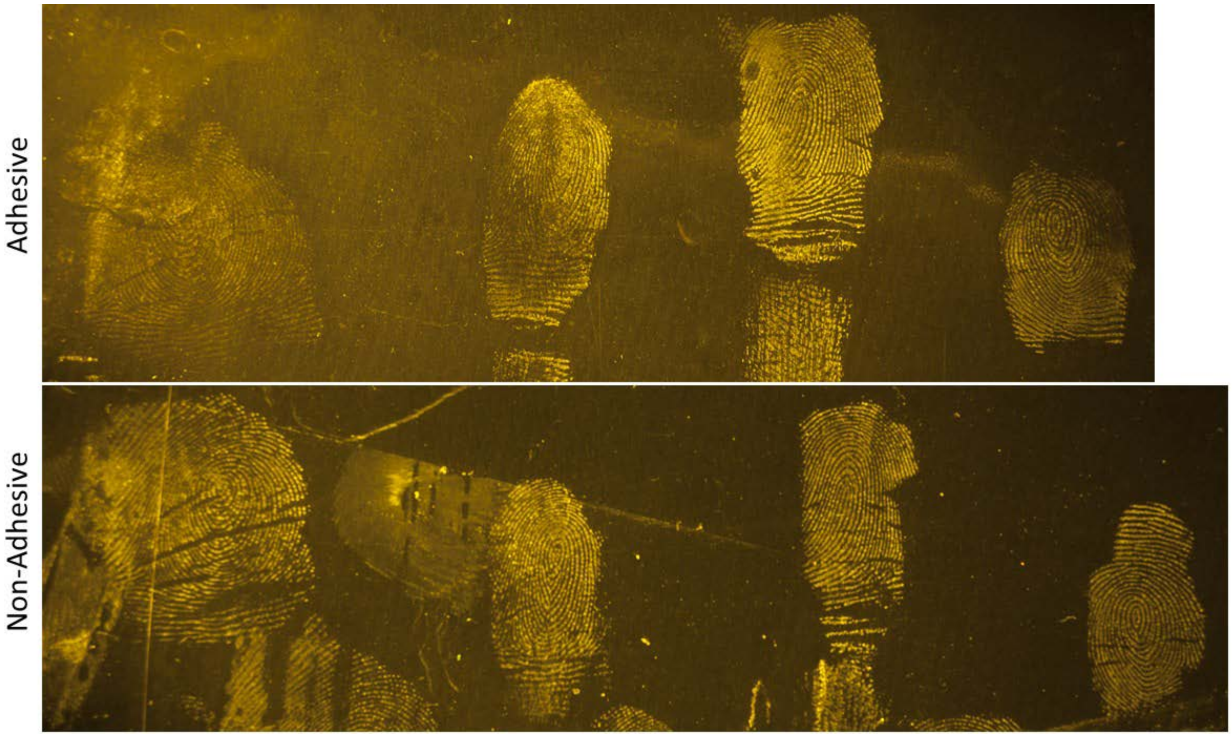


Figure 10- Packing tape processed in a solution of 0.05 g/L rhodamine 6G and 10% Tween 20.

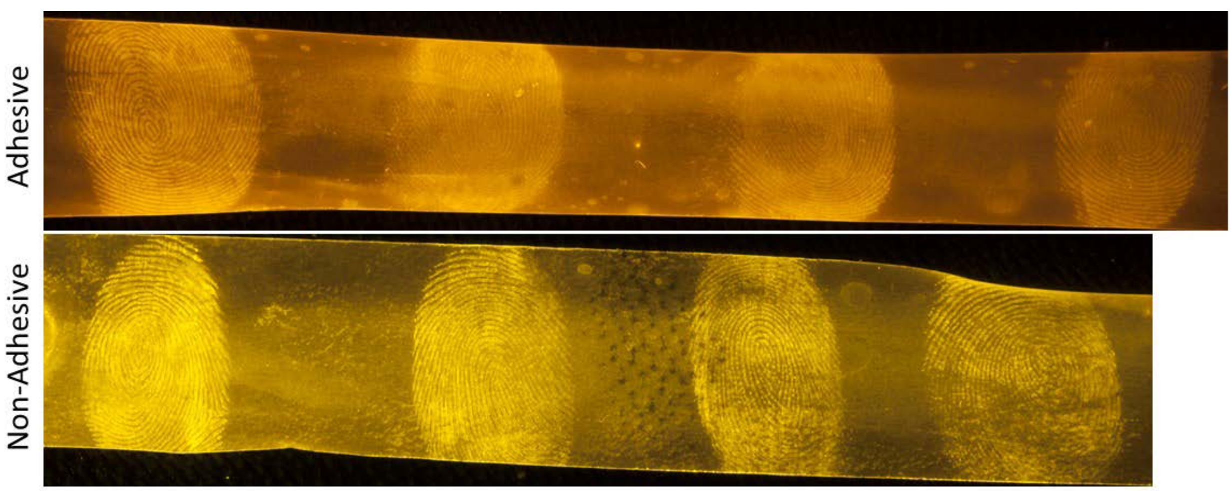


Figure 11- Clear tape processed in a solution of 0.05 g/L rhodamine 6G and 10% Tween 20.

Conclusion

The Tween 20 method tested in these studies is a viable option for the processing of latent prints of both adhesive and non-adhesive sides of tape simultaneously. It results in clear, identifiable prints and is comparable to standard methods of processing, yet requires less time, fewer steps, and fewer materials.

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