



Development of fingerprints on Latex gloves: The solution to a challenging surface

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ABSTRACT

Used Latex gloves found at crime scenes can provide strong evidence against a suspect as they almost certainly contain both the fingerprints and DNA of the perpetrator who had worn them. However, over the years, Latex gloves have proved to be a rather difficult substrate for fingerprints development, with most of the standard techniques producing poor results. In this study, the two main protocols for development on either porous or non-porous surfaces: Ninhydrin-HFE and superglue fuming followed by crystal violet (CV) dyeing, respectively, had been examined on 100 disposable Latex gloves from twenty five donors. The results distinctly showed a high superiority of Ninhydrin-HFE over the superglue fuming indicating the porous rather than the non-porous properties of the interior of the gloves. Yet, not all the usual ninhydrin development formulations yielded the desirable results, leading to the conclusion that the success of development rests on the solvent-sensitive structure of the gloves. As natural latex contains contaminant proteins, that were found to cause allergic reactions in different people, the manufacturing of disposable gloves had been altered over the years to prevent contact with these proteins by adding an intrinsic polymer-coating. Thus, it was essential to use an inert solvent system that should keep the interior polymer-coating intact, allowing a reaction only with the amino acids on the surface rather than the latex proteins in the glove. The SEM analyses showed that HFE-7100 as opposed to petroleum ether, does not harm the inner coating, hence, providing the ideal solution to this challenging surface.

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1. Introduction

Latex gloves are one of the most important exhibits that can connect a suspect to a crime scene, as they potentially contain both the fingerprints and the DNA profile of the person who had worn them. Over the years, the use of disposable Latex gloves has become quite popular among criminals, who wish to avoid leaving traces of fingerprints at crime scenes. Several approaches had been attempted in the past for developing latent fingerprints on the interior of Latex gloves. Among the different methods were: powders and powder suspensions, crystal violet, superglue fuming, SPR, MMD, and gel lifters [1]. Unfortunately, many of these standard methods yielded poor results [1–4]. Some casework studies had suggested that ninhydrin, which is usually used for porous surfaces, may also be applied for developing latent

fingerprints on Latex gloves. These studies had used a heptane-based ninhydrin solution, reporting some potential for development [5–7]. However, n-alkanes, such as pentane, hexane and heptane, are known for their ability to readily dissolve Latex rubber [8], thus, making this ninhydrin formulation impractical for operational purposes due to the potential deterioration of the gloves. Another downside for using ninhydrin or other amino acid reagents for Latex gloves is the fact that natural latex rubber contains different contaminant proteins [9,10], which can also react with ninhydrin, hence leading to a high background staining and low resolution of the developed marks. Over the past three decades, the manufacturing processes of Latex gloves have been greatly improved, due to the realization that these proteins are also the main cause of hypoallergenic reactions in different people [9–14]. In order to achieve a low level of protein content and reduce their leaching to the interior surface, several technologies are available nowadays: (1) deproteinization by either enzymatic or chemical means; (2) chlorination; and (3) polymer coating [11]. The changes in the manufacturing of the gloves inevitably led to an

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alteration of the gloves structure, so they can no longer be treated as a mere non-porous surface. This study aimed to re-examine first whether disposable Latex gloves should be considered as porous or non-porous surfaces, and second, the connection between the structure of the gloves and the solvent used with development by ninhydrin.

2. Materials and methods

2.1. Substrates

The disposable gloves used for the experiments were of “PureShield™” powder-free Latex examination gloves (natural rubber latex, non-sterile). Twenty five random donors were selected and asked to put on gloves on both hands for 10 min. The process had been repeated once more so that each donor gave two sets of gloves (in total 100 gloves). The gloves were then taken off so the intrinsic side was now exterior, while randomly separating the gloves from each donor into two groups (total of 50 gloves in each group) for the two development methods – ninhydrin-HFE and Superglue followed by CV (fluorescent dyes were not used due to high degree of background staining of the latex surface). Each group was then randomly divided into 5 sub-groups (10 gloves in each group) to be developed after different times: (1) one hour; (2) one week; (3) two weeks; (4) three weeks; and (5) one month.

Most of the solvents were purchased from Bio-lab, unless stated otherwise. HFE-7100 was purchased from 3 M, crystal violet from Nile Chemicals, Wetwop™ from Kjell Carlsson, Liquidrin – Nin Plus Ultra™ from Mistral, Superglue (ethyl cyanoacrylate) was purchased from Alteco Chemical, and ninhydrin from Sigma Aldrich.

2.2. Development by ninhydrin-HFE

The ninhydrin solution contained 5 g of ninhydrin, 2 mL ethyl acetate, 5 mL acetic acid, 45 mL ethanol, 1 L HFE 7100. Development was carried out by dipping the gloves in the solution for approximately 10 s. As our in-house standard protocol for development by ninhydrin does not involve heating in a humidified chamber, but rather, natural drying in a fume hood for the required time for each exhibit, the gloves were left to dry in a fume-hood for 1–2 h before observing the fingermarks under white light.

2.3. Development by ninhydrin-petroleum ether (Liquidrin)

An attempt for development by the second formulation of ninhydrin solution (Liquidrin – Nin Plus Ultra™) was carried out by dipping the gloves in the solution for approximately 10 s, drying in a fume-hood and followed by observation under white light.

2.4. Development by superglue and crystal violet (CV)

Development was carried out by placing the gloves in a superglue cabinet (Misonix, CA-3000) for 15 min at 80% RH. The gloves were then dipped in a CV solution (3 g of CV in 1 L of ethanol) and allowed to dry in a fume hood for 1 h. The fingermarks were observed under white light.

2.5. Development by black powder suspension (Wetwop™)

Ten gloves from 10 different donors, which had been worn for 10 min, were developed by painting the inner side of the gloves

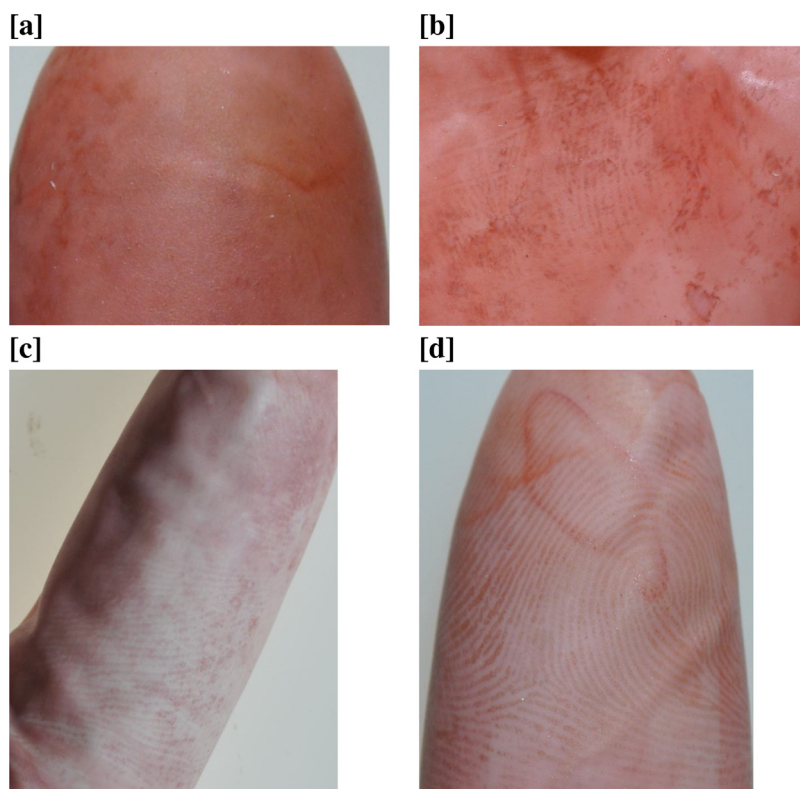


Fig. 1. An example for the assessment of the fingermarks (post development by ninhydrin-HFE): [a] grade 0 – no visible marks; [b] grade 1 – partial fingermarks unsuitable for comparison; [c] grade 2 – comparable fingermarks; [d] grade 3 – very high quality comparable fingermarks. The fingermarks were photographed using the Foster & Freeman DSC-5 system.

with black powder suspension (Wetwop™) followed by washing with tap-water. The fingermarks were observed under white light.

2.6. Fingermarks assessment

The examination of the developed fingermarks had been done by dividing each glove to six different sections – five fingers and a palm, where each section was counted as a single mark. The fingermarks quality was assessed by a fingerprint identification practitioner. The quality of the marks was determined using the following scale (an example shown in Fig. 1):

- Zero: no visible marks
- Grade 1: partial fingermarks, unsuitable for comparison
- Grade 2: comparable fingermarks
- Grade 3: very high quality comparable fingermarks

2.7. SEM analyses

The gloves samples for the SEM analyses were dipped in either HFE-7100 or petroleum ether for 10 s, and allowed to dry in a fume hood. The SEM analyses of the Latex gloves were performed using a

JEOL JSM-6480LV Scanning Electron Microscope with a Tungsten filament and an Oxford instrument detector model 7573SP.

3. Results and discussion

When dealing with challenging surfaces, it is important to determine whether they are porous or non-porous. In the first experiments we attempted to examine the results of the standard protocol for development on non-porous surfaces, superglue fuming followed by CV dyeing, compared to that for porous surfaces, ninhydrin-HFE [15]. Two sets of Latex gloves from 25 different donors, which had been worn for 10 min, were randomly separated (one from each hand) into two groups to be developed by one of the above methods after different time intervals: one hour, one week, two weeks, three weeks and one month. The gloves had then been examined by a fingerprint identification practitioner, who assessed the quality of the fingermarks according to a grading scale from 0 to 3. By assuming a total contact of the hands with the inner surface, the gloves had been divided into six sections for the assessment of the developed marks: a palm and five fingers, while each section had been counted as a single fingerprint (total of 300 potential marks for each method). The results are summarised in Table 1 and Fig. 2.

Table 1

Grading of fingermarks developed with either ninhydrin or superglue and CV over different time intervals.

Development method	Week	Number of fingermarks for each grade ^a			
		0	1	2	3
Ninhydrin HFE-7100	0	18	2	5	35
	1	6	8	3	43
	2	0	4	10	46
	3	5	4	11	40
	4	0	5	7	48
	Overall	29	23	36	212
Superglue fuming and crystal violet	0	53	6	0	1
	1	54	5	1	0
	2	47	11	2	0
	3	45	13	2	0
	4	49	8	3	0
	Overall	248	43	8	1

^a Fingermarks quality was assessed by a fingerprint identification practitioner. The quality of the marks was determined using the following scale: grade 0 – no visualization; grade 1 – partial fingermarks unsuitable for comparison; grade 2 – comparable fingermarks; grade 3 – very high quality comparable fingermarks.

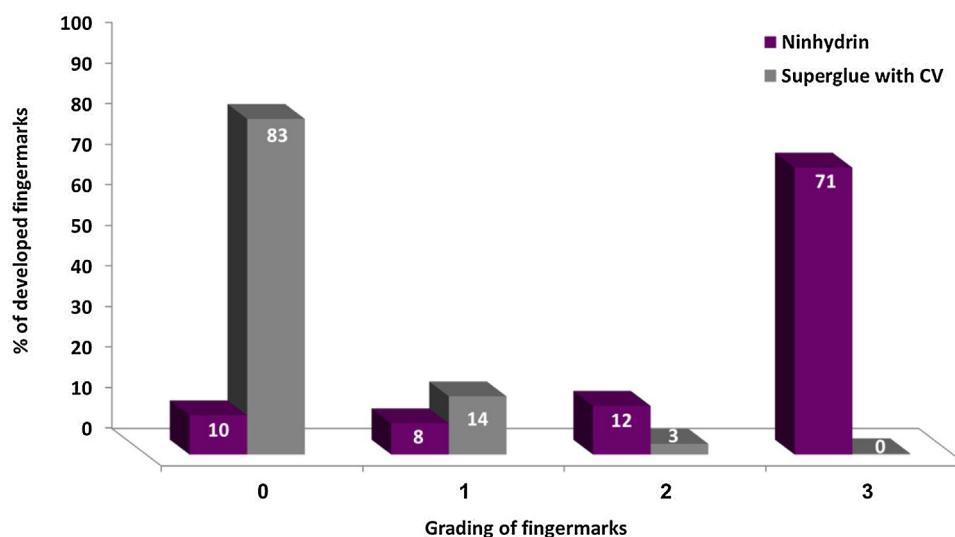


Fig. 2. The percentage of fingermarks in each grade after development by either ninhydrin or superglue and CV.

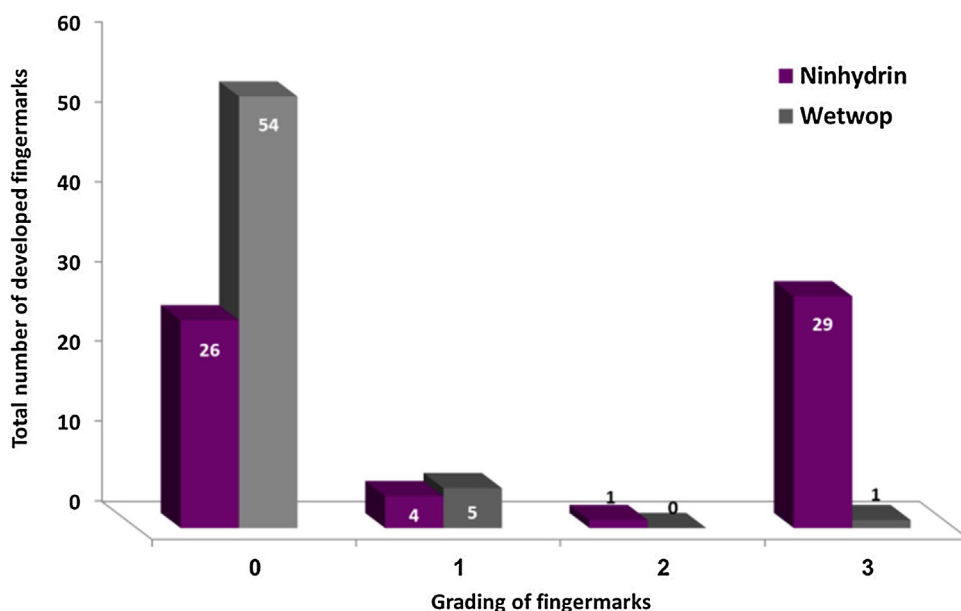


Fig. 3. The percentage of fingermarks in each grade after development by either ninhydrin or Wetwop™.

When examining the results, there is a distinct superiority to development by ninhydrin compared to the standard method of Superglue and CV, as for the first method over 80% of the developed marks were comparable (grades 2 and 3), while only 3% for the latter. In addition, the results clearly indicate that the time after deposition does not have an effect on the quantity and quality of the developed fingermarks.

At the next stage, the development procedure of ninhydrin-HFE had been compared to the method recommended for Latex gloves

by the Fingermark Visualisation Manual and the 2007 research of Pleckaitis [15,2] – black powder suspension (Wetwop™). A similar preliminary experiment had been conducted on a small-scale. The results summarized in Fig. 3 reveal that black powder suspension is far from ideal for this specific kind of surface, as only one out of 60 potential fingermarks had been successfully developed.

After understanding that ninhydrin could be a better candidate for the development of fingermarks on Latex gloves, another formulation based on petroleum ether had been tested in order to

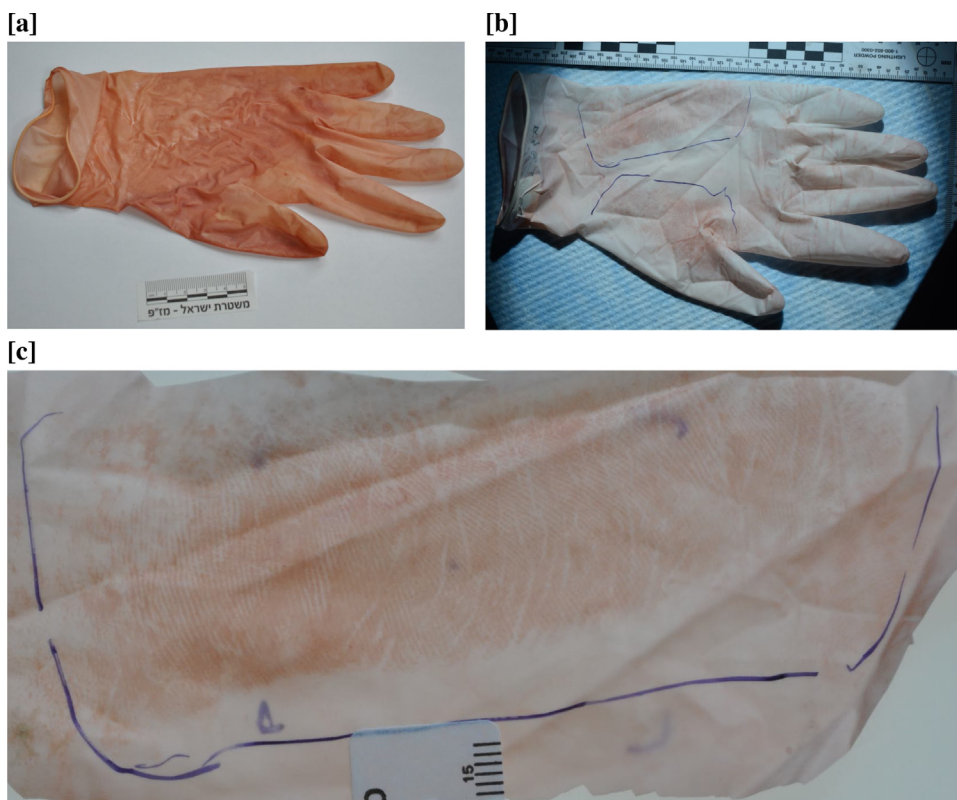


Fig. 4. Latex gloves after development by: [a] ninhydrin-petroleum ether; [b] ninhydrin-HFE; [c] enlargement of the top palm-marks of [b].

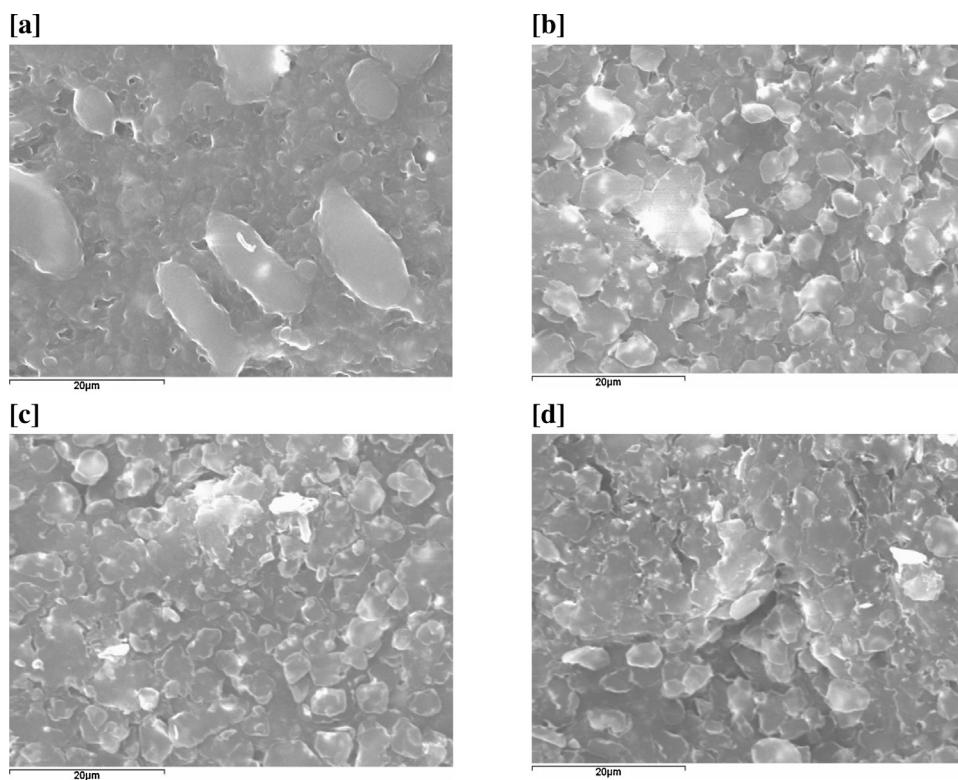


Fig. 5. SEM images of Latex gloves: [a] external layer; [b] internal layer; [c] internal layer after dipping in HFE; [d] internal layer after dipping in petroleum ether.

examine whether the development is also solvent-dependent (Fig. 4). As can be seen in Fig. 4[a], the formulation with the petroleum ether led to a complete deformation of the glove, resulting in pink staining of the entire surface. The HFE formulation, on the other hand, kept the gloves intact, while showing a high quality of development in terms of both ridge detail and contrast (Fig. 4[b] and [c]).

In order to study the effect of the solvent on the surface of the gloves, it was first important to comprehend the structure of the gloves, and how it may be affected by the solvent. Over the past thirty years, Latex gloves have been known for their allergenic potential among different people. The cause of this hypersensitivity, according to much research work in the field, appeared to be proteins, which are found in natural Latex rubber and leach out to the surface [9–14]. The transfer of the Latex proteins to the skin was greatly enhanced in the case of powdered gloves, as the powder helped in absorbing the proteins. In order to reduce this leaching effect of the proteins, the manufacturing of the gloves had been altered to produce powder-free Latex gloves. This may be done by two main processes: 1) chlorination and 2) polymer-coating of the inner side. Many powder-free disposable Latex gloves nowadays are produced by the latter process. Although this polymer coating may be an effective barrier against the leaching of the Latex protein to the surface, it may still be susceptible to deformation by certain solvents, such as Petroleum ether.

A deformation of the polymer inner coating, in the case of fingermarks development, may be a critical issue, as the ninhydrin would be able to penetrate the inner layer and react with the Latex proteins in the glove (Fig. 4[a]).

In order to examine the effect of the solvent on the surface, Latex gloves were analyzed by Scanning Electron Microscopy (SEM), before and after dipping in HFE or petroleum ether. The SEM images show a distinct difference between the outer and the inner layer of the glove (Fig. 5[a] and [b], respectively). In addition, it can

be seen that while the inner layer of the glove that had been treated with HFE remained unchanged (Fig. 5[c]), the one dipped in petroleum ether showed distinct signs of deformation (Fig. 5[d]). It is suggested that the inertness of the HFE solvent prevents the reaction and deformation of the inner polymer-coating of the glove and consequently, the penetration of ninhydrin and its reaction with the rest of the Latex proteins in the glove.

4. Conclusions

In this study, the standard protocol for non-porous surfaces, superglue fuming followed by CV dyeing, had been compared to that for porous surfaces, Ninhydrin-HFE, as the development procedure for Latex gloves. The results for ninhydrin-HFE were highly superior to that of the other method, with over 80% of the developed fingermarks assessed as suitable for comparison. In addition, the ninhydrin method had also been compared to another reported procedure, powder suspension again producing much better results. Later on, the two standard formulations of ninhydrin had also been compared in order to examine the effect of the solvent on the structure of the gloves. It was very clear that the petroleum ether formulation causes deformation to the gloves, resulting in pink staining of the entire surface, while that with HFE-7100 does not harm the surface. Our assumption that the special structure of the polymer-coated Latex gloves is affected by the solvent had been strengthened by the SEM analyses of the interior of the gloves before and after dipping in the two solvents, showing a clear deterioration of the polymer inner coating with petroleum ether. This explains the staining of surface, as the ninhydrin was able to penetrate the polymer coating and react with the proteins present in the latex. This study led to our recommendation and implementation of the Ninhydrin-HFE method as the standard operational protocol for Latex gloves to all field crime scene investigators.

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