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The Use of Liquid Latex for Soot Removal from Fire Scenes and Attempted Fingerprint Development with Ninhydrin*

ABSTRACT: Throughout the United States, clearance rates for arson cases remain low due to fire's destructive nature, subsequent suppression, and a misconception by investigators that no forensic evidence remains. Recent research shows that fire scenes can yield fingerprints if soot layers are removed prior to using available fingerprinting processes. An experiment applying liquid latex to sooted surfaces was conducted to assess its potential to remove soot and yield fingerprints after the dried latex was peeled. Latent fingerprints were applied to glass and drywall surfaces, sooted in a controlled burn, and cooled. Liquid latex was sprayed on, dried, and peeled. Results yielded usable prints within the soot prior to removal techniques, but no further fingerprint enhancement was noted with Ninhydrin. Field studies using liquid latex will be continued by the (US) Virginia Fire Marshal Academy but it appears that liquid latex application is a suitable soot removal method for forensic applications.

KEYWORDS: forensic science, fire investigation, fingerprinting, soot removal, liquid latex, Ninhydrin

Fire is an extremely destructive force, affecting both human lives and property. The United States Fire Administration determined that fires killed 3,245 people and destroyed 11.3 billion dollars' worth of property in 2006. An estimated 51,500 fires have been classified as intentionally set (1). Many of these arson scenes are an attempt to conceal evidence of another crime such as car-jacking or homicide. These statistics clearly indicate the human cost as well as the physical damage caused by the crime of arson.

Unfortunately, arson cases are extremely difficult to investigate. A typical scene for the fire investigator may be completely or partially destroyed by the effects of the fire itself, or by ensuing fire fighting efforts. Fires generate high thermal temperatures, which may ruin any fragile forensic evidence left behind. The principal means of fighting fire is by water suppression and subsequent overhaul to keep the fire from re-igniting, which further damages the scene. Smoke from the fire leaves sooty residues throughout the area, covering any patent or latent evidence that may be on the surface. These issues have historically stymied investigators in their efforts to recover forensic evidence with conventional crime scene processing.

The training of fire investigators in some jurisdictions may also be lacking. Most fire investigation classes are focused principally on assessing the cause and origin of a fire, and not necessarily on how to find the perpetrator(s) if the fire turns out to be incendiary. While technological advances in chemistry have allowed investigators to find increasingly minute amounts of ignitable liquids that are often left behind at arson scenes, this detection does not usually implicate a particular suspect. Successful prosecution of fire cases in court is usually based on witness statements and other types of evidence, not forensic evidence. Forensic advances in fingerprinting and DNA amplification may assist investigators with identifying the arsonist, but these techniques in preservation and analysis often do not make their way from the laboratory to those who recover the evidence on the scenes.

While research is currently being conducted on the possibility of DNA recovery despite elevated thermal temperatures, there is little published about fingerprinting at fire scenes, largely due to the fact that conventional powders and chemicals are not conducive to wet and sooty conditions. Most of the research that is available has come out of the United Kingdom. In 2006, Deans (2) conducted eight sets of controlled burn experiments whereupon he recovered fingerprints on a plethora of surfaces that were burned at various temperatures. His results clearly indicated that there was a significant chance of finding fingerprints and/or DNA on a fire scene provided that investigators looked in the appropriate areas. Because soot covered most of the remaining materials found in a fire, laboratories had turned their attention to the removal of soot on potential forensic evidence.

Historically, soot was used to make latent fingerprints visible. Harper used soot from a Bunsen burner to develop a fingerprint on a glass microscope slide, and published his results in 1938 (3). He observed that the carbon particles adhered to the print despite the heat put out from the flame. Harper conducted further research by heating and sooting fingerprints on a tin can to a temperature of *c.* 500°C (930°F). He then used a water rinse to remove excess soot, and found several latent prints to be permanently fixed upon the surface. This early work proved that fingerprints could sustain high heat and still be recovered. Harper's method was refined by others and eventually became known as the flame technique. An object of interest was held under a burning substance such as camphor or pine tar and the soot was allowed to coat the surface. Excess soot was then brushed away using a conventional fingerprint brush which left carbon particles attached to the secretion (4).

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A 1994 article in Fingerprint Whorld suggested that soot may actually shield the remaining fingerprint deposits from high heat. Research was conducted using a cold water rinse and lifting tape to remove excess soot. Spawn (5) achieved good results on items placed several feet away from the seat of a fire in a controlled burn setting. A more recent technique to remove soot from smaller items, such as glass bottles, is the application of Microsil, a compound traditionally used for casting toolmarks on crime scenes. The Microsil is applied, allowed to dry, and when peeled, removes a substantial amount of the soot covering the item. Any remaining soot may be tape lifted, or a second coat of Microsil may be applied. Conventional processing techniques may then be used to obtain prints on the object (6).

Another recent method reportedly used by police agencies in the United Kingdom is the application of a sodium hydroxide solution to the object, followed up with a water rinse. Stow and McGurry (7) researched using 1% and 2% sodium hydroxide washes on soot-covered glass and had excellent results obtaining partial or complete fingerprints thereafter. The team also recommended 1% or 2% sodium hydroxide as a soak to remove heavy soot contamination without the destruction of prints.

While this work on soot removal is commendable, various problems arise with the practicality of the techniques on a crime scene. Washing potential objects of evidence, whether with water or with sodium hydroxide, may diminish the likelihood of any DNA and/or ignitable liquid recovery. Tape lifting is a rather invasive method to remove soot considering the fragility of the prints underneath, and is also not practical for larger surfaces, such as walls in a room. Microsil, while relatively easy to work with, is expensive, time consuming to apply, and is thus not conducive for application to larger areas.

Recent research conducted by the Home Office Scientific Development Branch reported excellent soot removal with the application of liquid latex to larger areas such as windows or walls. The research team used a paint sprayer to apply several layers of liquid latex to a previously sooty surface. When the latex dried, it was peeled away, removing much of the soot while keeping the surface intact for potential blood spatter or fingerprint analysis (8). This process was demonstrated at an International Association of Blood Pattern Analysts conference in October of 2006, to rave reviews.

Because no known research in latex application for soot removal had been attempted in the United States, an initial study by the Virginia Fire Marshal Academy was carried out in order to evaluate the potential of this method for future use at fire scenes. Following the soot removal, Ninhydrin was used to attempt fingerprint recovery. Other published papers recommend the use of Physical Developer for chemical treatment in arson cases where water is used to suppress the fire but in this study no direct water suppression was applied to the materials that were sooted. Moreover, a recent study by West Virginia University indicates that amino acids present in fingerprint residues will remain after exposure to high heat at *c.* 500°C (930°F) (9). Ninhydrin was thus chosen as the processing method in this research, because Ninhydrin effectively reacted with amino acids.

This study hoped to answer the following questions:

Is latex application a suitable process to remove soot from fire scenes without destruction of any potentially remaining latent print evidence?

Does the application of Ninhydrin develop fingerprints that may have survived the thermal effects of the fire after soot removal?

Materials and Methods

It was decided to use two panels of untreated wallboard (drywall) and a pane of unframed window glass as burn substrates, as these surfaces are among those commonly encountered on arson scenes. Thirteen areas of a drywall board were circled, and 13 sets of palm/fingerprint residues were intentionally placed across the surface by four different fire investigators. The glass pane was coated with latent prints as well but these were not marked in order to give the investigators a more realistic scenario for powder processing after the experiment. A vial of blood was sprayed with a syringe onto the surface of the other panel of drywall in order to simulate blood spatter. These items were then placed near a controlled burn in an outdoor burn facility at the Hanover Fire Academy, on a warm spring morning with relatively high humidity. The items were photographed prior to burning, showing the locations of the print application and the blood spatter in relation to the burn area. Because most surfaces in a typical fire scene were heavily sooted, the decision was made to subject our samples to lower heat (ceiling temperatures under 538°C or 1000°F) and high soot. The application of soot, however, proved to be a formidable process.

Because our first burn attempt was at a training facility, we were limited as to the type of fuel load that we were permitted to burn. Our preliminary efforts began 20 min after application of the latent residues, with bails of hay for fuel. Although we maintained a relatively low heat (ceiling temperatures peaked at 257°C or 494°F), the samples did not appear significantly sooted. Ten minutes after the initial burn, we placed the samples into another burn using hay and diesel oil, and recorded ceiling temperatures of up to 538°C or 1000°F. Fortunately, this burn did coat our samples significantly. These samples were allowed to cool, and then removed from the facility for the latex application.

One gallon of liquid latex was purchased from an online company primarily specializing in theater and art business. The latex was devoid of any glitter or fillers, white in color at application, and dried clear on the surface. The initial thought was to apply the latex using a garden sprayer but the latex was too thick to properly apply to the samples so a professional paint sprayer was used (see Fig. 1). Four thin applications were sprayed onto the surfaces, with 20 min of drying time in between applications. After the final application, another 30 min of drying time was allotted, and the samples were photographed again before the peeling began.

Ninhydrin crystals (5 g) were dissolved in 45 mL of ethanol, and then 2 mL of ethyl acetate was added, followed by 5 mL of

FIG. 1—*Spraying liquid latex onto heavily sooted wallboard.*

glacial acetic acid. The solution was mixed for *c.* 15 min, until all of the crystals were completely dissolved. One liter of HFE 7100 (3M Chemical Company, St. Paul, MN) solvent was added to the Ninhydrin and stirred until a milky yellow solution was formed. The solvent was allowed to settle for 30 min, and then the solution was placed into a brown glass bottle 2 weeks before use. The Ninhydrin was tested on the day of the burn by applying fingerprints onto a piece of plain copy paper, and then dipping this paper into a pan containing Ninhydrin. After the paper was removed and allowed to dry, the latent prints became visible within a few minutes, thus indicating that the Ninhydrin was working correctly. Ninhydrin was later applied to the wallboard surface with a plastic spray bottle set to a fine mist. A second coat of Ninhydrin was applied and allowed to dry. A commercial steam iron was then held over the surfaces to provide additional humidity and to attempt to accelerate the development process.

In contrast to the chemical processing of the wallboard, conventional powder processing (black powder, magna powder, and fingerprint brushes) was applied to the window glass to mimic the equipment limitations of an investigator on a fire scene.

Results and Discussion

Immediately following the second attempt at soot application, fingerprints and a partial palm print were clearly visible within the soot on the wallboard. While this supports previous research on soot adhesion to fingerprint residues, our results were curious because they were not fingerprint residues left by our investigators. Rather, these residues were apparently from previous handling of the wallboard. The marked areas where fingerprint residues were applied yielded no visible fingerprints in soot whatsoever. The soot prints contained viable friction ridge-detail, and were thus photographed before the latex was applied to the wallboard (see Fig. 2). Documentation of any fingerprints must be carried out before applying latex, and before peeling the dried latex, as the latex will not keep its form after removal from the surface.

The latex peeled quite easily and successfully removed almost all of the soot from the glass and the drywall samples. A notable observation was that in the areas with little or no soot on the drywall, the latex peeled away some of the paper outer coating that was exposed. Caution should be taken on a scene to only apply/peel the latex from areas with significant soot, thus avoiding any destruction of the surface. The blood spatter on the drywall was clearly visible and appeared unchanged from before the soot and latex application. The latex on the glass windowpane was beginning to slide downward due to its own weight against the slick surface. This could be remedied easily by placing the pane flat against the ground but might be a potential problem on actual fire scenes where the glass was still vertical and intact.

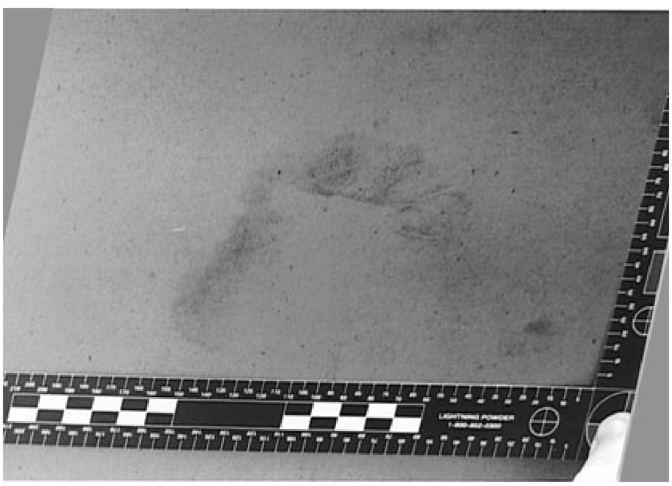

FIG. 2—*A partial palm print in soot photographed before the latex application.*

Conventional fingerprint processing did not produce any visible fingerprints on the glass pane. This result was similar to previous field research, where fingerprints on glass directly exposed to high heat for a significant period of time were not typically recovered (2). Despite several applications of Ninhydrin to the drywall, no additional fingerprint detail was observed. Although the latest research supports the theory that amino acids can survive a fire scene, amino acids were apparently not present on the wallboard here. This observation may have been due to the fact that our initial burn exposed the surfaces to heat without coating the surface with soot, which would have protected the fingerprint residues somewhat from thermal stress.

Conclusion

Soot-laden drywall and glass samples were treated with liquid latex which successfully removed most of the soot from the surface when dried and peeled. This technique may be extremely useful to fire investigators who need to view walls or floors of a suspicious fire for burn pattern information. Moreover, this process is very useful in removal of soot to view underlying blood spatter, to collect samples for potential DNA analysis, or to process surfaces for fingerprinting. While this study failed to yield additional fingerprint evidence with Ninhydrin postlatex application, more research is needed before the process is ruled out at arson scenes. Future studies will be performed at the Academy to apply soot with greater accuracy (maximize high soot with heat below 500°C or below 1000°F), to add more substrates upon which to test the latex technique, and to investigate the use of other fingerprint chemical enhancers such as Physical Developer and DFO.

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